CLASS TEST

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DESIGN OF STEEL STRUCTURES

CIVIL ENGINEERING

Date of Test : 22/08/2022

ANSWER KEY

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

DETAILED EXPLANATIONS

2. (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.

4. (a)

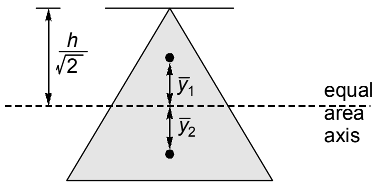
$$\text{Elastic section modulus} = \frac{bh^2}{24}$$

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

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

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

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



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

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

8. (a)

When $\theta < 60°$

The design force for connection is $V \cot\theta$.

$$V = \frac{2.5}{100} \times 750 = 18.75 \text{ kN}$$

$$\therefore \quad V \cot 45° = 18.75 \text{ kN.}$$

9. (d)

$$\text{Length of plastic hinge} = l\left(1 - \frac{1}{SF}\right) = 6 \times \left(1 - \frac{1}{3/2}\right) = 2 \text{ m}$$

11. (a)

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

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

$$= \text{minmum of} \left[\frac{40}{3 \times 22}, \frac{60}{3 \times 22} - 0.25, \frac{400}{410}, 1\right] = 0.606$$

$$\text{Bearing strength} = \frac{2.5 \times 0.606 \times 20 \times 20 \times 410}{1.25} = 198.77 \text{ kN}$$

12. (d)

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

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

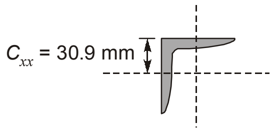
$$\therefore \quad M_p = \frac{wl^2}{16}$$

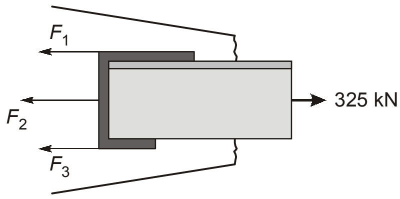
$$M_p = \frac{wa^2}{2}$$

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

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

13. (d)





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

$$F_2 = \frac{350 \times 110}{1000} = 38.5 \text{ kN}$$

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

For no torsional moment to develop,

$$F_1(30.9) - F_3(110 - 30.9) - F_2(55 - 30.9) = 0 \quad \text{...(ii)}$$

Solving (i) and (ii)

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

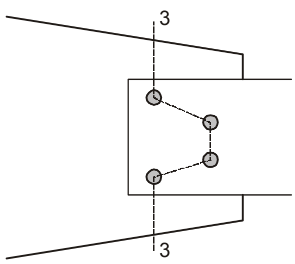
14. (a)

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

$$100 \times 10^3 = \frac{410}{\sqrt{3} \times 1.25} \times (0.707 \times 5) \times l$$

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

15. (d)



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

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

16. (d)

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

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

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

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

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

18. (b)

$$t \geq \sqrt{\frac{2.5w\left(a^2 - \mu b^2\right)}{\left(\frac{f_y}{\gamma_{m0}}\right)}}$$

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

$$\therefore \quad t \geq \sqrt{\frac{2.5 \times \frac{1}{6}}{\frac{250}{1.1}} \times \left(600^2 - 0.25 \times 600^2\right)}$$

$$\therefore \quad t \geq 22.25 \text{ mn}$$

19. (d)

$$W_{collapse} = \frac{16M_p}{l^2}$$

$$W_{yeild} = \frac{12M_p}{l^2}$$

$$\Rightarrow \quad \frac{W_{collapse}}{W_{yield}} = \frac{\frac{16M_p}{l^2}}{\frac{12M_p}{l^2}} = \frac{4}{3}$$

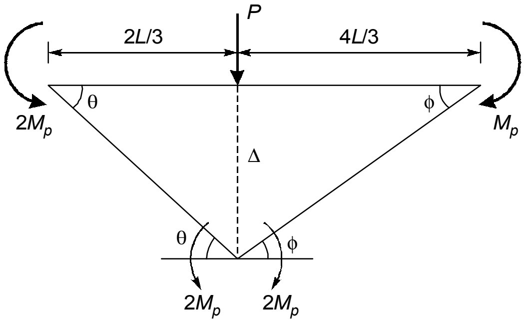
20. (a)

$$D_s = 2$$

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

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

Mechanism-1



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

$$\Rightarrow \quad \theta = 2\phi$$

By principle of critical work done,

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

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

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

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

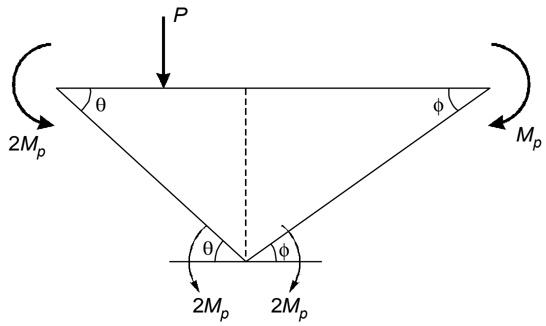
$$\Rightarrow \quad P_u = 8.25\,M_p/L$$

Mechanism-2

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

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

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



21. (c)

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

22. (a)

$$\text{Vertical force on rivet 1} = \frac{P}{4} = \frac{54.8}{4} = 13.7 \text{ kN}$$

$$\text{Moment to which the river is subjected} = 54.8 \times 0.25 = 13.7 \text{ kNm}$$

$$\text{Force acting on rivet 1 due to moment, } r = \sqrt{80^2 + 80^2} \simeq 13.7 \text{ mm}$$

$$\frac{M \times r}{4\,r^2} = \frac{13.7 \times 0.113}{4 \times 0.113^2} = 30.27 \text{ kN}$$

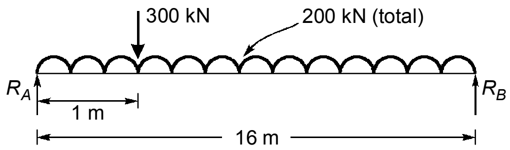
$$\text{Net force acting} = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$= \sqrt{13.7^2 + 30.27^2 + 2 \times 13.7 \times 30.27 \times \frac{1}{\sqrt{2}}} = 41.11 \text{ kN}$$

24. (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,

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

Load on gantry girder through each wheel = $\frac{381.25}{2}$ = 190.63 kN

25. (b)

$$f_{cd} = \frac{x f_y}{\gamma_{m_0}} \qquad \left(\text{where, } x = \frac{1}{\phi + \sqrt{\phi^2 - \lambda_e^2}}\right)$$

$$\phi = [(1 + \alpha(\lambda_e - 0.2) + \lambda_e{}^2)] \times 0.5$$

$$\lambda_e = \sqrt{\frac{f_y}{\frac{\pi^2 E}{\lambda^2}}} = 0.416$$

$$\phi = 0.64$$

$$x = 0.89$$

$$f_{cd} = \frac{0.89 \times 250}{1.1} = 202.27 \text{ N/mm}^2$$

26. (c)

Design strength of weld, $P_{dw} = l_w \times t_t \times \frac{f_u}{\sqrt{3}\gamma_{mw}}$ ...(i)

Minimum permissible weld size upto 20 mm thick plate as per **IS 800:2007** is

$$s = 5 \text{ mm}$$

$$t_t = 0.7 \times 5 = 3.5 \text{ mm} \qquad (> 3 \text{ mm})$$

Substituting in equation (i)

$$\Rightarrow \quad 200 \times 10^3 = l_w \times 3.5 \times \frac{410}{\sqrt{3} \times 1.5}$$

$$\Rightarrow \quad l_w = 362.1 \text{ mm}$$

27. (c)

$$I_{xx} = 2(I_{xx})_{\text{only}} = 54.4 \times 10^4 \text{ mm}^4$$

$$I_{yy} = 2[(I_{yy})_{\text{one}} + A_{\text{one}}[C_{yy} + s/2]^2$$

$$= 2[8.8 \times 10^4 + 552[10.4 + s/2]^2$$

$$I_{xx} = I_{yy}$$

$$27.2 \times 10^4 = 8.8 \times 10^4 + 552(10.4 + s/2)^2$$

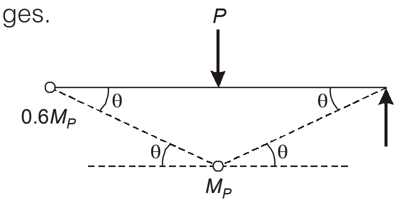
$$\therefore \quad s = 15.7 \text{ mm}$$

28. (c)

Since in purlins, maximum moment about both the principal axes are not equal i.e., one moment is lesser than the other. So, there is no point in giving equal section modulus in both the principal axes. Hence, equal angles are not economical in case of purlins.

29. (a)

Failure in the left/right span can be caused by formation of two hinges.



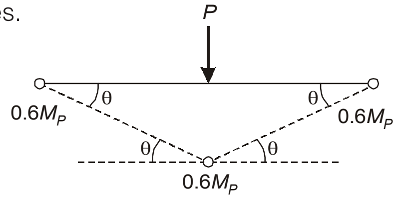
(Right Span)

Using virtual work method

$$\Rightarrow \quad P \cdot \frac{L}{2}\theta = M_P \cdot (2\theta) + 0.6M_P \cdot \theta$$

$$\Rightarrow \quad P = \frac{5.2M_P}{L}$$

The failure in the middle span will be caused by formation of 3 hinges.



(Middle Span)

$$\Rightarrow \quad P \cdot \frac{L}{2} \cdot \theta = 0.6M_P(\theta + 2\theta + \theta)$$

$$\Rightarrow \quad P = \frac{4.8M_P}{L}$$

Hence, collapse load is the minimum of the above two values, i.e. $\frac{4.8M_P}{L}$.

30. (d)

$$\text{Total area of cross-section} = 40 \times 100 + 100 \times 20 = 6000 \text{ mm}^2$$

For equal area axis

$$40 \times y = \frac{6000}{2}$$

$$\therefore \quad y = 75 \text{ mm}$$

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