Company Name	IIT Bombay	Project Title	Tension Member
Group/Team Name	Osdag	Subtitle	Bolted to End Gusset
Designer	Engineer#1	Job Number	2.1.5
Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

1 Input Parameters

Module	Tension Member Design - Bolted to End Gusset
Axial (kN)*	500.0
Length (mm) *	3000.0
Section Profile*	Back to Back Channels
Section Size*	Ref List of Input Section
Section Material	E 300 (Fe 440)
Ultimate Strength, F_u (MPa)	410
Yield Strength, F_y (MPa)	250
Bolt Details - Input and Design Preference	
Diameter (mm)	[20, 24]
Property Class	[8.8, 9.8, 10.9]
Type	Bearing Bolt
Hole Type	Over-sized
Detailing - Design Preference	
Edge Preparation Method	Rolled, machine-flame cut, sawn and planed
Are the Members Exposed to Corrosive Influences?	False
Plate Details - Input and Design Preference	
Thickness (mm)	[16, 18, 20]
Material	E 250 (Fe 410 W)A

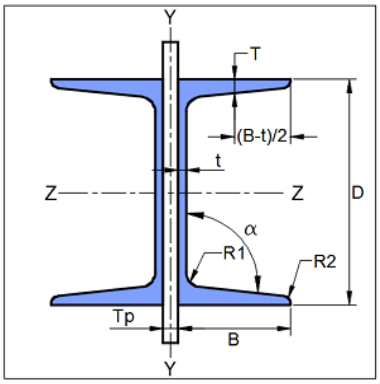
1.1 List of Input Section

Section Size*	'MC 75', 'MC 100', 'MC 125', 'MC 125*', 'MC 150', 'MC 150*', 'MC 175', 'MC 175*', 'MC 200', 'MC 200*', 'MC 225', 'MC 225*', 'MC 250', 'MC 250*', 'MC 250*', 'MC 300', 'MC 300*', 'MC 300*', 'MC 350', 'MC 400', 'JC 100', 'JC 125', 'JC 150', 'JC 175', 'JC 200', 'LC 75', 'LC 100', 'LC 125', 'LC (P) 125', 'LC 150', 'LC (P) 150', 'LC 175', 'LC 200', 'LC (P) 200', 'LC 225', 'LC 250', 'LC 300', 'LC (P) 300', 'LC 350', 'LC 400', 'MPC 75', 'MPC 100', 'MPC 125', 'MPC 125*', 'MPC 150', 'MPC 150*', 'MPC 175', 'MPC 175*', 'MPC 200', 'MPC 200*', 'MPC 225', 'MPC 225*', 'MPC 250', 'MPC 250*', 'MPC 250*', 'MPC 300', 'MPC 300*', 'MPC 300*', 'MPC 350', 'MPC 400'

2 Design Checks

Design Status	Fail

2.1 Selected Member Data



Section Size*		('JC 175', 'Back to Back Channels')	
Material		E 300 (Fe 440)	
Mass, m (kg/m)		22.4	
Area, A (cm^2)		2840.0	
D (mm)	175	I_y(cm^4)	186.18
B (mm)	60	r_z (cm)	7.12
t (mm)	3.6	r_y (cm)	2.56
T (mm)	6.9	Z_z (cm^3)	164.57
T_p (mm)	16.0	Z_y (cm^3)	31.03
Flange Slope	91.5	Z_{pz} (cm^3)	185.96
R_1 (mm)	7.0	Z_{py} (cm^3)	52.26
R_2 (mm)	3.0	Radius of gyration, r (cm)	39.7
I_z (cm^4)	1440.0		

2.2 Spacing Check

Check	Required	Provided	Remarks
Min. Diameter (mm)		$d = 20$	
Hole Diameter (mm)		$d_0 = 24$	
Minimum Bolts (nos)		$r_l = 2$	
Min. Gauge Distance (mm)	$p/g_{\min} = 2.5d$ $= 2.5 \times 20.0$ $= 50.0$ [Ref. IS 800:2007, Cl.10.2.2]	50	Pass

Check	Required	Provided	Remarks
Min. Edge Distance (mm)	$e_{\min} = 1.5d_0$ $= 1.5 \times 24.0$ $= 36.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	40	Pass
Spacing Check	depth $= 2\ e + (rl - 1)\ g$ $= 2 \times 40 + (2 - 1) \times 50$ $= 130$	147.2	Pass

2.3 Member Check

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{\text{dg}} = \frac{A_g f_y}{\gamma_{m0}}$ $= \frac{2840.0 \times 300}{1.1 \times 10^3}$ $= 774.55$ [Ref. IS 800:2007, Cl.6.2]	
Slenderness	$\frac{KL}{r} \leq 400$	$\frac{KL}{r} = \frac{1 \times 3000.0}{39.7}$ $= 75.57$ [Ref. IS 800:2007, Cl.7.1.2]	Pass

2.4 Bolt Design

Check	Required	Provided	Remarks
Diameter (mm)	Bolt Quantity Optimization	$d = 20$	
Hole Diameter (mm)		$d_0 = 24$	
Property Class	Bolt Grade Optimization	10.9	
Bolt Ultimate Strength (N/mm2)		$f_{u_b} = 1040.0$	

Company Name	IIT Bombay	Project Title	Tension Member
Group/Team Name	Osdag	Subtitle	Bolted to End Gusset
Designer	Engineer#1	Job Number	2.1.5
Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

Check	Required	Provided	Remarks
Bolt Yield Strength (N/mm2)		$f_{y_b} = 940.0$	
Nominal Stress Area (mm2)		$A_{n_b} = 245$ ([$Ref.\ IS\ 1367 - 3\ (2002)$])	
Min. Pitch Distance (mm)	$p_{\min} = 2.5d$ $= 2.5 \times 20.0$ $= 50.0$ [Ref. IS 800:2007, Cl.10.2.2]	60	**Pass**
Max. Pitch Distance (mm)	$p/g_{\max} = \min(32t,\ 300)$ $= \min(32 \times 3.6,\ 300)$ $= \min(115.2,\ 300)$ $= 115.2$ Where, $t = \min(16.0, 3.6)$ [Ref. IS 800:2007, Cl.10.2.3]	60	**Pass**
Min. Gauge Distance (mm)	$p_{\min} = 2.5d$ $= 2.5 \times 20.0$ $= 50.0$ [Ref. IS 800:2007, Cl.10.2.2]	60	**Pass**
Max. Gauge Distance (mm)	$p/g_{\max} = \min(32t,\ 300)$ $= \min(32 \times 3.6,\ 300)$ $= \min(115.2,\ 300)$ $= 115.2$ Where, $t = \min(16.0, 3.6)$ [Ref. IS 800:2007, Cl.10.2.3]	60	**Pass**

Check	Required	Provided	Remarks
Min. End Distance (mm)	$e_{min} = 1.5d_0$ $= 1.5 \times 24.0$ $= 36.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	45	**Pass**
Max. End Distance (mm)	$e_{max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 3.6 \times \sqrt{\frac{250}{300}} = 39.44$ $e_2 = 12 \times 16.0 \times \sqrt{\frac{250}{250}} = 192.0$ $e_{max} = \min(e_1,\ e_2) = 39.44$ [Ref. IS 800:2007, Cl.10.2.4.3]	45	**Fail**
Min. Edge Distance (mm)	$e_{min} = 1.5d_0$ $= 1.5 \times 24.0$ $= 36.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	45	**Pass**
Max. Edge Distance (mm)	$e_{max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 3.6 \times \sqrt{\frac{250}{300}} = 39.44$ $e_2 = 12 \times 16.0 \times \sqrt{\frac{250}{250}} = 192.0$ $e_{max} = \min(e_1,\ e_2) = 39.44$ [Ref. IS 800:2007, Cl.10.2.4.3]	45	**Fail**

Company Name	IIT Bombay	Project Title	Tension Member
Group/Team Name	Osdag	Subtitle	Bolted to End Gusset
Designer	Engineer#1	Job Number	2.1.5
Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

Check	Required	Provided	Remarks
Kb		$k_b = \min\left(\frac{e}{3d_0},\ \frac{p}{3d_0} - 0.25,\ \frac{f_{ub}}{f_u},\ 1.0\right)$ $= \min\left(\frac{45}{3 \times 24.0},\ \frac{60}{3 \times 24.0} - 0.25,\ \frac{1040.0}{440},\ 1.0\right)$ $= \min(0.62, 0.58, 2.36, 1.0)$ $= 0.58$ [Ref. IS 800:2007, Cl.10.3.4]	
Shear Capacity (kN)		$V_{\text{dsb}} = \frac{f_{ub} n_n A_{nb}}{\sqrt{3}\gamma_{mb}}$ $= \frac{1040.0 \times 2 \times 245}{1000 \times \sqrt{3} \times 1.25}$ $= 235.37$ [Ref. IS 800:2007, Cl.10.3.3]	
Bearing Capacity (kN)		$V_{\text{dpb}} = \frac{2.5 k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.44 \times 20.0 \times 7.2 \times 440}{1000 \times 1.25}$ $= 39.03$ [Ref. IS 800:2007, Cl.10.3.4]	
Capacity (kN)		$V_{\text{db}} = \min\ (V_{\text{dsb}},\ V_{\text{dpb}})$ $= \min\ (235.37,\ 39.03)$ $= 39.03$ [Ref. IS 800:2007, Cl.10.3.2]	
No. of Bolts	$R_u = \sqrt{V_u^2 + A_u^2}$ $n_{\text{trial}} = R_u / V_{bolt}$ $R_u = \frac{\sqrt{0.0^2 + 500.0^2}}{39.03}$ $= 13$	$n = 0$	
No. of Bolt Columns		$n_c = 2$	

Check	Required	Provided	Remarks
No. of Bolt Rows		$n_r = 2$	
Long Joint Reduction Factor	if $l_j \geq 15d$ then $V_{\text{rd}} = \beta_{lj} V_{\text{db}}$ if $l_j < 15d$ then $V_{\text{rd}} = V_{\text{db}}$ where, $l_j = ((nc \text{ or } nr) - 1) \times (p \text{ or } g)$ $\beta_{lj} = 1.075 - l/(200d)$ but $0.75 \leq \beta_{lj} \leq 1.0$ [Ref. IS 800:2007, Cl.10.3.3.1]	$l_j = ((n_c \text{ or } n_r) - 1) \times (p \text{ or } g)$ $= (2 - 1) \times 60 = 60$ $= (2 - 1) \times 60 = 60$ $l = 60$ $15 \times d = 15 \times 20.0 = 300.0$ since, $l_j < 15 \times d$ then $\beta_{lj} = 1.0$ [Ref. IS 800:2007, Cl.10.3.3.1]	
Large Grip Length Reduction Factor	if $l_g \geq 5d$, then $V_{\text{rd}} = \beta_{lg} V_{\text{db}}$ if $l_g < 5d$ then $V_{\text{rd}} = V_{\text{db}}$ $l_g \leq 8d$ where, $l_g = \Sigma(t_{\text{ep}} + t_{\text{member}})$ $\beta_{lg} = 8d/(3d + l_g)$ but $\beta_{lg} \leq \beta_{lj}$ [Ref. IS 800:2007, Cl.10.3.3.2]	$l_g = \Sigma\ (t_p + t_{\text{member}})$ $= 23.2$ $5d = 100.0$ $8d = 160.0$ since, $l_g < 5d$; $\beta_{lg} = 1.0$ [Ref. IS 800:2007, Cl.10.3.3.2]	
Capacity (kN)	0.0	$V_{\text{rd}} = \beta_{lj} \beta_{lg} V_{\text{db}}$ $= 1.0 \times 1.0 \times 39.03$ $= 0.0$	

3 Design Log

2021-02-04 15:36:00 - Osdag - WARNING - Minimum end/edge distance is greater than max end/edge distance.

2021-02-04 15:36:00 - Osdag - ERROR - : Design is unsafe.

2021-02-04 15:36:00 - Osdag - INFO - :==========End Of design==========