ANSWER KEY ➤ Steel Structure

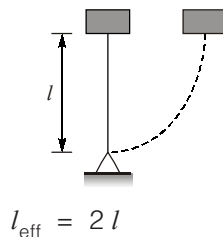| 1.	(a)	7.	(c)	13.	(d)	19.	(b)	25.	(a)
2.	(c)	8.	(a)	14.	(a)	20.	(a)	26.	(c)
3.	(d)	9.	(b)	15.	(d)	21.	(a)	27.	(a)
4.	(c)	10.	(a)	16.	(d)	22.	(a)	28.	(c)
5.	(b)	11.	(a)	17.	(c)	23.	(d)	29.	(d)
6.	(b)	12.	(b)	18.	(a)	24.	(b)	30.	(c)

DETAILED EXPLANATIONS

3.　(d)

The minimum diameter to be provided is greater of $3t$ or 25 mm.

$$D \geq (3t \text{ or } 25 \text{ mm})$$
$$D \geq (18 \text{ mm or } 25 \text{ mm})$$
$$D = 25 \text{ mm}$$

4.　(c)

$$l_{\text{eff}} = 2l$$

5. (b)

As I_{yy} of combination is less than I_{xx} of combination, face to face arrangement will be better because it will lead to larger I_{min} for a given spacing.

8. (a)

$$\text{Elastic section modulus} = \frac{bh^2}{24}$$

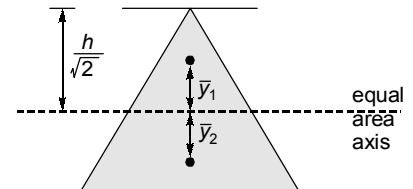$$\text{Plastic section modulus} = \frac{A}{2}(\bar{y}_1 + \bar{y}_2)$$

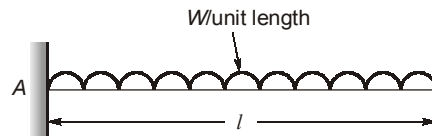$$A = \frac{bh}{2}$$

$$\bar{y}_1 = \frac{h}{3\sqrt{2}}$$

$$\bar{y}_2 = 0.1548\,h$$

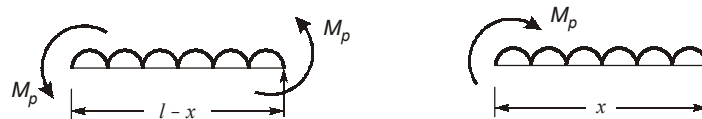∴ $$z_p = \frac{A}{2}(\bar{y}_1 + \bar{y}_2) = 0.0976\,bh^2$$

∴ $$\text{S.F.} = \frac{z_p}{z_y} = 2.343$$

9. (b)

W/unit length

In plastic hinge occur at x distance from propped end

Now, $$M_P = \frac{Wx^2}{2}$$

and $$M_P = \frac{w(l-x)^2}{4}$$

∴ $$x = 0.414\,l$$

Putting x, $$M_P = 0.085\,wl^2$$

10. (a)

The connection in the lug angle with the gusset plate is designed for 1.2 times the force in outstanding leg.

∴ $$F = 1.2 \times 60 = 72 \text{ kN}$$

11. (a)

$$\text{Bearing strength} = \frac{2.5\,k_b\,d.t.f_u}{\gamma_{m1}}$$

$$k_b = \text{minmum of}\left[\frac{e}{3d_0},\frac{p}{3d_0}-0.25,\frac{f_{ub}}{f_u},1\right]$$

$$= \text{minmum of}\left[\frac{40}{3\times22},\frac{60}{3\times22}-0.25,\frac{400}{410},1\right] = 0.606$$

$$\text{Bearing strength} = \frac{2.5\times0.606\times20\times20\times410}{1.25} = 198.77\text{ kN}$$

12. (b)

In shear yielding and tension rupture
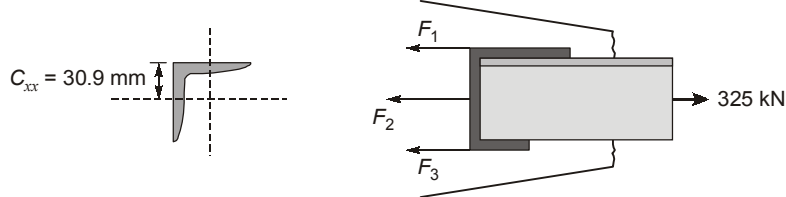
$$\text{Block shear strength} = \frac{f_y}{\sqrt{3}\,\gamma_{m1}}A_{vg} + \frac{0.9f_u}{\gamma_{m1}}A_{tn}$$

$$A_{vg} = (60+40)\times20\times2 = 4000\text{ mm}^2$$
$$A_{tn} = (100-2\times22)\times20 = 1120\text{ mm}^2$$

$$\text{Block shear strength} = \frac{250}{\sqrt{3}\times1.1}\times4000 + \frac{0.9\times410}{1.25}\times1120 = 855.487\text{ kN}$$

13. (d)

$$F_1 + F_2 + F_3 = 325\text{ kN}$$

$$F_2 = \frac{350\times110}{1000} = 38.5\text{ kN}$$

$$\Rightarrow \qquad F_1 + F_3 = 286.5\text{ kN} \qquad\qquad \text{...(i)}$$

For no torsional moment to develop,

$$F_1(30.9) - F_3(110-30.9) - F_2(55-30.9) = 0 \qquad\qquad \text{...(ii)}$$
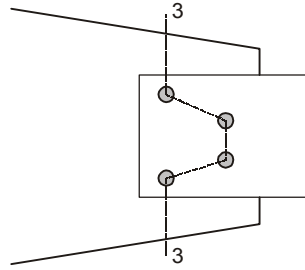
Solving (i) and (ii)

$$F_1 = 214.45\text{ kN}$$

14. (a)

$$P = \frac{f_u}{\sqrt{3}\,\gamma_{mw}}\times t\times l$$

$$100\times10^3 = \frac{410}{\sqrt{3}\times1.25}\times(0.707\times5)\times l$$

$$\therefore \qquad l = 149.38\text{ mm}$$

15. (d)

$$A_{\text{net 3-3}} = \left(360 - 4 \times 20 + 2 \times \frac{60^2}{4 \times 60}\right) \times 10$$

$$A_{\text{net 3-3}} = 3100 \, \text{mm}^2$$

16. (d)

When angles are not tack-reveted, both the angles will act individually

$$\therefore \qquad A_{\text{net}} = 2[A_1 + kA_2]$$

$$k = \frac{3A_1}{3A_1 + A_2} = \frac{3 \times 775}{3 \times 775 + 950} = 0.7099$$

$$\therefore \qquad A_{\text{net}} = 2[775 + 0.7099 \times 950]$$

$$= 2899 \, \text{mm}^2$$

17. (c)

$$I_{xx \, combi} = 2 \times (I_{xx})_{\text{one ISMC}} + 2 \times \left[\frac{240 \times 8^3}{12} + 240 \times 8 \times \left(\frac{175}{2} + 4\right)^2\right]$$

$$I_{xx} = 56.63 \times 10^6 \, \text{mm}^4$$

$$I_{yy \, combi} = 2 \times \left[121 \times 10^4 + 2438 \times \left(22 + \frac{90}{2}\right)^2 + \frac{8 \times 240^3}{12}\right]$$

$$I_{yy} = 42.74 \times 10^6 \, \text{mm}^4$$

$$I_{\text{min}} = 42.74 \times 10^6 \, \text{mm}^4$$

$$A_{\text{total}} = 2 \times 2438 + 2 \times 240 \times 8 = 8716 \, \text{mm}^2$$

$$r = \sqrt{\frac{I_{\text{min}}}{A_{\text{total}}}} = \sqrt{\frac{42.74 \times 10^6}{8716}} = 70.026 \, \text{mm}$$

$$\therefore \qquad \lambda = \frac{6000}{70.026} = 85.68$$

19. (b)

$$t \geq \sqrt{\frac{2.5w(a^2 - \mu b^2)}{\left(\dfrac{f_y}{\gamma_{m_0}}\right)}}$$

$$\therefore \qquad w = \frac{60 \times 10^3}{600^2} = \frac{1}{6} \, \text{N/mm}^2$$

$$\therefore \qquad t \ge \sqrt{\dfrac{2.5 \times \dfrac{1}{6}}{\dfrac{250}{1.1}} \times \left(600^2 - 0.25 \times 600^2\right)}$$

$$\therefore \qquad t \ge 22.25 \text{ mn}$$

20. (a)

$$Z_e = 410 \times 10^3 \text{ mm}^3$$

$$I_{xx} \text{ of plates only} = 2\left[100 \times \dfrac{10^3}{12} + 100 \times 10 \times \left(125 + \dfrac{10}{2}\right)^2\right]$$

$$= 33.8167 \times 10^6 \text{ mm}^4$$

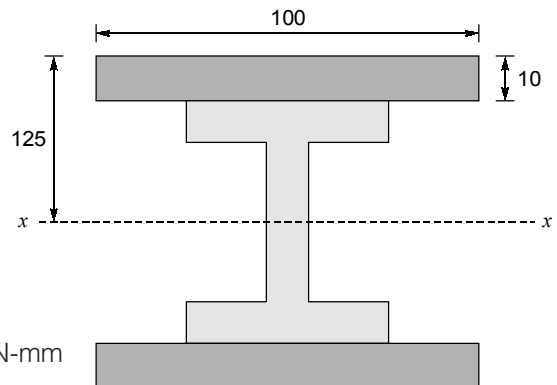$$Z_{xx} \text{ of plates only} = \dfrac{33.8167 \times 10^6}{(125 + 10)}$$

$$= 250.494 \times 10^3 \text{ mm}^3$$

$$Z_{xx} \text{ of whole section} = (250.494 + 410) \times 10^3$$

$$= 660.494 \times 10^3 \text{ mm}^3$$

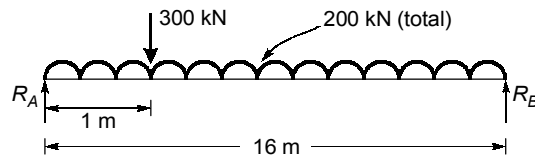$$\therefore \text{ Enhanced moment capacity} = \dfrac{250}{1.1} \times 660.494 \times 10^3 \text{ N-mm}$$

$$= 150 \text{ kNm}$$

21. (a)

Total load supported by crane girder = 300 kN (250 + 50 kN)

Self weight of crane girder = 200 kN

this load is transferred to gantry girder through 2 wheels,

$$\therefore \qquad R_A = \dfrac{300 \times 15}{16} + \dfrac{200}{2} = 381.25 \text{ kN}$$

Load an gantry girder through each wheel = $\dfrac{381.25}{2} = 190.63$ kN

22. (a)

(ii) Strain distribution is linear so that plane section surface bending remains plane after bending.

(iii) Stress-strain curve is elastic-plastic.

23. (d)

$$w_{\text{collapse}} = \dfrac{16 M_p}{l^2}$$

$$w_{\text{yeild}} = \dfrac{12 M_p}{l^2}$$

$$\Rightarrow \qquad \frac{w_{\text{collapse}}}{w_{\text{yield}}} = \frac{\dfrac{16\,M_p}{l^2}}{\dfrac{12\,M_p}{l^2}} = \frac{4}{3}$$
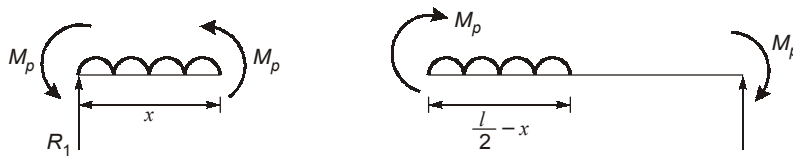
24. (b)

$$\text{Length of plastic hinge} = l\sqrt{1 - \frac{1}{SF}}$$

$$SF = \frac{3}{2}$$

$$\therefore \qquad \text{Length of plastic hinge} = \frac{l}{\sqrt{3}} = 0.577\,l$$

26. (c)

$$2\,M_p = \frac{wx^2}{2}$$

$$2M_p - w\left(\left(\frac{l}{2} - x\right) \times \left(\frac{l}{2} + \frac{1}{2}\left(\frac{l}{2} - x\right)\right)\right) = 0$$

$$x = \frac{3l}{8}$$

$$\therefore \qquad 2\,M_p = \frac{w}{2}\left(\frac{3l}{8}\right)^2$$

$$\therefore \qquad w = \frac{28.44\,M_p}{l^2}$$

27. (a)
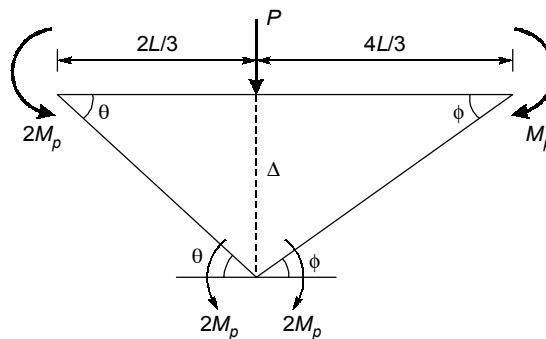
$$D_s = 2$$

$\therefore$ No. of plastic hinges required for complete collapse

$$D_s + 1 = 2 + 1 = 3$$

Mechanism-1

$$\Delta = \frac{2L}{3}\theta = \frac{4L}{3}\phi$$

$$\Rightarrow \qquad \theta = 2\phi$$

By principle of critical work done,

$$-2M_p\theta - 2M_p\theta - 2M_p\phi - M_p\phi + P\left(\frac{2L}{3}\theta\right) = 0$$

$$\Rightarrow \qquad 4M_p\theta + 3M_p\phi = \frac{2P_L}{3}\theta$$

$$\Rightarrow \qquad 8M_p\phi + 3M_p\phi = \frac{4P_L}{3}\phi$$

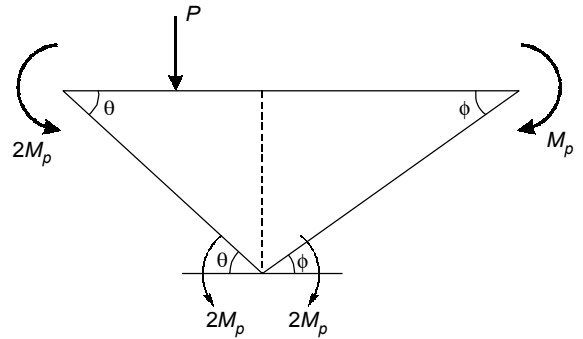$$\Rightarrow \qquad P_u = \frac{33M_p}{4L}$$

$$\Rightarrow \qquad P_u = 8.25\,M_p/L$$

Mechanism-2

$$2M_p\theta + M_p\theta + M_p\theta + M_p\theta = P\left(\frac{2L}{3}\right)$$

$$\Rightarrow \qquad P_u = \frac{15}{2L}M_p$$

$$\Rightarrow \qquad P_u = \frac{7.5}{L}M_p$$

28. **(c)**

Bearing stiffners are used to prevent local buckling and column splice has no role to play in shear capacity of steel girder.

29. **(d)**

For simultaneous collapse of *AB* and *BC*. Plastic hinge are formed at *A*, *B* and midspan of *AB*.

$$\therefore \qquad 2M_p = \frac{wl^2}{8}$$

$$\therefore \qquad M_p = \frac{wl^2}{16}$$

$$M_p = \frac{wa^2}{2}$$

$$\therefore \qquad \frac{a^2}{2} = \frac{l^2}{16}$$

$$\therefore \qquad a = \frac{l}{2\sqrt{2}}$$

30. **(c)**

$$1.5\,M_p = \frac{Pl}{4}$$

$$P = \frac{6M_p}{l}$$

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