DETAILED SOLUTIONS

MADE EASY

India's Best Institute for IES, GATE & PSUs

Test Centres: Delhi, Noida, Hyderabad, Bhopal, Jaipur, Lucknow, Bhubaneswar, Indore, Pune, Kolkata, Patna

MPSC 2019 : Main Exam

ASSISTANT ENGINEER

CIVIL ENGINEERING

Test 7

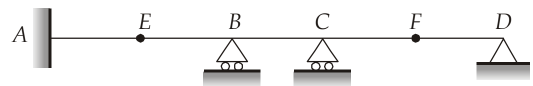
Full Syllabus Test-1 | Paper-I

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)



$$\text{Displacement at } A = 0$$
$$E = \theta_{E_1}, \theta_{E_2}, y_E, x_E = 4$$
$$B = \theta_B, x_B = 2$$
$$C = \theta_C, x_C = 2$$
$$F = \theta_{F_1}, \theta_{F_2}, x_C, y_F = 4$$
$$D = \theta_D = 1$$

Total degree of kinematic indeterminacy

$$D_K = 4 + 2 + 2 + 4 + 1 = 13$$

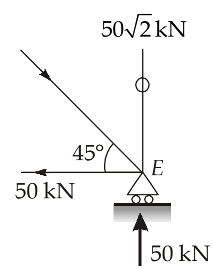
2. (a)

$$D_s = m + r - 2j = 17 + 3 - 2 \times 10 = 0 \text{ (statically determinate)}$$

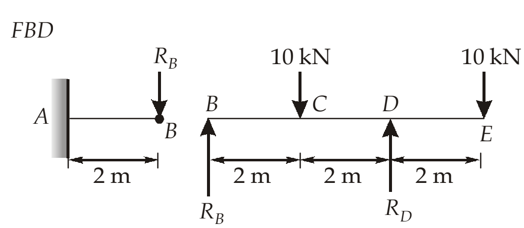
Also, given truss has three independent roller supports, whose lines of actions are neither all parallel, nor concurrent. Hence, this is a stable system.

3. (a)

Consider equilibrium of joint E,



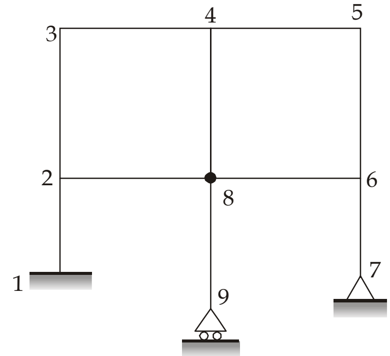
4. (a)



Considering right part of hinge B,

$$\Sigma M_B = 0$$
$$R_D \times 4 - 10 \times 6 - 10 \times 2 = 0$$
$$R_D = 20 \text{ kN}$$
$$\therefore \quad R_B = 0$$
$$M_A = R_B \times 2 = 0 \text{ kNm}$$

5. (b)



If members are treated inextensible,

Number of members = 10

Number of joint = 9

Numer of reactions = 3 + 2 + 1 = 6

$D_k = 3j - R$ + additional D.O.F. – m

Additional D.O.F. = (4 – 1) in joint hinge 8 = 3

$D_K = 3 \times 9 - 6 + 3 - 10 = 14$

6. (a)

Kani's method is an iterative displacement method of analysis and not force method.

7. (b)

We know that

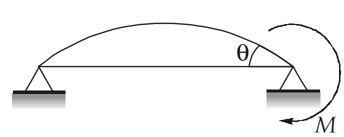
$$\text{Meber stiffness, } k = \frac{M}{\theta}$$

1. Cantilever

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

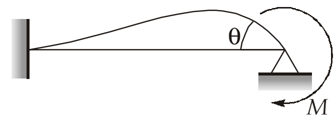
$$\frac{M}{\theta} = \frac{EI}{L}$$

2. Far end hinged



$$\frac{M}{\theta} = k = \frac{3EI}{L}$$

3. Far end fixed



$$\frac{M}{\theta} = k = \frac{4EI}{L}$$

8. (a)

Joint	Member	Member stiffness (MS)	Joint stiffness (JS)	Distribution factor (D.F) = $\frac{MS}{JS}$
C	CE	$\frac{4EI}{3}$	$\frac{13}{3}$ EI	$\frac{4}{13}$
	CB	$\frac{4E(2I)}{4}$		$\frac{6}{13}$
	CD	$\frac{3EI}{3}$		$\frac{3}{13}$

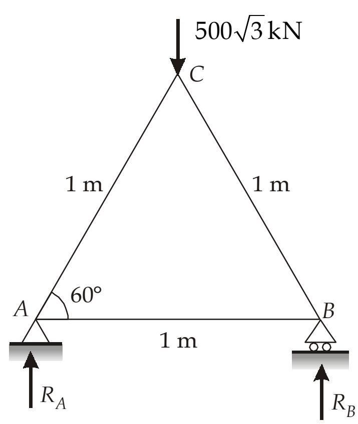
For member, CE

$$DF = \frac{4}{13}$$

10. (a)

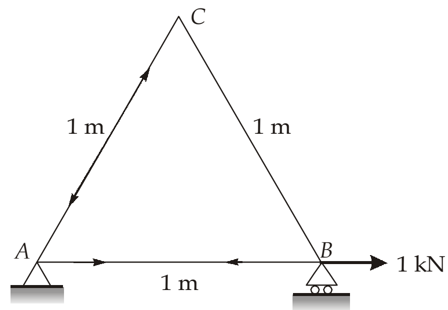
$$\frac{M_{BA}}{M_{CD}} = \frac{6EI\frac{\Delta}{L^2}}{\frac{3E(0.5I)\Delta}{\left(\frac{L}{2}\right)^2}} = \frac{6}{6} = 1.0$$

11. (b)



$$P_{AB} = 250\sqrt{3}\ \text{kN}$$

$$P_{AB} = R_A \cdot \cot 60° = 250\sqrt{3} \times \frac{1}{\sqrt{3}} = 250 \text{ kN}$$



$$k_{AB} = 1$$

$$k_{CA} = k_{CB} = 0$$

$$\delta = \sum \frac{PkL}{AE} = \frac{250 \times 10^3 \times 1 \times 1000}{50 \times 2 \times 10^5} = 25 \text{ mm}$$

12. (c)

Removing support B and allowing beam to get deflect.

$$\delta_B = \frac{5}{384} \cdot \frac{w(2L)^4}{EI} (\downarrow)$$

Due to reaction at B the vertical upward displacement at B,

$$\delta_B' = \frac{R \times (2L)^3}{48EI} \uparrow$$

As per compatibility condition,

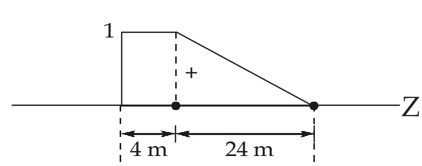
$$\delta_B + \delta_B' = 0$$

$$\frac{5}{384} \cdot \frac{w(2L)^4}{EI} = \frac{R(2L)^3}{48EI}$$

$$\Rightarrow \quad R = \frac{5wL}{4}$$

13. (b)

ILD for shear force at H is shown below

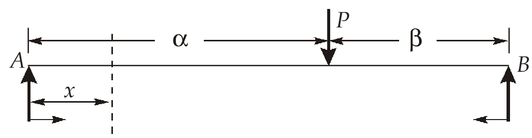


So, maximum shear force at section H is given as

$$V_{\max, H} = \left(1 \times 4 + \frac{1}{2} \times 24 \times 1\right) \times 4 = 64 \text{ kN}$$

14. (c)

Consider a simply supported beam is as shown in figure,



$\alpha + \beta = l$

$$R_A = \frac{P\beta}{\alpha+\beta} = \frac{P.\beta}{l}$$

$$R_B = \frac{P.\alpha}{\alpha+\beta} = \frac{P.\alpha}{l}$$

Strain energy stored by the beam AB = Strain energy stored by AC + strain energy stored by BC

$$= \int_0^{\alpha}\left(\frac{P\beta}{l}\right)^2 (x)^2 \frac{dx}{2EI} + \int_0^{\beta}\left(\frac{P\alpha}{l}\right)^2 x^2 \frac{dx}{2EI}$$

$$= \frac{P^2\beta^2\alpha^3}{6EIl^2} + \frac{P^2\alpha^2\beta^3}{6EIl^2} = \frac{P^2\alpha^2\beta^2}{6EIl^2}(\alpha+\beta)$$

$$U_{AB} = \frac{P^2\alpha^2\beta^2}{6EIl^2}\times l = \frac{P^2\alpha^2\beta^2}{6EIl}$$

15. (d)

For parabolic arch

$$\frac{x}{\sqrt{y}} = \text{constant} \qquad (c \text{ is taken as origin})$$

$$\frac{l_1}{\sqrt{h_1}} = \frac{l_2}{\sqrt{h_2}}$$

$$\frac{l_1}{l_2} = \sqrt{\frac{h_1}{h_2}} = \sqrt{\frac{4}{5}} = \frac{2}{\sqrt{5}}$$

$$\frac{l_2}{l_1} = \frac{\sqrt{5}}{2} = 1.118 \simeq 1.12$$

16. (b)

$$M_{FBA} = M_{FAB} = 0$$

$$M_{FBC} = \frac{-50\times 3\times (2)^2}{(5)^2} = -24 \text{ kNm}$$

Using slope deflection equation

$$M_{BA} = M_{FBA} + \frac{2EI}{5}\left(2\theta_B + \theta_A - \frac{3\delta}{L}\right) = \frac{4EI\theta_B}{5}$$

$$M_{BC} = M_{FBC} + \frac{2EI}{5}\left(2\theta_B + \theta_C - \frac{3\delta}{L}\right) = -24 + \frac{4EI\theta_B}{5}$$

By joint equilibrium equation at joint B,

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

$$\frac{4}{5}EI\theta_5 - 24 + \frac{4EI\theta_B}{5} = 0$$

$$\frac{8EI\theta_B}{5} = 24$$

$$\therefore \quad \theta_B = \frac{15}{EI}$$

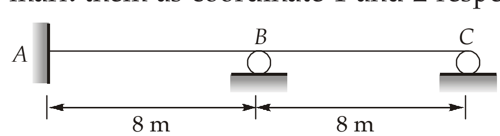
17. (c)

Important points in respect of a flexibility matrix.

- Order of matrix is the number of coordinate chosen for solution of problem.
- Elements of flexibility matrix are displacements.
- Flexibility matrix will always be a square matrix.
- Elements along the diagonal will always be non-zero and positive, other elements can be zero or negative.
- Matrix will always be a symmetric matrix about its main diagonal. (This follows from Maxwell's Reciprocal theorem)
- Flexibility matrix can be calculated only for stable structure in which there is no rigid body displacements.

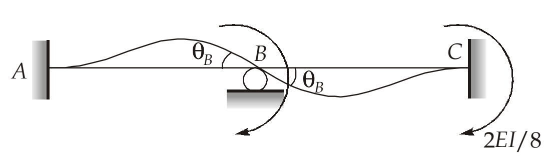
18. (b)

Since, stiffness is the amount of force/moment generated due to unit displacement/rotation. Here θ_B and θ_C are two unknown, mark them as coordinate 1 and 2 respectively.



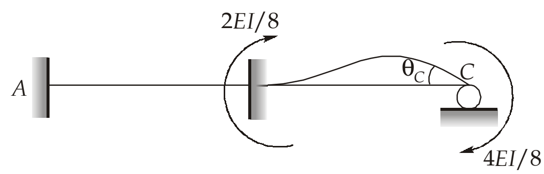
For 1st column:

$$k_{11} = \frac{4EI}{8} + \frac{4EI}{8} = \text{EI}$$



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

For 2nd column:



$$k_{12} = \frac{2EI}{8} = \frac{EI}{4}$$

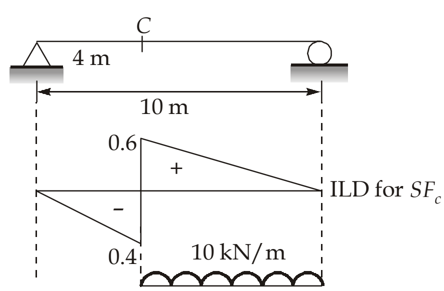
$$k_{22} = \frac{4EI}{8} = \frac{EI}{2}$$

$\therefore$
$$k = \begin{bmatrix} k_{11} & k_{12} \\ k_{21} & k_{22} \end{bmatrix} = \begin{bmatrix} EI & \frac{EI}{4} \\ \frac{EI}{4} & \frac{EI}{2} \end{bmatrix} = \frac{EI}{4}\begin{bmatrix} 4 & 1 \\ 1 & 2 \end{bmatrix}$$

19. (a)

If a two hinged or three hinged parabolic arch is subjected to udl throughout its length, bending moment is zero everywhere.

20. (b)



Maximum shear force in the beam = $\frac{1}{2} \times 0.6 \times 6 \times 10$ = 18 kN

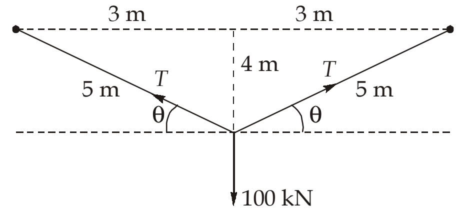
21. (a)

For 2-hinged arches,

$$H = \frac{\int \frac{M_x y dx}{EI} + \alpha t l}{\int \frac{y^2 dx}{EI} + \frac{l}{AE} + k}$$

t(↑)inc., H (↑) inc

22. **(b)**



$$2T\sin\theta = 100$$

$$2T \times \frac{4}{5} = 100$$

$$T = 62.5 \text{ kN}$$

23. **(a)**

The cable is assumed to be perfectly flexible, so that it cannot resist any axial compression, bending moment or shear force.

25. **(d)**

Following data should be collected on the basis of careful and in-depth site investigation.

- Depth of GWT.
- Classification of subsoil state based on trial pits and trial bores.
- Actual length measured on site in case of road, canal and pipeline works.
- An accurate survey giving realistic ground levels connected to a standard datum level like GTS Benchmark.
- Soil bearing capacity based on testing of soil samples.

27. **(c)**

$$t_E = \frac{t_0 + 4t_L + t_p}{6}$$

$$(t_E)_{A\text{-}B} = \frac{3+4\times6+9}{6} = 6 \text{ days}$$

$$(t_E)_{B\text{-}C} = \frac{4+4\times7+9}{6} = \frac{41}{6} = 6.83 \text{ days}$$

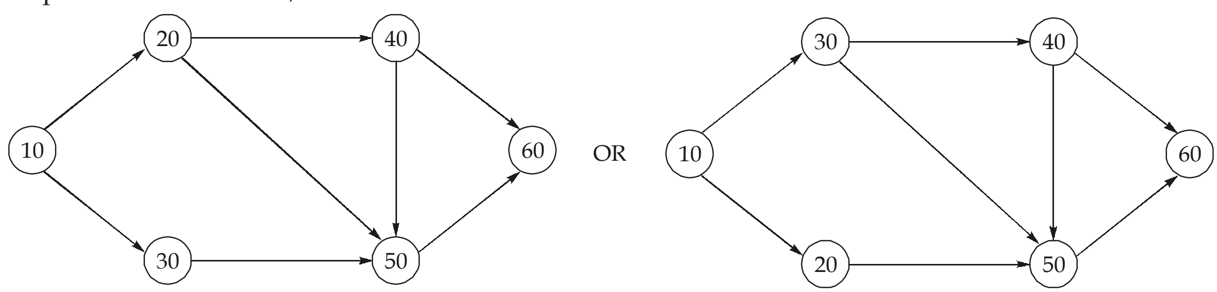
$$(t_E)_{C\text{-}D} = \frac{6+4\times8+10}{6} = 8 \text{ days}$$

$\therefore$ $(T_E)\text{project} = (t_E)_{A-B} + (t_E)_{B-C} + (t_E)_{C-D}$

$= 6 + 6.83 + 8 = 20.83$ days

28. **(d)**

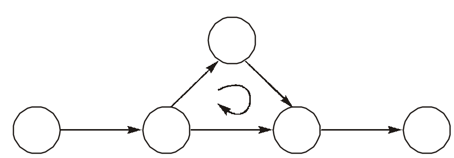
As per fulkerson's rule, the network can be numbered as shown below.



29. **(c)**

Redundancy error: It is caused due to excess number of dummies than required.

Looping/cyclic error:



- It is a time loop in which all the activities are dependent on each other and none of the activities in the loop can even get started.

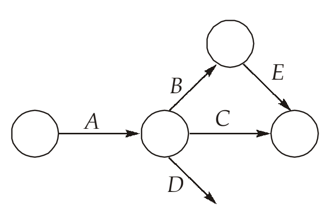
Wagon wheel error:

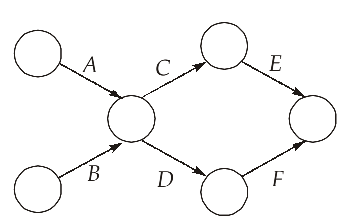
This is the most difficult error to be spot end this can be found out after examining the entire network in detail, this is a conceptual error.

Dangling error: A dangling error is caused in the following two cases:

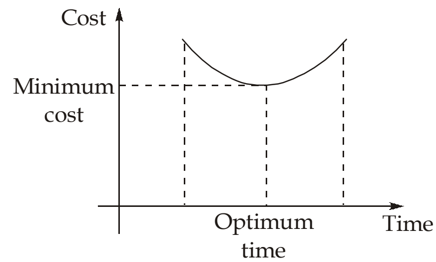
(a) An arrow emerging from an event but not entering into any event.

(b) If a network has more than one initial event or more than one final event, it results in dangling error.





30. (a)



- Decrease in project duration below optimum time also increases the cost.

31. (a)

Quality assurance is a management scheme whereas quality control is an inspection and sampling process.

32. (c)

The average annual cost as per straight line deprecation is given as

$$D = \frac{C_i - C_s}{n} = \frac{30-0}{6} = 5 \text{ lakhs/year}$$

38. (d)

This glass is made of several layers of plate glass and alternate layers consist of vinyl resin plastic. The outer layers of plate glass are made thinner than inner layers.

39. (c)

1 m^3 of concrete requires 1.52 m^3 of dry volume of concrete.

Hence, coarse aggregate proportion in 0.5 m^3 of concrete $= 0.5 \times 1.52 \times \frac{3.5}{6}$

$$= 0.443 \simeq 0.45 \text{ m}^3$$

40. (c)

The base, usually a metallic oxide, is the principal constituent of the paint. It makes the paint film opaque and possesses binding properties which reduce the shrinkage cracks in the film on drying.

43. (c)

Endogenous trees have limited engineering applications.

44. (b)

Corbel: A centilever projecting from the face of a wall to form a bearing of a wall to form a bearing.

Jamb: It is the side of openings like doors and windows.

46. (c)

- Magnesium lime is used for making mortar and plaster.
- Kankar lime is commonly used for making hydraulic lime.

48. (b)

- Calcium chloride is an accelerator, meaning that it accelerates the setting time of the concrete.
- On the other hand, gypsum and calcium sulphate are retarders and they tend to slow down the setting time of concrete.

50. (c)

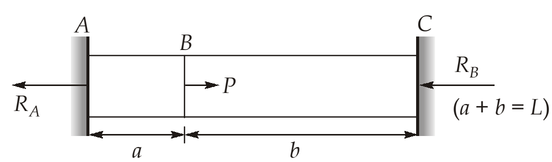
- **Bay window**: These windows project outside the external walls of a room.
- **Skylight**: These are the windows which are provided on the sloping surface of a pitched roof.
- **Dormer window**: These are the windows provided on the slopping roof.
- **Couvered window**: They allow free passage of air when closed and at the same time they maintain sufficient privacy.

54. (d)

At CC, total load = 45 kN

$$\sigma_{cc} = \frac{P}{A_2} = \frac{45 \times 10^3}{1500} = 30 \text{ N/mm}^2$$

55. (d)



$$R_A = \frac{Pb}{L}$$

$$R_B = \frac{Pa}{L}$$

Now, $$R_A = \frac{50 \times 4L}{5L} = 40 \text{ kN}$$

57. (c)

$$\sigma_1 + \sigma_2 = \sigma_x + \sigma_y$$

$$\sigma_2 = (100 + 200) - 250 = 50 \text{ MPa}$$

Also, $$\sigma_1 = \frac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$250 = \frac{100 + 200}{2} + \sqrt{\left(\frac{100 - 200}{2}\right)^2 + \tau_{xy}^2}$$

$$100 = \sqrt{(50)^2 + \tau_{xy}^2}$$

$$(100)^2 = (50)^2 + \tau_{xy}^2$$

$$\tau_{xy}^2 = (100)^2 - (50)^2 = 150 \times 50$$

$$\tau_{xy} = 50\sqrt{3} \text{ MPa}$$

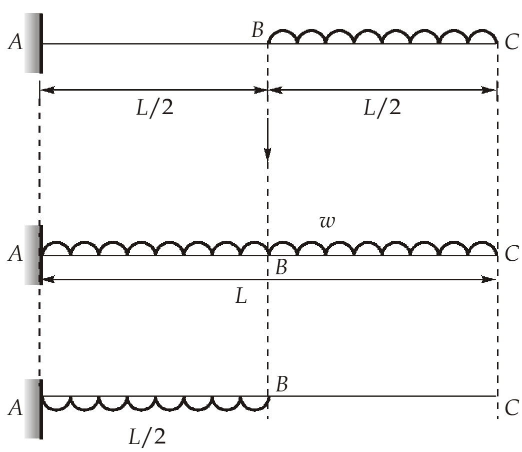
58. (d)

$$\theta_A = \frac{ML}{EI} = \frac{(PL/2)L}{EI} = \frac{PL^2}{2EI}$$

$$\theta_B = \frac{PL^2}{2EI} = \theta_A$$

$\Rightarrow$ $$\theta_A = \theta_B = \theta$$

59. (d)



$$\theta_{c_1} = \frac{wL^3}{6EI}$$

$$\theta_{c_2} = -\frac{w(L/2)^3}{6EI} = -\frac{wL^3}{48EI}$$

$\Rightarrow$ $$\theta_C = \theta c_1 + \theta c_2$$

$$= \frac{wL^3}{6EI} - \frac{wL^3}{48EI} = \frac{8wL^3 - wL^3}{48EI}$$

$$\theta_C = \frac{7wL^3}{48EI}$$

60. (c)

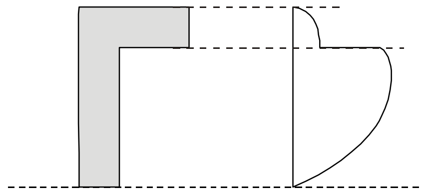
Deflection due to u.d.l. on a cantilever is given by

$$\delta = \frac{wL^4}{8EI}$$

w, L and E are same also I (moment of inertia) is same $\left(\frac{a^4}{12}\right)$ for both the sections and, thus the required ratio of deflection is equal to 1.

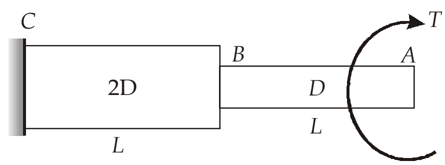
$$\frac{\delta_{(i)}}{\delta_{(ii)}} = 1$$

62. (d)



For 4 shear stress distribution.

63. (d)



Angle of twist,

$$\theta = \frac{TL}{GJ}$$

$$\theta \propto \frac{1}{J} \propto \frac{1}{D^4} \qquad \left[J_{BC} = \frac{\pi(2D)^4}{32} = \frac{\pi D^4}{32}\times 16\right]$$

$$\theta_B = \frac{TL}{G\,J_{BC}} = \frac{TL}{G\left(\frac{\pi D^4 \times 16}{32}\right)} \qquad \text{...(1)}$$

$$\theta_A = \theta_B + \frac{TL}{G\,J_{AB}}$$

$$= \frac{TL}{G\left(\frac{\pi D^4}{32}\times 16\right)} + \frac{TL}{G\left(\frac{\pi D^4}{32}\right)} = \frac{TL}{G\,\frac{\pi D^4}{32}\times 16}(1+16)$$

$$= \frac{TL}{G\cdot\frac{\pi D^4}{32}\times 16}\times 17 \qquad \text{(using eq. (i))}$$

$$\therefore \qquad \frac{\theta_A}{\theta_B} = 17$$

64. (a)

$$\sigma_{min} = 0$$

$$\frac{P}{A} - \frac{Pe}{z} = 0$$

$$e = \frac{z}{A} = \frac{\frac{\pi}{32D}(D^4 - d^4)}{\frac{\pi}{4}(D^2 - d^2)} = \frac{\frac{\pi}{32D}(D^2 - d^2)(D^2 + d^2)}{\frac{\pi}{4}(D^2 - d^2)}$$

$$e = \frac{D^2 + d^2}{8D}$$

66. (c)

For solid shaft,

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

$$= \frac{16 \times 4 \times 10^6}{\pi \times (80)^3} = \frac{10^3}{8\pi}\text{ N/mm}^2 = \frac{125}{\pi}\frac{\text{N}}{\text{mm}^2}$$

67. (a)

$$f(x) = x^4 - x - 10$$

$$f'(x) = 4x^3 - 1$$

$$x_{k+1} = x_k - \frac{f(x_k)}{f'(x_k)}$$

$$= x_k - \frac{x_k^4 - x_k - 10}{4x_k^3 - 1} = \frac{4x_k^4 - x_k - x_k^4 - x_k + 10}{4x_k^3 - 1}$$

$$x_{k+1} = \frac{3x_k^4 + 10}{4x_k^3 - 1}$$

68. (a)

$$I = \frac{h}{3}[(y_o + y_4) + 4(y_1 + y_3) + 2y_2]$$

$$= \frac{0.25}{3}[(1 + 0.5) + 4(0.9412 + 0.64) + 2 \times 0.8]$$

$$= 0.7854$$

69. (b)

$$f(x) = x^4 - 4x - 9$$

$$a = 2$$

$$f(2) = (2)^4 - 4 \times 2 - 9 = -1 < 0$$

$$a = 3$$

$$f(3) = (3)^4 - 4 \times 3 - 9 = 81 - 12 - 9 = 60 > 0$$

First approximation lies between 2 and 3

$$\text{First approximation} = \frac{2+3}{2} = \frac{5}{2} = 2.5$$

71. (a)

Since 5 is a root, $f(x)$ is divisible by $x - 5$,

$$
\begin{array}{r|l|l}
x-5 & x^2 - 10x^2 + 31x - 30 & x^2 - 5x + 6 \\
 & \underset{-}{x^2} \underset{+}{-5x^2} & \\
\hline
 & -5x^2 + 31x - 30 & \\
 & \underset{+}{-5x^2} \underset{-}{+25x} & \\
\hline
 & 6x - 30 & \\
 & 6x - 30 & \\
\hline
 & 0 & \\
\hline
\end{array}
$$

$$x^3 - 10x^2 + 31x - 30 = 0$$

$$\Rightarrow \quad (x-5)(x^2 - 5x + 6) = 0$$

Roots of $(x^2 - 5x + 6) = 0$ are 2 and 3.

Hence, the other two roots are 2 and 3.

72. (a)

Trapezoidal rule gives the best result in single variable function when the function is linear (degree 1).

73. (c)

$$f(x) = x^3 + 3x - 7$$

$$f'(x) = 3x^2 + 3$$

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

$$x_{n+1} = \frac{2x_n^3 + 7}{3x_n^2 + 3}$$

$$\Rightarrow \quad x_1 = \frac{2x_0^3 + 7}{3x_0^2 + 3} = \frac{2\times1+7}{3\times1+3} = \frac{9}{6} = 1.5$$

74. (a)

We have

$$\begin{bmatrix} 1 & 4 & -1 \\ 1 & 1 & -6 \\ 3 & -1 & -1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} -5 \\ -12 \\ 4 \end{bmatrix}$$

Operate $R_2 \to R_2 - R_1$ and $R_3 \to R_3 - 3R_1$

$$\begin{bmatrix} 1 & 4 & -1 \\ 0 & -3 & -5 \\ 0 & -13 & 2 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} -5 \\ -7 \\ 19 \end{bmatrix}$$

Operate $R_3 \to R_3 - 13/3\ R_2$

$$\begin{bmatrix} 1 & 4 & -1 \\ 0 & -3 & -5 \\ 0 & 0 & 71/3 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} -5 \\ -7 \\ 148/3 \end{bmatrix}$$

$$\frac{71}{3}x_3 = \frac{148}{3}$$

$$x_3 = \frac{148}{71} = 2.0845$$

75. (c)

Rewriting the equation as

$$\begin{bmatrix} 1 & 1 & 1 \\ 2 & -3 & 4 \\ 3 & 4 & 5 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 9 \\ 13 \\ 40 \end{bmatrix}$$

Operate, $R_2 \to R_2 - 2R_1$; $R_3 \to R_3 - 3R_1$

$$\begin{bmatrix} 1 & 1 & 1 \\ 0 & -5 & 2 \\ 0 & 1 & 2 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 9 \\ -5 \\ 13 \end{bmatrix}$$

Operate, $R_3 \to R_3 + 1/5R_2$

$$\begin{bmatrix} 1 & 1 & 1 \\ 0 & -5 & 2 \\ 0 & 1 & 12/5 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 9 \\ -5 \\ 12 \end{bmatrix}$$

Operate, $R_2 \to (-1)R_2$; $R_3 \to 5R_3$

$$\begin{bmatrix} 1 & 1 & 1 \\ 0 & 5 & -2 \\ 0 & 0 & 12 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 9 \\ 5 \\ 60 \end{bmatrix}$$

Operate, $R_2 \to R_2 + 1/6R_3$; $R_3 \to 1/12R_3$

$$\begin{bmatrix} 1 & 1 & 1 \\ 0 & 5 & 0 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 9 \\ 15 \\ 5 \end{bmatrix}$$

Operate, $R_2 \to 1/5R_2$

$$\begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 9 \\ 3 \\ 5 \end{bmatrix}$$

Operate, $R_1 \to R_1 - R_2 - R_3$

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 1 \\ 3 \\ 5 \end{bmatrix}$$

$$x = 1;\ y = 3;\ z = 5$$

$$(x, y, z) = (1, 3, 5)$$

81. (b)

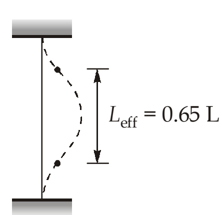
Cross-sections, which can develop plastic moment of resistance, but have inadequate plastic hinges rotation capacity for formation of plastic mechanism, due to local buckling are compact sections.

83. (b)

Lacing is designed to resist a transverse shear of 2.5% of axial force in the member.

$$V = \frac{2.5}{100} \times 160 = 4 \text{ kN}$$

84. (a)



L = unsupported length of member

85. (c)

IS: 800 specifies minimum web thickness required from serviceability point of view for different situation with regards to provision of stiffeners.

86. (b)

- In case of complete penetration of the groove weld the effective throat thickness is taken as the thickness of thinner member jointed.
- In case the full penetration of weld can't be achieved, an effective throat thickness of 7/8th of the thickness of thinner member should be used. But for calculating the strength, the effective throat thickness is assumed to be 5/8th of the thickness of thinner member.

89. (a)

$$x_c = \text{k.d.}$$

$$k = \frac{m\cdot \sigma_{cbc}}{m\cdot \sigma_{cbc} + \sigma_{st}}$$

For M20, Fe415

$$\sigma_{cbc} = 7\ \text{N/mm}^2;\ \sigma_{st} = 230\ \text{N/mm}^2$$

$$m = \frac{280}{3\sigma_{cbc}}$$

$$k = \frac{280/3}{\frac{280}{3} + 230} = 0.2886$$

$$\therefore \quad x_c = \text{k.d} = 0.2886 \times 300$$

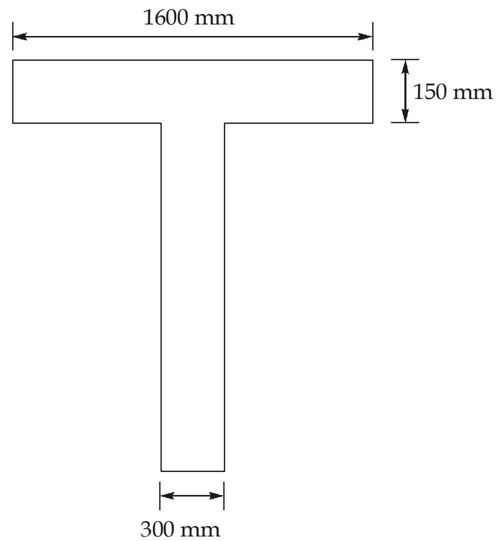
$$= 86.59\ \text{mm} \simeq 86.6\ \text{mm}$$

90. (b)

$$\text{Design bending moment} = \text{Maximum of} \begin{cases} 1.5\times DL + 1.5\times LL \\ 1.5DL + 1.5\times \text{seismic load} \\ 1.2\times DL + 1.2\times LL + 1.2\times \text{seismic load} \end{cases}$$

$$= \text{Maximum of} \begin{Bmatrix} 90 \\ 60 \\ 90 \end{Bmatrix} = 90\ \text{kNm}$$

91. (a)



As per IS 456: 2000 clause 23.1.2. For continuous beam; l_o may be assumed as 0.7 times the effective span.

Effective flange width

$$b_f = \frac{0.7 l_o}{6} + b_w + 6d_f$$

$$= \frac{0.7 \times 8000}{6} + 300 + 6 \times 150 = 2133.33 \text{ mm}$$

$$\simeq 2134 \text{ mm} \not> 1600 \text{ mm}$$

$$b_f = 1600 \text{ mm}$$

92. (c)

In compression τ_{bd} ↑es by 25%.

$$L_d = \frac{\phi f_s}{4\tau_{bd}} \quad \text{(for plain bars)}$$

For bars subjected to compression

$$L_d = \frac{\phi f_s}{4 \times 1.25 \tau_{bd}} = \frac{\phi f_s}{5\tau_{bd}}$$

93. (a)

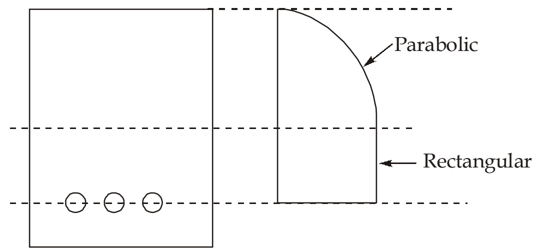
According to clause 26.5.1.1 of IS 456 : 2000

Minimum area of tension reinforcement

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

$$A_{st}^{\min} = \frac{0.85}{fy} bd$$

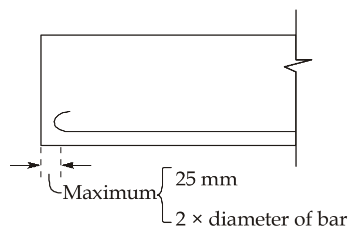
94. (c)



95. (a)

The critical section should be taken at the rear face of the stem and not d away from it, because there is no compression introduced by the support reaction and the probable inclined crack may extend ahead of the rear face of the column.

96. (a)

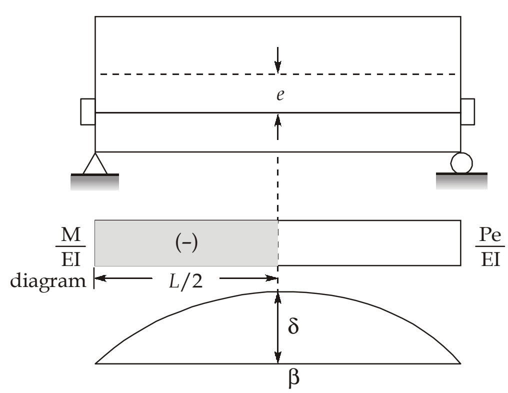


98. (b)

The different type of losses encountered in pretensioning are as given below:

i. Loss due to elastic shortening.
ii. Loss due to relaxation of steel.
iii. Loss due to shrinkage of concrete.
iv. Loss due to creep of conerete.

100. (d)



From moment area theorem,

δ = moment of area of M/EI diagram between *A* and *B* taken about *A*

$$= \frac{-Pe}{EI} \times \frac{L}{2} \times \frac{L}{4} = \frac{-PeL^2}{8EI}$$

– ve sign indicates upward deflection.