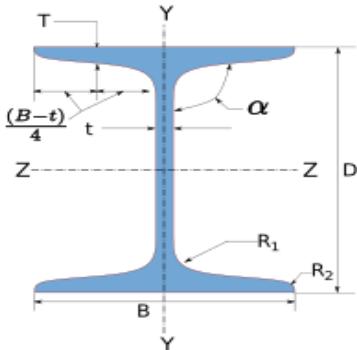




Company Name	IIT Bombay	Project Title	Moment Connection
Group/Team Name	Osdag	Subtitle	Beam-to-Beam End Plate
Designer	Engineer#1	Job Number	1.2.1.2.1.1.2
Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

1 Input Parameters

Main Module		Moment Connection		
Module		Beam-to-Beam End Plate Connection		
Connectivity		Coplanar Tension-Compression Flange		
End Plate Type		Flushed - Reversible Moment		
Bending Moment (kNm)		100.0		
Shear Force (kN)		40.0		
Axial Force (kN)		20.0		
Beam Section - Mechanical Properties				
	Beam Section		MB 400	
	Material		E 250 (Fe 410 W)C	
	Ultimate Strength, F_u (MPa)		410	
	Yield Strength, F_y (MPa)		250	
	Mass, m (kg/m)	61.55	I_z (cm ⁴)	20400.0
	Area, A (cm ²)	7840.0	I_y (cm ⁴)	622.0
	D (mm)	400.0	r_z (cm)	16.1
	B (mm)	140.0	r_y (cm)	2.81
	t (mm)	8.9	Z_z (cm ³)	1020.0
	T (mm)	16.0	Z_y (cm ³)	88.8
	Flange Slope	98	Z_{pz} (cm ³)	1170.0
	R_1 (mm)	14.0	Z_{py} (cm ³)	149.0
	R_2 (mm)	7.0		
Plate Details - Input and Design Preference				
Thickness (mm)		[22]		
Material		E 300 (Fe 440)		
Ultimate Strength, F_u (MPa)		440		
Yield Strength, F_y (MPa)		290		
Bolt Details - Input and Design Preference				
Diameter (mm)		[16]		
Property Class		[12.9]		
Type		Friction Grip Bolt		
Bolt Tension		Pre-tensioned		
Hole Type		Standard		



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Slip Factor, (μ_f)	0.48
Weld Details - Input and Design Preference	
Type of Weld Fabrication	Shop Weld
Material Grade Overwrite, F_u (MPa)	450.0
Beam Flange to End Plate	Groove Weld
Beam Web to End Plate	Fillet Weld
Stiffener	Fillet Weld
Detailing - Design Preference	
Edge Preparation Method	Rolled, machine-flame cut, sawn and planed
Gap Between Beams (mm)	0.0
Are the Members Exposed to Corrosive Influences?	True



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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)		$V_{dy} = \frac{A_v f_y}{\sqrt{3} \gamma_{m0}}$ $= \frac{0.6 \times 368.0 \times 8.9 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 257.86$ <p>[Ref. IS 800:2007, Cl.10.4.3]</p>	Restricted to low shear
Plastic Moment Capacity (kNm)		$M_{dz} = \frac{\beta_b Z_{pz} f_y}{\gamma_{m0}}$ $= \frac{1 \times 1170000.0 \times 250}{1.1 \times 10^6}$ $= 265.91$ <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)	$V_y = 40.0$	$V_{y \min} = \min(0.15 V_{dy}, 40.0)$ $= \min(0.15 \times 257.86, 40.0)$ $= \min(38.68, 40.0)$ $= 38.68$ $V_u = \max(V_y, V_{y \min})$ <p>but, $\leq V_{dy}$</p> $= \max(40.0, 38.68)$ <p>but, ≤ 257.86</p> $= 40.0$ <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)		$P_x = 20.0$	OK
Bending Moment (kNm)	$M_z = 100.0$	$M_{z\min} = 0.5M_{dz}$ $= 0.5 \times 265.91$ $= 132.96$ $M_u = \max(M_z, M_{z\min})$ $\text{but, } \leq M_{dz}$ $= \max(100.0, 132.96)$ ≤ 265.91 $= 132.96$ [Ref. IS 800:2007, Cl.8.2.1.2]	Pass
Effective Bending Moment (kNm)		$M_{ue} = M_u + P_x \times \left(\frac{D}{2} - \frac{T}{2} \right) \times 10^{-3}$ $= 132.96 +$ $20.0 \times \left(\frac{400.0}{2} - \frac{16.0}{2} \right) \times 10^{-3}$ $= 136.8$	OK

2.3 Bolt Optimization

Check	Required	Provided	Remarks
Diameter (mm)	Bolt Diameter Optimization	$d = 16$	Pass
Property Class	Bolt Property Class Optimization	12.9	Pass
Hole Diameter (mm)		$d_0 = 18.0$	OK
No. of Bolt Columns		$n_c = 2$	Pass
No. of Bolt Rows		$n_r = 4$	Pass
Total No. of Bolts		$n = n_r X n_c = 8$	Pass



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2.4 Detailing

Check	Required	Provided	Remarks
Min. Pitch Distance (mm)	$p_{\min} = 2.5d$ $= 2.5 \times 16.0$ $= 40.0$ [Ref. IS 800:2007, Cl.10.2.2]	55	Pass
Max. Pitch Distance (mm)	$p_{\max} = \min(32t, 300)$ $= \min(32 \times 22.0, 300)$ $= \min(704.0, 300)$ $= 300$ Where, $t = \min(22.0, 22.0)$ [Ref. IS 800:2007, Cl.10.2.3]	55	Pass
Min. End Distance (mm)	$e_{\min} = 1.5d_0$ $= 1.5 \times 18.0$ $= 27.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	30	Pass
Max. End Distance (mm)	$e_{\max} = 40 + 4t$ Where, $t = \min(22.0, 22.0)$ $= 40 + (4 \times 22)$ $e_{\max} = 128.0$ [Ref. IS 800:2007, Cl.10.2.4.3]	30	Pass
Min. Edge Distance (mm)	$e'_{\min} = 1.5d_0$ $= 1.5 \times 18.0$ $= 27.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	30	Pass



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

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{\max} = 40 + 4t$ <p>Where, $t = \min(22.0, 22.0)$</p> $= 40 + (4 \times 22)$ $e'_{\max} = 128.0$ <p>[Ref. IS 800:2007, Cl.10.2.4.3]</p>	30	Pass
Cross-centre Gauge Distance (mm)		84	Pass

2.5 Critical Bolt Design

Check	Required	Provided	Remarks
Slip Resistance (kN)	$V_{sf} = \frac{V_u}{n}$ $= \frac{40.0}{8}$ $= 5.0$	$V_{dsf} = \frac{\mu_f n_e K_h F_o}{\gamma_{mf}}$ <p>Where, $F_o = 0.7 f_{ub} A_{nb}$</p> $V_{dsf} = \frac{0.48 \times 1 \times 1 \times 0.7 \times 1220.0 \times 157}{1.25 \times 10^3}$ $= 51.49$ <p>[Ref. IS 800:2007, Cl.10.4.3]</p>	Pass
Lever Arm (mm)	$r = [346.0, 38.0, 291.0, 93.0]$ <p>Note: r_1 is the first row inside tension/top flange, r_2 is the first row inside compression/bottom flange. Further row(s) are added in a symmetrical manner with odd rows placed near the tension/top flange and even row placed near the compression/bottom flange respectively.</p> <p>Note: The lever arm is computed by considering the N.A at the centre of the bottom flange. Rows with identical lever arm values mean they are considered acting as bolt group near the tension or compression flange.</p>		Pass



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

Check	Required	Provided	Remarks
Tension Due to Moment (kN)	$T_1 = \frac{M_{ue}}{n_c \times \left(r_1 + \sum_{i=2}^{n_r} \frac{r_i^2}{r_1} \right)}$ $= \frac{136.8 \times 10^3}{2 \times \left(346.0 + \sum_{i=2}^4 \frac{r_i^2}{346.0} \right)}$ $= 110.34$ <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)	$Q = \frac{l_v}{2l_e} \left[T_e - \frac{\beta \eta f_o b_e t^4}{27 l_e l_v^2} \right]$ $l_v = e - \frac{R_1}{2}$ $= 30 - \frac{14.0}{2} = 23.0 \text{ mm}$ $f_o = 0.7 f_{ub}$ $= 0.7 \times 1220.0$ $= 854.0 \text{ N/mm}^2$ $l_e = \min \left(e, 1.1 t \sqrt{\frac{\beta f_o}{f_y}} \right)$ $= \min \left(30, 1.1 \times 22 \times \sqrt{\frac{1 \times 854.0}{290}} \right)$ $= \min(30, 41.53) = 30 \text{ mm}$ $\beta = 1 \text{ (pre-tensioned bolt)}$ $\eta = 1.5$ $b_e = \frac{B}{n_c}$ $= \frac{140.0}{2} = 70.0 \text{ mm}$ $Q = \frac{23.0}{2 \times 30} \times \left[110.34 - \left(\frac{1 \times 1.5 \times 854.0 \times 70.0 \times 22^4}{27 \times 30 \times 23.0^2} \right) \times 10^{-3} \right]$ $Q = 23.5$ <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)	$T_f = T_1 + Q$ $= 110.34 + 23.5$ $= 133.84$	$T_f = 0.90 f_{ub} A_n / \gamma_{mf}$ $< f_{yb} A_{sb} (\gamma_{m1} / \gamma_{m0})$ $= \min \left(0.90 \times 1220.0 \times 157 / 1.25, \right.$ $\left. 1100.0 \times 201.0 \times (1.25/1.1) \right)$ $= \min(137.91, 251.25)$ $= 137.91$ [Ref. IS 800:2007, Cl.10.3.5]	Pass
Combined Capacity, (I.R.)	≤ 1	$\left(\frac{V_{sf}}{V_{df}} \right)^2 + \left(\frac{T_f}{T_{df}} \right)^2 \leq 1.0$ $\left(\frac{5.0}{51.49} \right)^2 + \left(\frac{133.84}{137.91} \right)^2 = 0.95$ [Ref. IS 800:2007, Cl.10.3.6]	Pass

2.6 Compression Flange Check

Check	Required	Provided	Remarks
Tension in Bolt Rows (kN)		$T = [110.34, 12.12, 92.8, 29.66]$	OK
Reaction at Compression Flange (kN)	$R_c = n_c \sum_{n_r=1}^{n_r} T_{n_r}$ $= 2 \times \sum_{n_r=1}^4 T_{n_r}$ $= 2 \times 244.92$ $= 489.84$	$F_c = A_g f_y / \gamma_{m0}$ $= \frac{B T f_y}{\gamma_{m0}}$ $= \frac{140.0 \times 16.0 \times 250}{1.1 \times 1000}$ $= 509.09$	Pass



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2.7 End Plate Checks

Check	Required	Provided	Remarks
Height (mm)		$H_p = D + 25$ $= 400.0 + 25$ $= 425.0$	Pass
Width (mm)		$B_p = B + 25$ $= 140.0 + 25$ $= 165.0$	Pass
Moment at Critical Section (kNm)		$M_{cr} = T_1 l_v - Q l_e$ $= (110.34 \times 23.0 - 23.5 \times 30) \times 10^{-3}$ $= 1.83$ 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)	$t_p = \sqrt{\frac{4M_{cr}}{b_e(f_y/\gamma_{m0})}}$ $= \sqrt{\frac{4 \times 1.83 \times 10^6}{70 \times (290/1.1)}}$ $= 19.93$	22	Pass
Moment Capacity (kNm)	1.83	$M_p = \left(\frac{b_e t_p^2}{4}\right) \times \frac{f_y}{\gamma_{m0}}$ $= \frac{70 \times 22^2}{4} \times \frac{290}{1.1} \times 10^{-6}$ $= 2.23$	Pass

2.8 Longitudinal Stiffener Design

Check	Required	Provided	Remarks
Width (mm)		$W_{st} = B_p - \frac{t}{2}$ $= 165.0 - \frac{8.9}{2}$ $= 78$	Pass
Length (mm)		$L_{st} = 2W_{st}$ $= 2 \times 78$ $= 156$	Pass
Thickness (mm)	$t = 8.9$	$t_{st} = 10$	Pass



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

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

2.9 Weld Design - Beam Web to End Plate Connection

Check	Required	Provided	Remarks
Weld Strength (N/mm ²)	$f_{uw} = \min(f_w, f_u)$ $= \min(450.0, 440)$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	$f_{uw} = 440$	Pass
Total Weld Length (mm)		$L_w = 2 \times [D - (2 \times T) - (2 \times R1) - 20]$ $= 2 \times [400.0 - (2 \times 16.0) - (2 \times 14.0) - 20]$ $= 640$ Note: Weld is provided on both sides of the web	
Weld Size (mm)	$t_w = \frac{V_u}{f_{uw} k L_w} \times \sqrt{3} \gamma_{mw}$ $= \frac{40.0 \times 10^3}{440 \times 0.7 \times 640} \times \sqrt{3} \times 1.25$ $= 0.44$ [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> $t_{\text{thicker}} = \max(22.0, 8.9)$ $= 22.0$ $t_{w\min} = 6$ <p>2) $t_{w\min}$ – based on thickness of the thinner part</p> $t_{\text{thinner}} = \min(22.0, 8.9)$ $= 8.9$ $t_{w\min} \leq \min(6, 8.9)$ <p>[Ref. IS 800:2007, Table 21, Cl 10.5.2.3]</p>	$t_w = \max(t_w, t_{w\min})$ $= \max(0.44, 6)$ $= 6$	Pass
Max. Weld Size (mm)	<p>$t_{w\max}$ based on thickness of the thinner part</p> $t_{\text{thinner}} = \min(22.0, 8.9)$ $= 8.9$ $t_{w\max} = 8.9$ <p>[Ref. IS 800:2007, Cl.10.5.3.1]</p>	$t_w \leq t_{w\max}$ $6 \leq 8.9$	Pass
Normal Stress (N/mm ²)		$f_a = \frac{H}{0.7t_w L_w}$ $= \frac{20.0 \times 10^3}{0.7 \times 6 \times 640}$ $= 7.44$ <p>[Ref. IS 800:2007, Cl.10.5.9]</p>	OK



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Check	Required	Provided	Remarks
Shear Stress (N/mm ²)		$q = \frac{V}{0.7t_w L_w}$ $= \frac{40.0 \times 10^3}{0.7 \times 6 \times 640}$ $= 14.88$ [Ref. IS 800:2007, Cl.10.5.9]	OK
Equivalent Stress (N/mm ²)	$f_e = \sqrt{f_a^2 + 3q^2}$ $= \sqrt{7.44^2 + (3 \times 14.88^2)}$ $= 25.92$ [Ref. IS 800:2007, Cl.10.5.10.1.1]	$f_w = \frac{f_u}{\sqrt{3}\gamma_{mw}}$ $= \frac{440}{\sqrt{3} \times 1.25}$ $= 203.23$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	Pass



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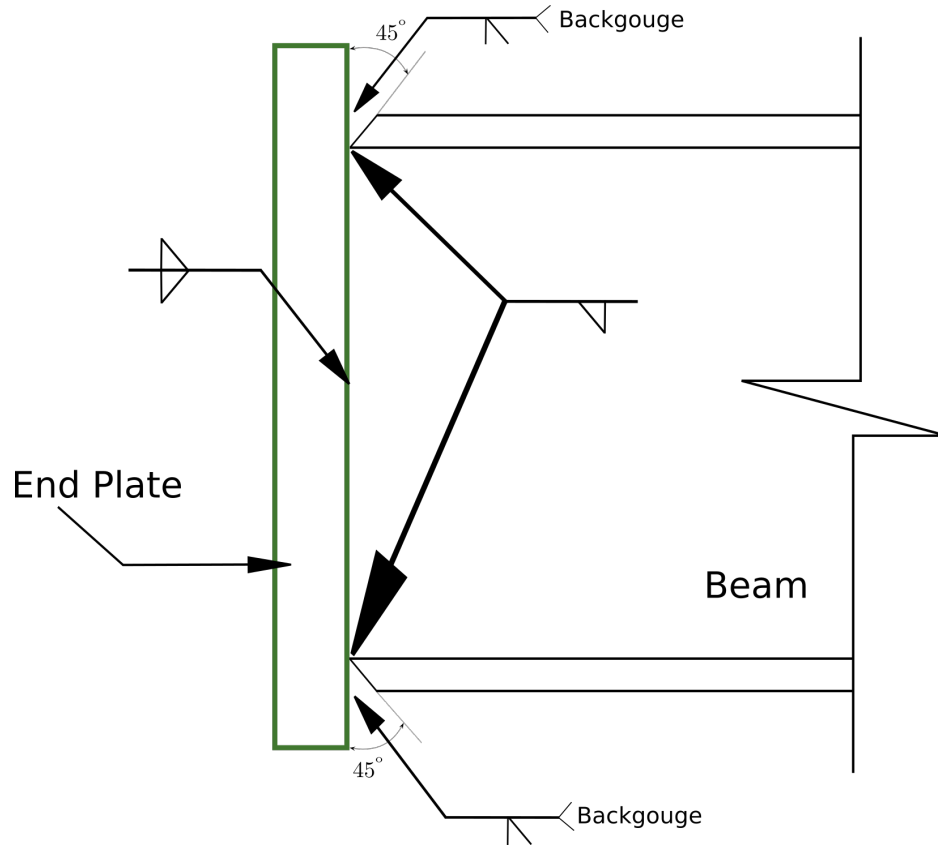


Figure 1: Typical Weld Details -- Beam to End Plate Connection

3 2D Drawings (Typical)

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Designer	Engineer#1	Job Number	1.2.1.2.1.1.2
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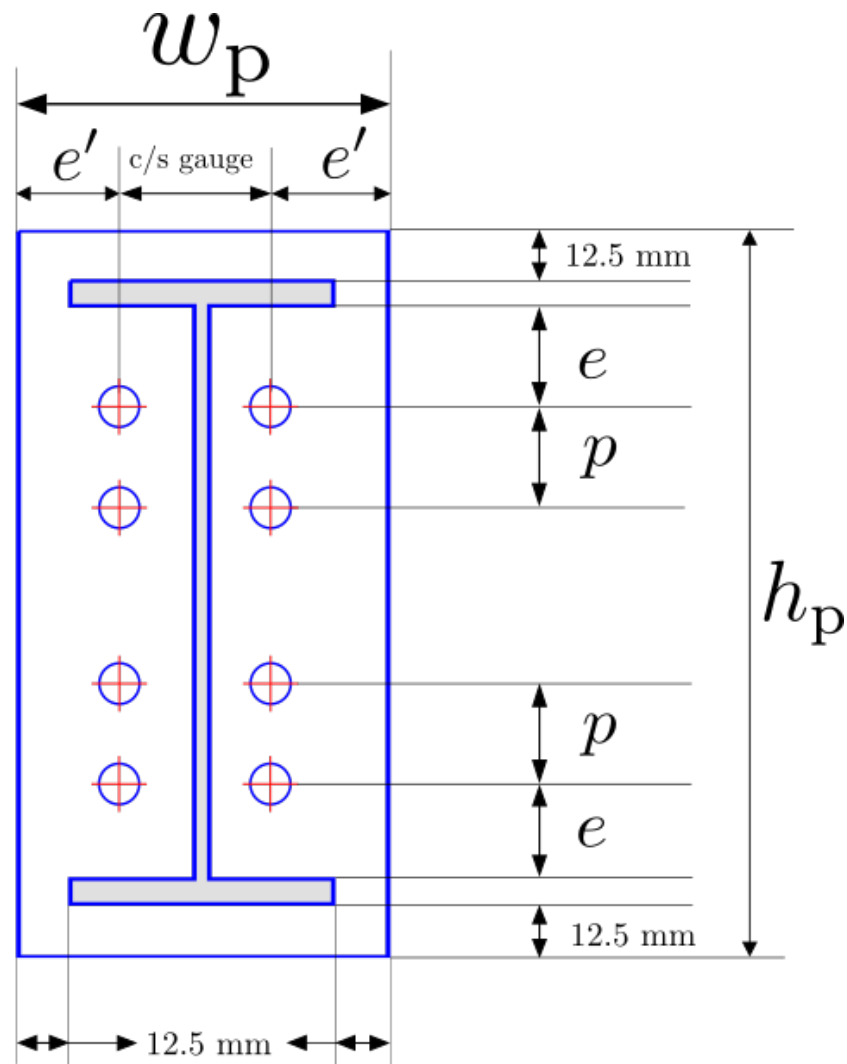


Figure 2: Typical Detailing



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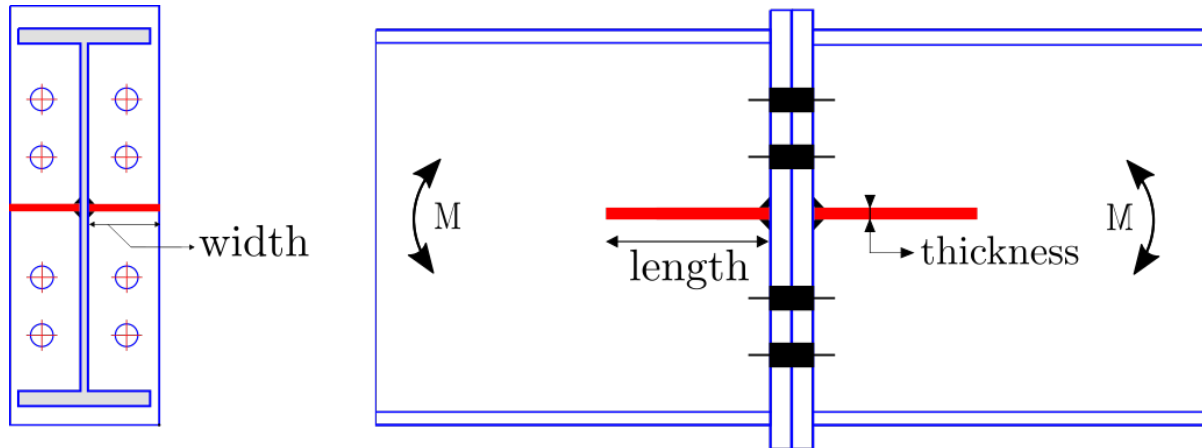
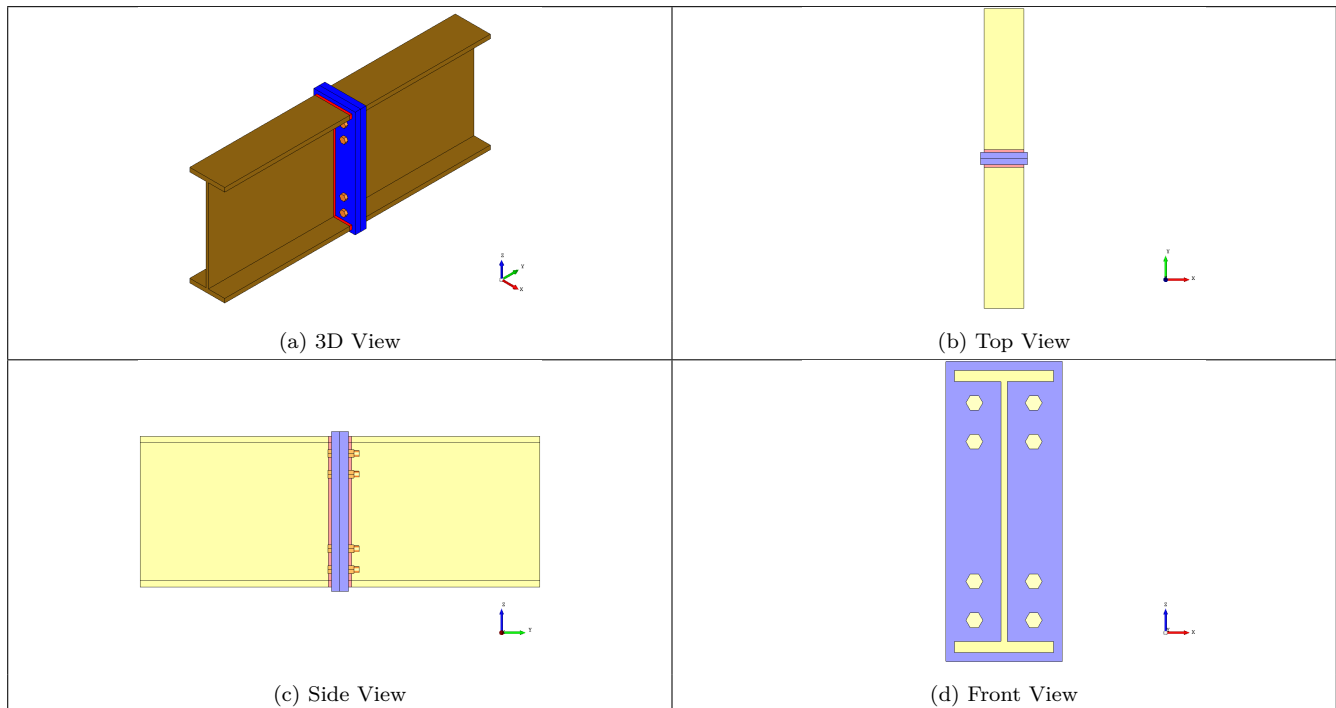




Figure 3: Typical Stiffener Details

4 3D Views



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Group/Team Name	Osdag	Subtitle	Beam-to-Beam End Plate
Designer	Engineer#1	Job Number	1.2.1.2.1.1.2
Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

5 Design Log

2021-02-04 13:23:57 - Osdag - WARNING - The Load(s) defined is/are less than the minimum recommended value [Ref. IS 800:2007, Cl.10.7].

2021-02-04 13:23:57 - Osdag - WARNING - [Minimum Factored Load] The external factored bending moment (100.0 kNm) is less than 0.5 times the plastic moment capacity of the beam (265.91 kNm)

2021-02-04 13:23:57 - 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 13:23:57 - 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 13:23:57 - Osdag - INFO - Designing the connection for a factored moment of 132.96 kNm

2021-02-04 13:23:57 - Osdag - INFO - [Bolt Design] Bolt diameter and grade combination ready to perform bolt design

2021-02-04 13:23:57 - Osdag - INFO - The solver has selected 1 combinations of bolt diameter and grade to perform optimum bolt design in an iterative manner

2021-02-04 13:23:57 - 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 13:23:57 - 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 13:23:57 - Osdag - INFO - [Flange Strength] The reaction at the compression flange of the beam 489.84 kN is less than the flange capacity 509.09 kN. The flange strength requirement is satisfied.

2021-02-04 13:23:57 - Osdag - INFO - [End Plate] The end plate of 22.0 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 13:23:57 - Osdag - INFO - [Bolt Design] The bolt of 16.0 mm diameter and 12.9 grade passes the tension check

2021-02-04 13:23:57 - Osdag - INFO - Total tension demand on bolt (due to direct tension + prying action) is 133.84 kN and the bolt tension capacity is (137.91 kN)

2021-02-04 13:23:57 - Osdag - INFO - [Bolt Design] The bolt of 16.0 mm diameter and 12.9 grade passes the combined shear + tension check

2021-02-04 13:23:57 - Osdag - INFO - The Interaction Ratio (IR) of the critical bolt is 0.951

2021-02-04 13:23:57 - Osdag - INFO - : ===== Design Status =====

2021-02-04 13:23:57 - Osdag - INFO - : Overall beam to beam end plate splice connection design is SAFE

2021-02-04 13:23:57 - Osdag - INFO - : ===== End Of Design =====