Steel Structures Test 2

Number of Questions: 30 **Time: 75 min.**

Directions for questions 1 to 30: Select the correct alternative from the given choices.

1. Minimum edge distance of bolted joint for hand flame cut edges is not less than
   (A) 1.5 × diameter of bolt hole
   (B) 1.5 × diameter of bolt
   (C) 1.7 × diameter of bolt hole
   (D) 1.7 × diameter of bolt

2. The type of weld used for joining two surfaces in two different planes is
   (A) Fillet weld (B) single *V* butt weld
   (C) double groove weld (D) None

3. If Bolts in any Bolt group is subjected to shear and tension; the interaction equation need to be satisfy as per IS 800 : 2007 is [V_b, V_{db} : Factored shear force and design shear strength and T_b, T_{db} : Factored tensile force and design tensile strength]
   (A) $\left[\frac{V_B}{V_{db}}\right] + \left[\frac{T_b}{T_{db}}\right] \le 2.0$
   (B) $\left[\frac{V_b}{V_{db}}\right]^2 + \left[\frac{T_b}{T_{dc}}\right]^2 \le 2.0$
   (C) $\left[\frac{V_b}{V_{db}}\right]^2 + \left[\frac{T_b}{T_{db}}\right]^2 \le 1.0$
   (D) None

4. The maximum length of a tension member with minimum radius of gyration of 20 mm carrying load reversals other than wind or earthquake forces as per IS 800 is ______?
   (A) 5.0 m (B) 1.5 m
   (C) 3.6 m (D) 6.0 m

5. Which of the following is the most efficient section for column for a given equal cross section area?
   (A) solid circular section
   (B) Angle section
   (C) I-section
   (D) tubular section

6. When the column is effectively held in position and restrained against rotation at both ends, the effective length of column is '*K*' times the unsupported length (*L*) of column where *K* is ———
   (A) 1.2 (B) 0.8
   (C) 0.65 (D) 1.0

7. A beam section is selected and provided on the basis of
   (A) shear (B) deflection
   (C) section modulus (D) All the above

8. While designing, for a steel column of Fe250 grade, a base plate resting on a concrete pedestal of M30 grade, the bearing strength of concrete (in N/mm^2) in limit state method of design as per IS 456 : 2000 is
   (A) 3.84 (B) 11
   (C) 13.5 (D) 15

9. In a roof truss if pitch is $\frac{\sqrt{3}}{2}$ and slope is $\sqrt{3}$, the angle of inclination with horizontal would be
   (A) 60° (B) 30°
   (C) 45° (D) 90°

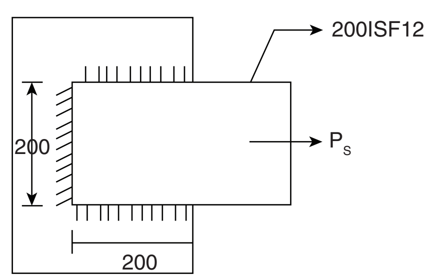
10. In an industrial building gantry girder of effective span 25.0 m carries a manually operated crane of 350 kN. The maximum deflection as per IS 800 – 2007 is
    (A) 50 mm (B) 30 mm
    (C) 25 mm (D) 75 mm

11. Two plates 12 mm and 20 mm thick are to be joined by a double cover butt joint with 8 mm thick packing plate. What will be the effect of packing on the design shear strength of bolt?
    (A) decreases by 10% (B) increases by 10%
    (C) decreases by 15% (D) increases by 15%

12. Calculate the design tensile capacity of M20 bolt of grade 4.6 is
    (A) 50 kN (B) 68 kN
    (C) 75 kN (D) 35 kN

13. Calculate the number of bolts required for a lap joint between two plates of 12 mm and 24 mm thick to transmit a factored load of 100 kN using M16 bolts of grade 4.6 and Fe410 plates. (assume minimum end distance = 27 mm; minimum pitch = 40 mm and thread intercept shear plane)
    (A) 2 (B) 6
    (C) 4 (D) 8

14. Determined the service load which can be applied to the fillet weld for the figure shown with a weld size of 5 mm. Use plates of grade 410 steel and workshop welding.

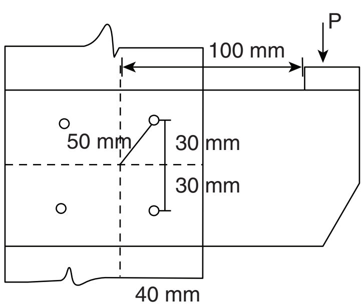


    (A) 450 kN (B) 500 kN
    (C) 350 kN (D) 265 kN

15. When length of side fillet weld is 400 times the effective throat thickness. Then the design shear capacity of fillet weld is
(A) decreased by 33%
(B) increased by 33%
(C) decreased by 20%
(D) decreased by 66%

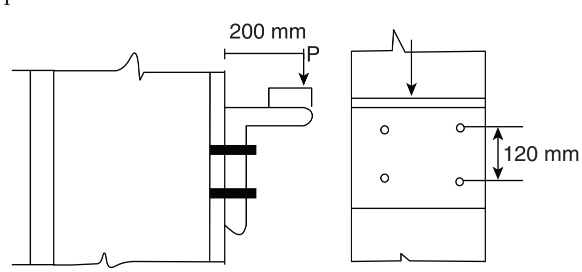
16. Two 12 mm thick plates are joined in the field by a single '*V*' bolt weld. The effective length of weld is 250 mm. Determine the design strength of welded joint. The yield and ultimate tensile strength of weld and steel are 250 Mpa and 410 Mpa respectively.
(A) 330.50 kN
(B) 437.50 kN
(C) 530.50 kN
(D) 357. 50 kN

17. Four the bolt systems shown in figure, the bolts are at a distance of 50 mm from Center of gravity of bolt group. The resultant force in the critical bolt is



(A) $P/4$
(B) $0.50P$
(C) $0.70P$
(D) $1.0P$

18. Each bolt shown in figure is capable of resisting design shear capacity of 25 kN and design tension capacity of 20 kN. The interaction equation between of forces as per limit state method of IS 800 : 2007?



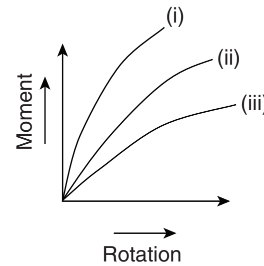
(A) $\left[\frac{P}{100}\right]+\left[\frac{P}{24}\right]\leq 10$

(B) $\left[\frac{P}{50}\right]^2+\left[\frac{P}{24}\right]^2\leq 1.0$

(C) $\left[\frac{P}{50}\right]^2+\left[\frac{P}{30}\right]^3\leq 1.0$

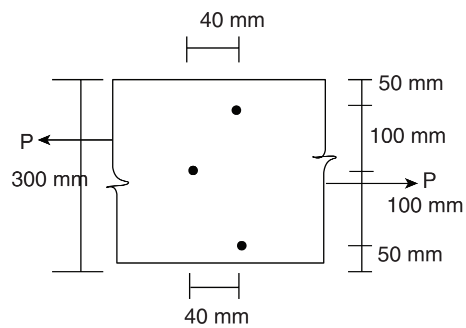
(D) $\left[\frac{P}{100}\right]^2+\left[\frac{p}{24}\right]^2\leq 1.0$

19. The moment rotation curve shown in figure is that of a



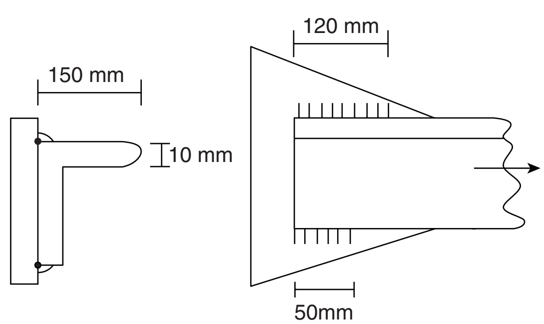
(A) (i) Semi Rigid Joint
(ii) Rigid.
(iii) Flexible
(B) (i) Rigid Joint
(ii) Semi Rigid.
(iii) Flexible
(C) (i) Flexible Joint
(ii) Semi Rigid.
(iii) Rigid
(D) None

20. What is the net effective sectional area of plate of thickness 12 mm as shown in the figure for carrying tension?
[take dh : 18 mm]



(A) 2500 mm^2
(B) 3048 mm^2
(C) 2750 mm^2
(D) 3500 mm^2

21. Compute the tensile strength of an angle section ISA 150 × 150 × 10 mm of Fe 410 grade of steel connected with guest plate as shown in figure based on gross sectional yielding.



(A) 450 kN
(B) 350 kN
(C) 660 kN
(D) none

22. The best tension member section will be a
(A) bolted single angle section
(B) welded single angle section
(C) channel section
(D) double angle section on opposite side of gusset plate

23. Determine service axial load on column section ISMB 350. Given that the height of column is 3.2 m and that is fixed on both ends. Assume f_y : 250 Mpa, f_u 410 Mpa and $E = 2 \times 10^5$ Mpa (properties of ISMB 350 are $A = 6670$ mm², $t_f = 14.2$ mm, $t_w = 8.1$ mm, $b = 140$ mm, $h = 350$ mm, $r_{zz} = 143$ mm and $r_{yy} = 28.4$ mm
(A) 720 KN (B) 850 KN
(C) 350 KN (D) None

24. A built up column consists of ISMC 300 channels placed back to back at a spacing of 250 mm and carries working load of 2000 kN, the double lacing provided with an angle of 50° with longitudinal axis. As per IS 800 – 2007 lacing member should be designed to resist design axial load of
(A) 19.5 kN (B) 24.5 kN
(C) 30.8 kN (D) 54.2 kN

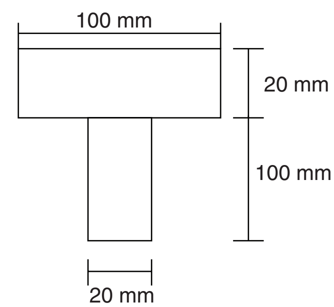
25. In laced columns, end tie plates are provided to
(A) check the buckling of column as a whole
(B) check the buckling of component column
(C) check the distortion of the column sections at ends because of unbalanced horizontal force from lacings
(D) keep the column components in position

26. A steel beam of circular c/s is clamped at both ends. Deformation is just observed when the U.D.L on the beam is 20 kN/m. At the instant of collapse, the load on the beam will be
(A) 15 kN/m (B) 30 kN/m
(C) 20 kN/m (D) 45 kN/m

27. For an rectangular beam the shape factor is 1.5. The factor of safety in bending is 1.5. If the allowable stress is increased by 15% for wind and earth quake loads, then the load factor is
(A) 1.95 (B) 1.40
(C) 1.65 (D) 1.80

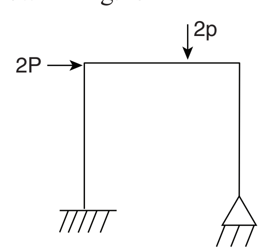
28. A propped cantilever beam *AB* of length '*L*' fixed at '*A*' and propped at *B* is subjected to a concentrated load '*w*' at its center. By kinematic approach calculate the ultimate collapse load (*w*) in terms of *Mp*.
(A) $w = \dfrac{2Mp}{L}$ (B) $w = \dfrac{6Mp}{L}$
(C) $w = \dfrac{4Mp}{L}$ (D) $w = \dfrac{8Mp}{L}$

29. The distance of plastic neutral axis from top of T-section shown below:



(A) 15 mm (B) 60 mm
(C) 20 mm (D) 40 mm

30. The number of possible independent mechanisms for a portal frame shown in fig. is



(A) 1 (B) 3
(C) 4 (D) 2

Answer Keys

1. C	**2.** A	**3.** C	**4.** C	**5.** D	**6.** C	**7.** D	**8.** C	**9.** A	**10.** A
11. A	**12.** B	**13.** C	**14.** D	**15.** A	**16.** B	**17.** C	**18.** D	**19.** B	**20.** B
21. C	**22.** D	**23.** A	**24.** B	**25.** C	**26.** D	**27.** A	**28.** B	**29.** C	**30.** D

Hints and Explanations

1. For hand flame cut edges miniumum edge distance = 1.7 × dia. of bolt hole. Choice (C)

2. For joining two surfaces in different planes, Fillet weld is used. Choice (A)

3. Interaction equation need to be satisfy as per IS : 8OO

is $\left[\dfrac{V_b}{v_{db}}\right]^2 + \left[\dfrac{T_b}{T_{db}}\right]^2 \leq 1.0$ Choice (C)

4. $\dfrac{\ell}{r} \leq 180$

$\ell = (180)(20)$

$\ell = 3600\text{mm}$

$\ell = 3.6\text{m}$ Choice (C)

5. For a given cross section area, tubular section is more efficient due to more (r) min. Choice (D)

6. Given end conditions are translations and rotations restrained at both ends. (i.e., fixed at both ends)
Effective length constant $K = 0.65$ Choice (C)

7. A beam section is selected based on all of the above. Choice (D)

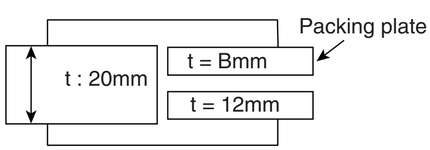
8. Maximum allowable bearing strength = 0.45 × 30
= 13.5 N/mm² Choice (C)

9. Slope of roof truss;
$\tan\theta = \sqrt{3}$ where θ : Angle of inclination with horizontal
$\theta = \tan^{-1}(\sqrt{3}) = 60°$ Choice (A)

10. Limiting deflection $= \dfrac{\text{Span}}{500}$

$= \dfrac{25000}{500} = 50\text{mm}$ Choice (A)

11.



Reduction factor (β_{pkg}) : $[t_{pkg} > 6\text{mm}]$
$B_{pkg} = 1 - 0.0125\, t_{pkg}$
$= 1 - 0.0125\,(8) = 0.90$
∴ Design shear strength of bolt decrease by 10% Choice (A)

12. Design tensile capacity of bolt = T_{db}

$$T_{db} = \frac{0.9 f_{ub}}{\gamma_{mb}} \times A_{nb} \leq \frac{f_{yb}}{\gamma_{mo}} A_{sb}$$

$$= \frac{0.9 \times 400}{1.25} \times 0.78 \times \frac{\pi}{4}(20)^2 \leq \frac{240}{1.10} \times \frac{\pi}{4}(20)^2$$

$= 70.572 \text{ kN} \leq 68.543$

T_{db} : 68.543 kN Choice (B)

13. Number of bolts $n = \dfrac{P}{V_{db}}$

V_{db} is least of V_{dsb}, V_{dpb}

$$V_{dsb} = \frac{f_{ub}}{\sqrt{3}\gamma_{mb}}(n_n A_{nb} + n_s A_{sb})$$ [$n_s = 0$ since thread intercept shearplane]

$$= \frac{400}{\sqrt{3} \times 1.25}\left[1 \times 0.78 \times \frac{\pi}{4} \times 16^2\right] = 28.974 \text{ kN}$$

$$V_{dpb} = \frac{2.5 dt\, K_b f_u}{\gamma_{mb}}$$

K_b is least of $\dfrac{e}{3dh}$; $\dfrac{P}{3dh} - 0.25$; $\dfrac{f_{ub}}{f_u}$; 1.0

$\dfrac{e}{3dh} = \dfrac{27}{3 \times 18} = 0.50$

$\dfrac{P}{3dh} - 0.25 - \dfrac{40}{3 \times 18} - 0.25 = 0.490$

$\dfrac{f_{ub}}{f_u} = \dfrac{400}{410} = 0.97$

Take least among these

$K_b = 0.490$

$$V_{dpb} = \frac{2.5 \times 16 \times 12 \times 0.490 \times 400}{1.25} = 75.264 \text{ kN}$$

∴ $V_{db} = 28.974$ kN

$n = \dfrac{P}{V_{db}} = \dfrac{100}{28.97} = 3.45 \sim 4$ Choice (C)

14. Given $S = 5$mm
Design requirement:
Design action ≤ design strength
∴ $P = P_{dw}$
Design shear strength of fillet weld

$$(P_{dw}) = (L_w \times t_t) \times \frac{f_u}{\sqrt{3}\gamma_{mw}}$$

$$= 600 \times 0.70 \times 5 \times \frac{410}{\sqrt{3} \times 1.25} = 397.678 \text{ kN}$$

∴ $P = P_{dw} = 397.678$ kN

$P_s = \dfrac{P}{1.5} = \dfrac{397.678}{1.5} = 265.11$ kN Choice (D)

15. $L_J = 400t_t$
If $L_J > 150t_t \Rightarrow$ a reduction factor need to be applied for design shear capacity of fillet weld.
Reduction factor (β_{LW}):

$$\beta_{LW} = 1.20 - \frac{0.20 L_J}{150 t_t} = 1.20 - \frac{0.20 \times 400t}{150 t_t}$$

$= 1.20 - 0.533 = 0.66$
So strength reduced by 33% Choice (A)

16. Design strength of single 'v' butt weld $= L_w \times \dfrac{5}{8} \times T \times \dfrac{f_y}{\gamma_{mw}}$

$= 350 \times \dfrac{5}{8} \times 12 \times \dfrac{250}{1.50} = 437.500$ kN Choice (B)

17. Load/moment is lying in plate of bolt group.
So bolt group is subjected to Direct concentric load (P) and Inplane moment/twisting moment ($M = Pe$)
Vertical shear force in any bolt due to direct concentric load is F_a

$$F_a = \frac{P}{n} = \frac{P}{4}$$

Shear force in any bolt due to twisting moment ($M = Pe$) is

$$F_m = \frac{p.e.r}{\Sigma r^2} = \frac{p.(100)(50)}{4(50)^2}$$

$$F_m = 0.5\,p \qquad \cos\theta = \frac{40}{50} = \frac{4}{5}$$

$(F_R)_{\max}$: maximum Resultant force

$$= \sqrt{\left(\frac{P}{4}\right)^2 + \left(\frac{P}{2}\right)^2 + 2\left(\frac{P}{4}\right)\left(\frac{P}{2}\right)\frac{4}{5}}$$

$= 0.71\,P$ Choice (C)

18. Load/moment is not lying in plane of bolt group.
So bolt group is subjected to direct Concentric load (P) and bending moment (M)
Vertical shear force in any bolt due to P is

$$q_1 = \frac{P}{n} = \frac{P}{4} = V_b$$

Stress in any bolt due to M is q_2

$$q_2 = \frac{M^1 y_n}{\Sigma y^2}$$

assume CG of bolt coincides with bending axis

$$M_1 = \frac{M}{2} = \frac{p.e}{2}$$

$$T_b = q_2 = \frac{p(200)(60)}{2\left(2(60)^2\right)} \qquad T_b = \frac{5P}{6}$$

$\therefore$ Interaction equation is

$$\left[\frac{V_b}{V_{db}}\right]^2 + \left[\frac{T_b}{T_{db}}\right]^2 \le 1.0$$

$$\left[\frac{P}{4}\times\frac{1}{25}\right] + \left[\frac{5P}{6}\times\frac{1}{20}\right]^2 \le 1.0$$

$$\left[\frac{P}{100}\right]^2 + \left[\frac{P}{24}\right]^2 \le 1.0$$

Choice (D)

20. $A_{net} = (B - n.dh)t + \frac{P_1^2}{4g_1}t_1 + \frac{P_2^2}{4g_2}t_2$

$$= [300 - 3(18)]12 + \frac{40^2\times 12}{4\times 100} + \frac{40^2\times 12}{4\times 100}$$

$= 3048\text{mm}^2$ Choice (B)

21. $T_{dg} = \frac{f_y}{r_{mo}} \times A_g$

$A_g = 150 \times 10 + (150 - 10) \times 10 = 2900\ \text{mm}^2$

$T_{dg} = \frac{250}{1.10} \times 2900 = 659.090\ \text{kN}$ Choice (C)

23. For $\frac{h}{b_f} = \frac{350}{140} = 2.5 > 12$ and $t_f < 40\text{mm}$

Buckling class about z-z axis – a
Buckling class about y-y axis is – b
$\alpha = 0.21$ (Buckling class a)
$= 0.34$ (Buckling class b)

Effective slenderness ratio $\frac{KL}{r_{\min}}$

$K = 0.65$ for ends fixed
Effective slenderness ratio

$$= \frac{0.65L}{r_{\min}} = \frac{0.65\times 3.2}{28.4} = 73.23\text{mm}$$

Non dimensional effective slenderness ratio = λ

$$\lambda = \sqrt{\frac{f_y\left(\frac{KL}{r}\right)^2}{\pi^2 E}} = \sqrt{\frac{250(73.25)^2}{\pi^2\times 2\times 10^2}}$$

$\lambda = 0.82$
$\phi = 0.5\,(1 + \alpha\,(\lambda - 0.2) + \lambda^2)$
$= 0.5\,(1 + 0.34\,(0.82 - 0.2) + 0.82^2)$
$= 0.9416$
Design strength of axial compression

$$f_{cd} = \frac{\frac{f_y}{r_{mo}}}{\phi + \left(\phi^2 - \lambda^2\right)^{0.5}} \le \frac{f_y}{r_{mo}}$$

$$= \frac{\frac{250}{1.10}}{0.9416 + \left(0.9416^2 - 0.82^2\right)^{0.5}}$$

$= 161.82\ \text{Mpa} \le 22727\text{Mpa}$
Design axial load on column $P = f_{c_d} \times A_e$
$= 161.82 \times 6670$
$= 1079.3\ \text{kN}$

Service load $= \frac{1079.3}{1.5} = 719.53\ \text{kN}$ Choice (A)

24. Design load on column $P = 1.5 \times 2000 = 3000\ \text{kN}$

Transverse shear (V) $= \frac{25}{100} \times 2000 \times 1.5 = 75\ \text{kN}$

Force in lacing member (F) $= \frac{V}{4\sin\theta}$

$= \frac{75}{4\times\sin 50} = 24.47\ \text{kN}$ Choice (B)

26. Given deformation just taken place

i.e., $M_y = \dfrac{wl^2}{12}$

At collapse $M_p = \dfrac{w_c l^2}{16}$

Shape factor $S = 1.70$

$$1.70 = \frac{w_c l^2 \times 12}{16 \times wl^2} = \frac{w_c \times 12}{16 \times 20}$$

$W_c = 45.33$ kN Choice (D)

27. Load factor = factor of safety × shape factor

$$= \frac{f_y}{f} \times S = \left[\frac{f_y}{1.15f}\right] \times 1.50$$

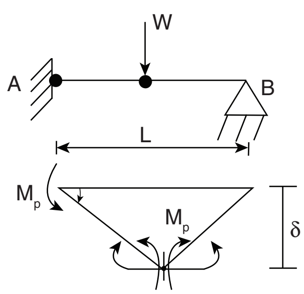
$$= \left[\frac{1}{1.15}\right] \times 1.5 \times 1.5 = 1.95$$ Choice (A)

28. Number of plastic hinges = $D_s + 1 = n$

$D_s = (2 + 1) - 2 = 1$

$n = 1 + 1 = 2$

one plastic hinge is formed at fixed end and other at point load.



$$\delta = \frac{L}{2}\theta$$

From principle of virtual work,

External work done by loads = Internal work done

$$w\frac{L}{2}\theta = M_p\theta + M_p(\theta + \theta)$$

$$w = \frac{6M_p}{L}$$ Choice (B)

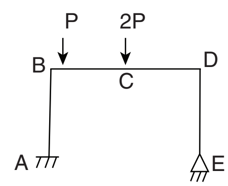
29. Area of flange = 100 × 20 = 2 × 10^3 mm^2

Area of web = 100 × 20 = 2 × 10^3 mm^2

Area of flange and area of web are equal so plastic NA lies at junction of flange and web

∴ distance of $N.A.$ from top = 20mm Choice (C)

30.



Number of Independent mechanisms = $N - Ds$

Where N – number of possible location of plastic hinges

D_s – Degree of static Indeterminacy

$D_s = r - 3 = 5 - 3 = 2$

$N = A, B, C, D = 4$

Number of independent mechanisms = 4 – 2 = 2

Choice (D)