



Company Name	IIT Bombay	Project Title	Sample Member Design
Group/Team Name	Osdag	Subtitle	Tension Member Bolted
Designer	Engineer #1	Job Number	2.1.1
Date	18 /12 /2020	Client	Somnath Mukherjee, MN Dastur, Kolkata

1 Input Parameters

Module	Tension Member Bolted
Axial (kN)*	235.0
Length (mm) *	2560.0
Section Profile*	Angles
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)	[16, 20]
Property Class	[4.6, 4.8]
Type	Bearing Bolt
Hole Type	Standard
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)	[10, 12, 14, 16]
Material	E 250 (Fe 410 W)A
Ultimate Strength, F_u (MPa)	410
Yield Strength, F_y (MPa)	250



Company Name	IIT Bombay	Project Title	Sample Member Design
Group/Team Name	Osdag	Subtitle	Tension Member Bolted
Designer	Engineer #1	Job Number	2.1.1
Date	18 /12 /2020	Client	Somnath Mukherjee, MN Dastur, Kolkata

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', '50 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', '80 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 x 130 x 10', '130 x 130 x 12', '130 x 130 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 120 x 15', '130 x 130 x 9', '150 x 150 x 15', '150 x 150 x 18', '180 x 180 x 15', '180 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', '50 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', '100 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'
---------------	--



Company Name	IIT Bombay	Project Title	Sample Member Design
Group/Team Name	Osdag	Subtitle	Tension Member Bolted
Designer	Engineer #1	Job Number	2.1.1
Date	18 /12 /2020	Client	Somnath Mukherjee, MN Dastur, Kolkata

2 Design Checks

Design Status	Pass
---------------	------

2.1 Selected Member Data

	Section Size*		('90 x 65 x 7', 'Angles')	
	Material		E 250 (Fe 410 W)A	
	Mass, m (kg/m)		8.24	
	Area, A (cm ²)		1050.0	
	A (mm)	90.0	I_v (cm ⁴)	20.9
	B (mm)	65.0	r_z (cm)	2.86
	t (mm)	7.0	r_y (cm)	1.9
	R_1 (mm)	8.0	r_u (cm)	3.13
	R_2 (mm)	0.0	r_v (cm)	1.41
	C_y (mm)	16.1	Z_z (cm ³)	13.9
	C_z (mm)	28.5	Z_y (cm ³)	7.7
	I_z (cm ⁴)	85.7	Z_{pz} (cm ³)	25.2
	I_y (cm ⁴)	37.8	Z_{py} (cm ³)	13.9
	I_u (cm ⁴)	102.0	Radius of gyration, r (cm)	14.1

2.2 Spacing Check

Check	Required	Provided	Remarks
Min. Diameter (mm)		$d = 20$	
Hole Diameter (mm)		$d_0 = 22$	
Minimum Bolts (nos)		$r_l = 1$	
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



Company Name	IIT Bombay	Project Title	Sample Member Design
Group/Team Name	Osdag	Subtitle	Tension Member Bolted
Designer	Engineer #1	Job Number	2.1.1
Date	18 /12 /2020	Client	Somnath Mukherjee, MN Dastur, Kolkata

Check	Required	Provided	Remarks
Min. Edge Dis- tance (mm)	$e_{min} = 1.5 d_0$ $= 1.5 \times 22.0$ $= 33.0$ <i>[Ref. IS 800 : 2007, Cl. 10.2.4.2]</i>	35	Pass
Spacing Check	$depth = 2 e + (r_l - 1) g$ $= 2 \times 35 + (1 - 1) \times 50$ $= 70$	75.0	Pass

2.3 Member Check

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $= \frac{1050.0 \times 250}{1.1 \times 10^3}$ $= 238.64$ <i>[Ref. IS 800 : 2007, Cl. 6.2]</i>	



Company Name	IIT Bombay	Project Title	Sample Member Design
Group/Team Name	Osdag	Subtitle	Tension Member Bolted
Designer	Engineer #1	Job Number	2.1.1
Date	18 /12 /2020	Client	Somnath Mukherjee, MN Dastur, Kolkata

Check	Required	Provided	Remarks
Tension Rupture Capacity (kN)		$\beta = 1.4 - 0.076 \times \frac{w}{t} \times \frac{f_y}{0.9f_u} \times \frac{b_s}{L_c}$ $\leq \frac{0.9 f_u \gamma_{m0}}{f_y \gamma_{m1}} \geq 0.7$ $= 1.4 - 0.076 \times \frac{65.0}{7.0} \times \frac{250}{0.9 \times 410} \times \frac{110.5}{250}$ $\leq \frac{0.9 \times 410 \times 1.1}{250 \times 1.25} \geq 0.7$ $= 1.19$ $T_{dn} = 1 \times \left(\frac{0.9 A_{nc} f_u}{\gamma_{m1}} + \frac{\beta A_{go} f_y}{\gamma_{m0}} \right)$ $= 1 \times \left(\frac{0.9 \times 427.0 \times 410}{1.25} + \frac{1.19 \times 455.0 \times 250}{1.1} \right)$ $= 249.11$ <p>[Ref. IS 800 : 2007, Cl. 6.3.3]</p>	
Block Shear Capacity (kN)		$T_{db1} = \frac{A_{vg} f_y}{\sqrt{3} \gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{db2} = \frac{0.9 A_{vn} f_u}{\sqrt{3} \gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = \min(T_{db1}, T_{db2}) = 255.32$ <p>[Ref. IS 800 : 2007, Cl. 6.4]</p>	
Tension Capacity (kN)	235.0	$T_d = \min(T_{dg}, T_{dn}, T_{db})$ $= \min(238.64, 249.11, 255.32)$ $= 238.64$ <p>[Ref. IS 800 : 2007, Cl. 6.1]</p>	Pass
Slenderness	$\frac{KL}{r} \leq 400$	$\frac{KL}{r} = \frac{1 \times 2560.0}{14.1}$ $= 181.56$ <p>[Ref. IS 800 : 2007, Cl. 7.1.2]</p>	Pass



Company Name	IIT Bombay	Project Title	Sample Member Design
Group/Team Name	Osdag	Subtitle	Tension Member Bolted
Designer	Engineer #1	Job Number	2.1.1
Date	18 /12 /2020	Client	Somnath Mukherjee, MN Dastur, Kolkata

Check	Required	Provided	Remarks
Utilization Ratio	≤ 1	$Utilization\ Ratio = \frac{F}{T_d} = \frac{235.0}{238.64} = 0.98$	
Axial Load Considered (kN)	$A_{c_{min}} = 0.3A_c$ $= 0.3 \times 238.64$ $= 71.59$ $A_{c_{max}} = 238.64$ [Ref. IS 800 : 2007, Cl. 10.7]	$A_u = 235.0$	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	4.8	
Bolt Ultimate Strength (N/mm ²)		$f_{ub} = 420.0$	
Bolt Yield Strength (N/mm ²)		$f_{yb} = 340.0$	
Nominal Stress Area (mm ²)		$A_{nb} = 245$ ([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



Company Name	IIT Bombay	Project Title	Sample Member Design
Group/Team Name	Osdag	Subtitle	Tension Member Bolted
Designer	Engineer #1	Job Number	2.1.1
Date	18 /12 /2020	Client	Somnath Mukherjee, MN Dastur, Kolkata

Check	Required	Provided	Remarks
Max. Pitch Distance (mm)	$p/g_{max} = \min(32 t, 300 \text{ mm})$ $= \min(32 \times 7.0, 300 \text{ mm})$ $= \min(224.0, 300 \text{ mm})$ $= 224.0$ <i>Where, $t = \min(12.0, 7.0)$</i> <i>[Ref. IS 800 : 2007, Cl. 10.2.3]</i>	50	Pass
Min. Gauge Distance (mm)	$p_{min} = 2.5 d$ $= 2.5 \times 20.0$ $= 50.0$ <i>[Ref IS 800 : 2007, Cl. 10.2.2]</i>	0	
Max. Gauge Distance (mm)	$p/g_{max} = \min(32 t, 300 \text{ mm})$ $= \min(32 \times 7.0, 300 \text{ mm})$ $= \min(224.0, 300 \text{ mm})$ $= 224.0$ <i>Where, $t = \min(12.0, 7.0)$</i> <i>[Ref. IS 800 : 2007, Cl. 10.2.3]</i>	0	
Min. End Distance (mm)	$e_{min} = 1.5 d_0$ $= 1.5 \times 22.0$ $= 33.0$ <i>[Ref. IS 800 : 2007, Cl. 10.2.4.2]</i>	35	Pass



Company Name	IIT Bombay	Project Title	Sample Member Design
Group/Team Name	Osdag	Subtitle	Tension Member Bolted
Designer	Engineer #1	Job Number	2.1.1
Date	18 /12 /2020	Client	Somnath Mukherjee, MN Dastur, Kolkata

Check	Required	Provided	Remarks
Max. End Dis- tance (mm)	$e_{max} = 12 t \varepsilon; \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 7.0 \times \sqrt{\frac{250}{250}} = 84.0$ $e_2 = 12 \times 12.0 \times \sqrt{\frac{250}{250}} = 144.0$ $e_{max} = \min(e_1, e_2) = 84.0$ <p>[Ref. IS 800 : 2007, Cl. 10.2.4.3]</p>	35	Pass
Min. Edge Dis- tance (mm)	$e_{min} = 1.5 d_0$ $= 1.5 \times 22.0$ $= 33.0$ <p>[Ref. IS 800 : 2007, Cl. 10.2.4.2]</p>	37.5	Pass
Max. Edge Dis- tance (mm)	$e_{max} = 12 t \varepsilon; \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 7.0 \times \sqrt{\frac{250}{250}} = 84.0$ $e_2 = 12 \times 12.0 \times \sqrt{\frac{250}{250}} = 144.0$ $e_{max} = \min(e_1, e_2) = 84.0$ <p>[Ref. IS 800 : 2007, Cl. 10.2.4.3]</p>	37.5	Pass
Kb		$k_b = \min\left(\frac{e}{3d_0}, \frac{p}{3d_0} - 0.25, \frac{f_{ub}}{f_u}, 1.0\right)$ $= \min\left(\frac{35}{3 \times 22.0}, \frac{50}{3 \times 22.0} - 0.25, \frac{420.0}{410}, 1.0\right)$ $= \min(0.53, 0.51, 1.02, 1.0)$ $= 0.51$ <p>[Ref. IS 800 : 2007, Cl. 10.3.4]</p>	



Company Name	IIT Bombay	Project Title	Sample Member Design
Group/Team Name	Osdag	Subtitle	Tension Member Bolted
Designer	Engineer #1	Job Number	2.1.1
Date	18 /12 /2020	Client	Somnath Mukherjee, MN Dastur, Kolkata

Check	Required	Provided	Remarks
Shear Capacity (kN)		$V_{dsb} = \frac{f_{ub} n_n A_{nb}}{\sqrt{3} \gamma_{mb}}$ $= \frac{420.0 \times 1 \times 245}{1000 \times \sqrt{3} \times 1.25}$ $= 47.53$ <p>[Ref. IS 800 : 2007, Cl. 10.3.3]</p>	
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5 k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.51 \times 20.0 \times 7.0 \times 410}{1000 \times 1.25}$ $= 58.55$ <p>[Ref. IS 800 : 2007, Cl. 10.3.4]</p>	
Capacity (kN)		$V_{db} = \min (V_{dsb}, V_{dpb})$ $= \min (47.53, 58.55)$ $= 47.53$ <p>[Ref. IS 800 : 2007, Cl. 10.3.2]</p>	
No. of Bolts	$R_u = \sqrt{V_u^2 + A_u^2}$ $n_{trial} = R_u / V_{bolt}$ $R_u = \frac{\sqrt{0.0^2 + 235.0^2}}{47.53}$ $= 5$	$n = 6$	
No. of Bolt Columns		$n_c = 6$	
No. of Bolt Rows		$n_r = 1$	



Company Name	IIT Bombay	Project Title	Sample Member Design
Group/Team Name	Osdag	Subtitle	Tension Member Bolted
Designer	Engineer #1	Job Number	2.1.1
Date	18 /12 /2020	Client	Somnath Mukherjee, MN Dastur, Kolkata

Check	Required	Provided	Remarks
Long Joint Reduction Factor	<p><i>if $l_j \geq 15d$ then $V_{rd} = \beta_{lj} V_{db}$</i></p> <p><i>if $l_j < 15d$ then $V_{rd} = V_{db}$</i></p> <p><i>where,</i></p> <p>$\beta_{lj} = ((n_c \text{ or } n_r) - 1) \times (p \text{ or } g)$</p> <p>$\beta_{lj} = 1.075 - l/(200d)$</p> <p><i>but $0.75 \leq \beta_{lj} \leq 1.0$</i></p> <p>[Ref. IS 800 : 2007, Cl. 10.3.3.1]</p>	<p>$l_j = ((n_c \text{ or } n_r) - 1) \times (p \text{ or } g)$</p> <p>$= (6 - 1) \times 50 = 250$</p> <p>$= (1 - 1) \times 0 = 0$</p> <p>$l = 250$</p> <p>$15 \times d = 15 \times 20.0 = 300.0$</p> <p><i>since, $l_j < 15 \times d$ then $\beta_{lj} = 1.0$</i></p> <p>[Ref. IS 800 : 2007, Cl. 10.3.3.1]</p>	
Large Grip Length Reduction Factor	<p><i>if $l_g \geq 5d$ then $V_{rd} = \beta_{lg} V_{db}$</i></p> <p><i>if $l_g < 5d$ then $V_{rd} = V_{db}$</i></p> <p>$l_g \leq 8d$</p> <p><i>where,</i></p> <p>$l_g = \Sigma(t_{ep} + t_{member})$</p> <p>$\beta_{lg} = 8d/(3d + l_g)$</p> <p><i>but $\beta_{lg} \leq \beta_{lj}$</i></p> <p>[Ref. IS 800 : 2007, Cl. 10.3.3.2]</p>	<p>$l_g = \Sigma(t_p + t_{member})$</p> <p>$= 19.0$</p> <p>$5d = 100.0$</p> <p>$8d = 160.0$</p> <p><i>since, $l_g < 5d$; $\beta_{lg} = 1.0$</i></p> <p>[Ref. IS 800 : 2007, Cl. 10.3.3.2]</p>	
Capacity (kN)	39.17	<p>$V_{rd} = \beta_{lj} \beta_{lg} V_{db}$</p> <p>$= 1.0 \times 1.0 \times 47.53$</p> <p>$= 47.53$</p>	Pass



Company Name	IIT Bombay	Project Title	Sample Member Design
Group/Team Name	Osdag	Subtitle	Tension Member Bolted
Designer	Engineer #1	Job Number	2.1.1
Date	18 /12 /2020	Client	Somnath Mukherjee, MN Dastur, Kolkata

2.5 Gusset Plate Check

Check	Required	Provided	Remarks
Min.Height (mm)		$H = 1 \times \text{Depth} + \text{clearance}$ $= (1 \times 90.0) + 30.0$ $= 120$	
Min.Plate Length (mm)		$L = (nc - 1)p + 2e$ $= (6 - 1) \times 50 + (2 \times 35)$ $= 320$	
Min.Member Length (mm)	640	2560.0	Pass
Thickness (mm)		$T = 12.0$	
Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $A_g = l \times t = 90.0 \times 12.0$ $= \frac{1080.0 \times 250}{1.1 \times 10^3}$ $= 245.45$ [Ref. IS 800 : 2007, Cl. 6.2]	
Tension Rupture Capacity (kN)		$T_{dn} = \frac{0.9 A_n f_u}{\gamma_{m1}}$ $= \frac{1 \times 0.9 \times (90.0 - 1 \times 22.0) \times 12.0 \times 410}{1.25}$ $= 240.88$ [Ref. IS 800 : 2007, Cl. 6.3.1]	
Block Shear Capacity (kN)		$T_{db1} = \frac{A_{vg} f_y}{\sqrt{3} \gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{db2} = \frac{0.9 A_{vn} f_u}{\sqrt{3} \gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = \min(T_{db1}, T_{db2}) = 437.69$ [Ref. IS 800 : 2007, Cl. 6.4]	



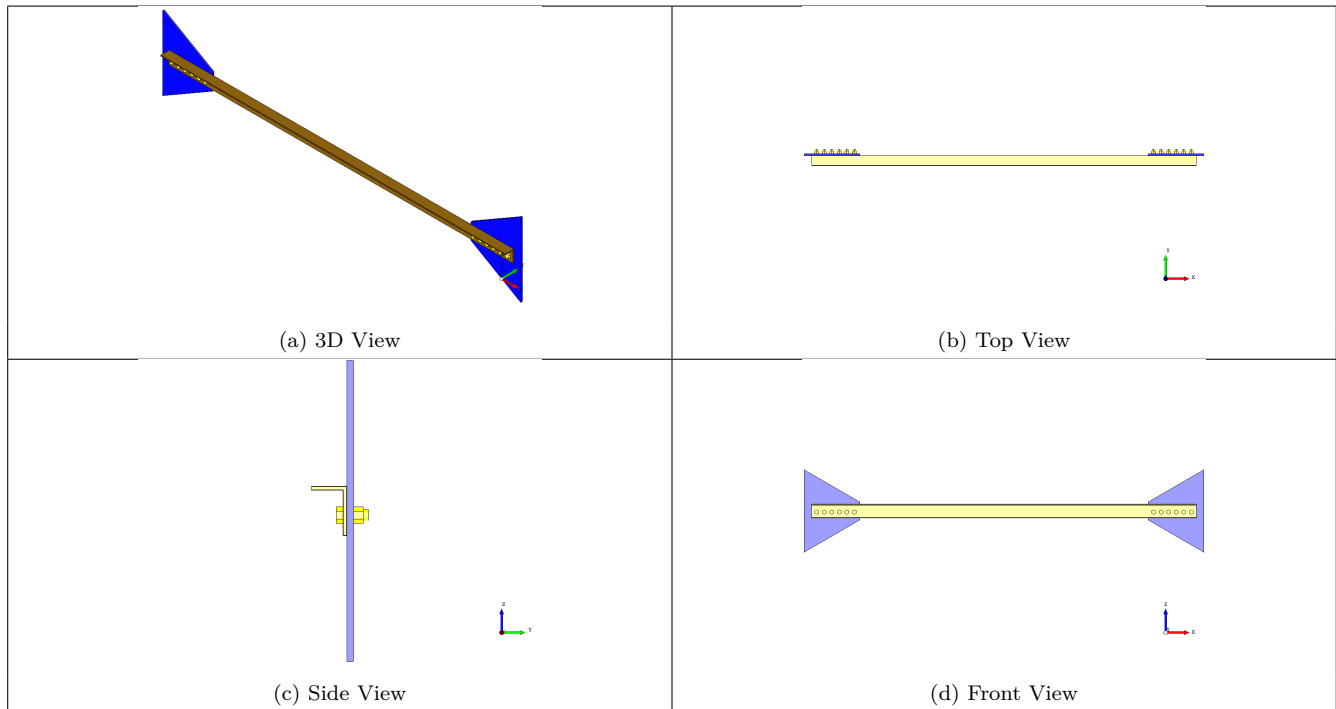
Company Name	IIT Bombay	Project Title	Sample Member Design
Group/Team Name	Osdag	Subtitle	Tension Member Bolted
Designer	Engineer #1	Job Number	2.1.1
Date	18 /12 /2020	Client	Somnath Mukherjee, MN Dastur, Kolkata

Check	Required	Provided	Remarks
Tension Capacity (kN)	$A = 235.0$	$T_d = \min(T_{dg}, T_{dn}, T_{db})$ $= \min(245.45, 240.88, 437.69)$ $= 240.88$ [Ref. IS 800 : 2007, Cl. 6.1]	Pass



Company Name	IIT Bombay	Project Title	Sample Member Design
Group/Team Name	Osdag	Subtitle	Tension Member Bolted
Designer	Engineer #1	Job Number	2.1.1
Date	18 /12 /2020	Client	Somnath Mukherjee, MN Dastur, Kolkata

3 3D Views



4 Design Log

2020-12-18 01:52:29 - 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 01:52:29 - 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 01:52:29 - Osdag - INFO - :Overall bolted tension member design is safe.