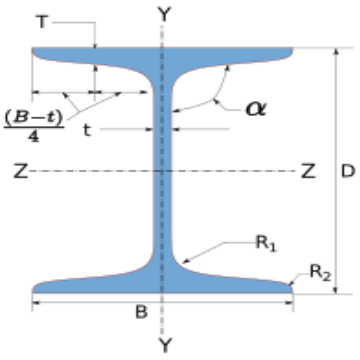
Company Name	IIT Bombay	Project Title	Moment Connection
Group/Team Name	Osdag	Subtitle	Beam-to-Column End Plate
Designer	Engineer#1	Job Number	1.2.2.1.1.1.1
Date	04 /02 /2021	Client	Prof. S R Satish Kumar, IIT Madras

1 Input Parameters

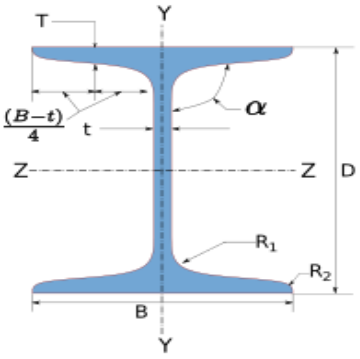
Main Module	Moment Connection
Module	Beam-to-Column End Plate Connection
Connectivity	Column Flange-Beam Web
End Plate Type	Flushed - Reversible Moment
Bending Moment (kNm)	220.0
Shear Force (kN)	95.0
Axial Force (kN)	32.0

Column Section - Mechanical Properties



Column Section		PBP 400 X 140.2	
Material		E 300 (Fe 440)	
Ultimate Strength, Fu (MPa)		440	
Yield Strength, Fy (MPa)		300	
Mass, m (kg/m)	140.2	I_z (cm^4)	40200.0
Area, A (cm^2)	178.0	I_y(cm^4)	16000.0
D (mm)	352.0	r_z (cm)	15.0
B (mm)	392.0	r_y (cm)	9.5
t (mm)	16.0	Z_z (cm^3)	2280.0
T (mm)	16	Z_y (cm^3)	820.0
Flange Slope	90	Z_{pz} (cm^3)	2540.0
R_1 (mm)	15.0	Z_{py} (cm^3)	1250.0
R_2 (mm)	0.0		

Beam Section - Mechanical Properties



Beam Section		WB 500	
Material		E 300 (Fe 440)	
Ultimate Strength, F_u (MPa)		440	
Yield Strength, F_y (MPa)		300	
Mass, m (kg/m)	95.12	I_z (cm^4)	52200.0
Area, A (cm^2)	121.0	I_y(cm^4)	2980.0
D (mm)	500.0	r_z (cm)	20.7
B (mm)	250.0	r_y (cm)	4.96
t (mm)	9.9	Z_z (cm^3)	2090.0
T (mm)	14.7	Z_y (cm^3)	239.0
Flange Slope	96	Z_{pz} (cm^3)	2350.0

	R_1 (mm)	15.0	Z_{py} (cm^3)	406.0
	R_2 (mm)	7.5		

Plate Details - Input and Design Preference	
Thickness (mm)	[8, 10, 12, 14, 16, 18, 20, 22, 25, 28, 32, 36, 40, 45, 50, 56, 63, 75, 80, 90, 100, 110, 120]
Material	E 300 (Fe 440)
Ultimate Strength, Fu (MPa)	440
Yield Strength, Fy (MPa)	290
Bolt Details - Input and Design Preference	
Diameter (mm)	[24, 30]
Property Class	[10.9, 12.9]
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)	510.0
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	Rolled, machine-flame cut, sawn and planed
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	$B_{req} = B_b + 25$ $= 250.0 + 25$ $= 275.0$	$B_{available} = B_c$ $= 392.0$	Compatible

2.2 Member Capacity - Supported Section

Check	Required	Provided	Remarks
Shear Capacity (kN)		$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{0.6 \times 470.6 \times 9.9 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 440.16$ [Ref. IS 800:2007, Cl.10.4.3]	Restricted to low shear
Plastic Moment Capacity (kNm)		$M_{dz} = \frac{\beta_b Z_{pz} fy}{\gamma_{m0}}$ $= \frac{1.0 \times 2350000.0 \times 300}{1.1 \times 10^6}$ $= 640.91$ [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)		$M_{dz} = \frac{\beta_b Z_{pz} fy}{\gamma_{m0}}$ $= \frac{0.9 \times 2540000.0 \times 300}{1.1 \times 10^6}$ $= 621.82$ 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)		$M_{dy} = \frac{\beta_b Z_{py} fy}{\gamma_{m0}}$ $= \frac{0.66 \times 1250000.0 \times 300}{1.1 \times 10^6}$ $= 223.64$ 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)		$P_x = 32.0$	OK

Check	Required	Provided	Remarks
Shear Force (kN)	$V_y = 95.0$	$V_{y_{min}} = \min(0.15V_{d_y},\ 40.0)$ $= \min(0.15 \times 440.16,\ 40.0)$ $= \min(66.02,\ 40.0)$ $= 40.0$ $V_u = \max(V_y,\ V_{y_{min}})$ but, $\leq V_{dy}$ $= \max(95.0,\ 40.0)$ but, ≤ 440.16 $= 95.0$ [Ref. IS 800:2007, Cl.10.7]	**Pass**
Bending Moment (major axis) (kNm)	$M_z = 220.0$	$M_{z_{min}} = 0.5M_{d_z}$ $= 0.5 \times 640.91$ $= 320.45$ $M_u = \max(M_z,\ M_{z_{min}})$ but, $\leq M_{d_z}$ of the column section $= \max(220.0, 320.45)$ ≤ 621.82 $= 320.45$ [Ref. IS 800:2007, Cl.8.2.1.2]	**Pass**
Effective Bending Moment (major axis) (kNm)		$M_{ue} = M_u + P_x \times \left(\frac{D}{2} - \frac{T}{2}\right) \times 10^{-3}$ $= 320.45 +$ $32.0 \times \left(\frac{500.0}{2} - \frac{14.7}{2}\right) \times 10^{-3}$ $= 328.21$	**OK**

2.5 Bolt Optimization

Check	Required	Provided	Remarks
Diameter (mm)	Bolt Diameter Optimization	$d = 24$	Pass
Property Class	Bolt Property Class Optimization	10.9	Pass
Hole Diameter (mm)		$d_0 = 26.0$	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)	$p_{\min} = 2.5d$ $= 2.5 \times 24.0$ $= 60.0$ [Ref. IS 800:2007, Cl.10.2.2]	80	Pass
Max. Pitch Distance (mm)	$p_{\max} = \min(32t,\ 300)$ $= \min(32 \times 25.0,\ 300)$ $= \min(800.0,\ 300)$ $= 300$ Where, $t = \min(25.0, 25.0)$ [Ref. IS 800:2007, Cl.10.2.3]	80	Pass
Min. End Distance (mm)	$e_{\min} = 1.5d_0$ $= 1.5 \times 26.0$ $= 39.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	40	Pass

Check	Required	Provided	Remarks
Max. End Distance (mm)	$e_{max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 25.0 \times \sqrt{\frac{250}{290}} = 278.54$ $e_2 = 12 \times 25.0 \times \sqrt{\frac{250}{290}} = 278.54$ $e_{max} = \min(e_1,\ e_2) = 278.54$ [Ref. IS 800:2007, Cl.10.2.4.3]	40	**Pass**
Min. Edge Distance (mm)	$e'_{min} = 1.5d_0$ $= 1.5 \times 26.0$ $= 39.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	40	**Pass**
Max. Edge Distance (mm)	$e'_{max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 25.0 \times \sqrt{\frac{250}{290}} = 278.54$ $e_2 = 12 \times 25.0 \times \sqrt{\frac{250}{290}} = 278.54$ $e'_{max} = min(e_1,\ e_2) = 278.54$ [Ref. IS 800:2007, Cl.10.2.4.3]	40	**Pass**
Cross-centre Gauge Distance (mm)		112	**Pass**

2.7 Critical Bolt Design

Check	Required	Provided	Remarks

Check	Required	Provided	Remarks
Shear Capacity (kN)		$V_{dsb} = \frac{f_{ub} n_n A_{nb}}{\sqrt{3}\gamma_{mb}}$ $= \frac{1040.0 \times 1 \times 353}{1000 \times \sqrt{3} \times 1.25}$ $= 169.57$ [Ref. IS 800:2007, Cl.10.3.3]	OK
Kb		$k_b = \min\left(\frac{e}{3d_0}, \frac{p}{3d_0} - 0.25, \frac{f_{ub}}{f_u}, 1.0\right)$ $= \min\left(\frac{40}{3 \times 26.0}, \frac{80}{3 \times 26.0} - 0.25, \frac{1040.0}{440}, 1.0\right)$ $= \min(0.51, 0.78, 2.36, 1.0)$ $= 0.51$ [Ref. IS 800:2007, Cl.10.3.4]	OK
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5 k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.51 \times 24.0 \times 25.0 \times 440}{1000 \times 1.25}$ $= 269.28$ [Ref. IS 800:2007, Cl.10.3.4]	OK
Bolt Capacity (kN)		$V_{db} = \min\ (V_{dsb},\ V_{dpb})$ $= \min\ (169.57,\ 269.28)$ $= 169.57$ [Ref. IS 800:2007, Cl.10.3.2]	

Check	Required	Provided	Remarks
Large Grip Length Reduction Factor		$l_g = \sum \left(t_p + t_{\text{member}}\right)$ $= \sum \left(25.0 + 16\right)$ $= 41.0$ mm $5d = 5 \times 24.0 = 120.0$ $8d = 8 \times 24.0 = 192.0$ Since, $l_g < 5d$ $\beta_{lg} = 1.0$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3.2$]	**Pass**
Bolt Capacity (post reduction factor) (kN)		$V_{\text{db}} = V_{\text{db}}\beta_{lg}$ $= 169.57 \times 1.0$ $= 169.57$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3.2$]	**OK**
Shear Demand (per bolt) (kN)	$V_{sb} = \frac{V_u}{n}$ $= \frac{95.0}{8}$ $= 11.88$	$V_{db} = 169.57$	**Pass**

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Designer	Engineer#1	Job Number	1.2.2.1.1.1.1
Date	04 /02 /2021	Client	Prof. S R Satish Kumar, IIT Madras

Check	Required	Provided	Remarks
Lever Arm (mm)	$r = [437.95, 47.35, 357.95, 127.35]$ 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. 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**
Tension Due to Moment (kN)	$T_1 = \frac{M_{ue}}{n_c \times \left(r_1 + \sum_{i=2}^{n_r} \frac{r_i^2}{r_1}\right)}$ $= \frac{328.21 \times 10^3}{2 \times \left(437.95 + \sum_{i=2}^{4} \frac{r_i^2}{437.95}\right)}$ $= 212.39$ 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 $f_o = 0.7 f_{ub}$ $= 0.7 \times 1040.0$ $= 728.0$ N/mm^2 $l_e = \min\left(e, 1.1t\sqrt{\frac{\beta f_o}{f_y}}\right)$ $= \min\left(40, 1.1 \times 25 \times \sqrt{\frac{2 \times 728.0}{290}}\right)$ $= \min(40,\ 61.62) = 40$ mm $\beta = 2$ (non pre-tensioned bolt) $\eta = 1.5$ $b_e = \frac{B}{n_c}$ $= \frac{250.0}{2} = 125.0$ mm $Q = \frac{32.5}{2 \times 40} \times$ $\left[212.39 - \left(\frac{2 \times 1.5 \times 728.0 \times 125.0 \times 25^4}{27 \times 40 \times 32.5^2}\right) \times 10^{-3}\right]$ $Q = 48.31$ [Ref. IS 800:2007, Cl.10.4.7]		OK

Check	Required	Provided	Remarks
Tension Demand (kN)	$T_b = T_1 + Q$ $= 212.39 + 48.31$ $= 260.7$	$T_{\text{db}} = 0.90 f_{ub} A_n \ / \ \gamma_{mb}$ $< \ f_{yb} A_{sb} (\gamma_{mb} \ / \ \gamma_{m0})$ $= \min \Big(0.90 \times 1040.0 \times 353 \ / \ 1.25,$ $940.0 \times 452.0 \times (1.25/1.1) \Big)$ $= \min(264.33, \ 482.82)$ $= 264.33$ [Ref. IS 800:2007, Cl.10.3.5]	**Pass**
Combined Capacity (I.R.)	≤ 1	$\left(\frac{V_{sb}}{V_{\text{db}}}\right)^2 + \left(\frac{T_{\text{b}}}{T_{\text{db}}}\right)^2 \leq 1.0$ $\left(\frac{11.88}{169.57}\right)^2 + \left(\frac{260.7}{264.33}\right)^2 = 0.98$ [Ref. IS 800:2007, Cl.10.3.6]	**Pass**

2.8 Compression Flange Check

Check	Required	Provided	Remarks
Tension in Bolt Rows (kN)		$T = [212.39, 22.96, 173.59, 61.76]$	**OK**
Reaction at Compression Flange (kN)	$R_c = n_c \sum_{n_r=1}^{n_r} T_{n_r}$ $= 2 \times \sum_{n_r=1}^{4} T_{n_r}$ $= 2 \times 470.7$ $= 941.4$	$F_c = A_g f_y \ / \ \gamma_{m0}$ $= \frac{BTf_y}{\gamma_{m0}}$ $= \frac{250.0 \times 14.7 \times 300}{1.1 \times 1000}$ $= 1002.27$	**Pass**

2.9 End Plate Checks

Check	Required	Provided	Remarks
Height (mm)		$H_p = D + 25$ $= 500.0 + 25$ $= 525.0$	**Pass**
Width (mm)		$B_p = B + 25$ $= 250.0 + 25$ $= 275.0$	**Pass**
Moment at Critical Section (kNm)		$M_{cr} = T_1\ l_v - Q\ l_e$ $= (212.39 \times 32.5 - 48.31 \times 40) \times 10^{-3}$ $= 4.97$ 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)	$t_p = \sqrt{\frac{4M_{cr}}{b_e(f_y/\gamma_{m0})}}$ $= \sqrt{\frac{4 \times 4.97 \times 10^6}{125 \times (290/1.1)}}$ $= 24.56$	25	**Pass**
Moment Capacity (kNm)	4.97	$M_p = \left(\frac{b_e t_p^2}{4}\right) \times \frac{f_y}{\gamma_{m0}}$ $= \frac{125 \times 25^2}{4} \times \frac{290}{1.1} \times 10^{-6}$ $= 5.15$	**Pass**

2.10 Longitudinal Stiffener Design

Check	Required	Provided	Remarks
Width (mm)		$W_{st} = B_p - \frac{t}{2}$ $= 275.0 - \frac{9.9}{2}$ $= 132.55$	**132.55**
Length (mm)		$L_{st} = 2W_{st}$ $= 2 \times 132.55$ $= 265.1$	**Pass**
Thickness (mm)	$t = 9.9$	$t_{st} = 10$	**Pass**

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

2.11 Weld Design - Beam Web to End Plate Connection

Check	Required	Provided	Remarks
Weld Strength (N/mm2)	$f_{u_w} = \min(f_w,\ f_u)$ $= \min(510.0,\ 440)$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	$f_{u_w} = 440$	Pass
Total Weld Length (mm)		$L_w = 2 \times \left[D - (2 \times T) - (2 \times R1) - 20\right]$ $= 2 \times \left[500.0 - (2 \times 14.7) - (2 \times 15.0) - 20\right]$ $= 831.3$ Note: Weld is provided on both sides of the web	OK
Weld Size (mm)	$t_w = \frac{V_u}{f_{uw} k L_w} \times \sqrt{3}\ \gamma_{mw}$ $= \frac{95.0 \times 10^3}{440 \times 0.7 \times 831.3} \times \sqrt{3} \times 1.25$ $= 0.8$ [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 $t_{\text{thicker}} = \max(25.0,\ 9.9)$ $= 25.0$ $t_{w\,\min} = 6$ 2) $t_{w\,\min}$ – based on thickness of the thinner part $t_{\text{thinner}} = \min(25.0,\ 9.9)$ $= 9.9$ $t_{w\,\min} \leq \min(6,\ 9.9)$ [Ref. IS 800:2007, Table 21, Cl 10.5.2.3]	$t_w = \max(t_w,\ t_{w\,\min})$ $= \max(0.8,\ 6)$ $= 6$	Pass
Max. Weld Size (mm)	$t_{w\,\max}$ based on thickness of the thinner part $t_{\text{thinner}} = \min(25.0,\ 9.9)$ $= 9.9$ $t_{w\,\max} = 9.9$ [Ref. IS 800:2007, Cl.10.5.3.1]	$t_w \leq t_{w\,\max}$ $6 \leq 9.9$	Pass
Normal Stress (N/mm2)		$f_a = \frac{H}{0.7 t_w L_w}$ $= \frac{32.0 \times 10^3}{0.7 \times 6 \times 831.3}$ $= 9.17$ [Ref. IS 800:2007, Cl.10.5.9]	

Check	Required	Provided	Remarks
Shear Stress (N/mm2)		$q = \frac{V}{0.7 t_w L_w}$ $= \frac{95.0 \times 10^3}{0.7 \times 6 \times 831.3}$ $= 27.21$ [Ref. IS 800:2007, Cl.10.5.9]	
Equivalent Stress (N/mm2)	$f_e = \sqrt{f_a^2 + 3q^2}$ $= \sqrt{9.17^2 + (3 \times 27.21^2)}$ $= 47.23$ [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**

2.12 Continuity Plate Check - Compression/Tension Flange

Check	Required	Provided	Remarks
Local Web Yielding Capacity (kN)		$P_{cw_1} = \frac{f_{wc}\ (5k + T_b)}{\gamma_{m0}}$ $k = T_c + R_{1\,c}$ $= 16 + 15.0$ $= 31.0$ $f_{wc} = f_{yc} t_c$ $= 300.0 \times 16.0$ $= 4800.0$ $P_{cw_1} = \frac{4800.0 \times ((5 \times 31.0) + 14.7)}{1.1 \times 1000}$ $= 740.51$ Note: subscript c denotes column section, and, subscript b denotes beam section	**OK**

Check	Required	Provided	Remarks
Web Compression Buckling Capacity (kN)		$P_{cw_2} = 10710 \left(\frac{t_c^3}{h_c}\right) \sqrt{\frac{f_{yc}}{\gamma_{m0}}}$ $h_c = D_c - (2k)$ $= 352.0 - (2 \times 31.0)$ $= 290.0$ $P_{cw_2} = 10710 \times \frac{16.0^3}{290.0} \times \sqrt{\frac{300.0}{1.1}} \times 10^{-3}$ $= 2498.13$	OK
Web Crippling Capacity (kN)		$P_{cw_3} = \left(\frac{300t_c^2}{\gamma_{m1}}\right)\left[1 + 3\left(T_b/D_c\right)\left(t_c/T_c\right)^{1.5}\right]\sqrt{f_{yc}\left(T_c/t_c\right)}$ $= \left(\frac{300 \times 16.0^2}{1.25}\right) \times \left[1 + 3 \times \left(14.7/352.0\right) \times \left(16.0/16\right)^{1.5}\right] \times \sqrt{300.0 \times \left(16/16.0\right)} \times 10^{-3}$ $= 1197.5$	OK
Compression Strength (kN)		$P_{cw} = \min(P_{cw_1},\ P_{cw_2},\ P_{cw_3})$ $= \min(740.51,\ 2498.13,\ 1197.5)$ $= 740.51$	OK
Continuity Plate Required?	$R_c = 941.4$	$P_{cw} = 740.51$	Yes

2.13 Continuity Plate Design - Compression/Tension Flange

Check	Required	Provided	Remarks
Area Required (mm2)	$A_{cp} = \frac{R_c - P_{cw}}{f_{y_{cp}}\gamma_{m0}}$ $= \frac{\left(941.4 - 740.51\right) \times 10^3}{290 \times 1.1}$ $= 629.75$		OK
Notch Size (mm)		$n = 24$	OK

Check	Required	Provided	Remarks
Length (mm)		l_{cp1} = Outer length $l_{cp1} = D_c - 2T_c$ $= 352.0 - (2 \times 16)$ $= 320.0$ l_{cp2} = Inner length $l_{cp2} = D_c - 2(T_c + n)$ $= 352.0 - \left[2 \times (16 + 24)\right]$ $= 272.0$	OK
Width (mm)		$w_{cp} = \frac{B_c - T_c - 2n}{2}$ $= \frac{392.0 - 16.0 - 2 \times 24}{2}$ $= 164.0$	OK

Check	Required	Provided	Remarks
Thickness (mm)	t_{cp1} = Minimum area criteria $t_{cp1} = \frac{A_{cp}/2}{w_{cp}}$ $= \frac{629.75/2}{164.0}$ $= 1.92$ t_{cp2} = Limiting b/t ratio criteria $t_{cp2} = \frac{l_{cp1}}{29.3\ \epsilon_{cp}}$ $\epsilon_{cp} = \sqrt{\frac{250}{f_{y_{cp}}}}$ $= \sqrt{\frac{250}{290}}$ $= 0.93$ $= \frac{320.0}{29.3 \times 0.93}$ $= 11.76$ t_{cp3} = Minimum thickness criteria $t_{cp3} = T_b$ $= 14.7$ $t_{cp} = \max(t_{cp1},\ t_{cp2},\ t_{cp3})$ $= \max(1.92, 11.76, 14.7)$ $= 14.7$	16	**Pass**

2.14 Weld Design - Continuity Plate

Check	Required	Provided	Remarks
Weld Strength (N/mm2)	$f_{uw} = \min(f_w,\ f_{u_{cp}})$ $= \min(510.0,\ 440)$ [*Ref. IS* 800 : 2007, *Cl.* 10.5.7.1.1]	$f_{u_w} = 440$	Pass
Total (effective) Weld Length (mm)		$L_{w\,cp} = 256.0$ Note: Provide weld on one side of the continuity plate	OK
Weld Size (mm)	$t_{w\,cp} = \frac{V_{cp}/2}{f_{uw} k L_{w\,cp}} \times \sqrt{3}\gamma_{mw}$ $= \frac{R_c - P_{cw}}{2 \times f_{uw} k L_{w\,cp}} \times \sqrt{3}\gamma_{mw}$ $= \frac{(941.4 - 740.51) \times 10^3}{2 \times 440 \times 0.7 \times 256.0} \times \sqrt{3} \times 1.25$ $= 2.76$ [*Ref. IS* 800 : 2007, *Cl.* 10.5.7]	5	Pass
Min. Weld Size (mm)	1) $t_{w\,\min}$ – based on thickness of the thicker part $t_{\text{thicker}} = \max(16,\ 16.0)$ $= 16$ $t_{w\,\min} = 5$ 2) $t_{w\,\min}$ – based on thickness of the thinner part $t_{\text{thinner}} = \min(16,\ 16.0)$ $= 16$ $t_{w\,\min} \leq \min(5,\ 16)$ [Ref. IS 800:2007, Table 21, Cl 10.5.2.3]	$t_w = \max(t_w,\ t_{w\,\min})$ $= \max(2.76,\ 5)$ $= 5$	Pass

Check	Required	Provided	Remarks
Max. Weld Size (mm)	$t_{w\max}$ based on thickness of the thinner part $t_{\text{thinner}} = \min(16,\ 16.0)$ $= 16$ $t_{w\max} = 16$ [Ref. IS 800:2007, Cl.10.5.3.1]	$t_w \leq t_{w\max}$ $5 \leq 16$	Pass

2.15 Column Web Shear Check

Check	Required	Provided	Remarks
Web Stiffener Plate Required?	$t_{wc} = \dfrac{1.9M_{ue}}{D_c D_b f_{yc}}$ $= \dfrac{1.9 \times 328.21}{352.0 \times 500.0 \times 300.0}$ $= 11.81$	$t_c = 16.0$	No

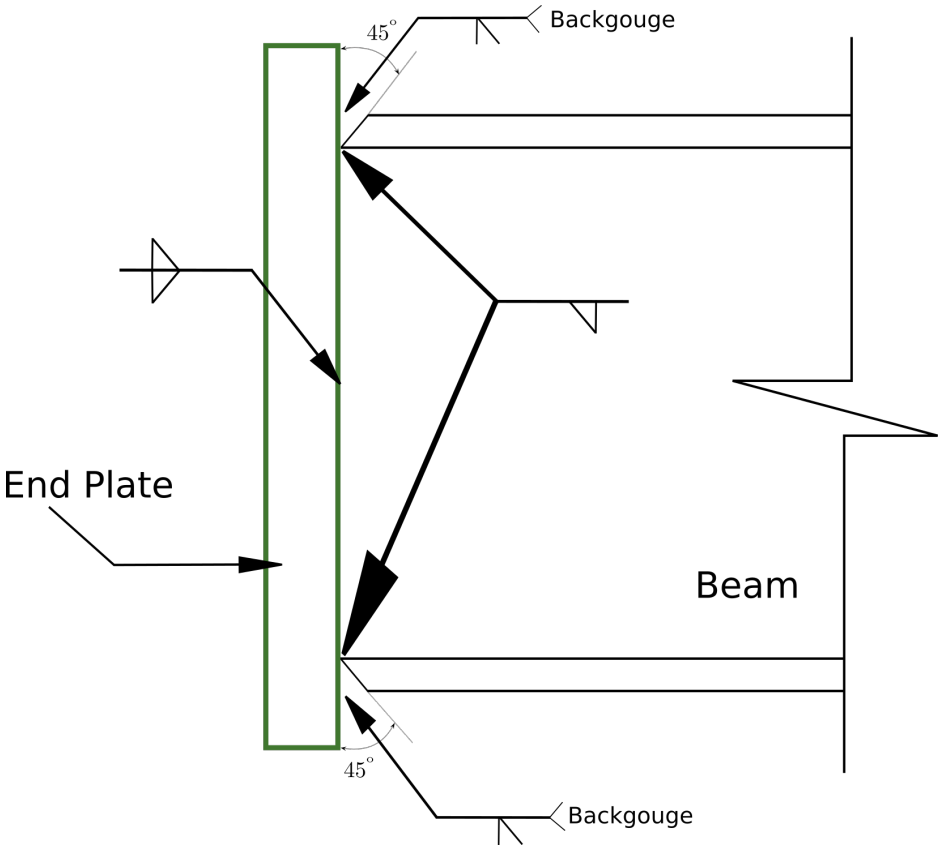


Figure 1: Typical Weld Details -- Beam to End Plate Connection

3 2D Drawings (Typical)

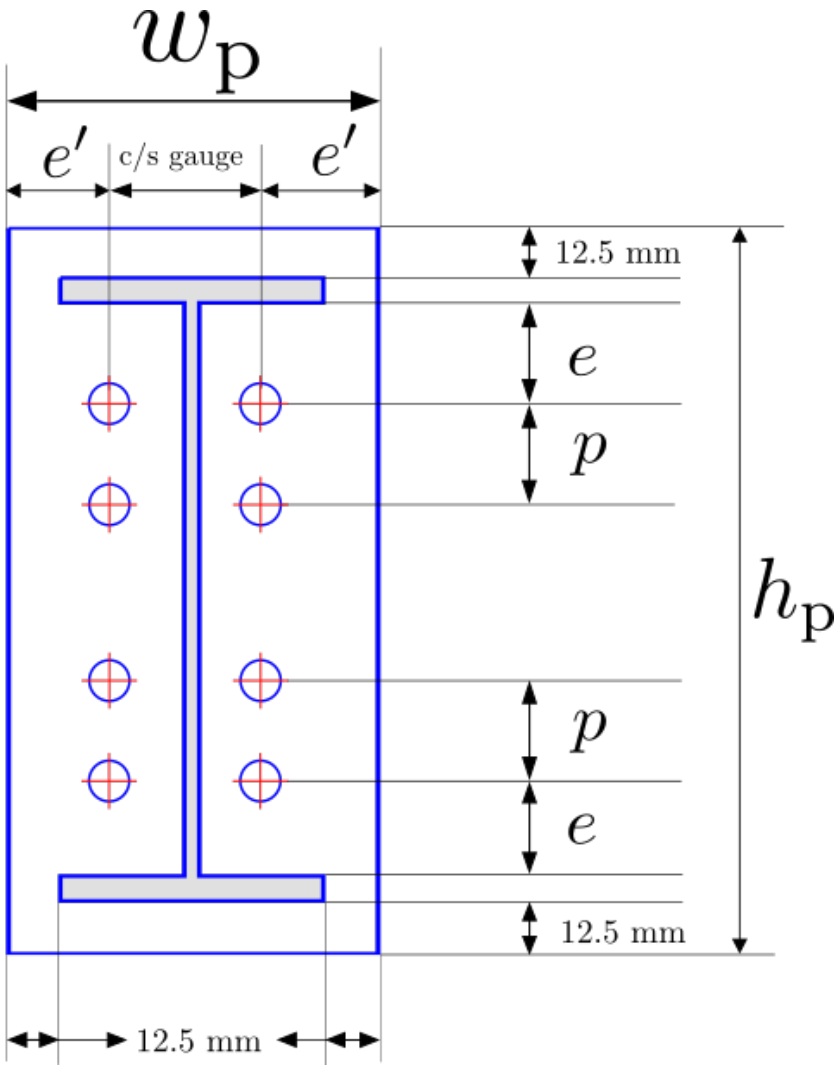


Figure 2: Typical Detailing

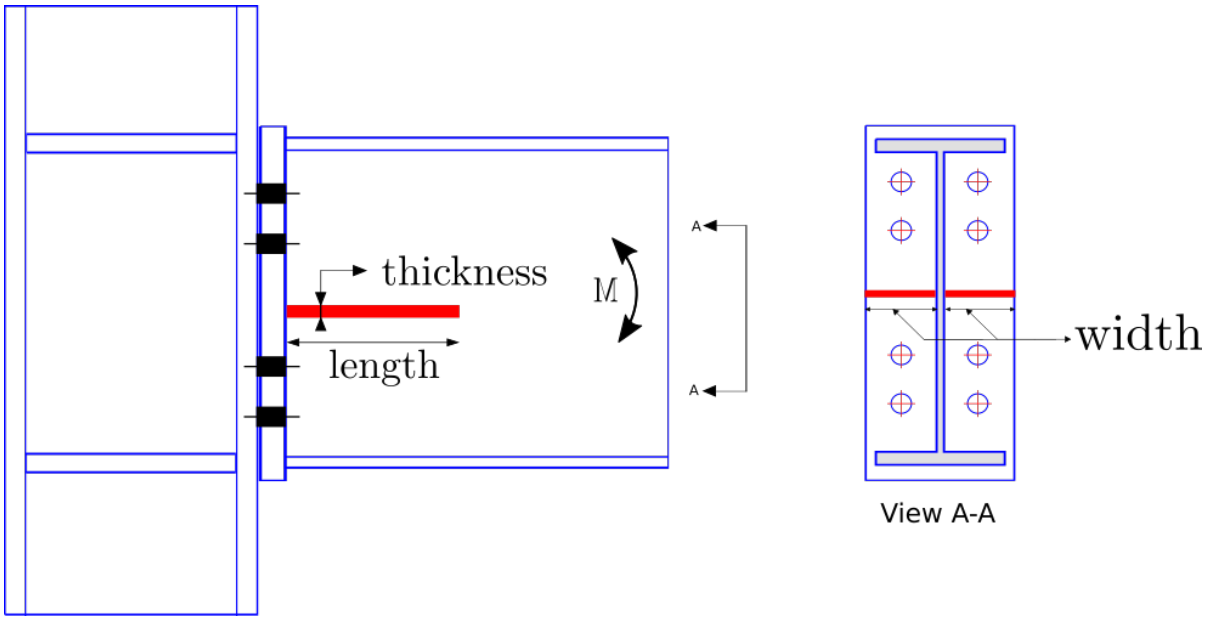
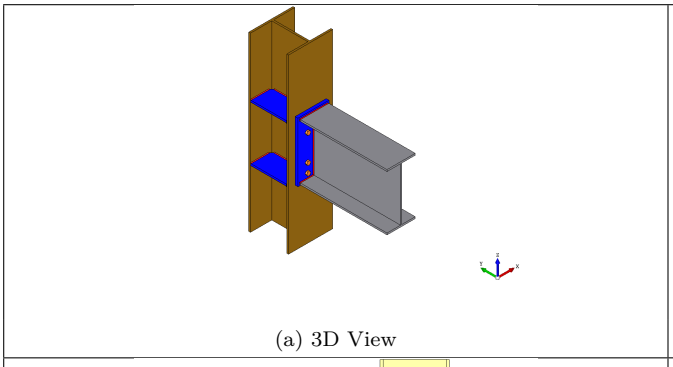
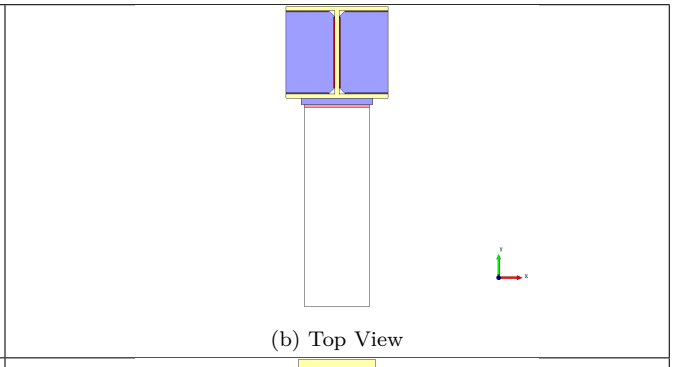


Figure 3: Typical Stiffener Details

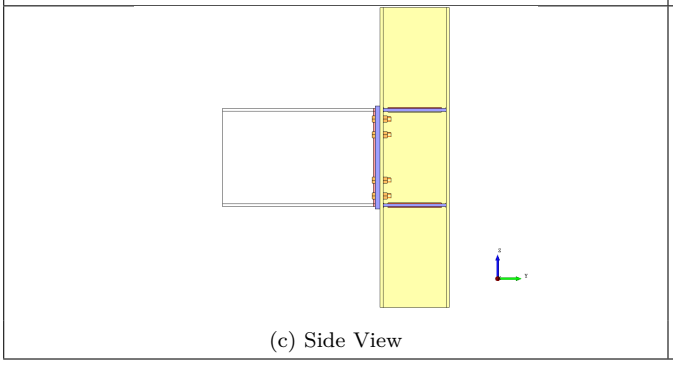
4 3D Views



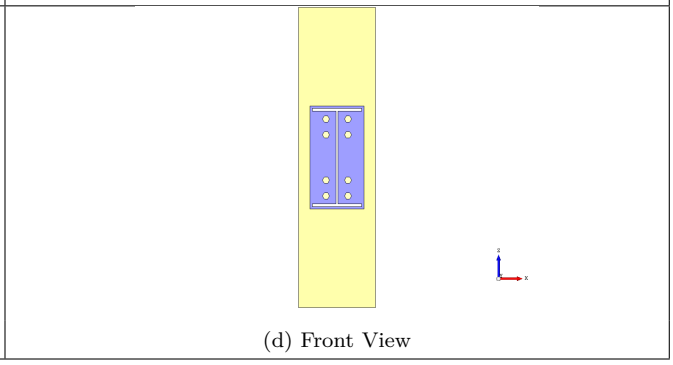
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

5 Design Log

2021-02-04 13:46:46 - Osdag - WARNING - The Load(s) defined is/are less than the minimum recommended value [Ref. IS 800:2007, Cl.10.7].
2021-02-04 13:46:46 - Osdag - WARNING - [Minimum Factored Load] The external factored bending moment (220.0 kNm) is less than 0.5 times the plastic moment capacity of the beam (640.91 kNm)
2021-02-04 13:46:46 - 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 13:46:46 - 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 13:46:46 - Osdag - INFO - Designing the connection for a factored moment of 320.45 kNm
2021-02-04 13:46:46 - Osdag - WARNING - [End Plate] The end plate of 8.0 mm is thinner than the thickest of the elements being connected
2021-02-04 13:46:46 - Osdag - INFO - Selecting a plate of higher thickness which is at least 16 mm thick
2021-02-04 13:46:46 - Osdag - WARNING - [End Plate] The end plate of 10.0 mm is thinner than the thickest of the elements being connected
2021-02-04 13:46:46 - Osdag - INFO - Selecting a plate of higher thickness which is at least 16 mm thick
2021-02-04 13:46:46 - Osdag - WARNING - [End Plate] The end plate of 12.0 mm is thinner than the thickest of the elements being connected
2021-02-04 13:46:46 - Osdag - INFO - Selecting a plate of higher thickness which is at least 16 mm thick
2021-02-04 13:46:46 - Osdag - WARNING - [End Plate] The end plate of 14.0 mm is thinner than the thickest of the elements being connected
2021-02-04 13:46:46 - Osdag - INFO - Selecting a plate of higher thickness which is at least 16 mm thick
2021-02-04 13:46:46 - Osdag - INFO - [Bolt Design] Bolt diameter and grade combination ready to perform bolt design
2021-02-04 13:46:46 - Osdag - INFO - The solver has selected 4.0 combinations of bolt diameter and grade to perform optimum bolt design in an iterative manner
2021-02-04 13:46:46 - 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 13:46:46 - Osdag - INFO - The minimum required thickness of the web i.e. 11.81 mm is satisfied
2021-02-04 13:46:46 - Osdag - INFO - Additional stiffening of the column web is not required
2021-02-04 13:46:46 - 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 13:46:46 - 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 13:46:46 - Osdag - INFO - [Flange Strength] The reaction at the compression flange of the beam 941.4 kN is less than the flange capacity 1002.27 kN. The flange strength requirement is satisfied.
2021-02-04 13:46:46 - Osdag - INFO - [End Plate] The end plate of 25.0 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 13:46:46 - Osdag - INFO - [Bolt Design] The bolt of 24.0 mm diameter and 10.9 grade passes the tension check
2021-02-04 13:46:46 - Osdag - INFO - Total tension demand on bolt (due to direct tension + prying action) is 260.6984096812406 kN and the bolt tension capacity is (264.33 kN)
2021-02-04 13:46:46 - Osdag - INFO - [Bolt Design] The bolt of 24.0 mm diameter and 10.9 grade passes the combined shear + tension

check

2021-02-04 13:46:46 - Osdag - INFO - The Interaction Ratio (IR) of the critical bolt is 0.978

2021-02-04 13:46:46 - Osdag - INFO - : ========== Design Status ==========

2021-02-04 13:46:46 - Osdag - INFO - : Overall beam to column end plate connection design is SAFE

2021-02-04 13:46:46 - Osdag - INFO - : ========== End Of Design ==========