Company Name	IIT Bombay	Project Title	Sample Member Design
Group/Team Name	Osdag	Subtitle	Tension Member Bolted
Designer	Engineer #1	Job Number	2.1.5
Date	18 /12 /2020	Client	V Kalyanaraman, Retd. Professor, IIT Madras

1 Input Parameters

Module	Tension Member Bolted
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)
Section Ultimate Strength, f_u (MPa)	440
Section Yield Strength, f_y (MPa)	300
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
Ultimate Strength, Fu (MPa)	410
Yield Strength, Fy (MPa)	250

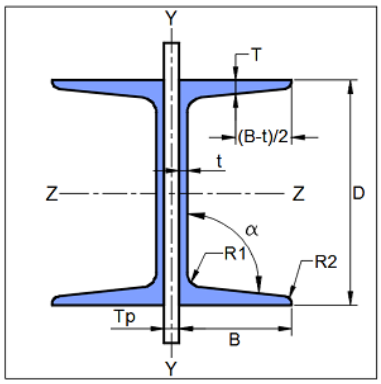
1.1 List of Input Section

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)	$p/g_{min} = 2.5\ d$ $= 2.5 \times 20.0$ $= 50.0$ [$Ref\ IS\ 800:2007,\ Cl.\ 10.2.2$]	50	**Pass**

Check	Required	Provided	Remarks
Min. Edge Distance (mm)	$e_{min} = 1.5\ d_0$ $= 1.5 \times 24.0$ $= 36.0$ [*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)		$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $= \frac{2840.0 \times 300}{1.1 \times 10^3}$ $= 774.55$ [*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)		$f_{ub} = 1040.0$	

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

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

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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)		$V_{dsb} = \frac{f_{ub}\ n_n\ A_{nb}}{\sqrt{3}\ \gamma_{mb}}$ $= \frac{1040.0 \times 2 \times 245}{1000 \times \sqrt{3}\ \times\ 1.25}$ $= 235.37$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3]$	
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5\ k_b\ d\ t\ f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.44 \times 20.0 \times 7.2 \times 440}{1000 \times 1.25}$ $= 39.03$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.4]$	
Capacity (kN)		$V_{db} = min\ (V_{dsb}, V_{dpb})$ $= min\ (235.37, 39.03)$ $= 39.03$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.2]$	
No. of Bolts	$R_u = \sqrt{V_u^2 + A_u^2}$ $n_{trial} = R_u / V_{bolt}$ $R_u = \frac{\sqrt{0.0^2 + 500.0^2}}{39.03}$ $= 13$	$n = 0$	
No. of Bolt Columns		$n_c = 2$	

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

3 Design Log

2020-12-18 02:01:30 - Osdag - WARNING - Minimum end/edge distance is greater than max end/edge distance.
2020-12-18 02:01:30 - Osdag - ERROR - : Design is unsafe.
2020-12-18 02:01:30 - Osdag - INFO - :==========End Of design==========