CLASS TEST

S.No.: 02DLSKCE_DEFGH_17926

MADE EASY
Leading Institute for IES, GATE & PSUs
Delhi | Bhopal | Hyderabad | Jaipur | Pune
Web: www.madeeasy.in | **E-mail:** info@madeeasy.in | **Ph:** 011-45124612

Design of Steel Structures

CIVIL ENGINEERING

Date of Test : 17/09/2026

ANSWER KEY

1.	(d)	7.	(d)	13.	(b)	19.	(b)	25.	(c)
2.	(c)	8.	(b)	14.	(a)	20.	(a)	26.	(b)
3.	(a)	9.	(c)	15.	(c)	21.	(c)	27.	(b)
4.	(d)	10.	(b)	16.	(b)	22.	(a)	28.	(b)
5.	(c)	11.	(b)	17.	(a)	23.	(d)	29.	(c)
6.	(c)	12.	(c)	18.	(b)	24.	(c)	30.	(c)

DETAILED EXPLANATIONS

1. (d)

Static method satisfies the equilibrium and yield conditions while the kinematic method satisfies the equilibrium and the mechanism conditions.

2. (c)

3. (a)

4. (d)

Radius of gyration, $$r = \sqrt{\frac{\text{Moment of inertia}}{\text{Cross-sectional area}}}$$

5. (c)

As per Clause 3.7.2 of IS 800 : 2007.

6. (c)

$$\lambda = \frac{1000}{6} = 166.67$$

$$\therefore \quad 85 < \lambda < 166.67$$

Hence only intermediate vertical stiffeners are required.

7. (d)

8. (b)

9. (c)

Type of load	Additional Load
(a) Vertical forces transferred to the rails.	
(i) For electric overhead cranes.	25% of maximum static wheel load.
(ii) For hand operated cranes.	10% of maximum static wheel load.
(b) Horizontal forces transferred to the rails.	
(i) For electric overhead cranes.	10% of the weight of the crab and weight lifted on the crane.
(ii) For hand operated cranes.	5% of the weight of the crab and weight lifted on the crane.
(c) Horizontal forces along the rails.	5% of the static wheel load.

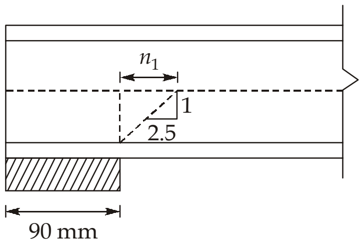
10. (b)

Live load is reduced by 0.02 kN/m^2. For each one degree above 10° slope.

$$\therefore \quad \text{Live load} = 0.75 - 0.02\,(15° - 10°)$$

$$= 0.65\ kN/m^2$$

11. (b)



$$\text{Web bearing strength, } F_w = (b + n_1)t_w \frac{f_{yw}}{\gamma_{m0}}$$

$$\because \quad n_1 = 2.5(t_f + R)$$

$$= 2.5\ (11.4 + 16) = 68.5 \text{ mm}$$

$$\therefore \quad F_w = (90 + 68.5) \times 7.4 \times \frac{250}{1.1}$$

$$= 266568.18 \text{ N} = 266.57 \text{ kN}$$

12. (c)

Given, factored load, $P_u = 2000$ kN

$$\text{Now, bearing pressure on the plate, } w = \frac{P_u}{L \times B} = \frac{2000 \times 10^3}{560 \times 410} = 8.71 \text{ N/mm}^2$$

$$\therefore \text{ Thickness of base plate, } \quad t = \sqrt{\frac{2.5w(a^2 - 0.3b^2)}{(f_y / \gamma_{m0})}}$$

where,

$$a = \text{larger projection} = \frac{560 - 400}{2} = 80 \text{ mm}$$

$$b = \text{smaller projection} = \frac{410 - 250}{2} = 80 \text{ mm}$$

$$\therefore \quad t = \sqrt{\frac{2.5 \times 8.71(80^2 - 0.3 \times 80^2)}{\left(\frac{250}{1.1}\right)}} = 20.718 \text{ mm} \not< t_f (= 12.7 \text{ mm})$$

So, provide, $t = 22$ mm

13. (b)

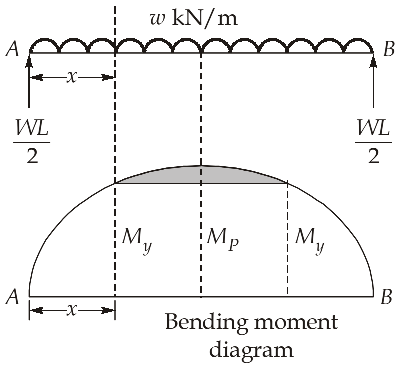
$$\text{B.M. at } x \text{ from } A = \frac{wL}{2}x - w \cdot x\frac{x}{2} = M_y$$

$$\text{B.M. at } x = \frac{L}{2} \text{ from } A = \frac{wL}{2}\left(\frac{L}{2}\right) - \frac{w}{2}\left(\frac{L}{2}\right)\left(\frac{L}{2}\right)$$

$$= \frac{wL^2}{4} - \frac{wL^2}{8} = +\frac{wL^2}{8} = M_p$$

$$\text{Shape factor, } \quad S = \frac{M_p}{M_y}$$

$$\Rightarrow \qquad S = \frac{\frac{wL^2}{8}}{\frac{wL}{2}x - w\cdot x\cdot \frac{x}{2}}$$



For rectangular cross-section,

$$S = 1.5$$

$$L = 10 \text{ m (given)}$$

$$\therefore \qquad (1.5)\left(\frac{10}{2}x - \frac{x^2}{2}\right) = \frac{(10)^2}{8}$$

$$\Rightarrow \qquad 15x - 1.5x^2 = 25$$

$$\Rightarrow \qquad 1.5x^2 - 15x + 25 = 0$$

$$\Rightarrow \qquad x = 2.113 \text{ m}$$

$$\text{Length of plastic hinge} = 2\left(\frac{L}{2} - x\right)$$

$$= L - 2x = 10 - 2.113 \times 2 = 5.774 \text{ m}$$

Alternative:

Length of plastic hinge for a simply supported beam carrying a uniformly distributed load is given by $l = L\sqrt{1 - \frac{1}{S.F}}$

Here shape factor, $S.F = 1.5$ and $L = 10$

$$\therefore \qquad l = 10\sqrt{1 - \frac{1}{1.5}} = \frac{10}{\sqrt{3}} = 5.7735 \text{ m} \approx 5.774 \text{ m}$$

14. (a)

Degree of static indeterminacy,

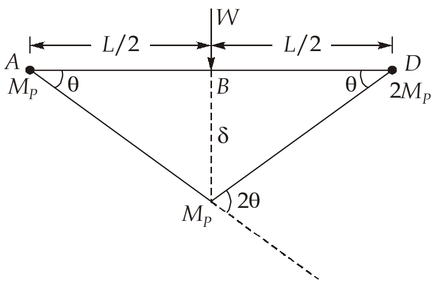
$$D_{si} = 4 - 2 = 2$$

No. of plastic hinges required for collapse

$$= D_{si} + 1 = 2 + 1 = 3$$

Possible location of hinges are A, B, C and D.

Case I: Plastic hinges at *A*, *B* and *D*



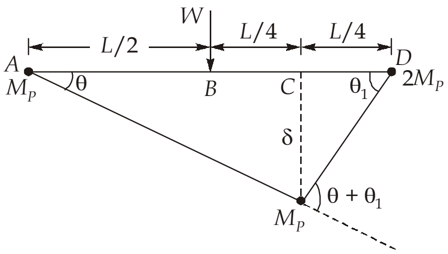
External work done = Internal work done

$$\Rightarrow \qquad W \times \delta = M_P\theta + M_P(2\theta) + 2M_P(\theta)$$

$$\Rightarrow \qquad W\left(\theta \times \frac{L}{2}\right) = 5\,M_p\,\theta$$

$$\Rightarrow \qquad W = \frac{10M_P}{L}$$

Case II: Plastic hinges at *A*, *C* and *D*



$$\text{External work done} = \text{Internal work done}$$

$$\Rightarrow \quad W\left(\theta \times \frac{L}{2}\right) = M_p\theta + M_p(\theta + \theta_1) + 2M_p(\theta_1)$$

$$\because \quad \delta = \theta \times \left(\frac{L}{2} + \frac{L}{4}\right) = \theta_1\left(\frac{L}{4}\right)$$

$$\Rightarrow \quad \frac{3}{4}\theta L = \frac{\theta_1 L}{4}$$

$$\Rightarrow \quad 3\theta = \theta_1$$

$$\therefore \quad W\left(\theta \times \frac{L}{2}\right) = M_p\theta + M_p(\theta + 3\theta) + 2M_p(3\theta)$$

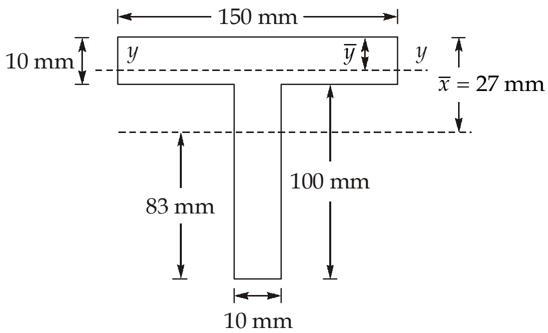
$$\Rightarrow \quad W\left(\theta \times \frac{L}{2}\right) = M_p\theta + 4M_p\theta + 6M_p\theta$$

$$\Rightarrow \quad W = \frac{22M_P}{L}$$

$$\therefore \quad \text{Collapse load} = \min\left\{\frac{10M_P}{L}, \frac{22M_P}{L}\right\} = 10\frac{M_P}{L}$$

15. **(c)**

Let $\bar{x}$ be the distance of centroidal axis from the top of the section



$$\bar{x} = \frac{150 \times 10 \times 5 + 100 \times 10 \times (10 + 50)}{150 \times 10 + 100 \times 10} = 27 \text{ mm}$$

$$I_{X\text{-}X} = \frac{150 \times 10^3}{12} + 150 \times 10 \times (27 - 5)^2 + \frac{10 \times 100^3}{12} + 10 \times 100 \times (10 + 50 - 27)^2$$

$$= 2660833.33 \text{ m}^2$$

Elastic section modulus,

$$Z_e = \frac{I_{X-X}}{y_{max}} = \frac{2660833.33}{83} = 32058.233 \text{ mm}^3$$

Let $\bar{y}$ be the distance of equal area axis from top

$$\therefore \quad 150 \times \bar{y} = \frac{150 \times 10 + 10 \times 100}{2}$$

$$\Rightarrow \quad \bar{y} = 8.33 \text{ mm}$$

Plastic section modulus,

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

where $\bar{y}_1$ = distance of C.G of area above equal area axis from equal area axis

$\bar{y}_2$ = distance of C.G of area below equal area axis from equal area axis

$$\bar{y}_1 = \frac{\bar{y}}{2} = \frac{8.33}{2}\text{mm} = 4.165 \text{ mm}$$

$$\bar{y}_2 = \frac{\frac{150 \times (10 - 8.33)^2}{2} + 100 \times 10 \times (10 - 8.33 + 50)}{150 \times (10 - 8.33) + 100 \times 10} = 41.487 \text{ mm}$$

$$Z_p = \frac{150 \times 10 + 10 \times 100}{2}(4.165 + 41.487) = 57065 \text{ mm}^3$$

Shape factor,
$$S = \frac{Z_P}{Z_e} = \frac{57065}{32058.233} = 1.780$$

16. (b)

For the built-up section,

$$2I_{xx} = 2\left[I_{yy} + A\left(\frac{s}{2} + C_{yy}\right)^2\right]$$

$$\Rightarrow \quad 6362.6 \times 10^4 = 310.8 \times 10^4 + 4564\left(\frac{s}{2} + 23.6\right)^2$$

$$\Rightarrow \quad s = 183.10 \text{ mm}$$

17. (a)

$$\text{Axial load} = 600 \text{ kN}$$

Maximum shear,
$$V = \frac{2.5}{100} \times 600 \times 10^3 = 15000 \text{ N}$$

$$\text{Transverse shear in each panel} = \frac{V}{N} = \frac{15000}{2} = 7500 \text{ N}$$

$$\text{Compressive force in lacing bars} = \frac{V}{N}\text{cosec}\,\theta$$

$$= 7500 \text{ cosec } 45° = 10606.6 \text{ N}$$

$$= 10.607 \text{ kN} \approx 10.61 \text{ kN}$$

18. (b)

$$\text{Axial load} = 400 \text{ kN}$$

$$\text{Transverse shear, } V = \frac{2.5}{100} \times 400 = 10 \text{ kN}$$

Longitudinal shear,
$$V_1 = \frac{VC}{NS}$$

Moment, $M = \dfrac{VC}{2N}$

Here, $S' = 200$ mm, $g = 50$ mm, $C = 1200$ mm, $N = 2$

$$S = S' + 2g$$
$$= 200 + 2 \times 50 = 300 \text{ mm}$$

$$\therefore \quad V_1 = \frac{10 \times 1200}{2 \times 300} = 20 \text{ kN}$$

$$M = \frac{10 \times 1200 \times 10^{-3}}{2 \times 2} = 3 \text{ kNm}$$

19. (b)

20. (a)

Throat thickness of weld, t_t = k.S
$$= 0.7 \times 8$$
$$= 5.6 \text{ mm}$$

Strength of fillet weld, $P_{dw} = \dfrac{f_u}{\sqrt{3}_{mw}} \times L_w \times t_t$

For connection to be safe, $P_{dw} = P_u$

$$\therefore \quad \frac{410}{\sqrt{3} \times 1.5} \times L_w \times 5.6 = 300 \times 10^3$$

$$L_w = 339.469 \text{ mm}$$
$$2 \times 2w = 339.469$$
$$n = \frac{139.469}{2} = 69.73 \text{ mm} \simeq 70 \text{ mm}$$

21. (c)

It is a deflection caused by bending about the axis corresponding to the largest slenderness ratio.

22. (a)

$$\beta = 1.4 - 0.076\left[\frac{w}{t}\right]\left[\frac{f_y}{f_u}\right]\left[\frac{b_s}{L_c}\right]$$

$$w = 60 \text{ mm}$$
$$t = 6 \text{ mm}$$
$$f_y = 250 \text{ MPa}$$
$$f_u = 410 \text{ MPa}$$
$$b_s = 60 + 50 - 6 = 104 \text{ mm}$$
$$L_c = 2 \times 50 = 100 \text{ mm}$$

So, $$\beta = 1.4 - 0.076\left(\frac{60}{6}\right)\left(\frac{250}{410}\right)\left(\frac{104}{100}\right) = 0.91$$

23. (d)

Diameter of rivet hole = 14 + 1.5= 15.5 mm

$$A_{\text{connected}} = \left[40 - 15.5 - \frac{6}{2}\right] \times 6 = 129 \text{ mm}^2$$

$$A_{\text{non-connected}} = \left[25 - \frac{6}{2}\right] \times 6 = 132 \text{ mm}^2$$

$$k = \frac{3A_c}{3A_c + A_{nc}} = \frac{3 \times 129}{3 \times 129 + 132} = 0.746$$

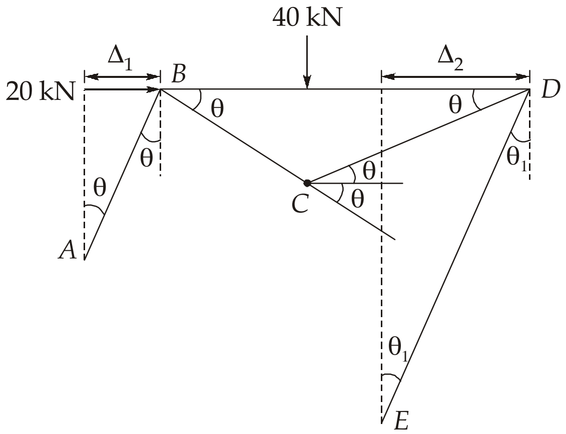
$$\therefore \quad A_{\text{net}} = A_c + kA_{nc}$$

$$= 129 + 0.746 \times 132 = 227.47 \text{ mm}^2$$

$$\text{Strength of member} = \frac{150 \times 227.47}{1000} = 34.12 \text{ kN}$$

24. (c)

Combined mechanism: The possible location of plastic hinges are A, C, D and E only.



$$\Delta_1 = \Delta_2$$

$$\Rightarrow \quad 3\theta = 6\theta_1$$

$$\Rightarrow \quad \theta = 2\theta_1$$

$$\text{External work done} = \Sigma \text{ load} \times \text{Deflection}$$

$$= 40 \times 2\theta + 20 + 3\theta$$

$$= 140\theta$$

$$\text{Internal work done} = \Sigma \text{ plastic moment} \times \text{Rotation}$$

$$= M_p\theta + 2M_p\theta + M_p\theta + M_p\theta_1 + M_p\theta_1$$

$$= M_p\theta + 2M_p\theta + M_p\theta + \frac{M_p\theta}{2} + \frac{M_p\theta}{2} \qquad \left(\theta_1 = \frac{\theta}{2}\right)$$

$$= 5M_p\theta$$

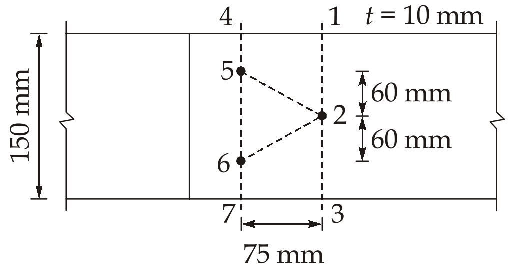
By the principle of virtual work:

$$\text{Internal work done} = \text{External work done}$$

$$\Rightarrow \quad 5M_p\theta = 140\theta$$

$$\Rightarrow \quad M_p = \frac{140}{5} = 28 \text{ kNm}$$

25. (c)



Given diameter of rivet = 20 mm

∴Gross diameter of rivet hole =20 + 1.5 = 21.5 m

Pitch = 75 mm

Gauge = 60 mm

For most critical sectional area, section should be placed at left most vertically.

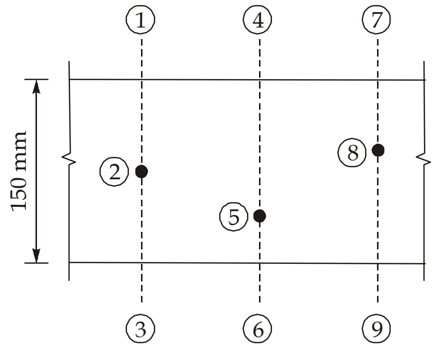
Section 4-5-6-7 (1st possible arrangement)

$$A_{net} = 10(150-2\times 21.5) = 1070 \text{ mm}^2$$

Most critical sectional area = 1070 mm^2

∴Maximum tensile force at that joint =150 × 1070 = 160.5 kN

2nd possible arrangement



$$A_{net}\ (1)\text{-}(2)\text{-}(3) = (150 - 21.5)\ 10 = 1285 \text{ mm}^2$$

$$P = \sigma_{at} \times A_{net}$$

$$P = 150 \times 1285$$

$$= 192.750 \text{ kN}$$

26. (b)

Section is plastic (given)

and $V < 0.6\ V_d$

So, $$M_d = \frac{\beta_b Z_p f_y}{\gamma_{m0}} \le \frac{1.2 Z_e f_y}{\gamma_{m0}}$$

β_b = 1 for plastic section

So, $$M_d = \frac{1\times 651.74\times 10^3\times 250}{1.1\times 10^6} \le \frac{1.2\times 573.6\times 10^3\times 250}{1.1\times 10^6}$$

$$= 148.1 \text{ kNm} \le 156.44 \text{ kNm} \qquad \text{(OK)}$$

27. **(b)**

Nominal diameter of bolt = 20 mm

$$d_0 = 20 + 2 = 22 \text{ mm}$$

$$\text{Minimum pitch} = 2.5\,d = 2.5 \times 20 = 50 \text{ mm}$$

Minimum end/edge distance $= 1.5\,d_0 = 1.5 \times 22 = 33$ mm

Let n be the number of bolts, then

$$2 \times 33 + (n - 1) \times 50 = 140$$

$$n = 2.48$$

Therefore, maximum 2 number of bolts can be provided.

28. **(b)**

29. **(c)**

30. **(c)**

Effective throat thickness = 0.7 × 6 = 4.2 mm

$$\text{Vertical shear stress} = \frac{P}{A} = \frac{100 \times 10^3}{2 \times 4.2 \times 200} = 59.52 \text{ MPa} \simeq 59.5 \text{ MPa}$$

$$\text{Horizontal shear stress due to bending} = \frac{M}{Z} = \frac{100 \times 10^3 \times 150}{2 \times \dfrac{4.2 \times 200^2}{6}} = 267.86 \text{ MPa} \simeq 267.9 \text{ MPa}$$

■■■■