		Created with Osdag®	
Company Name	IIT Bombay	Project Title	Sample Member Design
Group/Team Name	Osdag	Subtitle	Tension Member Bolted
Designer	Engineer #1	Job Number	2.1.4
Date	18 /12 /2020	Client	Harshavardhan Subbarao, Construma Consultancy, Mumbai

1 Input Parameters

Module	Tension Member Bolted
Axial (kN)*	240.0
Length (mm) *	3200.0
Section Profile*	Channels
Section Size*	Ref List of Input Section
Section Material	E 250 (Fe 410 W)A
Section Ultimate Strength, f_u (MPa)	410
Section Yield Strength, f_y (MPa)	250
Bolt Details - Input and Design Preference	
Diameter (mm)	[20]
Property Class	[8.8]
Type	Friction Grip Bolt
Hole Type	Standard
Slip Factor, (mu_f)	0.3
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)	[14]
Material	E 250 (Fe 410 W)A
Ultimate Strength, Fu (MPa)	410
Yield Strength, Fy (MPa)	250

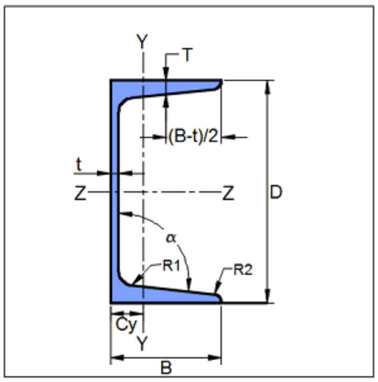
1.1 List of Input Section

Section Size*	'MC 250'

2 Design Checks

Design Status	Pass

2.1 Selected Member Data



Section Size*		('MC 250', 'Channels')	
Material		E 250 (Fe 410 W)A	
Mass, m (kg/m)		30.6	
Area, A (cm^2)		3890.0	
D (mm)	250	I_y(cm^4)	218.0
B (mm)	80	r_z (cm)	9.92
t (mm)	7.2	r_y (cm)	2.37
T (mm)	14.1	Z_z (cm^3)	306.0
Flange Slope	96	Z_y (cm^3)	38.2
R_1 (mm)	12.0	Z_{pz} (cm^3)	358.0
R_2 (mm)	3.2	Z_{py} (cm^3)	38.2
C_y (mm)	23.0	Radius of gyration, r (cm)	23.7
I_z (cm^4)	3820.0		

2.2 Spacing Check

Check	Required	Provided	Remarks
Min. Diameter (mm)		$d = 20$	
Hole Diameter (mm)		$d_0 = 22$	
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)	$e_{min} = 1.5\ d_0$ $= 1.5 \times 22.0$ $= 33.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2]$	35	**Pass**
Spacing Check	$depth = 2\ e + (rl - 1)\ g$ $= 2 \times 35 + (2 - 1) \times 50$ $= 120$	197.8	**Pass**

2.3 Member Check

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $= \frac{3890.0 \times 250}{1.1 \times 10^3}$ $= 884.09$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.2]$	

Check	Required	Provided	Remarks
Tension Rupture Capacity (kN)		$\beta = 1.4 - 0.076 \times \frac{w}{t} \times \frac{f_y}{0.9 f_u} \times \frac{b_s}{L_c} \leq \frac{0.9\ f_u\ \gamma_{m0}}{f_y\ \gamma_{m1}} \geq 0.7$ $= 1.4 - 0.076 \times \frac{80}{7.2} \times \frac{250}{0.9 \times 410} \times \frac{147.8}{100} \leq \frac{0.9 \times 410 \times 1.1}{250 \times 1.25} \geq 0.7$ $= 0.7$ $T_{dn} = 1 \times (\frac{0.9 A_{nc} f_u}{\gamma_{m1}} + \frac{\beta A_{go} f_y}{\gamma_{m0}})$ $= 1 \times (\frac{0.9 \times 1121.76 \times 410}{1.25} + \frac{0.7 \times 2256.0 \times 250}{1.1})$ $= 690.05$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.3.3]$	
Block Shear Capacity (kN)		$T_{dbl1} = \frac{A_{vg} f_y}{\sqrt{3} \gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{dbl2} = \frac{0.9 A_{vn} f_u}{\sqrt{3} \gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = min(T_{db1}, T_{db2}) = 359.98$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.4]$	
Tension Capacity (kN)	240.0	$T_d = min(T_{dg}, T_{dn}, T_{db})$ $= min(884.09, 690.05, 359.98)$ $= 359.98$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.1]$	Pass
Slenderness	$\frac{KL}{r} \leq 400$	$\frac{KL}{r} = \frac{1 \times 3200.0}{23.7}$ $= 135.02$ $[Ref.\ IS\ 800:2007,\ Cl.\ 7.1.2]$	Pass

Check	Required	Provided	Remarks
Utilization Ratio	≤ 1	$Utilization\ Ratio = \frac{F}{T_d} = \frac{240.0}{359.98} = 0.67$	
Axial Load Considered (kN)	$Ac_{min} = 0.3A_c = 0.3 \times 884.09 = 265.23$ $Ac_{max} = 884.09$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.7]$	$A_u = 265.23$	**Pass**

2.4 Bolt Design

Check	Required	Provided	Remarks
Diameter (mm)	Bolt Quantity Optimization	$d = 20$	
Hole Diameter (mm)		$d_0 = 22$	
Property Class	Bolt Grade Optimization	8.8	
Bolt Ultimate Strength (N/mm2)		$f_{ub} = 830.0$	
Bolt Yield Strength (N/mm2)		$f_{yb} = 660.0$	
Nominal Stress Area (mm2)		$A_{nb} = 245\ ([Ref\ IS\ 1367-3\ (2002)])$	
Min. Pitch Distance (mm)	$p_{min} = 2.5\ d = 2.5 \times 20.0 = 50.0$ $[Ref\ IS\ 800:2007,\ Cl.\ 10.2.2]$	50	**Pass**

Check	Required	Provided	Remarks
Max. Pitch Distance (mm)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 7.2,\ 300\ mm)$ $= \min(230.4,\ 300\ mm)$ $= 230.4$ $Where,\ t = min(14.0, 7.2)$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.3]$	50	**Pass**
Min. Gauge Distance (mm)	$p_{min} = 2.5\ d$ $= 2.5 \times 20.0$ $= 50.0$ $[Ref\ IS\ 800:2007,\ Cl.\ 10.2.2]$	50	**Pass**
Max. Gauge Distance (mm)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 7.2,\ 300\ mm)$ $= \min(230.4,\ 300\ mm)$ $= 230.4$ $Where,\ t = min(14.0, 7.2)$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.3]$	50	**Pass**
Min. End Distance (mm)	$e_{min} = 1.5\ d_0$ $= 1.5 \times 22.0$ $= 33.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2]$	35	**Pass**

Check	Required	Provided	Remarks
Max. End Distance (mm)	$e_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 7.2 \times \sqrt{\frac{250}{250}} = 86.4$ $e_2 = 12 \times 14.0 \times \sqrt{\frac{250}{250}} = 168.0$ $e_{max} = min(e_1, e_2) = 86.4$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3]$	35	**Pass**
Min. Edge Distance (mm)	$e_{min} = 1.5\ d_0$ $= 1.5 \times 22.0$ $= 33.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2]$	48.9	**Pass**
Max. Edge Distance (mm)	$e_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 7.2 \times \sqrt{\frac{250}{250}} = 86.4$ $e_2 = 12 \times 14.0 \times \sqrt{\frac{250}{250}} = 168.0$ $e_{max} = min(e_1, e_2) = 86.4$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3]$	48.9	**Pass**
Slip Resistance (kN)		$V_{dsf} = \frac{\mu_f\ n_e\ K_h\ F_o}{\gamma_{mf}}$ $Where\ , F_o = 0.7 f_{ub} A_{nb}$ $V_{dsf} = \frac{0.3 \times 1 \times 1.0 \times 0.7 \times 830.0 \times 245}{1.25 \times 10^3}$ $= 34.16$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.4.3]$	

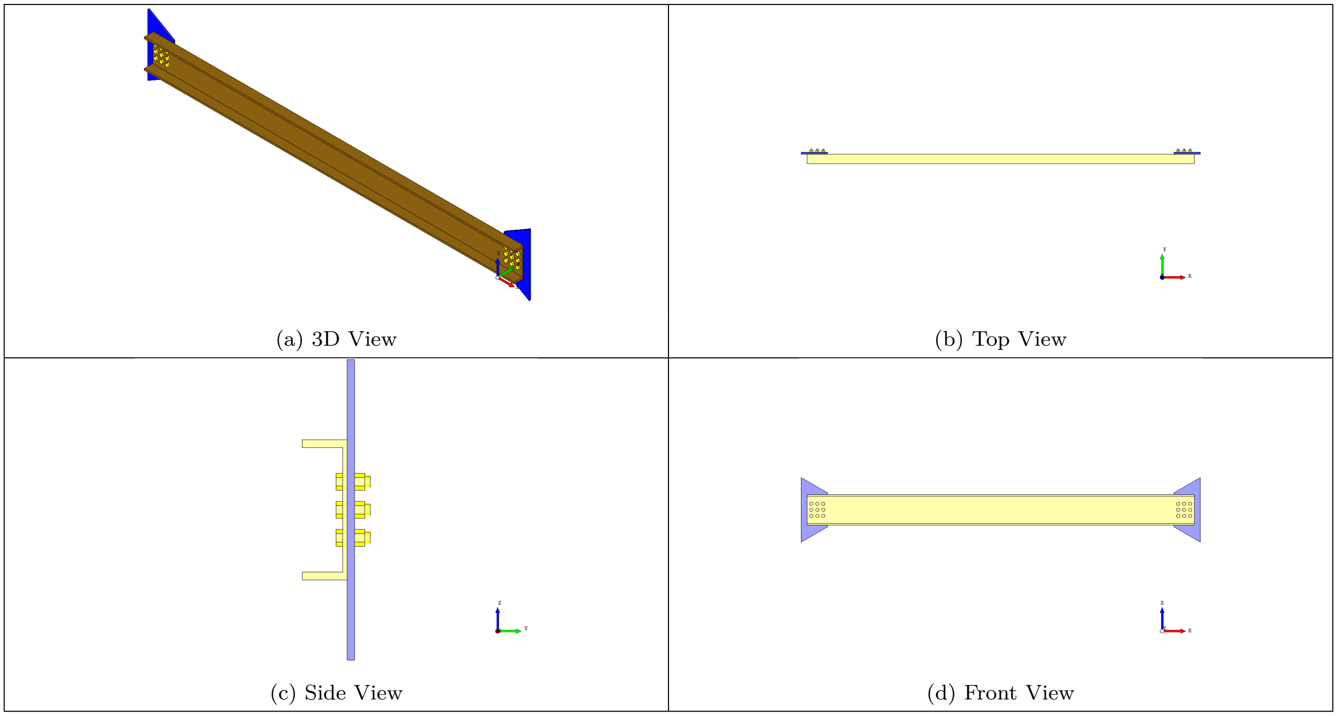
Check	Required	Provided	Remarks
No. of Bolts	$R_u = \sqrt{V_u^2 + A_u^2}$ $n_{trial} = R_u/V_{bolt}$ $R_u = \frac{\sqrt{0.0^2 + 265.23^2}}{34.16}$ $= 8$	$n = 9$	
No. of Bolt Columns		$n_c = 3$	
No. of Bolt Rows		$n_r = 3$	
Long Joint Reduction Factor	$if\ l_j \geq 15d\ then\ V_{rd} = \beta_{lj} V_{db}$ $if\ l_j < 15d\ then\ V_{rd} = V_{db}$ $where,$ $l_j = ((nc\ or\ nr) - 1) \times (p\ or\ g)$ $\beta_{lj} = 1.075 - l/(200d)$ $but\ 0.75 \leq \beta_{lj} \leq 1.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3.1]$	$l_j = ((n_c\ or\ n_r) - 1) \times (p\ or\ g)$ $= (3 - 1) \times 50 = 100$ $= (3 - 1) \times 50 = 100$ $l = 100$ $15 \times d = 15 \times 20.0 = 300.0$ $since,\ l_j < 15 \times d\ then\ \beta_{lj} = 1.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3.1]$	
Capacity (kN)	29.47	$V_{rd} = \beta_{lj} V_{db}$ $= 1.0 \times 34.16$ $= 34.16$	Pass

2.5 Gusset Plate Check

Check	Required	Provided	Remarks
Min.Height (mm)		$H = 1 \times Depth + clearance$ $= (1 \times 250) + 30.0$ $= 280$	
Min.Plate Length (mm)		$L = (nc - 1)p + 2e$ $= (3 - 1) \times 50 + (2 \times 35)$ $= 170$	

Check	Required	Provided	Remarks
Min.Member Length (mm)	340	3200.0	Pass
Thickness (mm)		$T_p = 14.0$	
Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $A_g = l \times t = 250 \times 14.0$ $= \frac{3500.0 \times 250}{1.1 \times 10^3}$ $= 795.45$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.2]$	
Tension Rupture Capacity (kN)		$T_{dn} = \frac{0.9 A_n f_u}{\gamma_{m1}}$ $= \frac{1 \times\ 0.9 \times (250 - 3 \times 22.0) \times 14.0 \times 410}{1.25}$ $= 760.44$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.3.1]$	
Block Shear Capacity (kN)		$T_{dbl1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{dbl2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = min(T_{db1}, T_{db2}) = 743.93$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.4]$	
Tension Capacity (kN)	$A = 265.23$	$T_d = min(T_{dg}, T_{dn}, T_{db})$ $= min(795.45, 760.44, 743.93)$ $= 743.93$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.1]$	Pass

3 3D Views



(a) 3D View

(b) Top View

(c) Side View

(d) Front View

4 Design Log

2020-12-18 01:57:51 - Osdag - INFO - :In the case of reverse loading, the slenderness value shall be less than 180 [Ref. Table 3, IS 800:2007].

2020-12-18 01:57:51 - Osdag - INFO - :To reduce the quantity of bolts, define a list of diameter, plate thickness and/or member size higher than the one currently defined.

2020-12-18 01:57:51 - Osdag - INFO - :The minimum design force based on the member size is used for performing the connection design, i.e. 265.23 kN [Ref. Cl. 10.7, IS 800:2007].

2020-12-18 01:57:51 - Osdag - INFO - :Overall bolted tension member design is safe.