01. Ans: 60%
Sol: \[ \eta = \frac{p - d}{p} \times 100 \]
\[ p_{\text{min}} = 2.5\phi \]
\[ d = \phi + 1.5 \]
\[ = \frac{2.5\phi - \phi}{2.5\phi} \times 100 \]
\[ = \frac{1.5\phi}{2.5\phi} \times 100 \]
\[ \eta = 60\% \]

05. Ans: (b)
Sol: ISA 50 \times 50 \times 6
\[ t = 5 \text{ mm} \]
\[ d = 16 \text{ mm} \]
\[ \sigma_{bt} = 250 \text{ MPa} \]
\[ P_b = d \times t \times \sigma_{bt} \]
\[ = 16 \times 5 \times 250 \]
\[ = 20 \text{ kN} \]

06. Ans: (43.29)
Sol:
Nominal dia of rivet (\( \phi \)) = 16 mm
For field Rivets permissible shear stress in Rivet
\[ \tau_{vf} = 90 \text{ MPa} \]
Bearing stress in Rivet \( \sigma_{pf} = 270 \text{ MPa} \)
Rivet value
\[ R_v = \text{lesser of } P_s \& P_b \]
\[ \phi = 16 \text{ mm (} \phi \leq 25 \text{ mm}) \]
\[ d = \phi + 1.5 = 17.5 \text{ mm} \]
\[ P_s = 2 \times \frac{\pi}{4} (d)^2 \times \tau_{vf} \]
\[ = 2 \times \left( \frac{\pi}{4} \right) (17.5)^2 \times 90 \]
\[ P_s = 43.29 \times 10^3 \text{ N} \]
\[ = 43.29 \text{ kN} \]
Bearing strength of one rivet
\[ P_b = d \times t \times \sigma_{pf} \]
\[ t = \text{thickness of main thinner plate (or) sum of cover plates thickness, which ever is minimum in cause of a butt joint} \]
\[ t (\text{MP}) = 12 \text{ mm} \]
t (cp + cp) = 8 + 8 = 16 mm
P_b = 17.5 × 12 × 270
P_b = 56.7 kN
R_v = lesser of P_s & P_b
∴ R_v = 43.29 kN

07. Ans: (d)
Sol:  
\[ P_s = 2 \times \frac{\pi}{4} (d)^2 \times \tau_{vf} = 80 \text{kN} \]
\[ P_s = \frac{\pi}{4} d^2 \times \tau_{vf} = 40 \text{kN} \]
\[ P_s = 40 \text{kN}, \quad P_b = 60 \text{kN}, \quad P_r = 70 \text{kN} \]
\[ n = \frac{P}{R_v} = \frac{200}{P_s} = 5 \]

10. Ans: (d)
Sol: Minimum pitch of rivets in compression zone
\[ 12t \text{mm} \] whichever is minimum
\[ 200 \text{mm} \]
\[ t = 10 \text{mm} \]
\[ 12t = 12 \times 10 = 120 \text{ mm} \] whichever is minimum
\[ 200 \text{ mm} \]

Pitch = 120 mm

03. Ans: (d)
Sol: \( f_u = 400 \text{ N/mm}^2 \)
\[ f_y = 0.6 f_u \]
\[ = 0.6 \times 400 \]
\[ = 240 \text{ N/mm}^2 \]

05. Ans: (d)
Sol:
\[ V_{d_{sb}} = \frac{f_{ub}}{\sqrt{3} \gamma_{mb}} (n_n A_{n_{nb}} + n_s A_{s_{sb}}) \]
\[ n_n (or) n_s = 3 \times 2 = 6 \]

06. Ans: (b)
Sol: \( P = 240 \text{ kN} ; \quad V_{dsb} = 40 \text{ kN} ; \quad V_{dpb} = 50 \text{ kN} ; \quad T_{db} = 30 \text{ kN} ; \quad V_{db} = \text{lesser of } V_{dsb}, V_{dpb} \)
\[ n = \frac{P}{V_{db}} = \frac{240}{40} \]
\[ n = 6 \text{ no’s} \]

07. Ans: (d)
Sol: Tensile force in each bolt due to \( P_a \cos \theta \)
\[ T_b = \frac{P_a \cos \theta}{n} = \frac{250 \times 4}{6} = 33.33 \text{ kN} \]
Shear force in each bolt due to \( P_u \sin \theta \)

\[
V_b = \frac{P_u \sin \theta}{n} = \frac{250 \times \frac{3}{5}}{6} = 25 \text{ kN}
\]

08. Ans: (d)
Sol:

For M16 bolt \( d = 16 \text{ mm} \)

For Grade 4.6; \( f_{ub} = 400 \text{ MPa} \)
\( f_{yb} = 240 \text{ MPa} \)

Design tensile strength of bolt \( T_{db} = ? \)

\( T_{db} \) is based on Gross section

\[
T_{db1} = \frac{A_{sb} f_{yb}}{\gamma_{mo}} = \frac{\pi \times (16)^2 \times 240}{1.1} = 43.86 \times 10^3 \text{ N} = 43.86 \text{ kN}
\]

\( T \) is based on net section rupture

\[
T_{db2} = \frac{0.9 A_{nb} f_{ub}}{\gamma_{mb}} = \frac{0.9 (0.78 \times \frac{\pi}{4} \times (16)^2 \times 400)}{1.25} = 45.166 \text{ kN}
\]

\( T_{db} \) is lesser of \( T_{db1} \) & \( T_{db2} \)

\[
\therefore T_{db} = 43.86 \text{ kN}
\]

09. Ans: (c)
Sol: Hanger connection looks like this one

In hanger connections bolts experience only tensile stress. Then we clearly taken,

Strength of rivet is equal to the design strength of bolt in tension.

\( P_{db} = 45 \text{ kN} \) = Design bolt strength

Number of bolts required = \( \frac{180 \text{ kN}}{45 \text{ kN}} = 4 \) no’s

10. Ans: (b)
Sol: Design strength values

\( V_{dpb} = 1,50,000 \text{ N} \)
\( T_{dp} = 1,80,000 \text{ N} \)
\( T_{sp} = 2,40,000 \text{ N} \)
\( V_{dsb} = 1,60,000 \text{ N} \)

\( \eta = \frac{\text{design strength of bolted connection} (V_{dc}) \times 100}{\text{design strength of solid plate} (T_{sp})} \)

\( V_{dc} \) is lesser of \( \left( \frac{V_{dpb}}{V_{db}}, \frac{T_{db}}{T_{dp}} \right) \)

\[
\eta = \frac{1,50,000}{2,40,000} \times 100 = 62.5\%
\]

\( \eta = 62.5\% \)
Chapter- 3
Welded Connections

07. Ans: (20)
Sol: Permissible stress in the weld are reduced by 20% when the welding is done in the field.

08. Ans: (d)
Sol:

\[ S = 8 \text{ mm}, \quad \tau_{vf} = 110 \text{ N/mm}^2 \]

Working stress method \( \Rightarrow \)

\[ P_s = L_w \times t_t \times \tau_{vf} \quad [\therefore t_t = 0.7 \times S = 0.7 \times 8] \]

\( L_w = \) Effective length of fillet weld

\[ = (80+80+60) \times (0.7 \times 8) \times 110 \]

\[ = 135 \text{ kN} \]

09. Ans: (a)
Sol:

\[ S = 6 \text{ mm} \]

\[ T_{a} = P_r \times r \]

Size of weld (S) = 6 mm

Torque \( T = 8 \text{ kN-m} \)

\[ = 8 \times 10^6 \text{ N-mm} \]

Maximum stress in weld \( q = ? \)

Twisting moment capacity of weld

Given data:
Permissible tensile stress in the plate \( \sigma_{at} = 150 \text{ MPa} \)

What is maximum tension \( P = ? \)?

We can allow Maximum tension load up to strength of butt weld

\[ P = T_s = I_w \cdot t_c \cdot \sigma_{at} \]

\[ \therefore \text{In case of single ‘V’ butt weld} \]

\[ t_c = \frac{5^{th} \text{ thickness of thinner member in case of single V}}{8} \]

\[ = 150 \times \frac{5}{8} \times 12 \times 150 \]

\[ = 168.78 \times 10^3 \text{ N} \]

\[ P = 168.75 \text{ kN} \]

10. Ans: (b)
Sol:

\[ T = 8 \text{ kN-m} \]

\[ \tau = \frac{T}{td} \]

150 mm
Chapter- 4
Eccentric Connections

11. Ans: (b)
Sol:
\[ S = 10 \text{ mm}; \quad f_y = 250 \text{ Mpa}, \quad f_yw = f_y; \quad f_u = 410 \text{ Mpa}; \]
\[ \gamma_{mw} = 1.25; \quad P = 270 \text{ kN} \]

\[ \Rightarrow L_w = l_j + l_j = 2l_j \]

\[ P \leq P_{dw} = L_w \times t_{w} \times \frac{f_u}{\sqrt{3} \gamma_{mw}} \]

\[ \Rightarrow 270 \times 10^3 = (2 \times \ell_j) \times (k \times S) \times \frac{f_u}{\sqrt{3} \gamma_{mw}} \]

\[ \Rightarrow 270 \times 10^3 = (2 \times \ell_j) \times (0.7 \times 10) \times \frac{410}{\sqrt{3} \times 1.25} \]

\[ \ell_j = 101.8 \text{ mm} \approx 105 \text{ mm} \]

12. Ans: 60
Sol: Throat thickness = 0.7\times 6 \text{ mm} = 4.2 \text{ mm}

Effective length of weld = 100 + 100 + 50 = 250 \text{ mm}

Permissible stress in the weld = 150 \text{ MPa}

Strength of weld = (4.2 \times 250) \times 150 \text{ N} = 115.5 \text{ kN}

Strength of plate= \[ 50 \times 8 \] \times 150 \text{ N} = 60 \text{ kN}

Then before the failure of weld joint plate fails.

The permissible load allowable = 60 \text{ kN}

02. Ans: (a)
Sol: \( r = \text{Max (1, 3, 4 & 6)} \quad \theta = \min (1) \)

Hence critical bolt is Bolt No. 1

03. Ans: (b)
Sol:
\[ \left( \frac{V_{bh}}{V_{db}} \right)^2 + \left( \frac{T_b}{T_{db}} \right)^2 \leq 1.0 \]

\[ x^2 + y^2 = r^2 \quad (r = 1) \]

It is circle equation

04. Ans: (c)
Sol:

(1) \( F_a \propto r \)
(2) \( F_m \propto r \)
(3) \( F_a < 0.5 \ V_{db} \)
(4) \( F_m \leq r \)
05. Ans: 5.99
Sol: Given load \( P = 10 \) kN
Eccentricity = 150 mm
Number of rivets = 4

Force in rivet 1 due to direct loading = \( \frac{P}{4} \)

\[ F_1 = 2.5 \text{ kN} \]

Force in rivet 1 due to twisting moment

\[ F_1 = \frac{M \cdot r_e}{\sum r_i^2} \]

\[ M = P[150] \text{ kN-mm} \]

\[ F_2 = \frac{10 \times 150 \times 50}{4 \times 50^3} = 7.5 \text{ kN} \]

Resultant force \( F_R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2 \cos \theta} \)

\[ \theta = 135^\circ \]

\[ F_R = 5.99 \text{ kN} \]

06. Ans: (c)
Sol: Design shear stress \( V_{db} = 20 \) kN
Design tensile capacity \( \tau_{bd} = 15 \text{ kN} \)

1) \( P \rightarrow \) cause shear force in bolt = \( P/8n \).
2) \( M = P \times e = P \times 150 = 150P \text{ kN-mm} \).

\( V_b = \frac{P}{n} = \frac{P}{4} \)

\[ M = \frac{f}{y} \]

\[ f = \left( \frac{M}{I} \right) y \]

\[ T_b = f \cdot A = \frac{M}{I} \cdot y \cdot A \]

\[ M = 150P \text{ kN-mm} \]

\[ y = \frac{120}{2} = 60 \text{ mm} \]

\[ I_{xx} = [I_{CG} + Ag]4 \]

\[ = \left[ \frac{\pi d^4}{64} + A(60)^2 \right] 4 \]

\( \left( \frac{\pi d^4}{64} \right) \) neglected

because it is very smaller than \( (60^2) A \).

\[ = 14400 \text{ A mm}^4 \]

\[ T_b = \frac{M}{I} \times y \times A \]
07. Ans: 156.20

Sol: An eccentric load may be replaced by set of one direct concentric load (p) and in plane moment (M)

\[ M = p \cdot e \]
\[ = (100) (600) \]
\[ = 6 \times 10^4 \text{kN-mm} \]

Force in each bolt due to direct concentric load \( (F_a) \)

\[ F_a = \frac{P}{n} = \frac{100}{5} = 20 \text{kN} \]

Force in critical bolt due to moment \( (F_m) \)

\[ F_m = \frac{p \cdot e \cdot r}{r^2} \]
\[ = \frac{M \cdot r}{\Sigma r^2} \]
\[ = \frac{6 \times 10^4 \times 75\sqrt{2}}{4 \times (75\sqrt{2})^2 + 0} \]
\[ = 141.42 \text{kN} \]

Maximum Resultant force in critical bolt 1 and 2 is

\[ F_{R_{\text{max}}} = \sqrt{F_m^2 + F_a^2 + 2F_a F_m \cos \theta} \]
\[ = \sqrt{(141.42)^2 + (20)^2 + 2 \times 20 \times (141.42) \times \left(\frac{1}{\sqrt{2}}\right)} \]
\[ = 156.20 \text{kN} \]

08. Ans: 20 kN

10. Ans: (d)

Sol:

Design shear strength of bolt \( V_{db} = 30 \text{kN} \)
Design tensile strength of bolt \( T_{db} = 40 \text{kN} \)
Factored shear force in any bolt due to vertical component of 6P

\[ V_b = \frac{P \cos 45^\circ}{4} = \frac{P}{4\sqrt{2}} \]

Factored tensile force in any bolt due to vertical component of 6P

\[ T_b = \frac{P \sin 45^\circ}{n} = \frac{P \sin 45^\circ}{4} \]

\[ \left(\frac{V_b}{V_{db}}\right)^2 + \left(\frac{T_b}{T_{db}}\right)^2 \leq 1.0 \]

\[ \left(\frac{P}{4\sqrt{2} \times 30}\right)^2 + \left[\frac{P}{4\sqrt{2} \times 40}\right]^2 \leq 1.0 \]
\[
\frac{P^2}{16 \times 2 \times 900} + \frac{P^2}{16 \times 2 \times 1600} = 1
\]

\[ P = 135.76 \text{ kN} \]

The maximum design load applied can be on the joint is 135.76 kN

11. Ans: 173.21 MPa

Sol: Equivalent stress of \( q_1 \) & \( q_2 \) act on the fillet weld is \( f_e \)

\[ f_e = \sqrt{3(q_{1\text{cal}})^2 + (q_{2\text{cal}})^2} \]

\[ = \sqrt{3 \times (50)^2 + (150)^2} \]

\[ = 173.21 \text{ MPa} \]

Chapter- 5
Tension Members

01. Ans: 240

Sol: \( f_y = 400 \text{ MPa} \)

Permissible tensile stress \( (\sigma_{\text{at}}) = 0.6 \times f_y \)

\[ = 0.6 \times 400 \]

\[ \sigma_{\text{at}} = 240 \text{ MPa} \]

02. Ans: (d)

Sol: \[ A_1 = 775 \text{ mm}^2 \]

\[ A_2 = 950 \text{ mm}^2 \]

\[ A_{\text{net}} = A_1 + A_2 K_1 \]

\[ K_1 = \frac{3A_1}{3A_1 + A_2} = \frac{3 \times 775}{3 \times 775 + 950} = 0.709 \]

\[ K_1 = \text{Reduction factor} = 0.709 \]

\[ A_{\text{net}} = A_1 + A_2 \times K_1 \]

\[ = (2 \times 775) + (2 \times 950) \times 0.709 \]

\[ A_{\text{net}} = 2899 \text{ mm}^2 \]

03. Ans: (c)

Sol: \[ P_t = A_{\text{net}} \times \sigma_{\text{at}} \]

\( (\sigma_{\text{at}} = 0.6 f_y \text{ is same (1) & (2)} \)

\[ P_t \propto A_{\text{net}} \]

\[ P_{(1)t} > P_{(2)t} \]

\[ A_{\text{net}(2)} > A_{\text{net}(1)} \]

\[ (B - 2d)t + \frac{P^2 t}{4g} > (B - d)t \]

\[ Bt - 2dt + \frac{P^2 t}{4g} > Bt - dt \]

\[ - dt - dt + \frac{P^2 t}{4g} > -dt \]

\[ \frac{P^2 t}{4g} > dt \]

\[ \Rightarrow P^2 > 4gd \]
04. Ans: (d)
Sol:  ISA: 100 × 100 × 10  
\[ \sigma_{at} = 150 \text{ N/mm}^2 \]
Nominal dia of rivet \( \phi = 20 \text{ mm} \)

Gross dia \( d = \phi + 1.5 \)  
\[ = 21.5 \text{ mm} \] (\( \phi = 20 \text{ mm} \))

Safe tensile strength = \( P_t \) = \( A_{net} \times \sigma_{at} \)
\[ A_{net} = A_1 + A_2 K_1 \]
\[ A_1 = (x - d - t/2) t \]
\[ = (100 - 21.5 - 10) \times 10 \]
\[ = 735 \text{ mm}^2 \]
\[ A_2 = (y - t/2) t \]
\[ = (100 - 10) \times 10 \]
\[ = 950 \text{ mm}^2 \]
\[ K_1 = \frac{3A_1}{3A_1 + A_2} = \frac{3 \times 735}{3 \times 735 + 950} \]
\[ K_1 = 0.70 \]
\[ A_{net} = A_1 + A_2 K_1 \]
\[ = 735 + 950 \times 0.70 = 1400 \text{ mm}^2 \]
\[ P_t = A_{net} \times \sigma_{at} = 1400 \times 150 \]
\[ P_t = 210 \text{ kN} \]

07. Ans: (c)
Sol:  
\[ (a) \]
\[ (b) \]
\[ (c) \]
\[ (d) \]

Tracking bolted
\[ A_{net} = A_1 + A_3 k_2 \]
\[ C.G \text{ tracking bolted} \]
\[ e = 0, M= 0 \]
\[ A_{net} = A_t \text{ - Area of rivet hole} \]
\[ A_{net} = A_1 + A_3 k_1 \]

\[ K_1 = \frac{3A_1}{3A_1 + A_2} ; \quad K_2 = \frac{5A_1}{5A_1 + A_2} \]
\[ P_t = A_{net} \times \sigma_{at} \]
\[ w(a) = w(b) = w(c) = w(d) \]
\[ A_{net} > A_{net} (a) > A_{net} (b) = A_{net} (d) \]
\[ P_t (c) > P_t (a) > P_t (b) = P_t (d) \]
08. Ans: (c)
Sol: \( r_{\min} = 200 \text{ mm} \)

Slenderness ratio of trial section \( \leq \lambda_{\text{limit}} \)

\[
\frac{\ell_{\max}}{r_{\min}} \leq 350 \\
\ell_{\max} \leq 350 \times r_{\min} \\
\ell_{\max} \leq 350 \times 6 \\
\ell_{\max} \leq 2100 \text{ mm} \ (or) \leq 7.0 \text{ m} \\
\ell_{\max} = 2.10 \text{ m}
\]

09. Ans: 40
Sol: \( \eta_2 \times R_V = 1.40 \ T_2 \)

\[
= 40\%
\]

11. Ans: (b)
Sol:

\[
\text{Hole dia} = 25 \text{ mm}
\]

Possible failure sections are

- 1–2–6–3–4
- 1–2–6–7

\[ A_n = (B - n d_o) \times t \]

\[ A_n = (300 - 2 \times 25) \times 10 = 2500 \text{ mm}^2 \]

\[ A_n = (B - n d_o) t + \frac{p_1^2 t}{4 g_1} + \frac{p_2^2 t}{4 g_2} \]

\[ = (300 - 2 \times 25) \times 10 + \frac{50^2 \times 10}{4 \times 100} + \frac{50^2 \times 10}{4 \times 100} \]

\[ = 2562.5 \text{ mm}^2 \]

\[ \therefore A_n = 2375 \text{ mm}^2 \]

Hence Critical sectional area \( A_n = 2375 \text{ mm}^2 \)

01. Ans: 50
Sol: \( KL = \text{effective length} \)

\( \frac{KL}{r} = 200 \)

\( \frac{\ell}{d} = ? \)

\( K = 1 \)
Radius of gyration, \( r_{\text{min}} = \sqrt{\frac{I}{A}} \)

\[= \frac{\pi d^4}{64 \times \pi d^3} \]

\[= \frac{d^2}{16} = \frac{d}{4} \]

\[\frac{KL}{r_{\text{min}}} = \frac{1.0 \ell}{d} = 200 \quad (\therefore k = 1)\]

\[\ell = \frac{200}{4} = 50 \]

05. Ans: 30.6

Sol:

Symmetric w.r.t yy axis

\[A = 1903 \text{ mm}^2\]

\[I_{zz} = I_{yy} = 177 \times 10^4 \text{ mm}^4\]

\[I_{yy} = 2(I_{xy} + Az^2)\]

Gusset plates one at joint member only.

\[I_{zz} = 2I_{zz} = 2 \times 177 \times 10^4 \]

\[= 354 \times 10^4 \text{ mm}^4\]

\[I_{\text{min}} = 2 \times I_{zz}\]

\[r_{\text{min}} = \sqrt{\frac{I_{zz}}{A}} = \sqrt{\frac{2 \times 177 \times 10^4}{2 \times 1903}} = \sqrt{\frac{354 \times 10^4}{3806}}\]

\[= 30.49 \text{ mm} \approx 30.5 \text{ mm}\]

07. Ans: 37.5

Sol: Service load = 1000 kN

Factored load = 1.5 \times 1000 = 1500 kN

\[V = 2.5\% \text{ of factored column load} = \frac{2.5}{100} \times 1500 = 37.5 \text{ kN}\]

08. Ans: (d)

Sol: Force in lacing member

\[F = \frac{V}{N \sin \theta} \]

\[= \frac{37.5}{2 \times \sin 45^\circ} = 26.52 \text{ kN}\]

09. Ans: (b)

Sol:
10. Ans: (d)  
Sol:  
\[ \text{Skin buckling} \]

\[ \text{Bearing strength of concrete is } 0.45 f_{ck} \]  
\[ f_{ck} = 20 \text{ Mpa} \]  
\[ = 0.45 \times 20 = 9 \text{ N/mm}^2 \]  

02. Ans: 9  
Sol:  
\[ \text{Bearing strength of concrete is } 0.45 f_{ck} \]  
\[ f_{ck} = 20 \text{ Mpa} \]  
\[ = 0.45 \times 20 = 9 \text{ N/mm}^2 \]  
\[ \text{We know that allowable bearing strength of} \]  
\[ \text{concrete } = \frac{\text{factored load}(P)}{\text{area of base slab}} \]  
\[ \text{Here maximum bearing strength is } 0.45 f_{ck} \]  
\[ \therefore \ 0.45 f_{ck} = \frac{2000 \times 10^3}{650 \times 420} \]  
\[ \therefore \ f_{ck} = 16.28 \]  
\[ \therefore \ \text{Minimum grade of concrete required is M20} \]  

03. Ans: (b)  
Sol:  
\[ \text{Bearing strength of concrete is } 0.45 f_{ck} \]  
\[ f_{ck} = 20 \text{ Mpa} \]  
\[ = 0.45 \times 20 = 9 \text{ N/mm}^2 \]  
\[ \text{We know that allowable bearing strength of} \]  
\[ \text{concrete } = \frac{\text{factored load}(P)}{\text{area of base slab}} \]  
\[ \text{Here maximum bearing strength is } 0.45 f_{ck} \]  
\[ \therefore \ 0.45 f_{ck} = \frac{2000 \times 10^3}{650 \times 420} \]  
\[ \therefore \ f_{ck} = 16.28 \]  
\[ \therefore \ \text{Minimum grade of concrete required is M20} \]  

04. Ans: 26.3  
Sol:  
\[ t_s = \sqrt{\frac{2.5w(a^2 - 0.3b^2)}{f_y}} \]  
\[ L = 250 \text{ mm}, B = 450 \text{ mm}, \]  
\[ P = 300 \text{ mm} \]  
\[ t_f = 11.6 \text{ mm} \]  
\[ b_f = 250 \text{ mm} \]  
\[ D = 300 \text{ mm} \]  
\[ w = 9.0 \text{ N/mm}^2 \]  
\[ w = \frac{P}{L \times B} \]  

05. Ans: (b)  
Sol:  
\[ t_s = \sqrt{\frac{2.5w(a^2 - 0.3b^2)}{f_y}} \]  
\[ L = 250 \text{ mm}, B = 450 \text{ mm}, \]  
\[ P = 300 \text{ mm} \]  
\[ t_f = 11.6 \text{ mm} \]  
\[ b_f = 250 \text{ mm} \]  
\[ D = 300 \text{ mm} \]  
\[ w = 9.0 \text{ N/mm}^2 \]  
\[ w = \frac{P}{L \times B} \]
\[ t = C \sqrt{\frac{2.75w}{f_y}} \]

\[ W = \frac{P}{L \times B} \]

\[ \therefore \text{If area}\uparrow, \text{the W}\downarrow \text{but here area} \Rightarrow \text{same} \]

So \[ \sqrt{\frac{W}{f_y}} \Rightarrow \text{constant for all options} \]

\[ \therefore t \propto c \]

Gusset plate to be provided along full width of base plate cantilever projection is available along length of base plate direction

a) \[ c = \frac{600 - 140}{2} = 230 \text{ mm} \]

b) \[ c = \frac{600 - 400}{2} = 100 \text{ mm} \]

c) \[ c = \frac{500 - 140}{2} = 180 \text{ mm} \]

d) \[ c = \frac{720 - 400}{2} = 160 \text{ mm} \]

**06. Ans: (d)**

Sol:

\[ \frac{6Pe}{fB} \]

\[ \frac{6Pe}{fB^2} \]
Chapter- 8
Beams

08. Ans: 100
Sol: \( Z_c = 500 \text{ cm}^3, Z_p = 650 \text{ cm}^3 \)
Laterally unrestrained beam semi compact section
Design bending compressive stress \( f_{bd} = 200 \) MPa
The flexural (or) bending strength

\[
Bending \ stress = \frac{M}{Z} = \frac{Pe}{BL^2} = \frac{6Pe}{BL^2}
\]

\[
Combined \ stress = \frac{P}{LB} + \frac{6Pe}{BL^2}
\]

\[
Z = \frac{1}{y} = \frac{BL^3}{12} \times \left( \frac{2}{L} \right) = \frac{BL^2}{6}
\]

\[
\Rightarrow \frac{BL^2}{6}
\]

\( \therefore \) Zero at one end compression at other end.

Chapter- 10
Gantry Girders

09. Ans : 669.2
Sol: \( ISMB = 500, \ h = 500 \text{ mm} \)
\( f_y = 250 \text{ N/mm}^2, \ \text{shear stress} = \frac{f_y}{\sqrt{3}} \)
\( f_u = 410 \text{ MPa}, \ \gamma_m = 1.10, \ \gamma_l = 1.25 \)
Design shear strength = \( (V_d) = \text{Design shear stress} \times \text{shear area} \)

\[
= \frac{f_y}{\sqrt{3} \gamma_m} \times (h.t_w)
\]

\[
= \frac{(500 \times 10.2) \times 250}{\sqrt{3} \times 1.1} = 669.20 \text{ kN}
\]