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Steel Structure

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CLASS TEST 2019-2020

CIVIL ENGINEERING

Date of Test : 10/08/2019

ANSWER KEY ➤ Steel Structure

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

DETAILED EXPLANATIONS

2. (c)

3. (c)

For $\theta = 120°$, $k = 0.5$

Throat thickness, $t = 0.5\ s$

$\therefore$ Size of weld $s = \dfrac{t}{0.5} = 10$ mm

5. (a)

When $\theta < 60°$

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

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

$\therefore$ $V \cot 45° = 18.75$ kN.

6. (a)

For lacing plate, $I = \dfrac{bt^3}{12}$

$$\because \quad r = \sqrt{\frac{I}{A}} = \sqrt{\frac{bt^3}{12 \times bt}} = \frac{t}{\sqrt{12}}$$

Also, $\lambda = \dfrac{KL}{r} < 145$

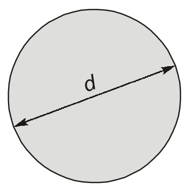
$$\therefore \quad \frac{L}{\frac{t}{\sqrt{12}}} < 145$$

$$\Rightarrow \quad L < \frac{145 \times 5\sqrt{12}}{\sqrt{12}} = 725 \text{mm}$$

Therefore, maximum value of L is 725 mm.7

8. (a)

$$z_e = \frac{\pi d^3}{32}$$



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

$$= \frac{\pi d^2}{4 \times 2} \times \left(\frac{4}{3 \times a} \times \left(\frac{d}{2}\right)\right) \times 2$$

$$\therefore \quad \text{Shape factor} = \frac{z_p}{z_e} = \frac{d^3}{6} \times \frac{32}{\pi d^3} = \frac{32}{6\pi} = 1.697$$

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. (b)

$$\text{Shearing capacity of bolt} = \frac{f_{ub}}{\sqrt{3}}\times\frac{1}{\gamma_{m_1}}A_{sb} = \frac{800}{\sqrt{3}}\times\frac{1}{1.25}\times\frac{\pi}{4}\times 20^2 = 116.08\text{ kN}$$

$$\text{Bearing capacity of bolt} = \frac{2.5\,k_b\,d.t\,f_u}{\gamma_{m_1}}$$

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

$$= \text{minimum}\left[\frac{40}{3\times 22},\frac{50}{3\times 22}-0.25,\frac{800}{410},1\right] = 0.508$$

$$= \frac{2.5\times 0.508\times 20\times 10\times 410}{1.25} = 83.31\text{ kN}$$

12. (a)

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

Moment to which the river is subjected = 54.8 × 0.25 = 13.7 kNm

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

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

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

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

13. (c)

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

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

s = 5 mm

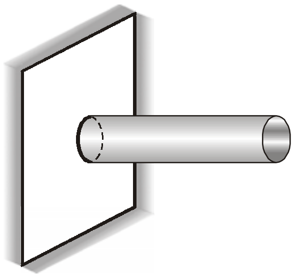
t_t = 0.7 × 5 = 3.5 mm (> 3 mm)

Substituting in equation (i)

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

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

15. (d)



$$\frac{f}{r} = \frac{T}{J}$$

$$f = \frac{T \cdot d/2}{\frac{\pi}{4} \cdot d^3 \cdot t} = \frac{2T}{\pi d^2 t} \qquad \left[\because \; J = \frac{\pi}{4} d^3 t\right]$$

Alternatively,

$$T = F \cdot r$$

$$F = \text{Shear force} = \text{Stress} \times \text{Area} = f \times (\pi d \times t)$$

$$r = \frac{d}{2}$$

$$T = f \times \pi dt \times \frac{d}{2}$$

$$f = \frac{2T}{\pi d^2 t}$$

16. (a)

For shear rupture and tension yielding

$$A_{vn} = (230 - 4.5 \times 18) \times 6 = 894 \text{ mm}^2$$

$$A_{tg} = 40 \times 6 = 240 \text{ mm}^2$$

$$F = 0.9 \frac{f_u}{\sqrt{3}\, \gamma_{m_1}} A_{vn} + \frac{f_y \times A_{tg}}{\gamma_{m_0}} = 206.9 \text{ kN}$$

For shear yielding and tension rupture

$$A_{vg} = 230 \times 6 = 1380 \text{ mn}^2$$

$$A_{tn} = \left(40 - \frac{18}{2}\right) = 186 \text{ mn}^2$$

$$F = \frac{f_y}{\sqrt{3}} \frac{A_{vg}}{\gamma_{m_0}} + \frac{f_v \times A_{tn} \times 0.9}{\gamma_{m_1}} = 236 \text{ kN}$$

$\therefore$ Block shear strength $= 206.9$ kN

18. (b)

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

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

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

$$\phi = 0.64$$

$$x = 0.89$$

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

19. (a)

$$f_{cd} = 59.2 \text{ N/mm}^2$$

$$A_{\text{grass}} = \frac{65 \times 10^3}{59.2} = 1097.97 \text{ mm}^2$$

20. (c)

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

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

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

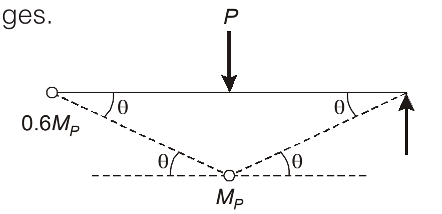
$$I_{xx} = I_{yy}$$

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

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

21. (a)

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



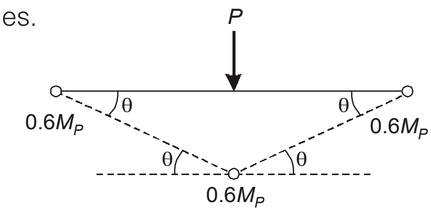
(Right Span)

Using virtual work method

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

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

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



(Middle Span)

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

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

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

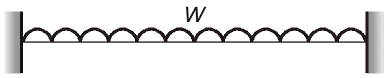
22. (b)

$$\text{Minimum depth of purlin} = \frac{l}{45} = 66.67 \text{ mm}$$

$$\text{Minimum width of purlin} = \frac{l}{60} = 50 \text{ mm}$$

23. (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.

24. (a)
Where s is the shape factor



$$M_p = \frac{W_c l^2}{16}$$

$$W_c = \frac{16 M_p}{l^2}$$

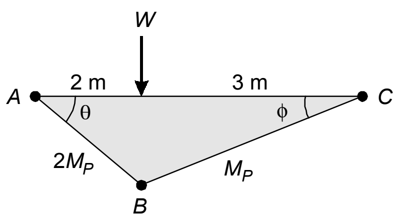
$$M_y = \frac{W_y l^2}{12}$$

$$W_y = \frac{12 M_s}{l^2}$$

$$\therefore \quad \frac{W_c}{W_s} = \frac{16}{12} \times \frac{M_p}{M_y}$$

$$\frac{W_c}{W_s} = \frac{4}{3} s$$

26. (b)



$$2 M_P \theta + M_P (\theta + \phi) = W 3\phi$$

28. (b)
SF for rectangular = 1.5
SF for circular section = 1.7
SF for square section with diagonal horizontal = 2

29. (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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