CLASS TEST

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DESIGN OF STEEL STRUCTURES

CIVIL ENGINEERING

Date of Test : 29/08/2022

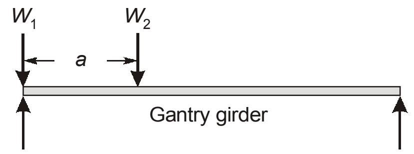
ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

For maximum shear force in gantry girders, load on wheels should be as close as possible.



where, W_1 and W_2 are wheel loads

2. (d)

Radiography is used to find defects in butt weld and ultrasonic method is used to find defect in fillet welds.

4. (a)

Maximum size of fillet weld depends on size of thinner plate to be connected. It is 1.5 mm less than the thickness of thinner plate.

6. (d)

Fire resistance of a steel member depends upon all these four factors.

8. (b)

9. (b)

Plastic section can develop plastic moment resistance and plastic hinge, but compact section can reach upto plastic moment of resistance and cannot make plastic hinge.

10. (d)

Wind-induced oscillations come under limit state of serviceability.

11. (b)

Depth of web plate, $d = 2000$ mm

Spacing of transverse stiffeners,

$$c = 1000 \text{ mm}$$

$$c/d = \frac{1000}{2000} < \sqrt{2}$$

$\therefore$ Minimum moment of inertia of transverse stiffener

$$I_s = \frac{1.5d^3t_w^3}{c^2}$$

$$= \frac{1.5 \times (2000)^3 \times \left(\frac{2000}{67}\right)^3}{(1000)^2} \qquad \left(\text{Since } \; t_w = \frac{d}{67}\right)$$

$$= 31918.82 \times 10^4 \text{ mm}^4$$

12. (c)

For Fe410 grade steel, $f_y = 250$ MPa

$\therefore$ Shear area $(A_v) = ht_w = 300 \times 7.5 = 2250 \text{ mm}^2$

$\therefore$ Design shear strength of the beam section $= \dfrac{f_{yw}A_v}{\gamma_{m0}\sqrt{3}}$

$$= \frac{250 \times (300 \times 7.5)}{1.1 \times \sqrt{3}} = 295235.93\text{N} = 295.236 \text{ kN}$$

13. (b)

$\because$ Section is plastic (given)

And $V < 0.6\, V_d$

So, it is a case of low shear and thus design bending

$$M_d = \frac{\beta_b Z_p f_y}{\gamma_{m0}} \leq \frac{1.2 Z_e f_y}{\gamma_{m0}}$$

β_b = 1 for plastic section

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

$$= 148.12 \text{ kNm} \leq 156.44 \text{ kNm} \qquad \text{(OK)}$$

So design bending strength = 148.12 kNm.

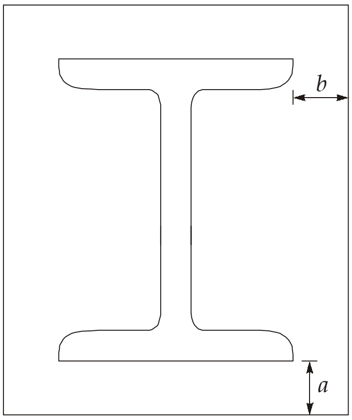
14. (b)

Bearing strength of concrete

$$= 0.60\, f_{ck} = 0.60 \times 20 = 12 \text{ N/mm}^2$$

For factored load, P_u = 1000 kN

Bearing pressure, $$w = \frac{1000 \times 10^3}{400 \times 300} = 8.33 \text{ N/mm}^2 < 12 \text{ N/mm}^2$$



Now, longer projection, $$a = \frac{400 - 300}{2} = 50 \text{ mm}$$

Smaller projection, $$b = \frac{300 - 250}{2} = 25 \text{ mm}$$

So, minimum thickness of base plate required is

$$t = \sqrt{\frac{2.5w\left(a^2 - 0.3b^2\right)\gamma_{mo}}{f_y}}$$

$$= \sqrt{\frac{2.5 \times 8.33 \times \left\{50^2 - 0.3(25)^2\right\} \times 1.1}{250}} = 14.56 \text{ mm}$$

15. (d)

$$\text{Resultant force} = \sqrt{3^2 + 4^2} = 5\text{kN}$$

$$\text{Stress in rivet} = \frac{5000}{500} = 10 \text{ N/mm}^2$$

But, $$F_2 = \frac{P}{2}$$

$\therefore$ $P = 3 \times 2 = 6$ kN

16. (b)

Since load is applied out of the plane of bolts. So, all four four bolts will experience equal amount of shear force.

$$\therefore \quad \text{Shear force} = \frac{1000}{4} = 250 \text{ N}$$

$$\text{Shear stress} = \frac{250 \times 4}{\pi \times 36} = 8.84 \text{ N/mm}^2$$

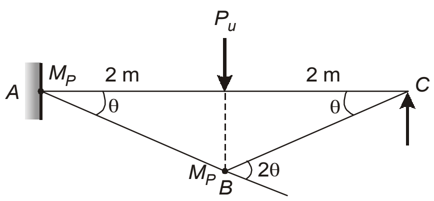
19. (a)

Degree of static indeterminacy = 1

∴ Number of plastic hinges required for collapse = 1 + 1 = 2

At failure,

Plastic hinges form at *A* and *B*



$$\text{External work} = P_u \times 2\theta = 2P_u\theta$$

$$\text{Internal work} = M_P\theta + M_P \times 2\theta = 3M_P\theta$$

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

$$\Rightarrow \quad 2P_u\theta = 3M_P\theta$$

$$\Rightarrow \quad P_u = \frac{3}{2} \times 100 = 150 \text{ kN}$$

21. (b)

$$\text{Size of the weld} = 8 \text{ mm}$$

$$\therefore \quad \text{Throat thickness} = 0.7 \times 8 = 5.6 \text{ mm}$$

$$\text{Vertical shear stress in weld } (f_s) = \frac{W}{2 \times d \times t} = \frac{100 \times 10^3}{2 \times 300 \times 5.6} = 29.76 \text{ MPa}$$

Maximum bending stress will be at the extreme points,

$$f_b = \frac{6We}{2td^2} = \frac{6 \times 100 \times 10^3 \times 50}{2 \times 5.6 \times 300^2} = 29.76 \text{ MPa}$$

$$\therefore \quad \text{Maximum resultant stress} = \sqrt{f_s^2 + f_b^2} = \sqrt{29.76^2 + 29.76^2} = \sqrt{2} \times 29.76 = 42.09 \text{ MPa}$$

22. (b)

Number of plastic hinge location, $N = 6$

Number of redundancy, $r = 3$

Number of independent mechanisms = 6 – 3 = 3

23. (b)

$$\text{Total weld length} = 250 \times 2 + 80 = 580 \text{ mm}$$

$$\text{Strength of weld} = 0.7 \times 8 \times 108 = 604.8 \text{ N/mm}$$

$$\text{Maximum load} = 604.8 \times 580 \simeq 350.78 \text{ kN}$$

24. (a)

Maximum allowable slenderness ratio = 350

$$\Rightarrow \quad \frac{l}{r_{min}} = 350$$

For $\quad l = 6000$ mm

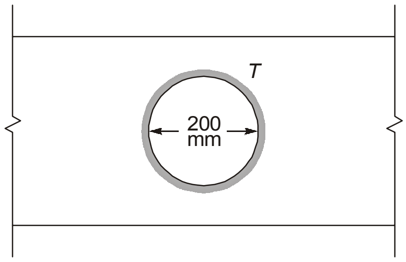
$$r_{min} = \frac{6000}{350} = 17.14 \text{ mm}$$

25. (c)

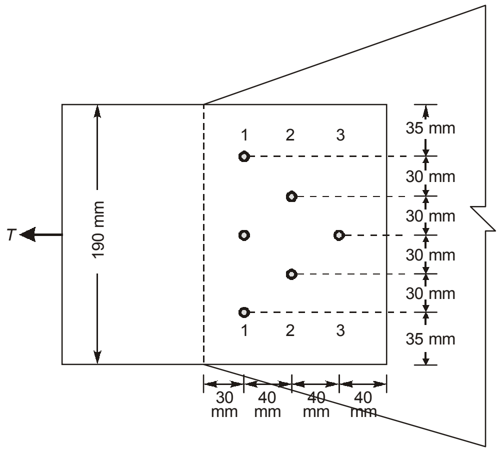
$$\text{Strength of weld, } f_s = \frac{f_u}{\sqrt{3}\times\gamma_{mw}}\times t_t = \frac{410}{\sqrt{3}\times 1.25}\times 0.7\times 6\times 1 = 795.36 \text{ N/mm}$$

$$\text{Torque resisted} = f_s\times \pi d\times\frac{d}{2}$$

$$= 795.36\times\pi\times 200\times\frac{200}{2} = 49.97 \text{ kNm}$$



26. (c)



For 20 mm diameter bolt, diameter of bolt hole = 22 mm

Calculation of net area,

$$A_n\text{(path 111)} = (B - nd)\times t$$

where, $B = 190$ mm, $t = 6$ mm

$$(190 - 3\times 22)\times 6 = 744 \text{ mm}^2$$

$$A_n\text{(path 1221)} = \left(190 - 4\times 22 + \frac{(40)^2\times 2}{4\times 30}\right)\times 6 = 772 \text{ mm}^2$$

$$A_n\text{(path 12321) and path (12121)} = \left(190 - 5\times 22 + \frac{4\times(40)^2}{4\times 30}\right)\times 6 = 800 \text{ mm}^2$$

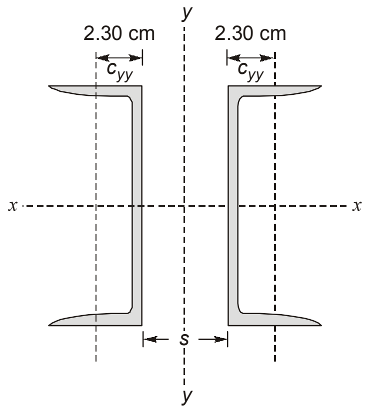
$$\therefore \quad A_{min} = 744 \text{ mm}^2$$

$$\therefore \quad \text{Net rupture strength} = \frac{0.9A_nf_u}{\gamma_{m1}} = \frac{0.9\times 410\times 744}{1.25}$$

$$= 219628.8 \text{ N}$$

$$\simeq 219 \text{ kN}$$

28. (c)



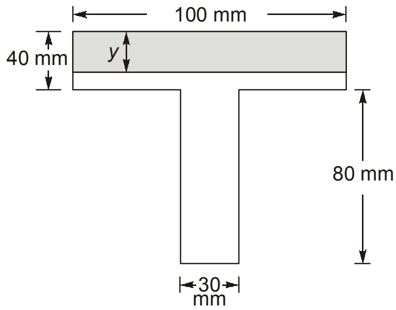
For optimum strength,

$$I_{xx} = I_{yy} \text{ (of section)}$$

$$\Rightarrow \quad 3816.8 \times 2 = \left[219.1 + 38.67\left(2.30 + \frac{s}{2}\right)^2\right] \times 2$$

$$\Rightarrow \quad s \simeq 14.7 \text{ cm}$$

29. (a)



We know that in plastic condition neutral axis will be equal area axis
So,

Calculation of location of equal area axis

Total area of section, $A = 40 \times 100 + 80 \times 30$
$= 6400 \text{ mm}^2$

$$\therefore \quad \frac{A}{2} = 3200 \text{ mm}^2$$

$\therefore$ Compressive force $=$ Area $\times$ Stress
$= (32 \times 100) \times 250$
$= 800 \text{ kN}$

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