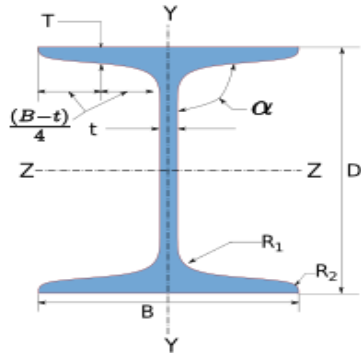




Company Name	IIT Bombay	Project Title	Moment Connection
Group/Team Name	Osdag	Subtitle	Column-to-Column End Plate
Designer	Engineer#1	Job Number	1.2.3.3.1.1
Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

## 1 Input Parameters

Module		Column-to-Column End Plate Connection		
Main Module		Moment Connection		
Bending Moment (kNm)		0.0		
Shear Force (kN)		0.0		
Axial Force (kN)		350.0		
Column Section - Mechanical Properties				
	Beam Section *		HB 250	
	Material		E 250 (Fe 410 W)A	
	Ultimate Strength, $F_u$ (MPa)		410	
	Yield Strength, $F_y$ (MPa)		250	
	Mass, $m$ (kg/m)	50.98	$I_z$ (cm <sup>4</sup> )	7730.0
	Area, $A$ (cm <sup>2</sup> )	64.9	$I_y$ (cm <sup>4</sup> )	1960.0
	$D$ (mm)	250.0	$r_z$ (cm)	10.9
	$B$ (mm)	250.0	$r_y$ (cm)	5.49
	$t$ (mm)	6.9	$Z_z$ (cm <sup>3</sup> )	619.0
	$T$ (mm)	9.7	$Z_y$ (cm <sup>3</sup> )	156.0
	Flange Slope	94	$Z_{pz}$ (cm <sup>3</sup> )	678.0
	$R_1$ (mm)	10.0	$Z_{py}$ (cm <sup>3</sup> )	262.0
	$R_2$ (mm)	5.0		
Bolt Details - Input and Design Preference				
Diameter (mm)		[24, 30]		
Property Class		[8.8, 9.8, 10.9, 12.9]		
Type		Bearing Bolt		
Bolt Tension		Non pre-tensioned		
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		



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## 2 Design Checks

Design Status	Pass
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### 2.1 Member Capacity

Check	Required	Provided	Remarks
Section Classification		Semi-Compact  [Ref: Table 2, Cl.3.7.2 and 3.7.4, IS 800:2007]	
Axial Capacity Member (kN)	350	$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ $= \frac{6490.0 \times 250}{1.1 \times 10^3}$ $= 1475.0$ [Ref. IS 800:2007, Cl.6.2]	Pass
Shear Capacity Member (kN)	0	$V_{dy} = \frac{A_v f_y}{\sqrt{3} \gamma_{m0}}$ $= \frac{230.6 \times 6.9 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 208.78$ [Ref. IS 800:2007, Cl.10.4.3]	
Plastic Moment Capacity (kNm)		$M_{dz} = \frac{\beta_b Z_p f_y}{\gamma_{m0} \times 10^6}$ $= \frac{0.91 \times 678000.0 \times 250}{1.1 \times 10^6}$ $= 140.68$ [Ref. IS 800:2007, Cl.8.2.1.2]	
Moment Deformation Criteria (kNm)		$M_{dc} = \frac{1.5 Z_e f_y}{\gamma_{m0} \times 10^6}$ $= \frac{1.5 \times 619000.0 \times 250}{1.1 \times 10^6}$ $= 211.02$ [Ref. IS 800:2007, Cl.8.2.1.2]	



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Check	Required	Provided	Remarks
Moment Capacity Member (kNm)	0	$M_{dz} = \min(M_{dz}, M_{dc})$ $= \min(140.68, 211.02)$ $= 140.68$  [Ref. IS 800:2007, Cl.8.2]	

## 2.2 Load Consideration

Check	Required	Provided	Remarks
Interaction Ratio		<p>I.R. axial <math>= P_x/T_{dg}</math>  <math>= 350.0/1475.0</math>  <math>= 0.24</math></p> <p>I.R. moment <math>= M_z/M_{dz}</math>  <math>= 0.0/140.68</math>  <math>= 0.0</math></p> <p>I.R. sum <math>= \text{I.R. axial} + \text{I.R. moment}</math>  <math>= 0.24 + 0.0</math>  <math>= 0.24</math></p>	



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Check	Required	Provided	Remarks
Minimum Required Load	<p>if I.R. axial <math>&lt; 0.3</math> and I.R. moment <math>&lt; 0.5</math></p> $P_{x\min} = 0.3T_{dg}$ $M_{z\min} = 0.5M_{dz}$ <p>elif sum I.R. <math>\leq 1.0</math> and I.R. moment <math>&lt; 0.5</math></p> <p>if <math>(0.5 - \text{I.R. moment}) &lt; (1 - \text{sum I.R.})</math></p> $M_{z\min} = 0.5 \times M_{dz}$ <p>else</p> $M_{z\min} = M_z + ((1 - \text{sum I.R.}) \times M_{dz})$ $P_{x\min} = P_x$ <p>elif sum I.R. <math>\leq 1.0</math> and I.R. axial <math>&lt; 0.3</math></p> <p>if <math>(0.3 - \text{I.R. axial}) &lt; (1 - \text{sum I.R.})</math></p> $P_{x\min} = 0.3T_{dg}$ <p>else</p> $P_{x\min} = P_x + ((1 - \text{sum I.R.}) \times T_{dg})$ $M_{z\min} = M_z$ <p>else</p> $P_{x\min} = P_x$ $M_{z\min} = M_z$ <p>Note: AL is the user input for load</p>	$M_{z\min} = 70.34$ $P_{x\min} = 442.5$ <p>[Ref. IS 800:2007, Cl.10.7]</p>	
Applied Axial Force (kN)	350.0	$P_u = \max(P_x, P_{x\min})$ $= \max(350.0, 442.5)$ $= 442.5$	



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Check	Required	Provided	Remarks
Applied Shear Force (kN)	0.0	$V_{y\min} = \min(0.15V_{dy}, 40.0)$ $= \min(0.15 \times 347.97, 40.0)$ $= 40.0$  $V_u = \max(V_y, V_{y\min})$ $= \max(0.0, 40.0)$ $= 40.0$  [Ref. IS 800:2007, Cl.10.7]	
Applied Moment (kNm)	0.0	$M_u = \max(M_z, M_{z\min})$ $= \max(0.0, 70.34)$ $= 70.34$  [Ref. IS 800:2007, Cl.8.2.1.2]	

## 2.3 Bolt Check

Check	Required	Provided	Remarks
Diameter (mm)	Bolt Quantity Optimization	$d = 30.0$	
Property Class	Bolt Grade Optimization	8.8	
Hole Diameter (mm)		$d_0 = 33.0$	
No. of Bolts (along one side of the web) (n)	$n_{bw} = 2 \times \left( \frac{D - (2 \times T_f) - (2 \times e)}{p} + 1 \right)$ $= 2 \times \left( \frac{250.0 - (2 \times 9.7) - (2 \times 50)}{75.0} + 1 \right)$ $= 4$	4	Pass
No. of Bolts (along one side of the flange overhang) (n)	$n_{bf} = 2 \times \left( \frac{b/2 - (T_w/2) - (2 \times e)}{p} + 1 \right)$ $= 2 \times \left( \frac{250.0/2 - (0.5 \times 6.9) - (2 \times 50)}{75.0} + 1 \right)$ $= 2$	2	Pass
Total No. of Bolts		4	



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Check	Required	Provided	Remarks
Shear Capacity (kN)		$V_{dsb} = \frac{f_{ub} n_n A_{nb}}{\sqrt{3} \gamma_{mb}}$ $= \frac{830.0 \times 1 \times 561}{1000 \times \sqrt{3} \times 1.25}$ $= 215.07$ <p>[Ref. IS 800:2007, Cl.10.3.3]</p>	
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5 k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.51 \times 30.0 \times 56.0 \times 410}{1000 \times 1.25}$ $= 702.58$ <p>[Ref. IS 800:2007, Cl.10.3.4]</p>	
Capacity (kN)	$V_{sb} = \frac{V}{n_{wb}}$ $= \frac{40.0}{4}$ $= 10.0$	$V_{db} = \min (V_{dsb}, V_{dpb})$ $= \min (215.07, 702.58)$ $= 215.07$ <p>[Ref. IS 800:2007, Cl.10.3.2]</p>	Pass
Tension due to Moment and Axial Force (kN)	$T_1 = \frac{P}{n} + \frac{M \times y_{max}}{y_{sqr}}$ $= \frac{442.5 \times 10^3}{4} + \frac{70340.91 \times 10^6 \times 185.45}{74800.45}$ $= 285.02$		



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Check	Required	Provided	Remarks
Prying force (kN)	$Q = \frac{l_v}{2l_e} \left[ T_e - \frac{\beta \eta f_o b_e t^4}{27 l_e l_v^2} \right]$ $l_v = e - t_w$ $= 50 - 0 = 50 \text{ mm}$ $f_o = 0.7 f_{ub}$ $= 0.7 \times 830.0$ $= 581.0 \text{ N/mm}^2$ $l_e = \min \left( e, 1.1 t \sqrt{\frac{\beta f_o}{f_y}} \right)$ $= \min \left( 50, 1.1 \times 56.0 \times \sqrt{\frac{2 \times 581.0}{250}} \right)$ $= \min(50, 93.91) = 50 \text{ mm}$ $\beta = 2 \text{ (non pre-tensioned bolt)}$ $\eta = 1.5$ $b_e = \frac{B}{n_c}$ $= \frac{250.0}{2} = 125.0 \text{ mm}$ $Q = \frac{50}{2 \times 50} \times \left[ 285.02 - \left( \frac{2 \times 1.5 \times 581.0 \times 125.0 \times 56.0^4}{27 \times 50 \times 50^2} \right) \times 10^{-3} \right]$ $Q = 0.0$ <p><i>Note : The end plate is sufficiently thick to prevent yielding of the plate. Thus, <math>Q = 0</math></i></p> <p>[Ref. IS 800:2007, Cl.10.4.7]</p>		OK



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Check	Required	Provided	Remarks
Tension demand (kN)	$T_b = T_1 + Q$ $= 285 + 0$ $= 285.02$	$T_{db} = 0.90 f_{ub} A_n / \gamma_{mb}$ $< f_{yb} A_{sb} (\gamma_{mb} / \gamma_{m0})$ $= \min \left( 0.90 \times 830.0 \times 561 / 1.25, \right.$ $\quad \left. 660.0 \times 707.0 \times (1.25/1.1) \right)$ $= \min(335.25, 530.25)$ $= 335.25$  [Ref. IS 800:2007, Cl.10.3.5]	Pass
Min. Pitch Distance (mm)	$p_{\min} = 2.5d$ $= 2.5 \times 30.0$ $= 75.0$  [Ref. IS 800:2007, Cl.10.2.2]	75.0	Pass
Max. Pitch Distance (mm)	$p/g_{\max} = \min(32t, 300)$ $= \min(32 \times 56.0, 300)$ $= \min(1792.0, 300)$ $= 300$  Where, $t = \min(56.0, 56.0)$  [Ref. IS 800:2007, Cl.10.2.3]	75.0	Pass
Min. End Distance (mm)	$e_{\min} = 1.5d_0$ $= 1.5 \times 33.0$ $= 49.5$  [Ref. IS 800:2007, Cl.10.2.4.2]	50	Pass





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Check	Required	Provided	Remarks
Max. End Distance (mm)	$e_{\max} = 12t\varepsilon; \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 56.0 \times \sqrt{\frac{250}{250}} = 672.0$ $e_2 = 12 \times 56.0 \times \sqrt{\frac{250}{250}} = 672.0$ $e_{\max} = \min(e_1, e_2) = 672.0$ <p>[Ref. IS 800:2007, Cl.10.2.4.3]</p>	50	Pass

## 2.4 End Plate Checks

Check	Required	Provided	Remarks
Min. Plate Length (mm)	250.0	250.0	Pass
Min. Plate Height (mm)	250.0	250.0	Pass
Min. Plate Thickness (mm)	$t_p = \max \left( \sqrt{\frac{4M_{cr}}{b_{eff}(f_y/\gamma_{m0})}}, \right.$ $\left. \sqrt[4]{\left(T_1 - \frac{2Ql_e}{l_v}\right) \times \left(\frac{27l_e l_v^2}{\beta \eta f_o b_e}\right)} \right)$ $= \max \left( \sqrt{\frac{4 \times 10.72 \times 10^6}{75 \times (250/1.1)}}, \right.$ $\left. \sqrt[4]{\left(285018.62 - \frac{2 \times 0 \times 50}{50}\right) \times \left(\frac{27 \times 50 \times 50^2}{2 \times 1.5 \times 581.0 \times 125.0}\right)} \right)$ $= 56.0$	56.0	
Moment Capacity (kNm)	$M_{ep} = \max (0.5 \text{ X Tension in first bolt X end distance,}$ $\text{Tension in second bolt X end distance})$ $= \max(0.5T_b 1e, T_b 2e)$ $= \max(0.5 \times 285018.62 \times 50, 214490.06 \times 50)$ $= 10.72$	$M_{dp} = \frac{b_{eff} t_p^2 f_y}{4\gamma_{m0}}$ $= \frac{75.0 \times 56.0^2 \times 250}{4 \times 1.1}$ $= 13.36$	Pass



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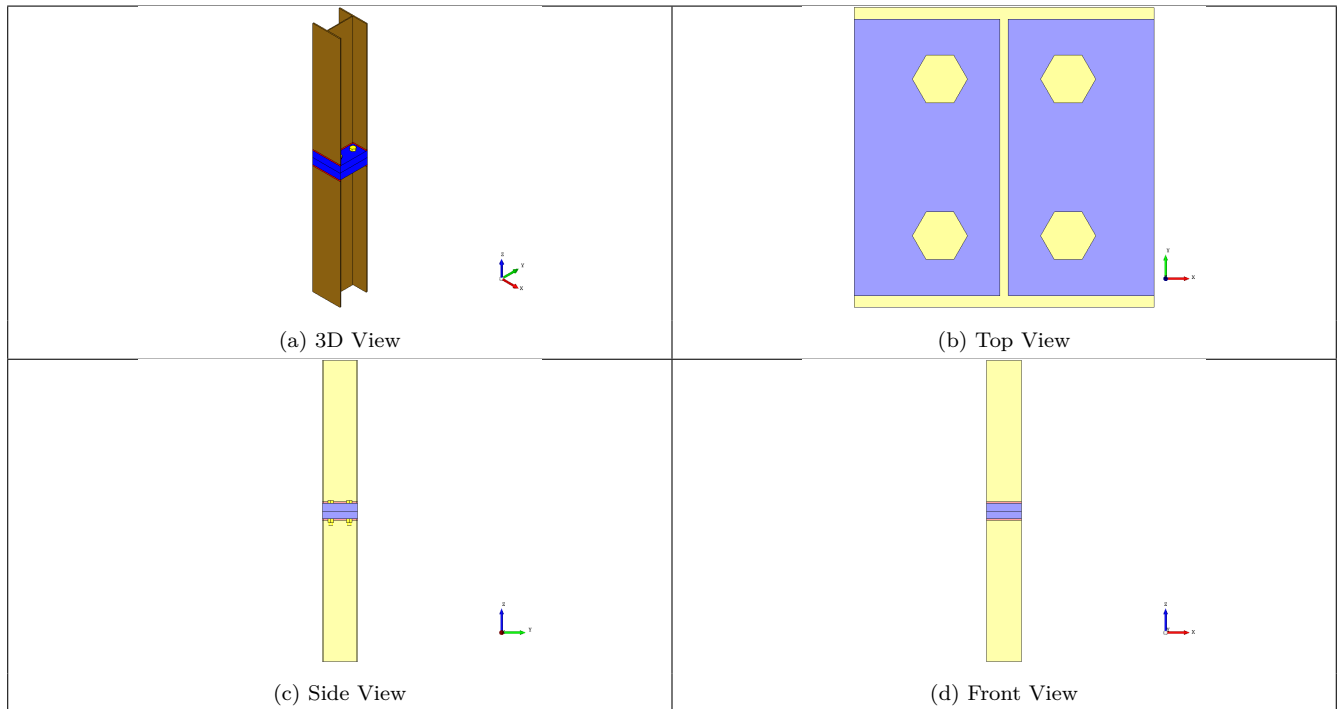
## 2.5 Bolt Checks

Check	Required	Provided	Remarks
Diameter (mm)	Bolt Quantity Optimisation	The number of bolts for given bolt size(s) are not sufficient to cater for the given section and loads combination.	



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### 3 3D Views



### 4 Design Log

2021-02-04 15:06:43 - Osdag - INFO - The Load(s) defined is/are less than the minimum recommended value [Ref. IS 800:2007, Cl.10.7].

2021-02-04 15:06:43 - Osdag - INFO - The value of load(s) is/are set at minimum recommended value as per IS 800:2007, Cl.10.7.

2021-02-04 15:06:43 - Osdag - INFO - : Overall Column End Plate connection design is SAFE

2021-02-04 15:06:43 - Osdag - INFO - :=====End Of design=====