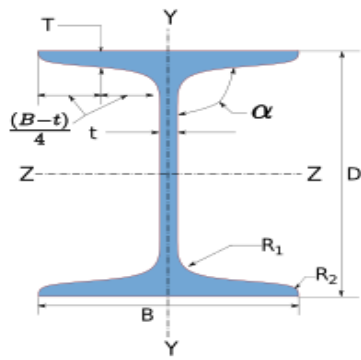




Company Name	IIT Bombay	Project Title	Moment Connection
Group/Team Name	Osdag	Subtitle	Beam-to-Beam End Plate
Designer	Engineer#1	Job Number	1.2.1.2.1.2.1
Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

1 Input Parameters

Main Module		Moment Connection		
Module		Beam-to-Beam End Plate Connection		
Connectivity		Coplanar Tension-Compression Flange		
End Plate Type		Extended One Way - Irreversible Moment		
Bending Moment (kNm)		300.0		
Shear Force (kN)		140.0		
Axial Force (kN)		50.0		
Beam Section - Mechanical Properties				
	Beam Section		UB 610 x 229 x 125	
	Material		E 300 (Fe 440)	
	Ultimate Strength, F_u (MPa)		440	
	Yield Strength, F_y (MPa)		300	
	Mass, m (kg/m)	125.1	I_z (cm ⁴)	98610.0
	Area, A (cm ²)	15930.0	I_y (cm ⁴)	3932.0
	D (mm)	612.0	r_z (cm)	24.9
	B (mm)	229.0	r_y (cm)	5.0
	t (mm)	11.9	Z_z (cm ³)	3221.0
	T (mm)	19.6	Z_y (cm ³)	343.0
	Flange Slope	90	Z_{pz} (cm ³)	3676.0
	R_1 (mm)	12.7	Z_{py} (cm ³)	535.0
	R_2 (mm)	0.0		
Plate Details - Input and Design Preference				
Thickness (mm)		[18, 20, 22]		
Material		E 250 (Fe 410 W)A		
Ultimate Strength, F_u (MPa)		410		
Yield Strength, F_y (MPa)		240		
Bolt Details - Input and Design Preference				
Diameter (mm)		[20, 24, 30]		
Property Class		[8.8, 10.9]		
Type		Bearing Bolt		
Bolt Tension		Non pre-tensioned		
Hole Type		Standard		



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Slip Factor, (μ_f)	0.3
Weld Details - Input and Design Preference	
Type of Weld Fabrication	Shop Weld
Material Grade Overwrite, F_u (MPa)	410.0
Beam Flange to End Plate	Groove Weld
Beam Web to End Plate	Fillet Weld
Stiffener	Fillet Weld
Detailing - Design Preference	
Edge Preparation Method	Sheared or hand flame cut
Gap Between Beams (mm)	0.0
Are the Members Exposed to Corrosive Influences?	False



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Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

2 Design Checks

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

2.1 Member Capacity

Check	Required	Provided	Remarks
Shear Capacity (kN)		$V_{dy} = \frac{A_v f_y}{\sqrt{3} \gamma_{m0}}$ $= \frac{0.6 \times 572.8 \times 11.9 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 643.98$ <p>[Ref. IS 800:2007, Cl.10.4.3]</p>	Restricted to low shear
Plastic Moment Capacity (kNm)		$M_{dz} = \frac{\beta_b Z_{pz} f_y}{\gamma_{m0}}$ $= \frac{1 \times 3676000.0 \times 300}{1.1 \times 10^6}$ $= 1002.55$ <p>[Ref. IS 800:2007, Cl.8.2.1.2]</p>	$V < 0.6 V_{dy}$

2.2 Load Consideration

Check	Required	Provided	Remarks
Shear Force (kN)	$V_y = 140.0$	$V_{y\min} = \min(0.15 V_{dy}, 40.0)$ $= \min(0.15 \times 643.98, 40.0)$ $= \min(96.6, 40.0)$ $= 40$ $V_u = \max(V_y, V_{y\min})$ $\text{but, } \leq V_{dy}$ $= \max(140.0, 40)$ $\text{but, } \leq 643.98$ $= 140.0$ <p>[Ref. IS 800:2007, Cl.10.7]</p>	Pass



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Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

Check	Required	Provided	Remarks
Axial Force (kN)		$P_x = 50.0$	OK
Bending Moment (kNm)	$M_z = 300.0$	$M_{zmin} = 0.5M_{dz}$ $= 0.5 \times 1002.55$ $= 501.27$ $M_u = \max(M_z, M_{zmin})$ but, $\leq M_{dz}$ $= \max(300.0, 501.27)$ ≤ 1002.55 $= 501.27$ [Ref. IS 800:2007, Cl.8.2.1.2]	Pass
Effective Bending Moment (kNm)		$M_{ue} = M_u + P_x \times \left(\frac{D}{2} - \frac{T}{2} \right) \times 10^{-3}$ $= 501.27 +$ $50.0 \times \left(\frac{612.0}{2} - \frac{19.6}{2} \right) \times 10^{-3}$ $= 516.08$	OK

2.3 Bolt Optimization

Check	Required	Provided	Remarks
Diameter (mm)	Bolt Diameter Optimization	$d = 20$	Pass
Property Class	Bolt Property Class Optimization	8.8	Pass
Hole Diameter (mm)		$d_0 = 22.0$	OK
No. of Bolt Columns		$n_c = 2$	Pass
No. of Bolt Rows		$n_r = 6$	Pass
Total No. of Bolts		$n = n_r X n_c = 12$	Pass



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2.4 Detailing

Check	Required	Provided	Remarks
Min. Pitch Distance (mm)	$p_{\min} = 2.5d$ $= 2.5 \times 20.0$ $= 50.0$ [Ref. IS 800:2007, Cl.10.2.2]	70	Pass
Max. Pitch Distance (mm)	$p_{\max} = \min(32t, 300)$ $= \min(32 \times 20.0, 300)$ $= \min(640.0, 300)$ $= 300$ Where, $t = \min(20.0, 20.0)$ [Ref. IS 800:2007, Cl.10.2.3]	70	Pass
Min. End Distance (mm)	$e_{\min} = 1.7d_0$ $= 1.7 \times 22.0$ $= 37.4$ [Ref. IS 800:2007, Cl.10.2.4.2]	40	Pass
Max. End Distance (mm)	$e_{\max} = 12t\varepsilon; \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 20.0 \times \sqrt{\frac{250}{240}} = 244.95$ $e_2 = 12 \times 20.0 \times \sqrt{\frac{250}{240}} = 244.95$ $e_{\max} = \min(e_1, e_2) = 244.95$ [Ref. IS 800:2007, Cl.10.2.4.3]	40	Pass
Min. Edge Distance (mm)	$e'_{\min} = 1.7d_0$ $= 1.7 \times 22.0$ $= 37.4$ [Ref. IS 800:2007, Cl.10.2.4.2]	40	Pass



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Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{\max} = 12t\varepsilon; \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 20.0 \times \sqrt{\frac{250}{240}} = 244.95$ $e_2 = 12 \times 20.0 \times \sqrt{\frac{250}{240}} = 244.95$ $e'_{\max} = \min(e_1, e_2) = 244.95$ <p>[Ref. IS 800:2007, Cl.10.2.4.3]</p>	40	Pass
Cross-centre Gauge Distance (mm)		106	Pass

2.5 Critical Bolt Design

Check	Required	Provided	Remarks
Shear Capacity (kN)		$V_{dsb} = \frac{f_{ub}n_n A_{nb}}{\sqrt{3}\gamma_{mb}}$ $= \frac{830.0 \times 1 \times 245}{1000 \times \sqrt{3} \times 1.25}$ $= 93.92$ <p>[Ref. IS 800:2007, Cl.10.3.3]</p>	OK
Kb		$k_b = \min \left(\frac{e}{3d_0}, \frac{p}{3d_0} - 0.25, \frac{f_{ub}}{f_u}, 1.0 \right)$ $= \min \left(\frac{40}{3 \times 22.0}, \frac{70}{3 \times 22.0} - 0.25, \frac{830.0}{440}, 1.0 \right)$ $= \min(0.61, 0.81, 1.89, 1.0)$ $= 0.61$ <p>[Ref. IS 800:2007, Cl.10.3.4]</p>	OK



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Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

Check	Required	Provided	Remarks
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.61 \times 20.0 \times 20.0 \times 410}{1000 \times 1.25}$ $= 200.08$ [Ref. IS 800:2007, Cl.10.3.4]	OK
Bolt Capacity (kN)		$V_{db} = \min (V_{dsb}, V_{dpb})$ $= \min (93.92, 200.08)$ $= 93.92$ [Ref. IS 800:2007, Cl.10.3.2]	
Large Grip Length Reduction Factor		$l_g = \sum (t_p + t_{member})$ $= \sum (20.0 + 20.0)$ $= 40.0 \text{ mm}$ $5d = 5 \times 20.0 = 100.0$ $8d = 8 \times 20.0 = 160.0$ Since, $l_g < 5d$ $\beta_{lg} = 1.0$ [Ref. IS 800 : 2007, Cl. 10.3.3.2]	Pass
Bolt Capacity (post reduction factor) (kN)		$V_{db} = V_{db} \beta_{lg}$ $= 93.92 \times 1.0$ $= 93.92$ [Ref. IS 800 : 2007, Cl. 10.3.3.2]	OK
Shear Demand (kN)	$V_{sb} = \frac{V_u}{n}$ $= \frac{140.0}{12}$ $= 11.67$	Vdb = 93.92	Pass



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Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

Check	Required	Provided	Remarks
Lever Arm (mm)	<p>$r = [592.4, 592.4, 49.8, 592.4, 592.4, 261.2]$</p> <p>Note: r_1 is the first row outside tension/top flange, r_2 is the first row inside tension/top flange, r_3 is the first row inside compression/bottom flange, r_4 is the second row inside tension/top flange r_5 is the second row outside tension/top flange, row(s) r_6 and beyond are rows inside the flange.</p> <p>Note: The lever arm is computed by considering the N.A at the centre of the bottom flange.</p> <p>Rows with identical lever arm values mean they are considered acting as bolt group near the tension or compression flange.</p>		Pass
Tension Due to Moment (kN)	$T_1 = \frac{M_{ue}}{4 \times n_c \times \left(r_1 + \frac{r_3^2}{r_1} + \sum_{i=6}^{n_r} \frac{r_i^2}{r_1} \right)}$ $= \frac{516.08 \times 10^3}{4 \times 2 \times \left(592.4 + \frac{49.8^2}{592.4} + \sum_{i=6}^6 \frac{r_i^2}{592.4} \right)}$ $= 90.64$ <p>Note: T_1 is the tension in the critical bolt. The critical bolt is the bolt nearest to the tension flange.</p>		OK



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Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

Check	Required	Provided	Remarks
Prying Force (kN)	$Q = \frac{l_v}{2l_e} \left[T_e - \frac{\beta \eta f_o b_e t^4}{27 l_e l_v^2} \right]$ $l_v = e - \frac{R_1}{2}$ $= 40 - \frac{12.7}{2} = 33.65 \text{ mm}$ $f_o = 0.7 f_{ub}$ $= 0.7 \times 830.0$ $= 581.0 \text{ N/mm}^2$ $l_e = \min \left(e, 1.1 t \sqrt{\frac{\beta f_o}{f_y}} \right)$ $= \min \left(40, 1.1 \times 20 \times \sqrt{\frac{2 \times 581.0}{240}} \right)$ $= \min(40, 48.41) = 40 \text{ mm}$ $\beta = 2 \text{ (non pre-tensioned bolt)}$ $\eta = 1.5$ $b_e = \frac{B}{n_c}$ $= \frac{229.0}{2} = 114.5 \text{ mm}$ $Q = \frac{33.65}{2 \times 40} \times \left[90.64 - \left(\frac{2 \times 1.5 \times 581.0 \times 114.5 \times 20^4}{27 \times 40 \times 33.65^2} \right) \times 10^{-3} \right]$ $Q = 27.14$ <p>[Ref. IS 800:2007, Cl.10.4.7]</p>		OK



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Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

Check	Required	Provided	Remarks
Tension Demand (kN)	$T_b = T_1 + Q$ $= 90.64 + 27.14$ $= 117.78$	$T_{db} = 0.90 f_{ub} A_n / \gamma_{mb}$ $< f_{yb} A_{sb} (\gamma_{mb} / \gamma_{m0})$ $= \min \left(0.90 \times 830.0 \times 245 / 1.25, \right.$ $\left. 660.0 \times 314.0 \times (1.25/1.1) \right)$ $= \min(146.41, 235.5)$ $= 146.41$ [Ref. IS 800:2007, Cl.10.3.5]	Pass
Combined Capacity, (I.R)	≤ 1	$\left(\frac{V_{sb}}{V_{db}} \right)^2 + \left(\frac{T_b}{T_{db}} \right)^2 \leq 1.0$ $\left(\frac{11.67}{93.92} \right)^2 + \left(\frac{117.78}{146.41} \right)^2 = 0.66$ [Ref. IS 800:2007, Cl.10.3.6]	Pass

2.6 Compression Flange Check

Check	Required	Provided	Remarks
Tension in Bolt Rows (kN)		$T = [90.64, 90.64, 30.48, 90.64, 90.64, 159.85]$	OK
Reaction at Compression Flange (kN)	$R_c = n_c \sum_{n_r=1}^{n_r} T_{n_r}$ $= 2 \times \sum_{n_r=1}^6 T_{n_r}$ $= 2 \times 552.89$ $= 1105.78$	$F_c = A_g f_y / \gamma_{m0}$ $= \frac{B T f_y}{\gamma_{m0}}$ $= \frac{229.0 \times 19.6 \times 300}{1.1 \times 1000}$ $= 1224.11$	Pass



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2.7 End Plate Checks

Check	Required	Provided	Remarks
Height (mm)		$H_p = D + 12.5 + (2 \times e) + p$ $= 612.0 + 12.5 + (2 \times 40) + 70$ $= 774.5$	Pass
Width (mm)		$B_p = B + 25$ $= 229.0 + 25$ $= 254.0$	Pass
Moment at Critical Section (kNm)		$M_{cr} = T_1 l_v - Q l_e$ $= (90.64 \times 33.65 - 27.14 \times 40) \times 10^{-3}$ $= 1.96$ Note: The critical section is at the toe of the weld or the edge of the flange from bolt center-line	OK
Plate Thickness (mm)	$t_p = \sqrt{\frac{4M_{cr}}{b_e(f_y/\gamma_{m0})}}$ $= \sqrt{\frac{4 \times 1.96 \times 10^6}{114 \times (240/1.1)}}$ $= 17.73$	20	Pass
Moment Capacity (kNm)	1.96	$M_p = \left(\frac{b_e t_p^2}{4}\right) \times \frac{f_y}{\gamma_{m0}}$ $= \frac{114 \times 20^2}{4} \times \frac{240}{1.1} \times 10^{-6}$ $= 2.5$	Pass

2.8 Stiffener Design

Check	Required	Provided	Remarks
Height (mm)		$H_{st} = H_p - D - 12.5$ $= 774.5 - 612.0 - 12.5$ $= 150$	Pass
Length (mm)		$L_{st} = \frac{H_{st}}{\tan 30^\circ}$ $= \frac{150}{\tan 30^\circ}$ $= 260$	Pass
Thickness (mm)	$t = 11.9$	$t_{st} = 12$	Pass



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Check	Required	Provided	Remarks
Weld Size (mm)	5	tw = 6	Pass

2.9 Weld Design - Beam Web to End Plate Connection

Check	Required	Provided	Remarks
Weld Strength (N/mm ²)	$f_{uw} = \min(f_w, f_u)$ $= \min(410.0, 410)$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	$f_{uw} = 410.0$	Pass
Total Weld Length (mm)		$L_w = 2 \times [D - (2 \times T) - (2 \times R1) - 20]$ $= 2 \times [612.0 - (2 \times 19.6) - (2 \times 12.7) - 20]$ $= 1054$ Note: Weld is provided on both sides of the web	
Weld Size (mm)	$t_w = \frac{V_u}{f_{uw} k L_w} \times \sqrt{3} \gamma_{mw}$ $= \frac{140.0 \times 10^3}{410.0 \times 0.7 \times 1054} \times \sqrt{3} \times 1.25$ $= 1.0$ [Ref. IS 800:2007, Cl.10.5.7]	6	Pass



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Check	Required	Provided	Remarks
Min. Weld Size (mm)	<p>1) $t_{w\min}$ – based on thickness of the thicker part</p> $t_{\text{thicker}} = \max(20.0, 11.9)$ $= 20.0$ $t_{w\min} = 5$ <p>2) $t_{w\min}$ – based on thickness of the thinner part</p> $t_{\text{thinner}} = \min(20.0, 11.9)$ $= 11.9$ $t_{w\min} \leq \min(5, 11.9)$ <p>[Ref. IS 800:2007, Table 21, Cl 10.5.2.3]</p>	$t_w = \max(t_w, t_{w\min})$ $= \max(1.0, 5)$ $= 6$	Pass
Max. Weld Size (mm)	<p>$t_{w\max}$ based on thickness of the thinner part</p> $t_{\text{thinner}} = \min(20.0, 11.9)$ $= 11.9$ $t_{w\max} = 11.9$ <p>[Ref. IS 800:2007, Cl.10.5.3.1]</p>	$t_w \leq t_{w\max}$ $6 \leq 11.9$	Pass
Normal Stress (N/mm ²)		$f_a = \frac{H}{0.7t_w L_w}$ $= \frac{50.0 \times 10^3}{0.7 \times 6 \times 1054}$ $= 11.29$ <p>[Ref. IS 800:2007, Cl.10.5.9]</p>	OK



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Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

Check	Required	Provided	Remarks
Shear Stress (N/mm ²)		$q = \frac{V}{0.7t_w L_w}$ $= \frac{140.0 \times 10^3}{0.7 \times 6 \times 1054}$ $= 31.6$ [Ref. IS 800:2007, Cl.10.5.9]	OK
Equivalent Stress (N/mm ²)	$f_e = \sqrt{f_a^2 + 3q^2}$ $= \sqrt{11.29^2 + (3 \times 31.6^2)}$ $= 54.84$ [Ref. IS 800:2007, Cl.10.5.10.1.1]	$f_w = \frac{f_u}{\sqrt{3}\gamma_{mw}}$ $= \frac{410.0}{\sqrt{3} \times 1.25}$ $= 189.37$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	Pass



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Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

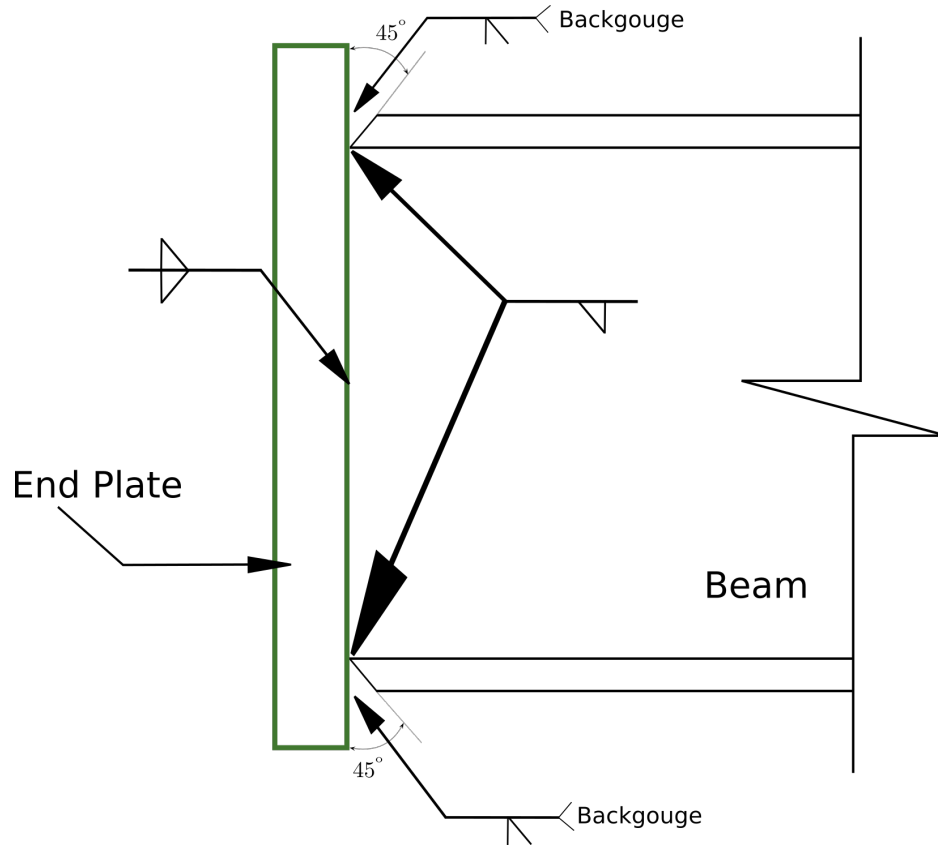


Figure 1: Typical Weld Details -- Beam to End Plate Connection

3 2D Drawings (Typical)



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Designer	Engineer#1	Job Number	1.2.1.2.1.2.1
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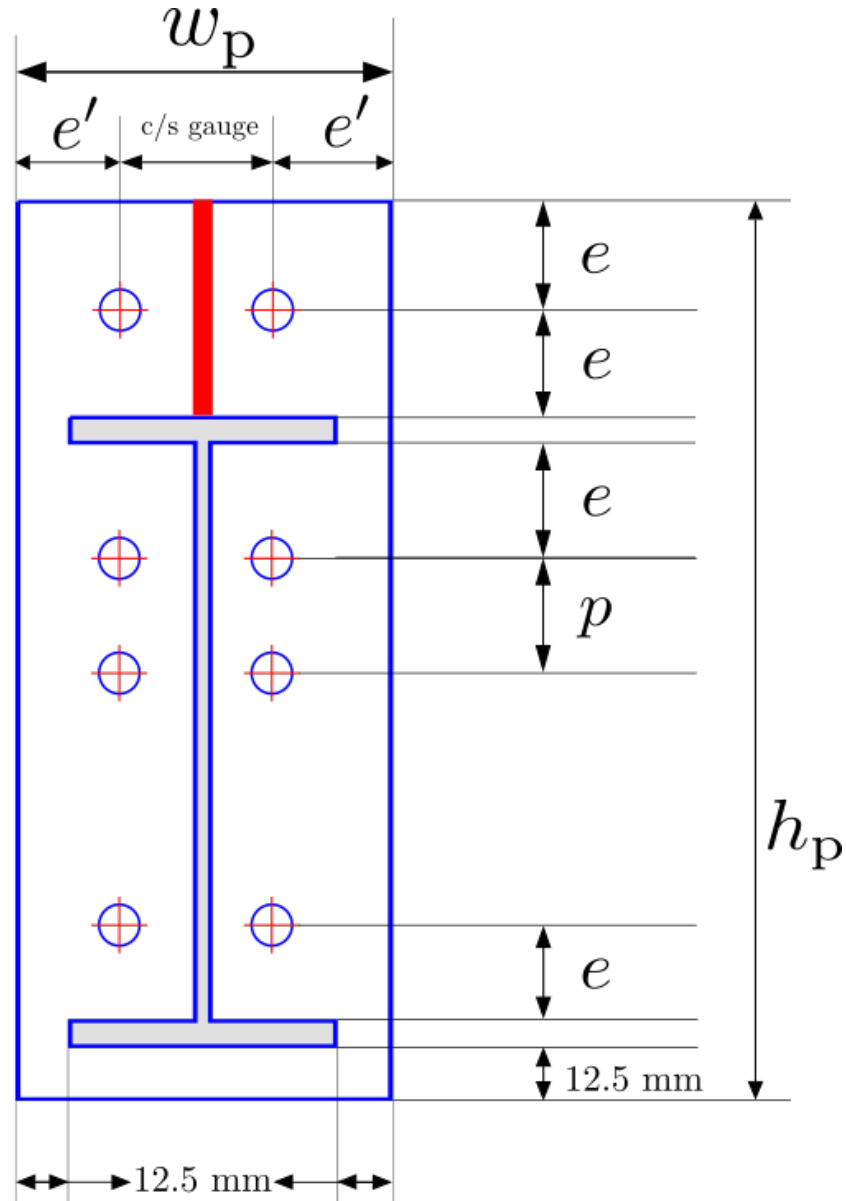


Figure 2: Typical Detailing



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Designer	Engineer#1	Job Number	1.2.1.2.1.2.1
Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

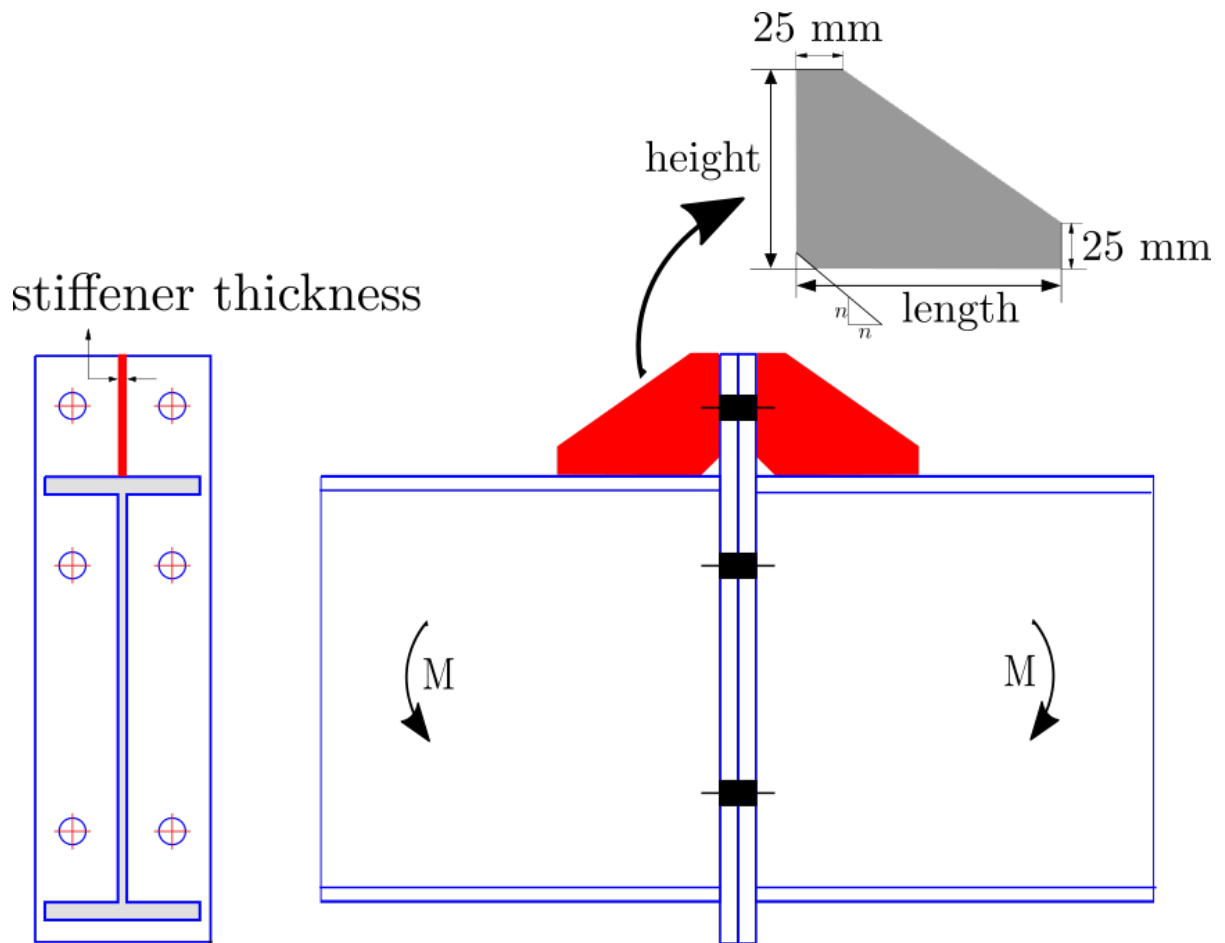
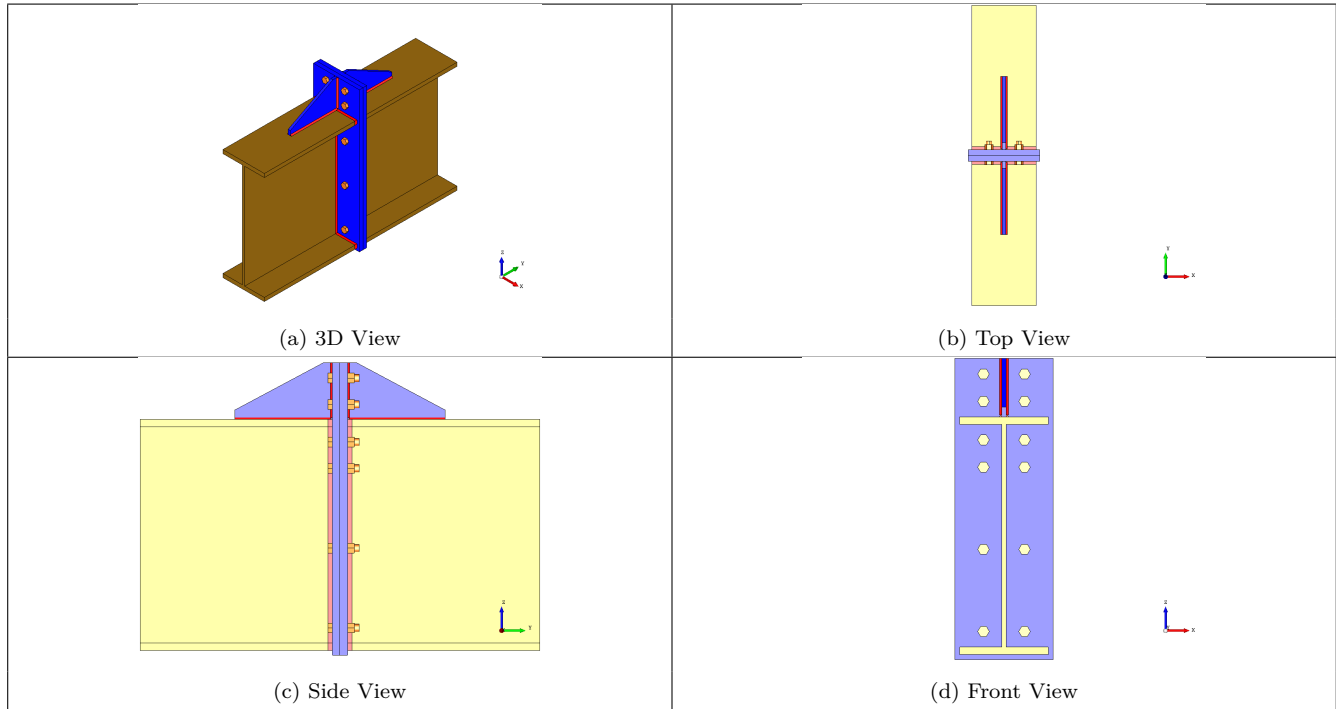


Figure 3: Typical Stiffener Details



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Group/Team Name	Osdag	Subtitle	Beam-to-Beam End Plate
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Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

4 3D Views



5 Design Log

2021-02-04 13:29:27 - Osdag - WARNING - The Load(s) defined is/are less than the minimum recommended value [Ref. IS 800:2007, Cl.10.7].

2021-02-04 13:29:27 - Osdag - WARNING - [Minimum Factored Load] The external factored bending moment (300.0 kNm) is less than 0.5 times the plastic moment capacity of the beam (1002.55 kNm)

2021-02-04 13:29:27 - Osdag - INFO - The minimum factored bending moment should be at least 0.5 times the plastic moment capacity of the beam to qualify the connection as rigid connection (Annex. F-4.3.1, IS 800:2007)

2021-02-04 13:29:27 - Osdag - INFO - The value of load(s) is/are set at minimum recommended value as per Cl.10.7 and Annex. F, IS 800:2007



2021-02-04 13:29:27 - Osdag - INFO - Designing the connection for a factored moment of 501.27 kNm

2021-02-04 13:29:27 - Osdag - WARNING - [End Plate] The end plate of 18.0 mm is thinner than the thickest part of the elements being connected

2021-02-04 13:29:27 - Osdag - INFO - Selecting a plate of higher thickness which is at least 19.6 mm thick

2021-02-04 13:29:27 - Osdag - INFO - [Bolt Design] Bolt diameter and grade combination ready to perform bolt design

2021-02-04 13:29:27 - Osdag - INFO - The solver has selected 6 combinations of bolt diameter and grade to perform optimum bolt design in an iterative manner

		Created with  Osdag®	
Company Name	IIT Bombay	Project Title	Moment Connection
Group/Team Name	Osdag	Subtitle	Beam-to-Beam End Plate
Designer	Engineer#1	Job Number	1.2.1.2.1.2.1
Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

2021-02-04 13:29:27 - Osdag - INFO - [Optimisation] Performing the design by optimising the plate thickness, using the most optimum plate and a suitable bolt diameter approach

2021-02-04 13:29:27 - Osdag - INFO - If you wish to optimise the bolt diameter-grade combination, pass a higher value of plate thickness using the Input Dock

2021-02-04 13:29:27 - Osdag - INFO - [Flange Strength] The reaction at the compression flange of the beam 1105.78 kN is less than the flange capacity 1224.11 kN. The flange strength requirement is satisfied.

2021-02-04 13:29:27 - Osdag - INFO - [End Plate] The end plate of 20.0 mm passes the moment capacity check. The end plate is checked for yielding due tension caused by bending moment and prying force

2021-02-04 13:29:27 - Osdag - INFO - [Bolt Design] The bolt of 20.0 mm diameter and 8.8 grade passes the tension check

2021-02-04 13:29:27 - Osdag - INFO - Total tension demand on bolt (due to direct tension + prying action) is 117.78 kN and the bolt tension capacity is (146.41 kN)

2021-02-04 13:29:27 - Osdag - INFO - [Bolt Design] The bolt of 20.0 mm diameter and 8.8 grade passes the combined shear + tension check

2021-02-04 13:29:27 - Osdag - INFO - The Interaction Ratio (IR) of the critical bolt is 0.663

2021-02-04 13:29:27 - Osdag - INFO - : ===== Design Status =====

2021-02-04 13:29:27 - Osdag - INFO - : Overall beam to beam end plate splice connection design is SAFE

2021-02-04 13:29:27 - Osdag - INFO - : ===== End Of Design =====