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1 Input Parameters

Module	Tension Members Bolted Design
Axial (kN) *	500.0
Length (mm) *	5000.0
Section Size*	Ref List of Input Section
Bolt Details	
Diameter (mm)*	[12.0, 16.0, 20.0, 24.0, 30.0, 36.0]
Grade *	[3.6, 4.6, 4.8, 5.6, 5.8, 6.8, 8.8, 9.8, 10.9, 12.9]
Type *	Bearing Bolt
Bolt hole type	Standard
Type of edges	a - Sheared or hand flame cut
Are the members exposed to corrosive influences	False
Plate Details	
Plate Thickness (mm)*	[3.0, 4.0, 5.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0, 22.0, 24.0, 25.0, 26.0, 28.0, 30.0, 32.0, 36.0, 40.0, 45.0, 50.0, 56.0, 63.0, 80.0]
Material *	E 250 (Fe 410 W)A
Ultimate strength, fu (MPa)	410
Yield Strength , fy (MPa)	250
Safety Factors - IS 800:2007 Table 5 (Clause 5.4.1)	
Governed by Yielding	$\gamma_{m0} = 1.1$
Governed by Ultimate Stress	$\gamma_{m1} = 1.25$
Connection Bolts - Bearing Type	$\gamma_{mb} = 1.25$

1.1 List of Input Section

Section Size*	['20 x 20 x 3', '20 x 20 x 4', '25 x 25 x 3', '25 x 25 x 4', '25 x 25 x 5', '30 x 30
	x 3', '30 x 30 x 4', '30 x 30 x 5', '35 x 35 x 3', '35 x 35 x 4', '35 x 35 x 5', '
	35 x 35 x 6', '40 x 40 x 3', '40 x 40 x 4', '40 x 40 x 5', '40 x 40 x 6', '45 x 45
	x 3', '45 x 45 x 4', '45 x 45 x 5', '45 x 45 x 6', '50 x 50 x 3', '50 x 50 x 4', '5
	0 x 50 x 5', '50 x 50 x 6', '55 x 55 x 4', '55 x 55 x 5', '55 x 55 x 6', '55 x 55 x
	8', '60 x 60 x 4', '60 x 60 x 5', '60 x 60 x 6', '60 x 60 x 8', '65 x 65 x 4', '65
	x 65 x 5', '65 x 65 x 6', '65 x 65 x 8', '70 x 70 x 5', '70 x 70 x 6', '70 x 70 x
	8', '70 x 70 x 10', '75 x 75 x 5', '75 x 75 x 6', '75 x 75 x 8', '75 x 75 x 10', '8

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	0 x 80 x 6', '80 x 80 x 8', '80 x 80 x 10', '80 x 80 x 12', '90 x 90 x 6', '90 x 90
	x 8', '90 x 90 x 10', '90 x 90 x 12', '100 x 100 x 6', '100 x 100 x 8', '100 x 100
	x 10', '100 x 100 x 12', '110 x 110 x 8', '110 x 110 x 10', '110 x 110 x 12', '110
	x 110 x 16', '130 x 130 x 8', '130 x130 x 10', '130 x130 x 12', '130 x130 x 16', '
	150 x 150 x 10', '150 x 150 x 12', '150 x 150 x 16', '150 x 150 x 20', '200 x 200 x
	12', '200 x 200 x 16', '200 x 200 x 20', '200 x 200 x 25', '50 x 50 x 7', '50 x 50
	x 8', '55 x 55 x 10', '60 x 60 x 10', '65 x 65 x 10', '70 x 70 x 7', '100 x 100 x
	7', '100 x 100 x 15', '120 x 120 x 8', '120 x 120 x 10', '120 x 120 x 12', '120 x 1
	20 x 15', '130 x 130 x 9', '150 x 150 x 15', '150 x 150 x 18', '180 x 180 x 15', '1
	80 x 180 x 18', '180 x 180 x 20', '200 x 200 x 24', '30 x 20 x 3', '30 x 20 x 4', '
	30 x 20 x 5', '40 x 25 x 3', '40 x 25 x 4', '40 x 25 x 5', '40 x 25 x 6', '45 x 30
	x 3', '45 x 30 x 4', '45 x 30 x 5', '45 x 30 x 6', '50 x 30 x 3', '50 x 30 x 4', '5
	0 x 30 x 5', '50 x 30 x 6', '60 x 40 x 5', '60 x 40 x 6', '60 x 40 x 8', '65 x 45 x
	5', '65 x 45 x 6', '65 x 45 x 8', '70 x 45 x 5', '70 x 45 x 6', '70 x 45 x 8', '70
	x 45 x 10', '75 x 50 x 5', '75 x 50 x 6', '75 x 50 x 8', '75 x 50 x 10', '80 x 50
	x 5', '80 x 50 x 6', '80 x 50 x 8', '80 x 50 x 10', '90 x 60 x 6', '90 x 60 x 8', '
	90 x 60 x 10', '90 x 60 x 12', '100 x 65 x 6', '100 x 65 x 8', '100 x 65 x 10', '10
	0 x 75 x 6', '100 x 75 x 8', '100 x 75 x 10', '100 x 75 x 12', '125 x 75 x 6', '125
	x 75 x 8', '125 x 75 x 10', '125 x 95 x 6', '125 x 95 x 8', '125 x 95 x 10', '125
	x 95 x 12', '150 x 115 x 8', '150 x 115 x 10', '150 x 115 x 12', '150 x 115 x 16',
	'200 x 100 x 10', '200 x 100 x 12', '200 x 100 x 16', '200 x 150 x 10', '200 x 150
	x 12', '200 x 150 x 16', '200 x 150 x 20', '40 x 20 x 3', '40 x 20 x 4', '40 x 20 x
	5', '60 x 30 x 5', '60 x 30 x 6', '60 x 40 x 7', '65 x 50 x 5', '65 x 50 x 6', '65
	x 50 x 7', '65 x 50 x 8', '70 x 50 x 5', '70 x 50 x 6', '70 x 50 x 7', '70 x 50 x
	8', '75 x 50 x 7', '80 x 40 x 5', '80 x 40 x 6', '80 x 40 x 7', '80 x 40 x 8', '80
	x 60 x 6', '80 x 60 x 7', '80 x 60 x 8', '90 x 65 x 6', '90 x 65 x 7', '90 x 65 x 8
	', '90 x 65 x 10', '100 x 50 x 6', '100 x 50 x 7', '100 x 50 x 8', '100 x 50 x 10',
	'100 x 65 x 7', '120 x 80 x 8', '120 x 80 x 10', '120 x 80 x 12', '125 x 75 x 12',
	'135 x 65 x 8', '135 x 65 x 10', '135 x 65 x 12', '150 x 75 x 9', '150 x 75 x 15',
	'150 x 90 x 10', '150 x 90 x 12', '150 x 90 x 15', '200 x 100 x 15', '200 x 150 x
	15', '200 x 150 x 18']

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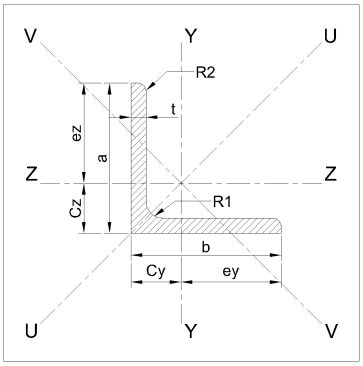
2 Design Checks

2.1 Selected Member Data



Section Size*		('100 x 100 x 12', 'Angles')	
Material *		E 250 (Fe 410 W)A	
Ultimate strength, fu (MPa)		410	
Yield Strength , fy (MPa)		250	
Mass	17.83	Iu(mm4)	3330000.0
Area(mm2) - A	2270.0	Iv(mm4)	872000.0
a(mm)	100.0	rz(mm)	30.4
b(mm)	100.0	ry(mm)	30.4
t(mm)	12.0	ru(mm)	38.3
R1(mm)	8.5	rv(mm)	19.6
R2(mm)	0.0	Zz(mm3)	29800.0
Cy(mm)	29.3	Zy(mm3)	29800.0
Cz(mm)	29.3	Zpz(mm3)	53600.0
Iz(mm4)	2100000.0	Zpy(mm3)	29800.0
Iy(mm4)	2100000.0	r(mm)	19.6

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2.2 Spacing Checks

Check	Required	Provided	Remarks
Min.Diameter (mm)		$d = 16$	
Hole Diameter (mm)		$d_0 = 18$	
Min. Gauge (mm)	$p/g_{min} = 2.5\ d$ $=2.5 * 16.0 \quad = 40.0$	40	Row Limit (rl) = 1
Min. Edge Distance (mm)	$e/e'_{min} = [1.5\ or\ 1.7] * d_0$ $= 1.7 * 18.0 = 30.6$	35	
Spacing Check	$depth = 2 * e + (r_l - 1) * g$ $= 2 * 35 + (1 - 1) * 40$ $= 70$	79.5	Pass

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2.3 Member Checks

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{dg}\ or\ A_c = \frac{1 * A_g\ f_y}{\gamma_{m0}}$ $= \frac{1 * 2270.0 * 250}{1.1}$ $= 515.91$	
Tension Rupture Capacity (kN)		$\beta = 1.4 - 0.076 * \frac{w}{t} * \frac{f_y}{0.9 * f_u} * \frac{b_s}{L_c}$ $\leq \frac{0.9 * f_u * \gamma_{m0}}{f_y * \gamma_{m1}} \geq 0.7$ $= 1.4 - 0.076 * \frac{100.0}{12.0} * \frac{250}{0.9 * 410} * \frac{148.25}{315}$ $\leq \frac{0.9 * 410 * 1.1}{250 * 1.25} \geq 0.7$ $= 1.2$ $T_{dn} = 1 * (\frac{0.9 * A_{nc} * f_u}{\gamma_{m1}} + \frac{\beta * A_{go} * f_y}{\gamma_{m0}})$ $= 1 * (\frac{0.9 * 840.0 * 410}{1.25} + \frac{1.2 * 1200.0 * 250}{1.1})$ $= 575.24$	
Block Shear Capacity (kN)		$T_{db1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{db2} = \frac{0.9 * A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = min(T_{db1}, T_{db2}) = 548.13$	
Tension Capacity (kN)	500.0	$T_d = min(T_{dg}, T_{dn}, T_{db})$ $= min(515.91, 575.24, 548.13)$ $= 515.91$	Pass
Slenderness	$\frac{K * L}{r} \leq 400$	$\frac{K * L}{r} = \frac{1 * 5000.0}{19.6}$ $= 255.1$	Pass
Utilization Ratio	$Utilization\ Ratio \leq 1$	$Utilization\ Ratio = \frac{F}{Td} = \frac{500.0}{515.91}$ $= 0.97$	
Axial Load Considered (kN)	$Ac_{min} = 0.3 * A_c$ $= 0.3 * 515.91$ $= 154.77$ $Ac_{max} = 515.91$	$A = 500.0$	Pass

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2.4 Bolt Checks

Check	Required	Provided	Remarks
Diameter (mm)	Bolt Quantity Optimisation	$d = 16$	
Hole Diameter (mm)		$d_0 = 18$	
Grade	Bolt Grade Optimisation	10.9	
Bolt Ultimate Strength (N/mm2)		$f_{ub} = 1040.0$	
Bolt Yield Strength (N/mm2)		$f_{yb} = 940.0$	
Nominal Stress Area (mm2)		$A_{nb} = 157$ $(Ref\ IS\ 1367 - 3\ (2002))$	
Min. Pitch (mm)	$p/g_{min} = 2.5\ d$ $=2.5 * 16.0 \quad = 40.0$	45	Pass
Max. Pitch (mm)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 *\ 12.0,\ 300\ mm)$ $= 300$ $t = min(24.0, 24.0)$	45	Pass
Min. Gauge (mm)	$p/g_{min} = 2.5\ d$ $=2.5 * 16.0 \quad = 40.0$	0	N/A
Max. Gauge (mm)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 *\ 12.0,\ 300\ mm)$ $= 300$ $t = min(24.0, 24.0)$	0	N/A
Min. End Distance (mm)	$e/e`_{min} = [1.5\ or\ 1.7] * d_0$ $= 1.7 * 18.0 = 30.6$	35	Pass
Max. End Distance (mm)	$e/e`_{max} = 12\ t\ \varepsilon$ $\varepsilon = \sqrt{\frac{250}{f_y}}$ $e/e`_{max} = 12\ * 12.0 * \sqrt{\frac{250}{250}}$ $= 144.0$	35	Pass
Min. Edge Distance (mm)	$e/e`_{min} = [1.5\ or\ 1.7] * d_0$ $= 1.7 * 18.0 = 30.6$	39.75	Pass
Max. Edge Distance (mm)	$e/e`_{max} = 12\ t\ \varepsilon$ $\varepsilon = \sqrt{\frac{250}{f_y}}$ $e/e`_{max} = 12\ * 12.0 * \sqrt{\frac{250}{250}}$ $= 144.0$	39.75	Pass

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Check	Required	Provided	Remarks
Kb		$k_b = min(\frac{e}{3*d_0}, \frac{p}{3*d_0} - 0.25, \frac{f_{ub}}{f_u}, 1.0)$ $= min(\frac{35}{3*18.0}, \frac{45}{3*18.0} - 0.25, \frac{1040.0}{410}, 1.0)$ $= min(0.65, 0.58, 2.54, 1.0)$ $= 0.58$	
Shear Capacity (kN)		$V_{dsb} = \frac{f_{ub}\ n_n\ A_{nb}}{\sqrt{3}\ \gamma_{mb}}$ $= \frac{1040.0 * 1 * 157}{\sqrt{3}\ *\ 1.25}$ $= 75.42$	
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5\ k_b\ d\ t\ f_u}{\gamma_{mb}}$ $= \frac{2.5\ * 0.58 * 16.0 * 12.0 * 410}{1.25}$ $= 91.32$	
Capacity (kN)		$V_{db} = min\ (V_{dsb}, V_{dpb})$ $= min\ (75.42, 91.32)$ $= 75.42$	
No of Bolts	$R_u = \sqrt{V_u^2 + A_u^2}$ $n_{trial} = R_u / V_{bolt}$ $R_u = \frac{\sqrt{0.0^2 + 500.0^2}}{75.42}$ $= 7$	$n = 8$	
No of Columns		$n_c = 8$	
No of Rows		$n_r = 1$	
Bolt Capacity post Long Joint (kN)	$if\ l \geq 15 * d\ then\ V_{rd} = \beta_{ij} * V_{db}$ $if\ l < 15 * d\ then\ V_{rd} = V_{db}$ $where,$ $l = ((nc\ or\ nr) - 1) * (p\ or\ g)$ $\beta_{ij} = 1.075 - l/(200 * d)$ $but\ 0.75 \leq \beta_{ij} \leq 1.0$	$l = ((nc\ or\ nr) - 1) * (p\ or\ g)$ $= (8 - 1) * 45 = 315$ $= (1 - 1) * 0 = 0$ $l = 315$ $15 * d = 15 * 16.0 = 240.0$ $since,\ l \geq 15 * d\ then\ V_{rd} = \beta_{ij} * V_{db}$ $\beta_{ij} = 1.075 - 315/(200 * 16.0) = 0.98$ $V_{rd} = 0.98 * 75.42 = 73.91$	
Capacity (kN)	62.5	73.91	Pass

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2.5 Gusset Plate Checks

Check	Required	Provided	Remarks
Min.Height (mm)		$H = 1 * Depth + clearance$ $= (1 * 100.0) + 30.0$ $= 130$	
Min.Length (mm)	5000.0	$L = (nc - 1) * p + 2 * e$ $= (8 - 1) * 45 + (2 * 35)$ $= 385$	Pass
Thickness (mm)		$t_p = 24.0$	
Tension Yielding Capacity (kN)		$T_{dg} = \frac{l * t * f_y}{\gamma_{mo}}$ $= \frac{1 * 100.0 * 24.0 * 250}{1.1}$ $= 545.45$	
Tension Rupture Capacity (kN)		$T_{dn} = \frac{0.9 * A_n * f_u}{\gamma_{m1}}$ $= \frac{1 * 0.9 * (100.0 - 1 * 18.0) * 24.0 * 410}{1.25}$ $= 580.95$	
Block Shear Capacity (kN)		$T_{db1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{db2} = \frac{0.9 * A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = min(T_{db1}, T_{db2}) = 1096.26$	
Tension Capacity (kN)	$A = 500.0$	$T_d = min(T_{dg}, T_{dn}, T_{db})$ $= min(545.45, 580.95, 1096.26)$ $= 545.45$	Pass

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3 3D View

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