DETAILED SOLUTIONS

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MPSC 2019 : Main Exam
ASSISTANT ENGINEER

CIVIL ENGINEERING

Test 11

Full Syllabus Test-5 | Paper-I

ANSWER KEY

1.	(c)	18.	(b)	35.	(a)	52.	(b)	69.	(d)	86.	(c)
2.	(b)	19.	(c)	36.	(a)	53.	(b)	70.	(c)	87.	(b)
3.	(c)	20.	(c)	37.	(a)	54.	(c)	71.	(b)	88.	(b)
4.	(a)	21.	(c)	38.	(b)	55.	(c)	72.	(a)	89.	(d)
5.	(c)	22.	(b)	39.	(d)	56.	(d)	73.	(b)	90.	(c)
6.	(b)	23.	(c)	40.	(d)	57.	(b)	74.	(c)	91.	(c)
7.	(b)	24.	(d)	41.	(a)	58.	(a)	75.	(b)	92.	(a)
8.	(c)	25.	(a)	42.	(b)	59.	(b)	76.	(a)	93.	(c)
9.	(b)	26.	(d)	43.	(b)	60.	(d)	77.	(d)	94.	(a)
10.	(a)	27.	(d)	44.	(b)	61.	(b)	78.	(c)	95.	(c)
11.	(c)	28.	(b)	45.	(b)	62.	(d)	79.	(b)	96.	(a)
12.	(c)	29.	(b)	46.	(a)	63.	(c)	80.	(a)	97.	(c)
13.	(d)	30.	(c)	47.	(c)	64.	(b)	81.	(d)	98.	(a)
14.	(a)	31.	(d)	48.	(a)	65.	(d)	82.	(b)	99.	(d)
15.	(b)	32.	(b)	49.	(d)	66.	(a)	83.	(b)	100.	(a)
16.	(c)	33.	(d)	50.	(a)	67.	(a)	84.	(a)		
17.	(c)	34.	(b)	51.	(a)	68.	(d)	85.	(b)		

DETAILED EXPLANATIONS

1. (c)

As per IS: 456-2000, values of partial safety factors for loads (Cl.18.2.3.1, 36.4.1 and B.4.3)

Load Combination	Limit state of collapse			Limit state of service ebility		
	DL	LL	WL/EQ	DL	LL	WL/EQ
$DL + LL$	1.5	1.5	–	1.0	1.0	–
$DL + WL/EQ$	1.5 or * 0.9	–	1.5	1.0	–	1.0
$DL + LL + WL/EQ$	1.2	1.2	1.2	1.0	0.8	0.8

- The value '0.9' is considered when stability against overturning or stress reversal is critical.

2. (b)

As per IS: 456 . 2000

A beam shall be deemed to be a deep beam when the ratio of effective span to overall depth, (L/D) is less than

i. 2.0 for a simply supported beam.

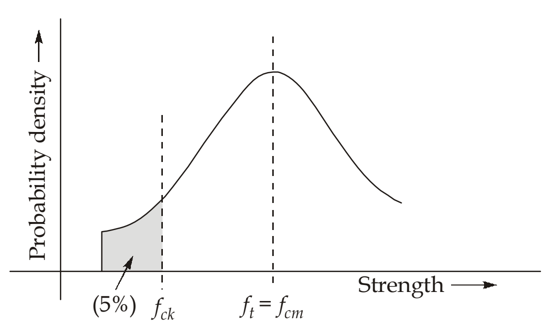
ii. 2.5 for a continuous beam.

4. (a)

Target mean strength (f_{cm}):

It is the strength for which the concrete is to be designed (proportioned) in order that the required characteristics strength is achieved.

Characteristics strength (f_{ck}): It is defined as the strength below which not more than 5% of test results are expected to fail.



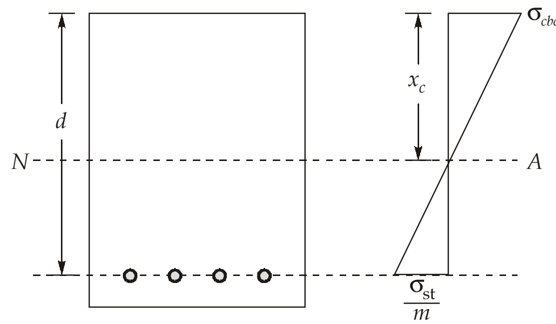
$$f_{cm} = f_{ck} + 1.65\sigma$$

5. (c)

As per ASCE 07 code clause 4.2.2.

In office building, or other building where partition location are subjected to change provisions for partition weight shall be made, whether or not partitions are shown on the construction documents, unless the specified load exceeds 80 psf (3.83 kN/m^2)

6. **(b)**



$$x_c = \text{Critical depth of NA}$$

From similarity of triangle,

$$\frac{\sigma_{cbc}}{x_c} = \frac{\sigma_{sx/m}}{d - x_c}$$

$$x_c = \left(\frac{m\sigma_{cbc}}{m\sigma_{cbc} + \sigma_{st}}\right)d$$

$$x_c = \frac{m}{m + (\sigma_{st}/\sigma_{cbc})}\,d$$

$$x_c = \left(\frac{m}{m+r}\right)d$$

7. **(b)**

If $\tau_v > \tau_{c,\,max}$ $\rightarrow$ Section should be redesigned

$\tau_v < 0.5\tau_c$ $\rightarrow$ no shear R/F (Reinforcement) is provided

$0.5\,\tau_c \le \tau_v \le \tau_c$, provide minimum shear reinforcement

If $\tau_c \le \tau_v \le \tau_{c,\,max}$, then shear reinforcement is designed for shear force,

$$V_{us} = V_u - V_c = \tau_v \cdot bd - \tau_c \cdot bd$$
$$= (\tau_v - \tau_c)bd$$

8. **(c)**

Even if calculations show that a beam has sufficient shear strength and shear stirrups are not required, a small quantity of shear stirrup is still provided. The reason is that tensile force may be induced into a beam through shrinkage or some restraint which will reduce the shear strength of concrete.

9. **(b)**

For Fe415 grade steel

$$M_{u,\,lim} = 0.138 f_{ck} bd^2$$
$$= 0.138 \times 25 \times 400 \times (600)^2 \times 10^{-6} = 496.8 \text{ kNm}$$

10. (a)

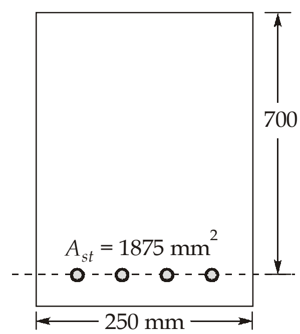
Minimum tension reinforcement

$$\frac{A_{st,\min}}{bd}\times 100 = \frac{0.85}{fy}\times 100$$

$$= \frac{0.85}{500}\times 100 = 0.17\%$$

Maximum tension reinforcement = 4%

11. (c)



For calculation of actual depth of NA.

$$\frac{bx_a^2}{2} = mA_{st}(d-x_a)$$

$$\frac{250x_a^2}{2} = 15\times 1875(700-x_a)$$

$$x_a^2 = 225(700-x_a)$$

$$x_a^2 + 225x_a - 157500 = 0$$

$$x_a = \frac{-225\pm\sqrt{(225)^2-4(1)\times(-157500)}}{2\times 1}$$

Neglective –ve sign

$$x_a = \frac{-225+825}{2} = \frac{600}{2} = 300 \text{ mm}$$

12. (c)

As per IS 456-2000, clause 23.3.

A simply supported or continuous beam shall be so proportioned that the clear distance between the lateral restraints does not exceed 60 or $\frac{250b^2}{d}$ whichever is less. For a cantilever, the clear distance from the free end of the cantilever to the lateral restraint shall not exceed 25b or $\frac{100b^2}{d}$ whichever is less.

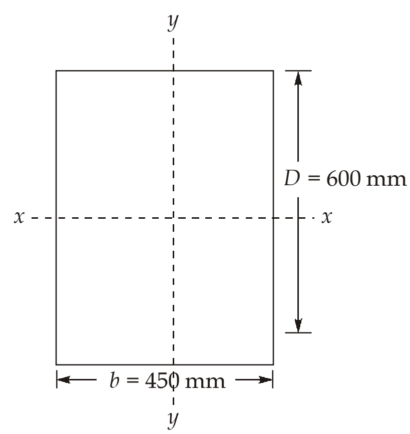
13. (d)

If a concrete is permitted to shrink, no stresses will induce due to shrinkage. But the movement of concrete is restricted by presence of reinforcement due to which shrinkage deformation occurs. However, if we place reinforcements symmetrically in the section, i.e. if the compression steel equal to tensile steel, then we can eliminate the shrinkage deflection in rectangular beams or slabs.

14. (a)

As per IS 456-2000 clause 24.1, for slabs spanning in two directions, the shorter of the two spans should be used for calculating the span to effective depth ratios.

15. (b)



$$e_{major} = \frac{L_{\text{un supported}}}{500} + \frac{D}{30}$$

$$= \frac{3000}{500} + \frac{600}{30} = 26 \text{ mm} > 20 \text{ mm} \quad \text{(O.K.)}$$

$$e_{minor} = \frac{L_{\text{un, supported}}}{500} + \frac{b}{30} = \frac{3000}{500} + \frac{450}{30}$$

$$= 21 \text{ mm} > 20 \text{ mm} \quad \text{(O.K.)}$$

16. (c)

$$\text{Hoop tension} = \frac{\gamma_w HD}{2} = \frac{10 \times 10 \times 5}{2} = 250 \text{ kN}$$

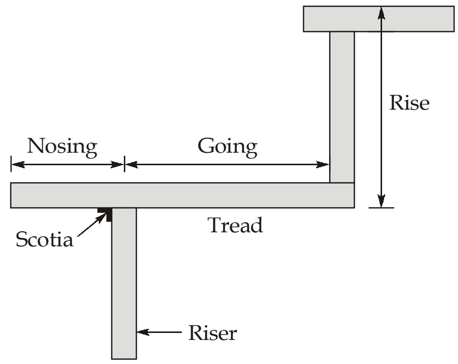
$$\text{For Fe415, } \sigma_{st} = 130 \text{ N/mm}^2$$

This total hoop tension will be taken by steel only

So, $$A_{st} = \frac{P}{A_{st}} = \frac{250 \times 10^3}{130} = 1923.08 \text{ mm}^2$$

$$\simeq 1924 \text{ mm}^2$$

18. (b)



Soffit : It is the underside of a stair.

Baluster: It is vertical member of wood or metal, supporting the hand rail.

Header: It is the horizontal structural member supporting stair stringers or landings.

19. (c)

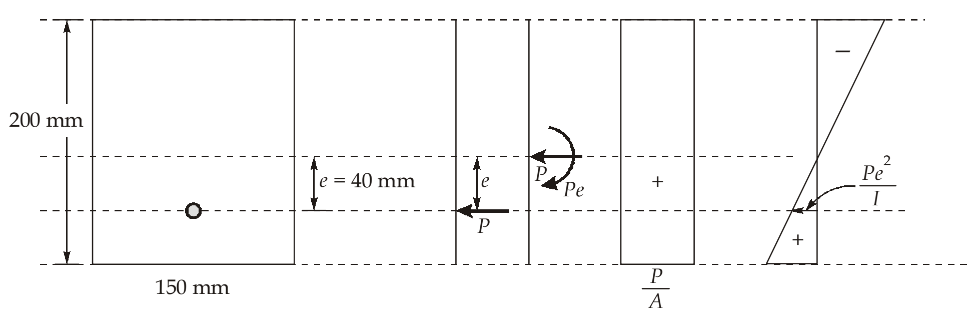
$$\begin{aligned} L_{\text{eff}} &= G + x + y \\ 2x &= 1.6 \text{ m} \\ x &= 0.8 \text{ m} < 1 \text{ m} \quad \text{(O.K.)} \\ 2y &= 2.4 \text{ m} \\ y &= 1.2 \text{ m} > 1 \text{ m}; y = 1 \text{ m} \\ l_{\text{eff}} &= 10 + 0.8 + 1 = 11.80 \text{ m} \end{aligned}$$

20. (c)

Counterforts are firmly attached to the face slab as well as the base slab. The earth pressure acting on the face slab is transferred to the counterforts which deflects as vertical cantilevers. The back of the rear counterforts comes in tension and their front face is under compression. So the inclined back face of rear counterforts should be provided with main reinforcement.

In case of front counterforts, the tension develops at the bottom face and it is provided with main reinforcement.

22. (b)



P = 200 kN

Now, stress at level of wire

$$f = \frac{P}{A} + \frac{Pe^2}{I} = \frac{200 \times 10^3}{150 \times 200} + \frac{200 \times 10^3 \times (40)^2}{\frac{150 \times (200)^3}{12}}$$

$$= 6.67 + 3.2 = 9.87 \text{ N/mm}^2$$
$$\simeq 10 \text{ N/mm}^2$$

24. (d)

$$\text{Loss of stress due to friction} = p_o(kx + \mu\alpha)$$
$$p_o = \text{initial stress}$$
$$\alpha = \text{cumulative angle in radian} = 0$$

(For straight cable profile)

$$x = \text{distance between points of application of prestressing force}$$

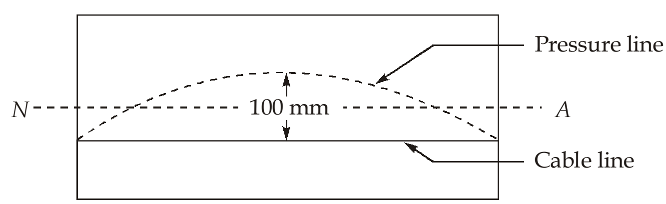
$$\therefore \quad \text{loss} = p_o[0.002 \times 10 + 0] = 0.02\, p_o$$

$$\%\text{age loss} = \frac{0.02 p_o}{p_o} \times 100 = 2\%$$

25. (a)

Bending moment at mid span,

$$M = \frac{wL^2}{8} = \frac{12 \times (8)^2}{8} = 96 \text{ kNm}$$



$$\text{Prestressing force, } P = A_{st} \times f_s$$
$$= 1200 \times 800 = 960 \text{ kN}$$

$$\therefore \quad \text{Shift} = \frac{M}{P} = \frac{96}{960} = 0.1 \text{ m} = 100 \text{ mm}$$

26. (d)

Transmission length: It is the length of wire from one end of pretensioned member beyond which full permissible prestressing force develops in nature.

27. (d)

$$E = 2G(1 + \mu) \quad \text{...(i)}$$
$$E = 3k(1 + 2\mu) \quad \text{...(ii)}$$

From eq. (i) and eq. (ii)

$$\frac{E}{2G} - 1 = \frac{1}{2} - \frac{E}{6k}$$

$$E\left(\frac{1}{2G} + \frac{1}{6k}\right) = \frac{3}{2}$$

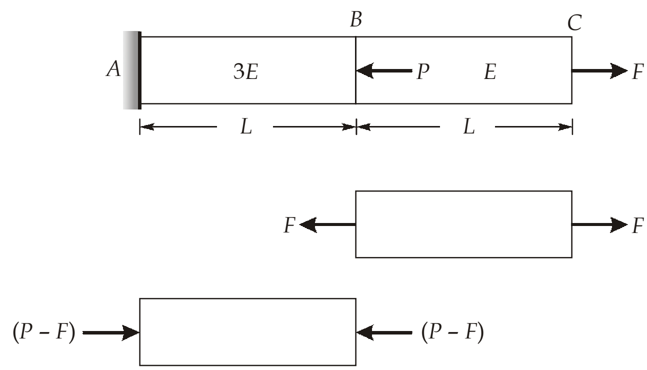
$$E\left(\frac{3k+G}{6kG}\right) = \frac{3}{2}$$

$$\frac{9}{E} = \frac{3k+G}{kG}$$

$$\frac{9}{E} = \frac{3}{G}+\frac{1}{k}$$

$$\frac{9}{E} = \frac{3}{G}+\frac{1}{k}$$

28. (b)



$$\Delta_c = 0$$

$$\Delta_{BC} + \Delta_{BA} = 0$$

$$\frac{FL}{AE} - \frac{(P-F)L}{A \cdot 3E} = 0$$

$$3F = P - F$$

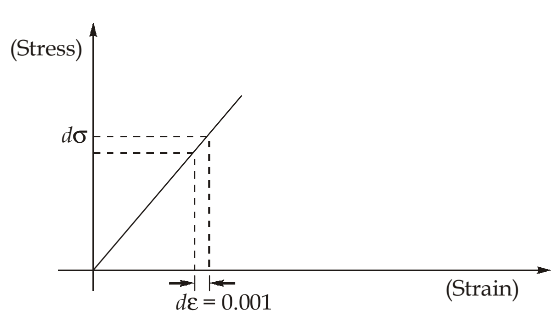
$$4F = P$$

$$\frac{P}{F} = 4$$

30. (c)

If a bar is free, it will expand freely on heating and no thermal stress will generate. Thermal stress gets generated only when bar is constrained.

31. (d)



Now, upto elastic limit

$$\text{Stress} \propto \text{strain}$$

i.e. $\sigma = \varepsilon \cdot E$ or slope is constant

$$\therefore \quad E = \frac{d\sigma}{d\varepsilon} = \frac{200}{0.001}$$

$$= 2 \times 10^5 \text{ N/mm}^2 = 200 \text{ GPa}$$

$$\mu = 0.4$$

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

$$G = \frac{E}{2(1+\mu)} = \frac{200}{2(1+0.4)} = \frac{200}{2.8} = 71.43 \text{ GPa}$$

33. (d)

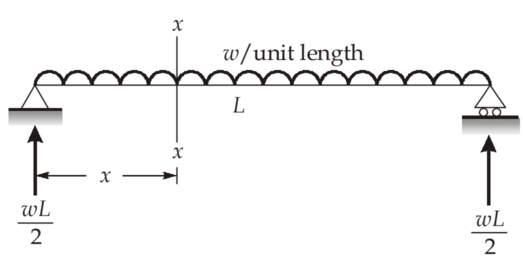
On plane *BE*,

$$\sigma_n = \frac{\sigma_1+\sigma_2}{2} + \frac{\sigma_1-\sigma_2}{2}\cos(2\times 30)$$

$$= \frac{100+100}{2} + \frac{100-100}{2}\cos(60^\circ)$$

$$= 100 \text{ MPa} = 100 \text{ N/mm}^2$$

34. (b)



At any section *x-x*

$$M_{xx} = \frac{wL}{2}x - \frac{wx^2}{2}$$

35. (a)

A point of contraflexure is the point where bending moment changes sign.

36. (a)

At *A*, S.F. ↓es by 12 kN ⇒ there must be a ↓ward point load of 12 kN. From *A* to *B* shear force is constant,

At *B*, *SF* drops to – 2 kN ⇒ there must be an ↑ward point load 10 kN.

From B to C, SF increases linearly from –2 kN to 38 kN,

⇒ There much be uniformly distributed load of intensity

$$\omega = \frac{dV}{dx} = \frac{38-(-2)}{4} = 10 \text{ kN/m}$$

+ve sign indicates loading intensity is upward.
At C, SF changes from 38 kN to –12 kN
⇒ There must be downward point load of 50 kN
C to D SF is constant,
At D, SF drops to zero ⇒ There must be upward point load of 12 kN.

38. (b)

Type of section	**Shape of core**
Rectangular	Rhombus
I-section	Rhombus
Circular	Circle
Square	Square

39. (d)

Euler's crippling load, $$P_{cr} = \frac{\pi^2 EI}{L^2} = \frac{\pi^2 E}{L^2} \times \left(\frac{\pi d^4}{64}\right)$$

$$P_{cr} = (1.5) = \frac{\pi^2 E}{L^2} \times \frac{\pi d^4}{64} \quad \text{... (i)}$$

$$(P_{cr})' = \frac{\pi^2 E}{L^2} \times \frac{\pi}{64} \times (0.9d)^4 = \frac{\pi^2 E}{L^2} \times \frac{\pi}{64} d^4 \times (0.4)^4$$

$$= (1.5)\ (0.9)^4 = P_{cr}(0.9)^4$$

Percentage reduction $$= \frac{P_{cr} - P'_{cr}}{P_{cr}} \times 100 = \left(1 - \frac{P'_{cr}}{P_{cr}}\right) \times 100$$

$$= [1 - (0.9)^4] \times 100 = (1 - 0.6561) \times 100$$

$$= 34.39\%$$

40. (d)

For solid shaft, $$\frac{\tau}{D/2} = \frac{G\theta}{L}$$

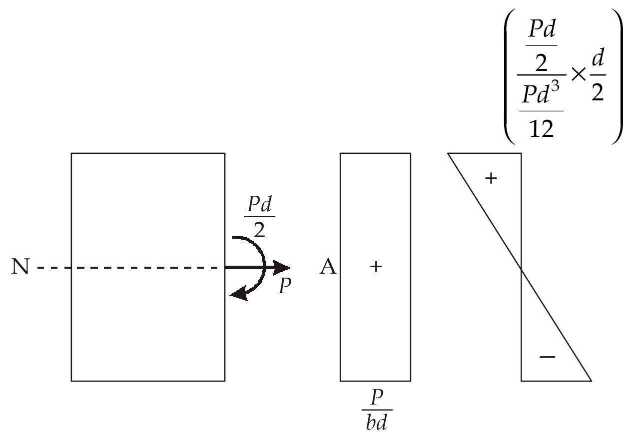
$$\tau = \frac{G\theta}{L}\left(\frac{D}{2}\right)$$

For hollow shaft, $$\frac{\tau_h}{D/2} = \frac{G\theta}{L}$$

$$\tau_h = \left(\frac{G\theta}{L}\right) \times \frac{D}{2} = \tau$$

42. (b)

At section A-A



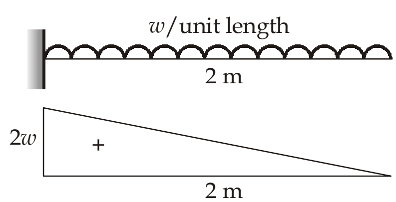
$\therefore$ Maximum tensile stress occur at top of beam at section A-A

$\therefore$

$$\tau_{max} = \frac{P}{bd} + \frac{Pd/2}{\left(\frac{bd^3}{12}\right)} \times \frac{d}{2}$$

$$= \frac{P}{bd} + \frac{Pd^2/4}{\left(\frac{bd^3}{12}\right)} = \frac{P}{bd} + \frac{3P}{bd} = \frac{4P}{bd}$$

43. (b)



Let UDL be (w kN/m)

$\therefore$ Maximum SF (V) = $2w$

For rectangular section,

$$\tau_{max} = \frac{3}{2}\tau_{av}$$

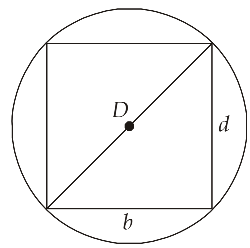
$$2 = \frac{3}{2} \times \frac{V}{A}$$

$$\frac{V}{A} = \frac{4}{3}$$

$$\frac{2\omega \times 10^3}{100 \times 200} = \frac{4}{3}$$

$$\omega = \frac{40}{3}\ \text{kN/m}$$

44. (b)



$$D^2 = b^2 + d^2$$

$$d^2 = D^2 - b^2 \quad \text{... (i)}$$

$$z = \frac{bd^2}{6} = \frac{b \times (D^2 - b^2)}{6} = \frac{bD^2 - b^3}{6}$$

For section to be strongest, $\frac{dz}{db} = 0$

$$D^2 - 3b^2 = 0$$

$\Rightarrow$ $b = \frac{D}{\sqrt{3}}$

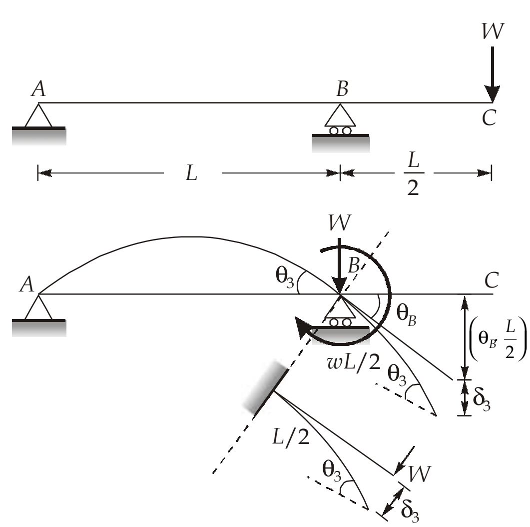
Now, from equation (i)

$$d^2 = D^2 - \frac{D^2}{3} = \frac{2}{3}D^2$$

$$d = \sqrt{\frac{2}{3}}D$$

$\therefore$ Dimension of rectangular beam $\frac{D}{\sqrt{3}}$ and $D\sqrt{\frac{2}{3}}$

45. (b)

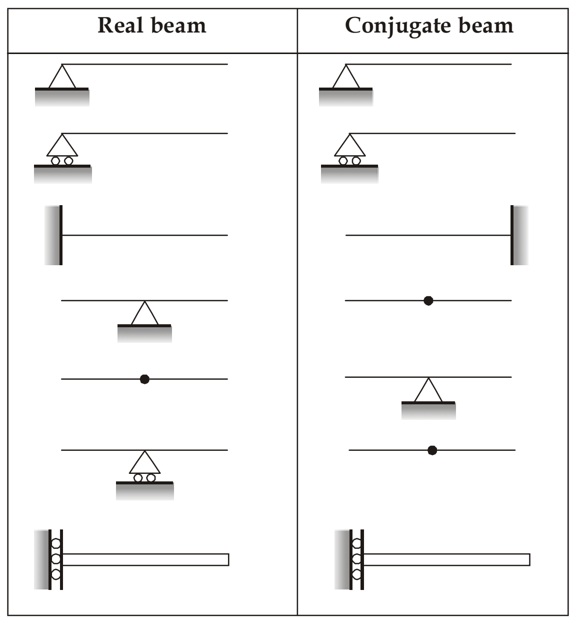


Now, $$\delta_c = \theta_B \times \frac{L}{2} + \delta_3 = \frac{(WL/2)\times L}{3EI} \times \frac{L}{2} + \frac{WL^3}{24EI}$$

$$= \frac{WL^3}{12EI} + \frac{WL^3}{24EI} = \frac{2WL^3 + WL^3}{24EI} = \frac{WL^3}{8EI}$$

46. (a)

Real beam can be converted into a conjugate beam by changing the support condition as shown below:



47. (c)

$$\theta = \frac{(M/2)L}{3EI} + \frac{(M/2)L}{6EI} = \frac{ML}{6EI} + \frac{ML}{12EI} = \frac{2ML + ML}{12EI}$$

$$\theta = \frac{ML}{4EI}$$

$\therefore$ $$\frac{ML}{EI} = 4\theta$$

50. (a)

$$\text{Injurity severity rate} = \frac{\text{Number of days lost} \times 10^3}{\text{Number of man hours worked}}$$

$$= \frac{100 \times 1000}{500 \times 8 \times 365 \times 3} = 0.023$$

52. **(b)**

It is better to start with crashing first that activity which has the lowest cost slope. Then we take another critical activity which is having next higher critical slope.

53. **(b)**

$$Z = \frac{T_S - T_E}{\sigma}, \quad \sigma = \sqrt{9} = 3 \text{ weeks}$$

$$1.647 = \frac{T_S - 60}{3}$$

$$T_s = 60 + 1.647 \times 3 = 64.94 \text{ weeks}$$

54. **(c)**

Independent float does not effect the float of preceding and succeeding activities

$$F_{ID} = T_E^{J} - T_L^{i} - t_{ij}$$

55. **(c)**

$$EOQ = \sqrt{\frac{2DC_o}{pc_h}} = \sqrt{\frac{2 \times 800 \times 150}{400 \times 0.015}} = 200$$

p = price/unit

D = annual demand

c_c/c_h = carrying cost/holding cost

C_o = ordering cost/order

57. **(b)**

The VED analysis is based on the criticality of the items.

$V \rightarrow$ Vital items

$E \rightarrow$ Essential items

$D \rightarrow$ Desirable items

61. **(b)**

C_3S is responsible for most of the early strength of cement while dicalcium silicate (C_2S) is responsible for the ultimate strength.

62. **(d)**

According to IS 4031 part 5, the initial setting time test is conducted on cement by gauging the cement with 0.85 times the water required to give a paste of standard consistency.

63. **(c)**

Bull mark is provided at specific distance to make sure that the required thickness of plastering is even/uniform throughout. It is small rectangular/hexagonal mark.

66. **(a)**

Maturity of concrete is defined as the summation of product of time and temperature Maturity = Σ(Time × temperature).

67. (a)

Rounded spherical shape aggregates have less surface area so less amount of paste is required for lubrication, they are more workable.

68. (d)

Chemicals like ammonium sulphate, borax, zinc chloride, boric acid etc. imports fire resistant property to timber.

Note: SirAbel's process is also used to make timber fire resistant.

70. (c)

Modular brick is standard brick of size 19 cm × 9 cm × 9 cm used for high class masonry work.

71. (b)

Varnish is a nearly homogenous solution of resin in oil, alcohol or turpentine.

74. (c)

Cork Flooring: It is such type of flooring which is perfectly noiseless, and is used in libraries, theaters, art galleries, broadcasting stations etc.

75. (b)

Fender piles and dolphins are used to protect water front structures against impact from ships or other floating objects.

77. (d)

$$A_n = \left[b - nd_h + \Sigma \frac{p_i^2}{4g_i}\right]t$$

In this case $n = 5$

$$\therefore \quad A_n = \left[b - 5d_h + \frac{4p^2}{4g}\right]t$$

79. (b)

The fillet weld (transverse and parallel) is always assumed to resist the load by shearing action on its throat.

80. (a)

Fillet welds when subjected to a combination of normal stress (due to axial tension/compression or bending tension/compression) and shear stresses, the equivalent stress fe should satisfy the following.

$$F_e = \sqrt{f_a^2 + 3q^2} \le \frac{f_u}{\sqrt{3}\gamma_{mw}}$$

f_a = normal stress

q = shear stress

81. (d)

$$f_{cd} = \frac{f_y/\gamma_{mo}}{\left[\phi + \left(\phi^2 - \lambda^2\right)^{1/2}\right]} = \chi \frac{f_y}{\gamma_{mo}}$$

where $\phi = 0.5\left(1 + \alpha\left(\bar{\lambda} - 0.2\right) + \bar{\lambda}^2\right)$

$\bar{\lambda}$ = Non-dimensional effective slenderness ratio

$$= \sqrt{\left(\frac{f_y}{f_{cr}}\right)}$$

$$f_{cr} = \frac{\pi^2 E}{\lambda^2}$$

$(\bar{\lambda} \geq 0.2)$

α = imperfection factor

82. (b)

V_d = design shear strength of the cross-section

83. (b)

The vertical deflection of a gentry girder should not exceed the values specified below:

i. When the cranes are manually operated - $\frac{L}{500}$

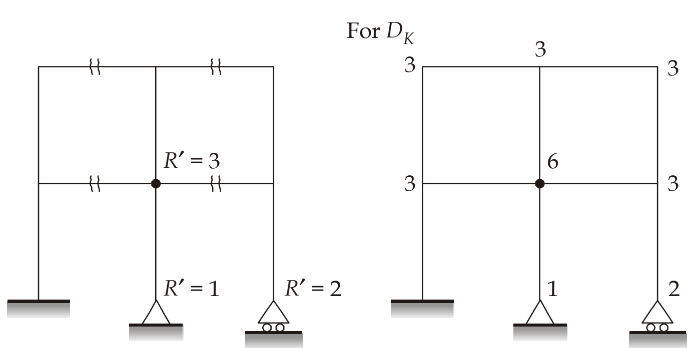
ii. Where the cranes are travelling overhead and operated electrically upto 500 kN - $\frac{L}{750}$

iii. Where the cranes are travelling overhead and operated electrically over 500 kN - $\frac{L}{1000}$

iv. Other moving loads such as charging cars etc. - $\frac{L}{600}$

84. (a)

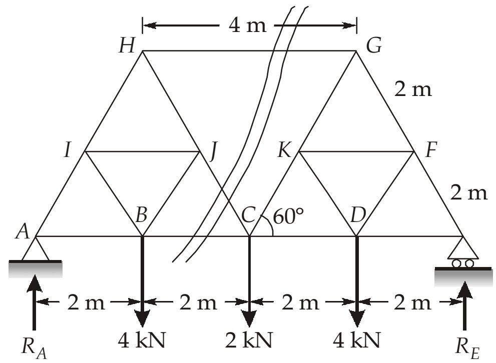
For D_S:



D_S = $3C - R' = 3 \times 4 - 6 = 6$

D_K = $(24 - 10) = 14$

85. (b)



$$R_A = R_E = 1 + \frac{4 \times 2}{8} + \frac{4 \times 6}{8} = 5\,\text{kN}$$

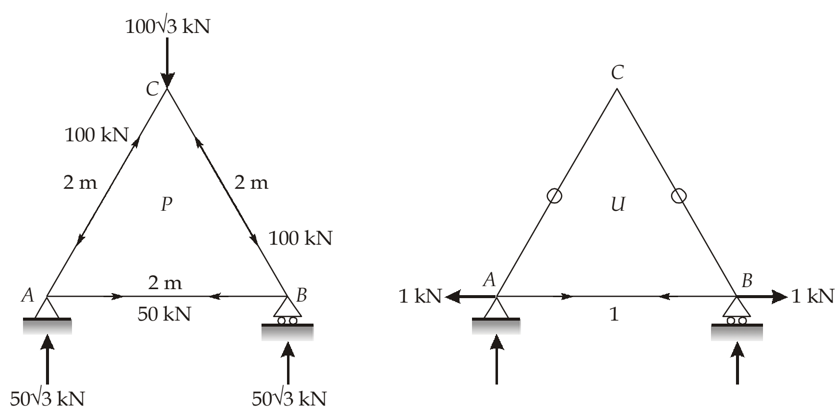
Considering a section perpendicular to AE at C and balancing moment about C = 0

$$\Sigma M_C = 0$$

$$-5 \times 4 + 4(2) + F_{HG}\,(4 \sin 60°) = 0$$

$$F_{HG} = 3.46 \text{ kN (C)}$$

86. (c)



$$\delta_B = \Sigma \frac{PUL}{AE} = \frac{50 \times 10^3 \times 1 \times 2000}{10 \times 10^6} = 10\,\text{mm}\,(\rightarrow)$$

87. (b)

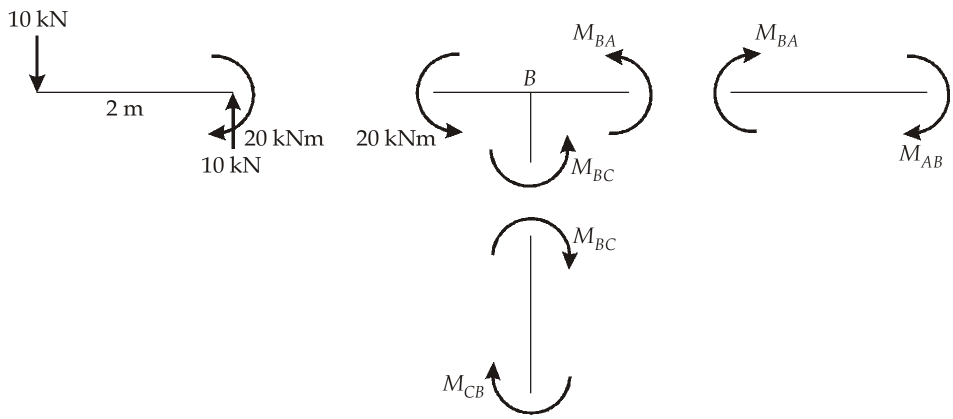
Given: M_C = 90 kNm, θ_{CD} = 0.005 rad, δ_C = 5 mm = 0.005 m, F_D = ?

From maxwell reciprocal theorem

$$F_D\,\delta_{CD} = M_C.\theta_{DC}$$

$$F_D = \frac{90 \times 0.005}{0.005} = 90\text{ kN}$$

88. **(b)**

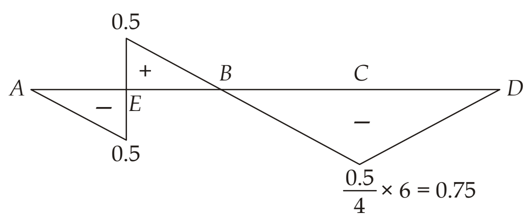


Now, at joint B equilibrium equation,

$$M_{BA} + M_{BC} + 20 = 0$$

89. **(d)**

Using Mulier Breshai principle



90. **(c)**

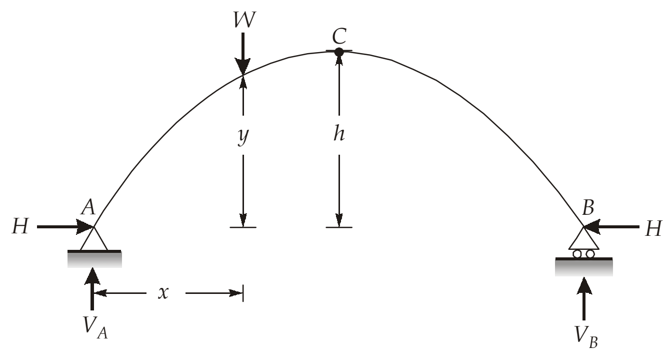
At joint D

Joint	Member	Member Stiffness (MS)	Joint Stiffness (JS)	DF = $\frac{MS}{JS}$
D	DA	$\frac{4EI}{L}$	$\frac{10EI}{L}$	$\frac{4}{10}$
	DB	$\frac{3EI}{L}$		$\frac{3}{10}$
	DC	$\frac{3EI}{L}$		$\frac{3}{10}$

$$M_{DA} = PL \times \frac{4}{10} = \frac{4PL}{10}$$

$$\therefore \quad M_{AD} = \frac{M_{DA}}{2} = \frac{2PL}{10} = \left(\frac{PL}{5}\right)$$

91. (c)



$$V_A = \frac{W(L-x)}{L}; \qquad V_B = \frac{Wx}{L}$$

$$\Sigma M_C = 0 \text{ (from right end)}$$

$$\Rightarrow \qquad H \times h = \frac{Wx}{L} \times \frac{L}{2}$$

$$H = \frac{Wx}{2h}$$

The maximum BM occurs under the load,

$$BM_{xx} = \frac{W(L-x)}{L} \times x - \frac{Wx}{2h} \times \frac{4h}{L^2} \times (L-x)x$$

$$= \frac{Wx(L-x)}{L} - \frac{2W}{L^2}x^2(L-x)$$

For maximum BM $\quad \frac{d}{dx}(BM_{xx}) = 0$

$$\frac{W}{L}(L-2x) = \frac{2W}{L^2}(2Lx - 3x^2)$$

$$6x^2 - 6xL + L^2 = 0$$

$$x = \frac{6L \pm \sqrt{36L^2 - 24L^2}}{2 \times 6} = \frac{6L \pm \sqrt{12L^2}}{12}$$

$$= \frac{L}{2} \pm \frac{L}{2\sqrt{3}}$$

Since $(x < L/2)$ neglect +ve sign

$$x = \frac{L}{2} - \frac{L}{2\sqrt{3}} \text{ from 4}$$

$\therefore$ From crown, distance of maximum BM on either side = $\frac{L}{2} - x = \frac{L}{2\sqrt{3}}$

92. (a)

$$L = l + \frac{2}{3}\left[\frac{h_1^2}{l_1} + \frac{h_2^2}{l_2}\right] = 50 + \frac{2}{3}\left[\frac{9^2}{30} + \frac{4^2}{20}\right]$$

$$= 52.33 \text{ m}$$

93. (c)

Elements of flexibility matrix are displacements;

96. (a)

$$\text{Step size } (h) = \frac{4-2}{2} = 1$$

x	2	3	4
$f(x)$	8	27	64
	$\downarrow$ y_0	$\downarrow$ y_1	$\downarrow$ y_2

By trapezoidal rule,

$$\int_2^4 x^3 dx = \frac{h}{2}\left[(y_0 + y_2) + 2y_1\right] = \frac{1}{2}\left[(8+64) + 2\times 27\right] = 63$$

97. (c)

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)} = x_n - \frac{x_n^3 + 3x_n - 7}{3x_n^2 + 3}$$

$$= \frac{3x_n^3 + 3x_n - x_n^3 - 3x_n + 7}{3x_n^2 + 3}$$

$$= \frac{2x_n^3 + 7}{3x_n^2 + 3}$$

$x_0 = 1,$

$$x_1 = \frac{2x_o^3 + 7}{3x_o^2 + 3} = \frac{2\times 1 + 7}{3\times 1 + 3} = \frac{9}{6} = 1.5$$

99. (d)

$$x + y + z = 9 \quad \text{... (i)}$$
$$2x - 3y + 4z = 13 \quad \text{... (ii)}$$
$$3x - 4y + 5z = 40 \quad \text{... (iii)}$$

Operate (ii) – 2 × (i) and (iii) – 3 × (i) to eliminate x

$$2x - 3y + 4z = -5 \quad \text{... (iv)}$$
$$y + 2z = 13 \quad \text{... (v)}$$

Operate (v) + 1/5 × 4 to eliminatey

$$y + 2z + \frac{1}{5}(-5y + 2z) = 13 + \frac{1}{5}(-5)$$

$$2z + \frac{2z}{5} = 12$$
$$12z = 60$$
$$z = 5$$

By back substitution from (v)

$$y = 13 - 2 \times 5 = 3$$

From (i) $\quad x = 9 - 3 - 5 = 1$

100. (a)

$$A = \begin{bmatrix} 2 & 6 & 0 \\ 4 & 12 & 8 \\ -2 & 0 & 4 \end{bmatrix} = (2)^3 \begin{bmatrix} 1 & 3 & 0 \\ 2 & 6 & 4 \\ -1 & 0 & 2 \end{bmatrix}$$

$$\text{Det(A)} = (2)^3 \times D = 8 \times (-12) = -96$$

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