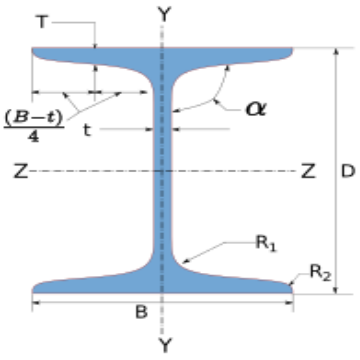
Company Name	IIT Bombay	Project Title	Moment Connection
Group/Team Name	Osdag	Subtitle	Beam-to-Column End Plate
Designer	Engineer#1	Job Number	1.2.2.1.1.2.1
Date	04 /02 /2021	Client	Mr. Yogesh D Pisal, Mumbai

1 Input Parameters

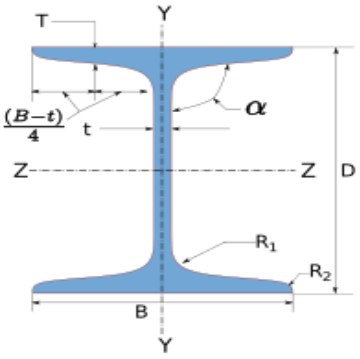
Main Module	Moment Connection
Module	Beam-to-Column End Plate Connection
Connectivity	Column Flange-Beam Web
End Plate Type	Extended One Way - Irreversible Moment
Bending Moment (kNm)	210.0
Shear Force (kN)	40.0
Axial Force (kN)	15.0

Column Section - Mechanical Properties



Column Section		HB 450	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, Fu (MPa)		410	
Yield Strength, Fy (MPa)		250	
Mass, m (kg/m)	87.22	I_z (cm^4)	39200.0
Area, A (cm^2)	111.0	I_y(cm^4)	2980.0
D (mm)	450.0	r_z (cm)	18.7
B (mm)	250.0	r_y (cm)	5.18
t (mm)	9.8	Z_z (cm^3)	1740.0
T (mm)	13.7	Z_y (cm^3)	238.0
Flange Slope	94	Z_{pz} (cm^3)	1950.0
R_1 (mm)	15.0	Z_{py} (cm^3)	394.0
R_2 (mm)	7.5		

Beam Section - Mechanical Properties



Beam Section		WB 450	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, F_u (MPa)		410	
Yield Strength, F_y (MPa)		250	
Mass, m (kg/m)	79.52	I_z (cm^4)	35100.0
Area, A (cm^2)	101.0	I_y(cm^4)	1700.0
D (mm)	450.0	r_z (cm)	18.6
B (mm)	200.0	r_y (cm)	4.1
t (mm)	9.2	Z_z (cm^3)	1560.0
T (mm)	15.4	Z_y (cm^3)	170.0
Flange Slope	96	Z_{pz} (cm^3)	1760.0

	R_1 (mm)	15.0	Z_{py} (cm^3)	284.0
	R_2 (mm)	7.0		

Plate Details - Input and Design Preference	
Thickness (mm)	[16, 18, 20, 22]
Material	E 250 (Fe 410 W)A
Ultimate Strength, Fu (MPa)	410
Yield Strength, Fy (MPa)	250
Bolt Details - Input and Design Preference	
Diameter (mm)	[20, 24, 30]
Property Class	[6.8, 8.8, 9.8]
Type	Bearing Bolt
Bolt Tension	Non pre-tensioned
Hole Type	Standard
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
Continuity Plate	Fillet Weld
Detailing - Design Preference	
Edge Preparation Method	Sheared or hand flame cut
Gap Between Members (mm)	0.0
Are the Members Exposed to Corrosive Influences?	False

2 Design Checks

Design Status	Pass

2.1 Beam to Column - Compatibility Check

Check	Required	Provided	Remarks
Beam Section Compatibility	$B_{req} = B_b + 25$ $= 200.0 + 25$ $= 225.0$	$B_{available} = B_c$ $= 250.0$	Compatible

2.2 Member Capacity - Supported Section

Check	Required	Provided	Remarks
Shear Capacity (kN)		$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{0.6 \times 419.2 \times 9.2 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 303.63$ [Ref. IS 800:2007, Cl.10.4.3]	Restricted to low shear
Plastic Moment Capacity (kNm)		$M_{dz} = \frac{\beta_b Z_{pz} fy}{\gamma_{m0}}$ $= \frac{1.0 \times 1760000.0 \times 250}{1.1 \times 10^6}$ $= 400.0$ [Ref. IS 800:2007, Cl.8.2.1.2]	V < 0.6 Vdy

2.3 Member Capacity - Supporting Section

Check	Required	Provided	Remarks
Plastic Moment Capacity (kNm)		$M_{dz} = \frac{\beta_b Z_{pz} fy}{\gamma_{m0}}$ $= \frac{0.89 \times 1950000.0 \times 250}{1.1 \times 10^6}$ $= 395.45$ Note: The capacity of the section is not based on the beam-colum or column design. The actual capacity might vary. [Ref. IS 800:2007, Cl.8.2.1.2]	Semi-compact
Plastic Moment Capacity (kNm)		$M_{dy} = \frac{\beta_b Z_{py} fy}{\gamma_{m0}}$ $= \frac{0.6 \times 394000.0 \times 250}{1.1 \times 10^6}$ $= 54.09$ Note: The capacity of the section is not based on the beam-colum or column design. The actual capacity might vary. [Ref. IS 800:2007, Cl.8.2.1.2]	Semi-compact

2.4 Load Consideration

Check	Required	Provided	Remarks
Axial Force (kN)		$P_x = 15.0$	OK

Check	Required	Provided	Remarks
Shear Force (kN)	$V_y = 40.0$	$V_{y_{min}} = \min(0.15V_{d_y},\ 40.0)$ $= \min(0.15 \times 303.63,\ 40.0)$ $= \min(45.54,\ 40.0)$ $= 40.0$ $V_u = \max(V_y,\ V_{y_{min}})$ but, $\leq V_{dy}$ $= \max(40.0,\ 40.0)$ but, ≤ 303.63 $= 40.0$ [Ref. IS 800:2007, Cl.10.7]	**Pass**
Bending Moment (major axis) (kNm)	$M_z = 210.0$	$M_{z_{min}} = 0.5M_{d_z}$ $= 0.5 \times 400.0$ $= 200.0$ $M_u = \max(M_z,\ M_{z_{min}})$ but, $\leq M_{d_z}$ of the column section $= \max(210.0, 200.0)$ ≤ 395.45 $= 210.0$ [Ref. IS 800:2007, Cl.8.2.1.2]	**Pass**
Effective Bending Moment (major axis) (kNm)		$M_{ue} = M_u + P_x \times \left(\frac{D}{2} - \frac{T}{2}\right) \times 10^{-3}$ $= 210.0 +$ $15.0 \times \left(\frac{450.0}{2} - \frac{15.4}{2}\right) \times 10^{-3}$ $= 213.26$	**OK**

2.5 Bolt Optimization

Check	Required	Provided	Remarks
Diameter (mm)	Bolt Diameter Optimization	$d = 20$	Pass
Property Class	Bolt Property Class Optimization	6.8	Pass
Hole Diameter (mm)		$d_0 = 22.0$	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

2.6 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)	$p_{\max} = \min(32t,\ 300)$ $= \min(32 \times 16.0,\ 300)$ $= \min(512.0,\ 300)$ $= 300$ Where, $t = \min(16.0, 16.0)$ [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

Check	Required	Provided	Remarks
Max. End Distance (mm)	$e_{max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 16.0 \times \sqrt{\frac{250}{250}} = 192.0$ $e_2 = 12 \times 16.0 \times \sqrt{\frac{250}{250}} = 192.0$ $e_{max} = \min(e_1,\ e_2) = 192.0$ [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**
Max. Edge Distance (mm)	$e'_{max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 16.0 \times \sqrt{\frac{250}{250}} = 192.0$ $e_2 = 12 \times 16.0 \times \sqrt{\frac{250}{250}} = 192.0$ $e'_{max} = min(e_1,\ e_2) = 192.0$ [Ref. IS 800:2007, Cl.10.2.4.3]	40	**Pass**
Cross-centre Gauge Distance (mm)		106	**Pass**

2.7 Critical Bolt Design

Check	Required	Provided	Remarks

Check	Required	Provided	Remarks
Shear Capacity (kN)		$V_{dsb} = \frac{f_{ub} n_n A_{nb}}{\sqrt{3}\gamma_{mb}}$ $= \frac{600.0 \times 1 \times 245}{1000 \times \sqrt{3} \times 1.25}$ $= 67.9$ [Ref. IS 800:2007, Cl.10.3.3]	OK
Kb		$k_b = \min\left(\frac{e}{3d_0}, \frac{p}{3d_0} - 0.25, \frac{f_{ub}}{f_u}, 1.0\right)$ $= \min\left(\frac{40}{3 \times 22.0}, \frac{70}{3 \times 22.0} - 0.25, \frac{600.0}{410}, 1.0\right)$ $= \min(0.61, 0.81, 1.46, 1.0)$ $= 0.61$ [Ref. IS 800:2007, Cl.10.3.4]	OK
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5 k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.61 \times 20.0 \times 16.0 \times 410}{1000 \times 1.25}$ $= 160.06$ [Ref. IS 800:2007, Cl.10.3.4]	OK
Bolt Capacity (kN)		$V_{db} = \min(V_{dsb}, V_{dpb})$ $= \min(67.9, 160.06)$ $= 67.9$ [Ref. IS 800:2007, Cl.10.3.2]	

Check	Required	Provided	Remarks
Large Grip Length Reduction Factor		$l_g = \sum \left(t_p + t_{\text{member}}\right)$ $= \sum \left(16.0 + 13.7\right)$ $= 29.7$ 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)		$V_{\text{db}} = V_{\text{db}}\beta_{lg}$ $= 67.9 \times 1.0$ $= 67.9$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3.2]$	**OK**
Shear Demand (per bolt) (kN)	$V_{sb} = \frac{V_u}{n}$ $= \frac{40.0}{8}$ $= 5.0$	$V_{db} = 67.9$	**Pass**
Lever Arm (mm)	$r = [434.6, 434.6, 47.7, 364.6]$ 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, row(s) r_5 and beyond are rows inside the flange. 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.		**Pass**

Check	Required	Provided	Remarks
Tension Due to Moment (kN)	$T_1 = \frac{M_{ue}}{2 \times n_c \times \left(r_1 + \sum_{i=3}^{n_r} \frac{r_i^2}{r_1} \right)}$ $= \frac{213.26 \times 10^3}{2 \times 2 \times \left(434.6 + \sum_{i=3}^{4} \frac{r_i^2}{434.6} \right)}$ $= 71.5$ Note: T_1 is the tension in the critical bolt. The critical bolt is the bolt nearest to the tension flange.		OK

Check	Required	Provided	Remarks
Prying Force (kN)	$Q = \frac{l_v}{2l_e}\left[T_e - \frac{\beta\eta f_o b_e t^4}{27 l_e l_v^2}\right]$ $l_v = e - \frac{R_1}{2}$ $= 40 - \frac{15.0}{2} = 32.5$ mm $f_o = 0.7 f_{ub}$ $= 0.7 \times 600.0$ $= 420.0$ N/mm^2 $l_e = \min\left(e, 1.1t\sqrt{\frac{\beta f_o}{f_y}}\right)$ $= \min\left(40, 1.1 \times 16 \times \sqrt{\frac{2 \times 420.0}{250}}\right)$ $= \min(40,\ 32.26) = 32.26$ mm $\beta = 2$ (non pre-tensioned bolt) $\eta = 1.5$ $b_e = \frac{B}{n_c}$ $= \frac{200.0}{2} = 100.0$ mm $Q = \frac{32.5}{2 \times 32.26} \times$ $\left[71.5 - \left(\frac{2 \times 1.5 \times 420.0 \times 100.0 \times 16^4}{27 \times 32.26 \times 32.5^2}\right) \times 10^{-3}\right]$ $Q = 31.49$ [Ref. IS 800:2007, Cl.10.4.7]		OK

Check	Required	Provided	Remarks
Tension Demand (kN)	$T_b = T_1 + Q$ $= 71.5 + 31.49$ $= 102.99$	$T_{\text{db}} = 0.90 f_{ub} A_n \ / \ \gamma_{mb}$ $< \ f_{yb} A_{sb} (\gamma_{mb} \ / \ \gamma_{m0})$ $= \min \left(0.90 \times 600.0 \times 245 \ / \ 1.25, \right.$ $\left. 480.0 \times 314.0 \times (1.25/1.1) \right)$ $= \min(105.84, \ 171.27)$ $= 105.84$ [Ref. IS 800:2007, Cl.10.3.5]	Pass
Combined Capacity (I.R.)	≤ 1	$\left(\frac{V_{sb}}{V_{\text{db}}}\right)^2 + \left(\frac{T_{\text{b}}}{T_{\text{db}}}\right)^2 \leq 1.0$ $\left(\frac{5.0}{67.9}\right)^2 + \left(\frac{102.99}{105.84}\right)^2 = 0.95$ [Ref. IS 800:2007, Cl.10.3.6]	Pass

2.8 Compression Flange Check

Check	Required	Provided	Remarks
Tension in Bolt Rows (kN)		$T = [71.5, 71.5, 15.69, 119.96]$	OK
Reaction at Compression Flange (kN)	$R_c = n_c \sum_{n_r=1}^{n_r} T_{n_r}$ $= 2 \times \sum_{n_r=1}^{4} T_{n_r}$ $= 2 \times 278.65$ $= 557.3$	$F_c = A_g f_y \ / \ \gamma_{m0}$ $= \frac{BTf_y}{\gamma_{m0}}$ $= \frac{200.0 \times 15.4 \times 250}{1.1 \times 1000}$ $= 700.0$	Pass

2.9 End Plate Checks

Check	Required	Provided	Remarks
Height (mm)		$H_p = D + 12.5 + (2 \times e)$ $= 450.0 + 12.5 + (2 \times 40)$ $= 542.5$	**Pass**
Width (mm)		$B_p = B + 25$ $= 200.0 + 25$ $= 225.0$	**Pass**
Moment at Critical Section (kNm)		$M_{cr} = T_1\ l_v - Q\ l_e$ $= (71.5 \times 32.5 - 31.49 \times 32.26) \times 10^{-3}$ $= 1.31$ 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)	$t_p = \sqrt{\frac{4M_{cr}}{b_e(f_y/\gamma_{m0})}}$ $= \sqrt{\frac{4 \times 1.31 \times 10^6}{100 \times (250/1.1)}}$ $= 15.17$	16	**Pass**
Moment Capacity (kNm)	1.31	$M_p = \left(\frac{b_e t_p^2}{4}\right) \times \frac{f_y}{\gamma_{m0}}$ $= \frac{100 \times 16^2}{4} \times \frac{250}{1.1} \times 10^{-6}$ $= 1.45$	**Pass**

2.10 Stiffener Design

Check	Required	Provided	Remarks
Height (mm)		$H_{st} = H_p - D - 12.5$ $= 542.5 - 450.0 - 12.5$ $= 80.0$	**80.0**
Length (mm)		$L_{st} = \frac{H_{st}}{\tan 30^\circ}$ $= \frac{80.0}{\tan 30^\circ}$ $= 140$	**Pass**
Thickness (mm)	$t = 9.2$	$t_{st} = 10$	**Pass**

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

2.11 Weld Design - Beam Web to End Plate Connection

Check	Required	Provided	Remarks
Weld Strength (N/mm2)	$f_{u_w} = \min(f_w,\ f_u)$ $= \min(410.0,\ 410)$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	$f_{u_w} = 410.0$	Pass
Total Weld Length (mm)		$L_w = 2 \times \left[D - (2 \times T) - (2 \times R1) - 20\right]$ $= 2 \times \left[450.0 - (2 \times 15.4) - (2 \times 15.0) - 20\right]$ $= 729.2$ Note: Weld is provided on both sides of the web	OK
Weld Size (mm)	$t_w = \frac{V_u}{f_{uw} k L_w} \times \sqrt{3}\ \gamma_{mw}$ $= \frac{40.0 \times 10^3}{410.0 \times 0.7 \times 729.2} \times \sqrt{3} \times 1.25$ $= 0.41$ [Ref. IS 800:2007, Cl.10.5.7]	6	Pass

Check	Required	Provided	Remarks
Min. Weld Size (mm)	1) $t_{w\,\min}$ – based on thickness of the thicker part $t_{\text{thicker}} = \max(16.0,\ 9.2)$ $= 16.0$ $t_{w\,\min} = 5$ 2) $t_{w\,\min}$ – based on thickness of the thinner part $t_{\text{thinner}} = \min(16.0,\ 9.2)$ $= 9.2$ $t_{w\,\min} \leq \min(5,\ 9.2)$ [Ref. IS 800:2007, Table 21, Cl 10.5.2.3]	$t_w = \max(t_w,\ t_{w\,\min})$ $= \max(0.41,\ 5)$ $= 6$	**Pass**
Max. Weld Size (mm)	$t_{w\,\max}$ based on thickness of the thinner part $t_{\text{thinner}} = \min(16.0,\ 9.2)$ $= 9.2$ $t_{w\,\max} = 9.2$ [Ref. IS 800:2007, Cl.10.5.3.1]	$t_w \leq t_{w\,\max}$ $6 \leq 9.2$	**Pass**
Normal Stress (N/mm2)		$f_a = \dfrac{H}{0.7 t_w L_w}$ $= \dfrac{15.0 \times 10^3}{0.7 \times 6 \times 729.2}$ $= 4.9$ [Ref. IS 800:2007, Cl.10.5.9]	

Check	Required	Provided	Remarks
Shear Stress (N/mm2)		$q = \frac{V}{0.7 t_w L_w}$ $= \frac{40.0 \times 10^3}{0.7 \times 6 \times 729.2}$ $= 13.06$ [Ref. IS 800:2007, Cl.10.5.9]	
Equivalent Stress (N/mm2)	$f_e = \sqrt{f_a^2 + 3q^2}$ $= \sqrt{4.9^2 + (3 \times 13.06^2)}$ $= 22.73$ [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**

2.12 Continuity Plate Check - Compression Flange

Check	Required	Provided	Remarks
Local Web Yielding Capacity (kN)		$P_{cw_1} = \frac{f_{wc}\ (5k + T_b)}{\gamma_{m0}}$ $k = T_c + R_{1c}$ $= 13.7 + 15.0$ $= 28.7$ $f_{wc} = f_{yc} t_c$ $= 250.0 \times 9.8$ $= 2450.0$ $P_{cw_1} = \frac{2450.0 \times ((5 \times 28.7) + 15.4)}{1.1 \times 1000}$ $= 353.91$ Note: subscript c denotes column section, and, subscript b denotes beam section	**OK**

Check	Required	Provided	Remarks
Web Compression Buckling Capacity (kN)		$P_{cw_2} = 10710 \left(\frac{t_c^3}{h_c}\right) \sqrt{\frac{f_{yc}}{\gamma_{m0}}}$ $h_c = D_c - (2k)$ $= 450.0 - (2 \times 28.7)$ $= 392.6$ $P_{cw_2} = 10710 \times \frac{9.8^3}{392.6} \times \sqrt{\frac{250.0}{1.1}} \times 10^{-3}$ $= 387.07$	OK
Web Crippling Capacity (kN)		$P_{cw_3} = \left(\frac{300 t_c^2}{\gamma_{m1}}\right) \left[1 + 3\left(T_b/D_c\right)\left(t_c/T_c\right)^{1.5}\right] \sqrt{f_{yc}\left(T_c/t_c\right)}$ $= \left(\frac{300 \times 9.8^2}{1.25}\right) \times \left[1 + 3 \times \left(15.4/450.0\right) \times \left(9.8/13.7\right)^{1.5}\right] \times \sqrt{250.0 \times \left(13.7/9.8\right)} \times 10^{-3}$ $= 457.67$	OK
Compression Strength (kN)		$P_{cw} = \min(P_{cw_1},\ P_{cw_2},\ P_{cw_3})$ $= \min(353.91,\ 387.07,\ 457.67)$ $= 353.91$	OK
Continuity Plate Required?	$R_c = 557.3$	$P_{cw} = 353.91$	Yes

2.13 Continuity Plate Design - Compression Flange

Check	Required	Provided	Remarks
Area Required (mm2)	$A_{cp} = \frac{R_c - P_{cw}}{f_{y_{cp}} \gamma_{m0}}$ $= \frac{\left(557.3 - 353.91\right) \times 10^3}{250 \times 1.1}$ $= 739.6$		OK
Notch Size (mm)		$n = 24$	OK

Check	Required	Provided	Remarks
Length (mm)		l_{cp1} = Outer length $l_{cp1} = D_c - 2T_c$ $= 450.0 - (2 \times 13.7)$ $= 422.6$ l_{cp2} = Inner length $l_{cp2} = D_c - 2(T_c + n)$ $= 450.0 - \left[2 \times (13.7 + 24)\right]$ $= 374.6$	OK
Width (mm)		$w_{cp} = \frac{B_c - T_c - 2n}{2}$ $= \frac{250.0 - 9.8 - 2 \times 24}{2}$ $= 96.0$	OK

Check	Required	Provided	Remarks
Thickness (mm)	t_{cp1} = Minimum area criteria $t_{cp1} = \frac{A_{cp}/2}{w_{cp}}$ $= \frac{739.6/2}{96.0}$ $= 3.85$ t_{cp2} = Limiting b/t ratio criteria $t_{cp2} = \frac{l_{cp1}}{29.3\ \epsilon_{cp}}$ $\epsilon_{cp} = \sqrt{\frac{250}{f_{y_{cp}}}}$ $= \sqrt{\frac{250}{250}}$ $= 1.0$ $= \frac{422.6}{29.3 \times 1.0}$ $= 14.42$ t_{cp3} = Minimum thickness criteria $t_{cp3} = T_b$ $= 15.4$ $t_{cp} = \max(t_{cp1},\ t_{cp2},\ t_{cp3})$ $= \max(3.85, 14.42, 15.4)$ $= 15.4$	16	**Pass**

2.14 Continuity Plate Check - Tension Flange

Check	Required	Provided	Remarks
Continuity Plate Required?	$= 0.4\sqrt{\frac{B_b T_b}{\gamma_{m0}}}$ $= 0.4\sqrt{\frac{200.0 \times 15.4}{1.1}}$ $= 21.17$	$T_c = 13.7$	Yes

2.15 Continuity Plate Design - Tension Flange

Check	Required	Provided	Remarks
Notch Size (mm)		$n = 24$	OK
Length (mm)		l_{cp1} = Outer length $l_{cp1} = D_c - 2T_c$ $= 450.0 - (2 \times 13.7)$ $= 422.6$ l_{cp2} = Inner length $l_{cp2} = D_c - 2(T_c + n)$ $= 450.0 - \left[2 \times (13.7 + 24)\right]$ $= 374.6$	OK
Width (mm)		$w_{cp} = \frac{B_c - T_c - 2n}{2}$ $= \frac{250.0 - 9.8 - 2 \times 24}{2}$ $= 96.0$	OK

Check	Required	Provided	Remarks
Thickness (mm)	t_{st1} = Minimum area criteria $t_{st1} = \frac{A_{cp}/2}{w_{cp}}$ $= \frac{739.6/2}{96.0}$ $= 3.85$ t_{st2} = Minimum thickness criteria $t_{st2} = T_b$ $= 15.4$ $t_{st} = \max(t_{st1},\ t_{st2})$ $= \max(3.85,\ 15.4)$ $= 15.4$	16	Pass

2.16 Weld Design - Continuity Plate

Check	Required	Provided	Remarks
Weld Strength (N/mm2)	$f_{uw} = \min(f_w,\ f_{ucp})$ $= \min(410.0,\ 410)$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.1.1$]	$f_{u_w} = 410.0$	Pass
Total (effective) Weld Length (mm)		$L_{wcp} = 364.8$ Note: Provide weld on one side of the continuity plate	OK
Weld Size (mm)	$t_{wcp} = \frac{V_{cp}/2}{f_{uw} k L_{wcp}} \times \sqrt{3}\gamma_{mw}$ $= \frac{R_c - P_{cw}}{2 \times f_{uw} k L_{wcp}} \times \sqrt{3}\gamma_{mw}$ $= \frac{(557.3 - 353.91) \times 10^3}{2 \times 410.0 \times 0.7 \times 364.8} \times \sqrt{3} \times 1.25$ $= 2.1$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7$]	5	Pass

Check	Required	Provided	Remarks
Min. Weld Size (mm)	1) $t_{w\min}$– based on thickness of the thicker part $t_{\text{thicker}} = \max(16,\ 9.8)$ $= 16$ $t_{w\min} = 5$ 2) $t_{w\min}$– based on thickness of the thinner part $t_{\text{thinner}} = \min(16,\ 9.8)$ $= 9.8$ $t_{w\min} \leq \min(5,\ 9.8)$ [Ref. IS 800:2007, Table 21, Cl 10.5.2.3]	$t_w = \max(t_w,\ t_{w\min})$ $= \max(2.1,\ 5)$ $= 5$	Pass
Max. Weld Size (mm)	$t_{w\max}$ based on thickness of the thinner part $t_{\text{thinner}} = \min(16,\ 9.8)$ $= 9.8$ $t_{w\max} = 10$ [Ref. IS 800:2007, Cl.10.5.3.1]	$t_w \leq t_{w\max}$ $5 \leq 10$	Pass

2.17 Column Web Shear Check

Check	Required	Provided	Remarks
Web Stiffener Plate Required?	$t_{wc} = \dfrac{1.9M_{ue}}{D_c D_b f_{yc}}$ $= \dfrac{1.9 \times 213.26}{450.0 \times 450.0 \times 250.0}$ $= 8.0$	$t_c = 9.8$	No

Company Name	IIT Bombay	Project Title	Moment Connection
Group/Team Name	Osdag	Subtitle	Beam-to-Column End Plate
Designer	Engineer#1	Job Number	1.2.2.1.1.2.1
Date	04 /02 /2021	Client	Mr. Yogesh D Pisal, Mumbai

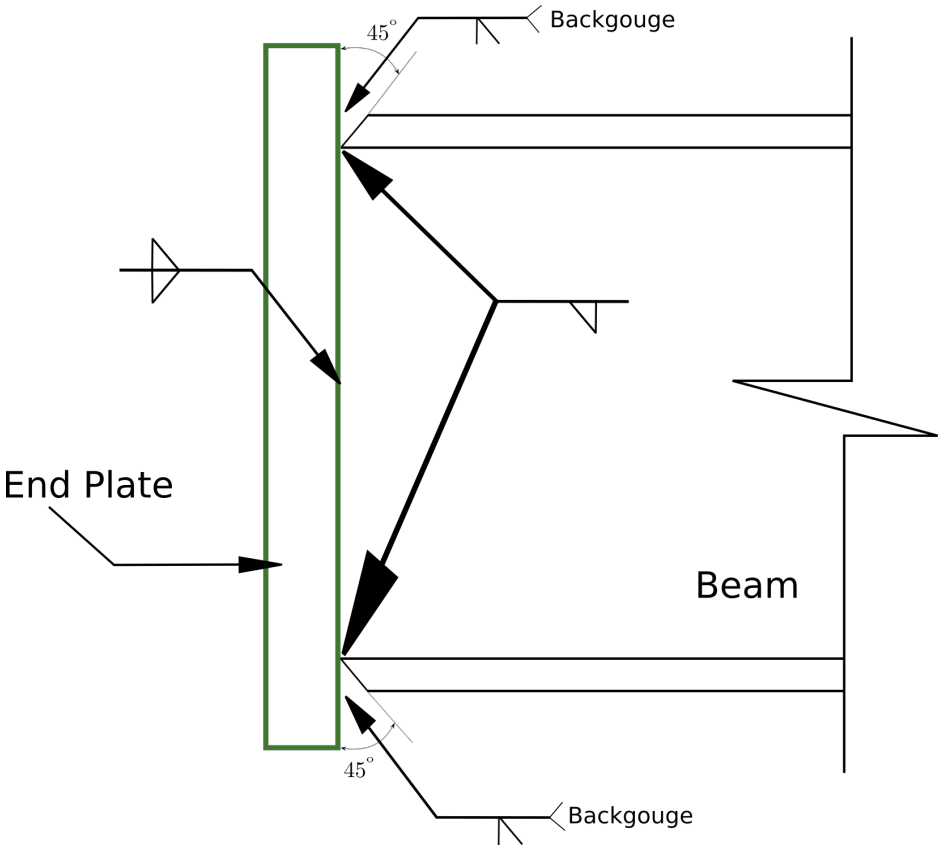


Figure 1: Typical Weld Details -- Beam to End Plate Connection

3 2D Drawings (Typical)

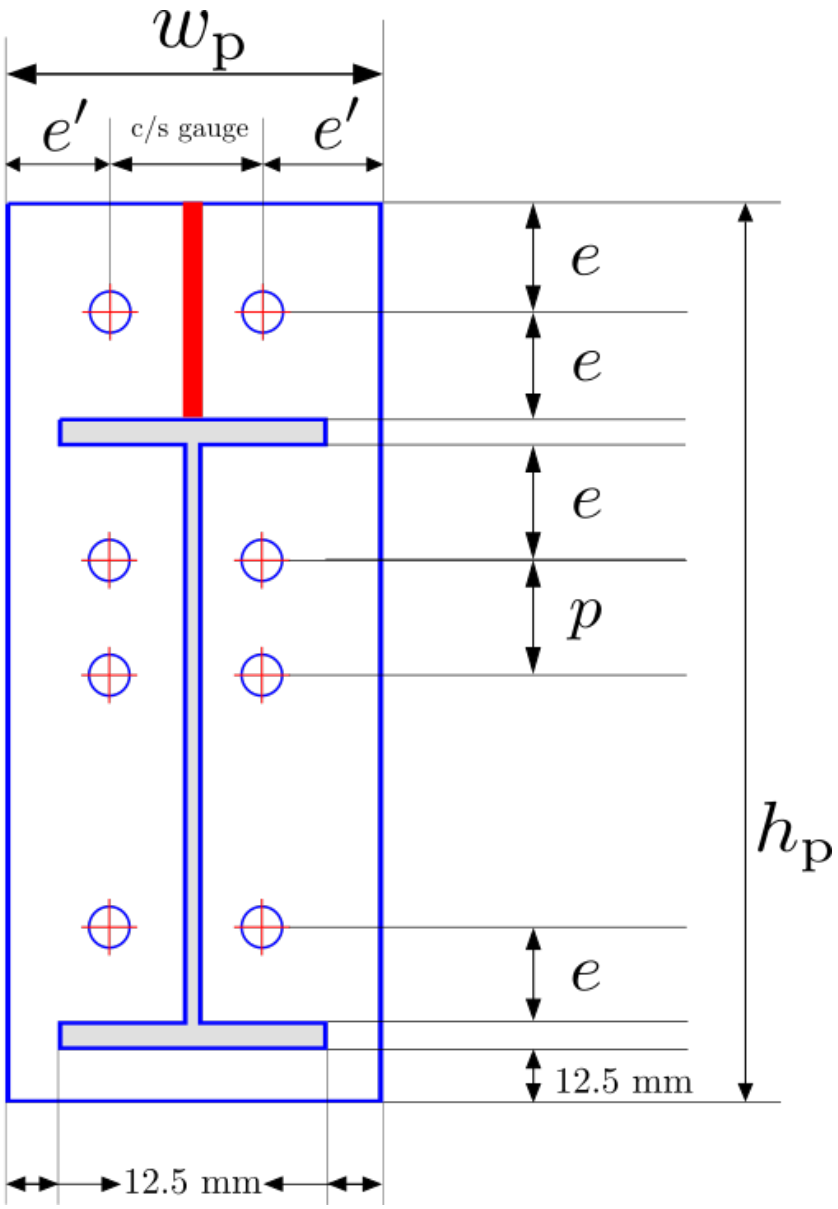


Figure 2: Typical Detailing

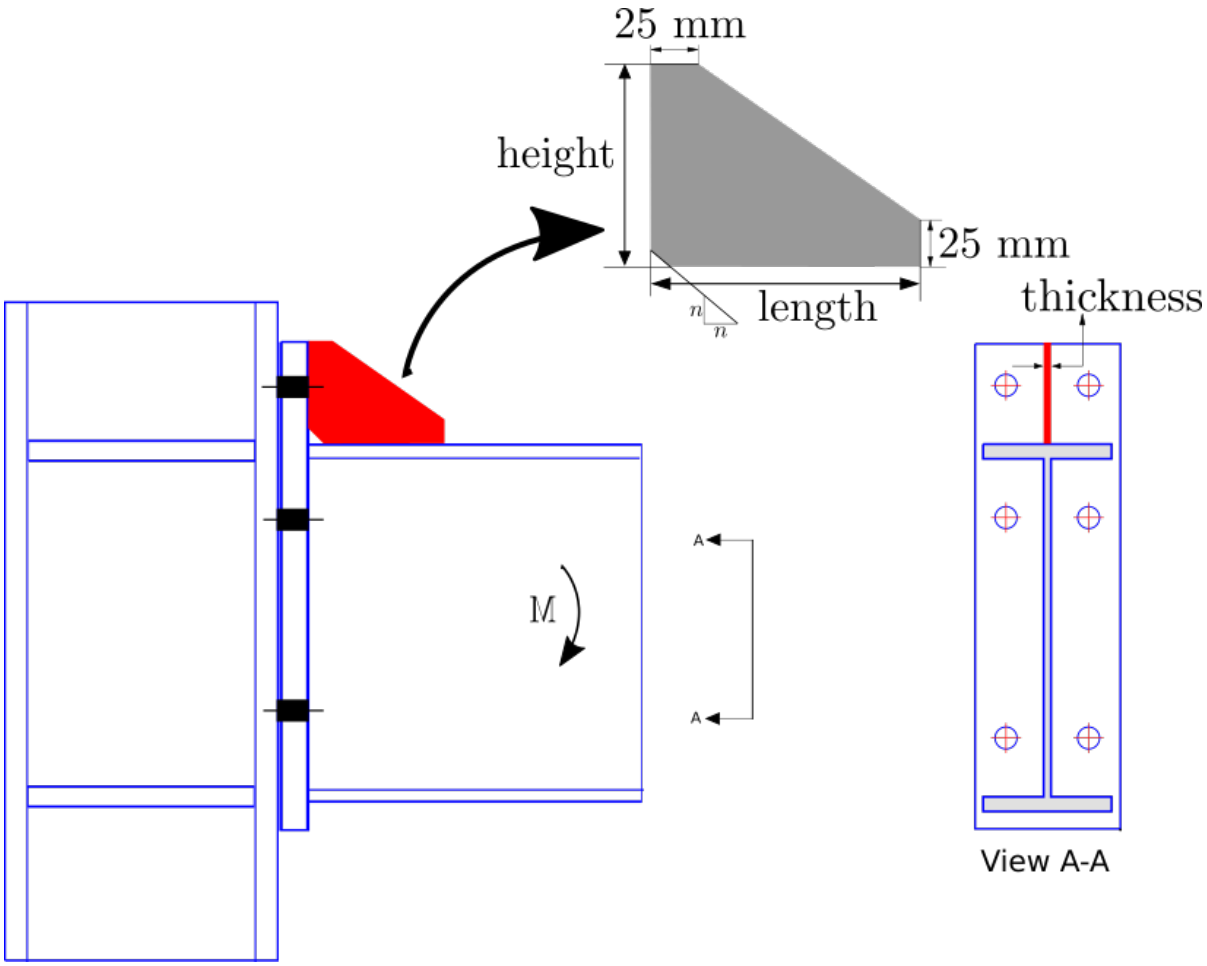
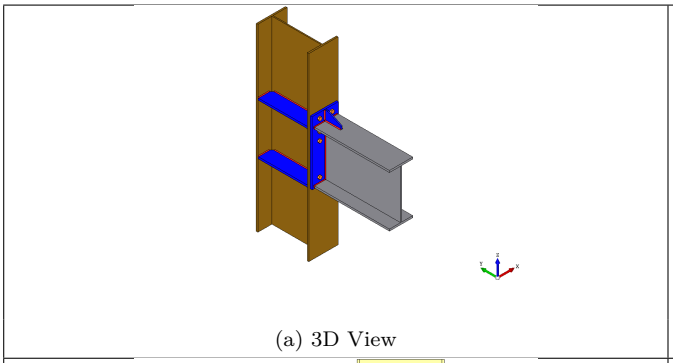
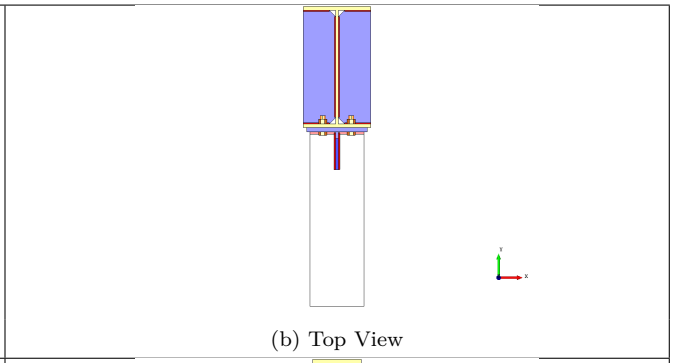


Figure 3: Typical Stiffener Details

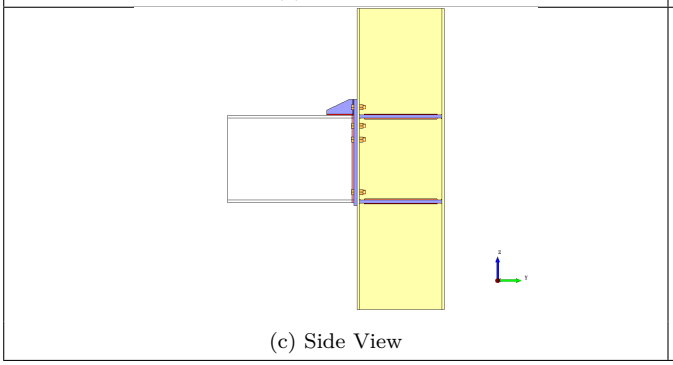
4 3D Views



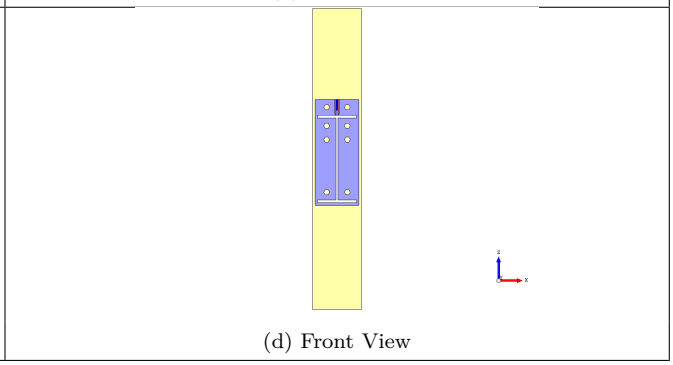
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

5 Design Log

2021-02-04 13:49:19 - Osdag - INFO - [Bolt Design] Bolt diameter and grade combination ready to perform bolt design
2021-02-04 13:49:19 - Osdag - INFO - The solver has selected 9.0 combinations of bolt diameter and grade to perform optimum bolt design in an iterative manner
2021-02-04 13:49:19 - Osdag - WARNING - [Column Web] The web of the column is safe against shear bucking due to the reaction transferred by the beam to the column
2021-02-04 13:49:19 - Osdag - INFO - The minimum required thickness of the web i.e. 8.0 mm is satisfied
2021-02-04 13:49:19 - Osdag - INFO - Additional stiffening of the column web is not required
2021-02-04 13:49:19 - 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 13:49:19 - 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 13:49:19 - Osdag - INFO - [Flange Strength] The reaction at the compression flange of the beam 557.3 kN is less than the flange capacity 700.0 kN. The flange strength requirement is satisfied.
2021-02-04 13:49:19 - Osdag - INFO - [End Plate] The end plate of 16.0 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 13:49:19 - Osdag - INFO - [Bolt Design] The bolt of 20.0 mm diameter and 6.8 grade passes the tension check
2021-02-04 13:49:19 - Osdag - INFO - Total tension demand on bolt (due to direct tension + prying action) is 102.98561191562932 kN and the bolt tension capacity is (105.84 kN)
2021-02-04 13:49:19 - Osdag - INFO - [Bolt Design] The bolt of 20.0 mm diameter and 6.8 grade passes the combined shear + tension check
2021-02-04 13:49:19 - Osdag - INFO - The Interaction Ratio (IR) of the critical bolt is 0.952
2021-02-04 13:49:19 - Osdag - INFO - : ========== Design Status ==========
2021-02-04 13:49:19 - Osdag - INFO - : Overall beam to column end plate connection design is SAFE
2021-02-04 13:49:19 - Osdag - INFO - : ========== End Of Design ==========