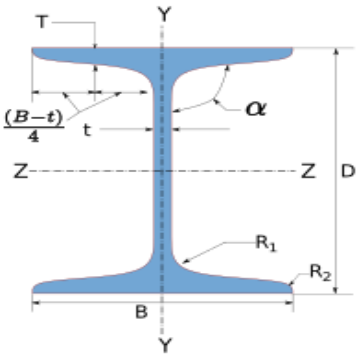
Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Beam-Column End Plate
Designer	Engineer #1	Job Number	1.2.2.1.1.1.2
Date	18 /12 /2020	Client	Manas M. Ghosh, INSDAG, Kolkata

1 Input Parameters

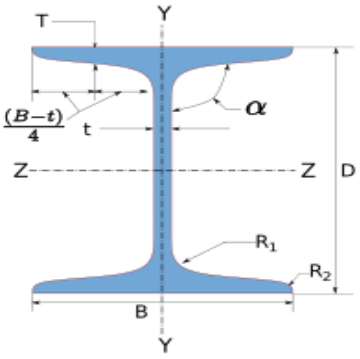
Main Module	Moment Connection
Module	Beam-Column End Plate
Connectivity	Column Flange-Beam Web
End Plate Type	Flushed - Reversible Moment
Bending Moment (kNm)	150.0
Shear Force (kN)	90.0
Axial Force (kN)	0.0

Column Section - Mechanical Properties



Column Section		UC 305 x 305 x 118	
Material		E 300 (Fe 440)	
Ultimate Strength, Fu (MPa)		440	
Yield Strength, Fy (MPa)		300	
Mass, m (kg/m)	117.9	I_z (cm^4)	27672.0
Area, A (cm^2)	150.2	I_y(cm^4)	9058.0
D (mm)	314.5	r_z (cm)	13.6
B (mm)	307.4	r_y (cm)	7.77
t (mm)	12.0	Z_z (cm^3)	1760.0
T (mm)	18.7	Z_y (cm^3)	589.0
Flange Slope	90	Z_{pz} (cm^3)	1958.0
R_1 (mm)	15.2	Z_{py} (cm^3)	895.0
R_2 (mm)	0.0		

Beam Section - Mechanical Properties



Beam Section		MB 500	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, Fu (MPa)		410	
Yield Strength, Fy (MPa)		250	
Mass, m (kg/m)	86.88	I_z (cm^4)	45200.0
Area, A (cm^2)	110.0	I_y(cm^4)	1360.0
D (mm)	500.0	r_z (cm)	20.2
B (mm)	180.0	r_y (cm)	3.51
t (mm)	10.2	Z_z (cm^3)	1800.0
T (mm)	17.2	Z_y (cm^3)	152.0
Flange Slope	98	Z_{pz} (cm^3)	2070.0

	R_1 (mm)	17.0	Z_{py} (cm^3)	259.0
	R_2 (mm)	8.5		

Plate Details - Input and Design Preference	
Thickness (mm)	[28]
Material	E 250 (Fe 410 W)A
Ultimate Strength, Fu (MPa)	410
Yield Strength, Fy (MPa)	240
Bolt Details - Input and Design Preference	
Diameter (mm)	[20]
Property Class	[12.9]
Type	Friction Grip Bolt
Bolt Tension	Pre-tensioned
Hole Type	Standard
Slip Factor, (mu_f)	0.48
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	Rolled, machine-flame cut, sawn and planed
Gap Between Members (mm)	0.0
Are the Members Exposed to Corrosive Influences?	True

2 Design Checks

Design Status	Pass

2.1 Beam to Column - Compatibility Check

Check	Required	Provided	Remarks
Beam Section Compatibility	$B_{req} = B_b + 25$ $= 180.0 + 25$ $= 205.0$	$B_{available} = B_c$ $= 307.4$	**Compatible**

2.2 Member Capacity - Supported Section

Check	Required	Provided	Remarks
Shear Capacity (kN)		$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{0.6 \times 465.6 \times 10.2 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 373.9$ $[Ref. IS\ 800 : 2007, Cl. 10.4.3]$	**Restricted to low shear**
Plastic Moment Capacity (kNm)		$M_{dz-z} = \frac{\beta_b Z_{pz} fy}{\gamma_{mo}}$ $= \frac{1.0 \times 2070000.0 \times 250}{1.1 \times 10^6}$ $= 470.45$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 8.2.1.2]$	**V < 0.6 Vdy**

2.3 Member Capacity - Supporting Section

Check	Required	Provided	Remarks

Check	Required	Provided	Remarks
Plastic Moment Capacity (kNm)		$M_{dz-z} = \frac{\beta_b Z_{pz} fy}{\gamma_{mo}}$ $= \frac{0.9 \times 1958000.0 \times 300}{1.1 \times 10^6}$ $= 480.0$ *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)		$M_{dy-y} = \frac{\beta_b Z_{py} fy}{\gamma_{mo}}$ $= \frac{0.66 \times 895000.0 \times 300}{1.1 \times 10^6}$ $= 160.64$ *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
Shear Force (kN)	$V_y = 90.0$	$V_{y_{min}} = min(0.15 \times V_{dy}, 40.0)$ $= min(0.15 \times 373.9,\ 40.0)$ $= min(56.08,\ 40.0)$ $= 40.0$ $V_u = max(V_y,\ V_{y_{min}})$ $= max(90.0,\ 40.0)$ $= 90.0$ [*Ref. IS* 800 : 2007, *Cl.* 10.7]	**OK**

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Beam-Column End Plate
Designer	Engineer #1	Job Number	1.2.2.1.1.1.2
Date	18 /12 /2020	Client	Manas M. Ghosh, INSDAG, Kolkata

Check	Required	Provided	Remarks
Axial Force (kN)		P_x = 0.0	OK
Bending Moment (major axis) (kNm)	$M_z = 150.0$	$M_{zmin} = 0.5 * M_{dz-z}$ $= 0.5 \times 470.45$ $= 235.22$ $M_u = max(M_z,\ M_{zmin})$ $but,\ \leq M_{dz-z}\ of\ the\ column\ section$ $= max(150.0, 235.22)$ ≤ 480.0 $= 235.22$ $[Ref.\ IS\ 800:2007,\ Cl.\ 8.2.1.2]$	OK
Effective Bending Moment (major axis) (kNm)		$M_{ue} = M_u\ +\ P_x \times \left(\frac{D}{2} - \frac{T}{2}\right) \times 10^{-3}$ $= 235.22\ +$ $0.0 \times \left(\frac{500.0}{2} - \frac{17.2}{2}\right) \times 10^{-3}$ $= 235.22$	OK

2.5 Bolt Optimization

Check	Required	Provided	Remarks
Diameter (mm)	Bolt Diameter Optimization	$d = 20$	Pass
Property Class	Bolt Property Class Optimization	12.9	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)	$p_{min} = 2.5\ d$ $= 2.5 \times 20.0$ $= 50.0$ $[Ref\ IS\ 800:2007,\ Cl.\ 10.2.2]$	70	Pass
Max. Pitch Distance (mm)	$p_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 28.0,\ 300\ mm)$ $= \min(896.0,\ 300\ mm)$ $= 300$ $Where,\ t = min(28.0, 28.0)$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.3]$	70	Pass
Min. End Distance (mm)	$e_{min} = 1.5\ d_0$ $= 1.5 \times 22.0$ $= 33.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2]$	35	Pass
Max. End Distance (mm)	$e_{max} = 40 + 4t$ $Where, t = min(28.0, 28.0)$ $= 40 + (4 \times 28)$ $e_{max} = 152.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3]$	35	Pass
Min. Edge Distance (mm)	$e'_{min} = 1.5\ d_0$ $= 1.5 \times 22.0$ $= 33.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2]$	35	Pass

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{max} = 40 + 4t$ $Where, t = min(28.0, 28.0)$ $= 40 + (4 \times 28)$ $e'_{max} = 152.0$ [*Ref. IS* 800 : 2007, *Cl.* 10.2.4.3]	35	**Pass**
Cross-centre Gauge Distance (mm)		98	**Pass**

2.7 Critical Bolt Design

Check	Required	Provided	Remarks
Slip Resistance (kN)	$V_{sf} = \frac{V_u}{n}$ $= \frac{90.0}{8}$ $= 11.25$	$V_{dsf} = \frac{\mu_f \, n_e \, K_h \, F_o}{\gamma_{mf}}$ $Where \, , F_o = 0.7 f_{ub} A_{nb}$ $V_{dsf} = \frac{0.48 \times 1 \times 1 \times 0.7 \times 1220.0 \times 245}{1.25 \times 10^3}$ $= 80.34$ [*Ref. IS* 800 : 2007, *Cl.* 10.4.3]	**Pass**
Lever Arm (mm)	$r = [439.2, 43.6, 369.2, 113.6]$ *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 row 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 NA 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)	$T_1 = \frac{M_{ue}}{n_c \times \left(r_1 + \sum_{i=2}^{n_r} \frac{r_i^2}{r_1} \right)}$ $= \frac{235.22 \times 10^3}{2 \times \left(439.2 + \sum_{i=2}^{4} \frac{r_i^2}{439.2} \right)}$ $= 150.15$ *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)	$Q = \frac{l_v}{2 \times l_e}\left[T_e - \frac{\beta \times \eta \times f_o \times b_e \times t^4}{27 \times l_e \times l_v^2}\right]$ $l_v = e - \frac{R_1}{2}$ $= 35 - \frac{17.0}{2} = 26.5\ mm$ $f_o = 0.7 \times f_{ub}$ $= 0.7 \times 1220.0$ $= 854.0\ N/mm^2$ $l_e = min\left(e, 1.1\ t\ \sqrt{\frac{\beta\ f_o}{f_y}}\right)$ $= min\left(35, 1.1 \times 28 \times \sqrt{\frac{1 \times 854.0}{240}}\right)$ $= min(35, 58.1) = 35\ mm$ $\beta = 1\ (pre - tensioned\ bolt)$ $\eta = 1.5$ $b_e = \frac{B}{n_c}$ $= \frac{180.0}{2} = 90.0\ mm$ $Q = \frac{26.5}{2 \times 35} \times$ $\left[150.15 - \left(\frac{1 \times 1.5 \times 854.0 \times 90.0 \times 28^4}{27 \times 35 \times 26.5^2}\right) \times 10^{-3}\right]$ $Q = 16.42$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.4.7]$		**OK**

Check	Required	Provided	Remarks
Tension Demand (kN)	$T_f = T_1 + Q$ $= 150.15 + 16.42$ $= 166.57$	$T_f = 0.90\ f_{ub}\ A_n\ /\ \gamma_{mf}$ $<\ f_{yb}\ A_{sb}\ (\gamma_{m1}\ /\ \gamma_{m0})$ $= min\Big(0.90\ \times 1220.0 \times 245\ /\ 1.25,$ $1100.0 \times 314.0 \times (1.25/1.1)\Big)$ $= min(215.21,\ 392.5)$ $= 215.21$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.5]$	**Pass**
Combined Capacity, (I.R)	≤ 1	$\left(\frac{V_{sf}}{V_{df}}\right)^2 + \left(\frac{T_f}{T_{df}}\right)^2 \leq 1.0$ $\left(\frac{11.25}{80.34}\right)^2 + \left(\frac{166.57}{215.21}\right)^2 = 0.62$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.6]$	**Pass**

2.8 Compression Flange Check

Check	Required	Provided	Remarks
Tension in Bolt Rows (kN)		$T = [150.15, 14.91, 126.22, 38.84]$	**OK**
Reaction at Compression Flange (kN)	$R_c = n_c \sum_{n_r=1}^{n_r} T_{n_r}$ $= 2 \times \sum_{n_r=1}^{4} T_{n_r}$ $= 2 \times 330.12$ $= 660.24$	$F_c = A_g f_y\ /\ \gamma_{m0}$ $= \frac{B \times T \times f_y}{\gamma_{m0}}$ $= \frac{180.0 \times 17.2 \times 250}{1.1 \times 1000}$ $= 703.64$	**Pass**

2.9 End Plate Checks

Check	Required	Provided	Remarks
Height (mm)		$H_p = D + 25$ $= 500.0 + 25$ $= 525.0$	**Pass**
Width (mm)		$B_p = B + 25$ $= 180.0 + 25$ $= 205.0$	**Pass**
Moment at Critical Section (kNm)		$M_{cr} = T_1\ l_v - Q\ l_e$ $= (150.15 \times 26.5 - 16.42 \times 35) \times 10^{-3}$ $= 3.4$ *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)	$t_p = \sqrt{\frac{4M_{cr}}{b_e(f_y/\gamma_{m0})}}$ $= \sqrt{\frac{4 \times 3.4 \times 10^6}{90 \times (240/1.1)}}$ $= 26.33$	28	**Pass**
Moment Capacity (kNm)	3.4	$M_p = \left(\frac{b_e t_p^2}{4}\right) \times \frac{f_y}{\gamma_{m0}}$ $= \frac{90 \times 28^2}{4} \times \frac{240}{1.1} \times 10^{-6}$ $= 3.85$	**Pass**

2.10 Longitudinal Stiffener Design

Check	Required	Provided	Remarks
Width (mm)		$W_{st} = B_p - \frac{t}{2}$ $= 205.0 - \frac{10.2}{2}$ $= 97.4$	**97.4**
Length (mm)		$L_{st} = 2 * W_{st}$ $= 2 * 97.4$ $= 194.8$	**Pass**
Thickness (mm)	$t = 10.2$	$tst = 12$	**Pass**

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

2.11 Weld Design - Beam Web to End Plate Connection

Check	Required	Provided	Remarks
Weld Strength (N/mm2)	$f_{uw} = min(f_w,\ f_u)$ $= min(410.0,\ 410)$ [*Ref. IS* 800 : 2007, *Cl.* 10.5.7.1.1]	$f_{uw} = 410.0$	**Pass**
Total Weld Length (mm)		$L_w = 2 \times \left[D - (2 \times T) - (2 \times R1) - 20\right]$ $= 2 \times \left[500.0 - (2 \times 17.2) - (2 \times 17.0) - 20\right]$ $= 813.0$ *Note : Weld is provided on both sides of the web*	**OK**
Weld Size (mm)	$t_w = \frac{V_u}{f_{uw} k L_w} \times \sqrt{3}\ \gamma_{mw}$ $= \frac{90.0 \times 10^3}{410.0 \times 0.7 \times 813.0} \times \sqrt{3} \times 1.25$ $= 0.84$ [*Ref. IS* 800 : 2007, *Cl.* 10.5.7]	6	**Pass**

Check	Required	Provided	Remarks
Min. Weld Size (mm)	1) t_{wmin} – *based on thickness of the thicker part* $t_{thicker} = max(28.0,\ 10.2)$ $= 28.0$ $t_{wmin} = 6$ 2) t_{wmin} – *based on thickness of the thinner part* $t_{thinner} = min(28.0,\ 10.2)$ $= 10.2$ $t_{wmin} \leq min(6,\ 10.2)$ [*Ref IS* 800 : 2007, *Table* 21 , *Cl*10.5.2.3]	$t_w = max(t_w,\ t_{wmin})$ $= max(0.84,\ 6)$ $= 6$	**Pass**
Max. Weld Size (mm)	t_{wmax} *based on thickness of the thinner part* $t_{thinner} = min(28.0,\ 10.2)$ $= 10.2$ $t_{wmax} = 10.2$ [*Ref. IS* 800 : 2007, *Cl.* 10.5.3.1]	$t_w \leq t_{wmax}$ $6 \leq 10.2$	**Pass**

2.12 Continuity Plate Check - Compression/Tension Flange

Check	Required	Provided	Remarks

Check	Required	Provided	Remarks
Local Web Yielding Capacity (kN)		$P_{cw_1} = \frac{f_{wc}\ (5k + T_b)}{\gamma_{m0}}$ $k = T_c + R_{1_c}$ $= 18.7 + 15.2$ $= 33.9$ $f_{wc} = f_{yc} \times t_c$ $= 300.0 \times 12.0$ $= 3600.0$ $P_{cw_1} = \frac{3600.0 \times ((5 \times 33.9) + 17.2)}{1.1 \times 1000}$ $= 611.02$ *Note : subscript c denotes column section, and, subscript b denotes beam section*	**OK**
Web Compression Buckling Capacity (kN)		$P_{cw_2} = 10710 \left(\frac{t_c^3}{h_c}\right) \sqrt{\frac{f_{yc}}{\gamma_{m0}}}$ $h_c = D_c - (2 \times k)$ $= 314.5 - (2 \times 33.9)$ $= 246.7$ $P_{cw_2} = 10710 \times \frac{12.0^3}{246.7} \times \sqrt{\frac{300.0}{1.1}} \times 10^{-3}$ $= 1238.88$	**OK**

Check	Required	Provided	Remarks
Web Crippling Capacity (kN)		$P_{cw_3} = \left(\frac{300t_c^2}{\gamma_{m1}}\right)\left[1+3\left(T_b/D_c\right)\left(t_c/T_c\right)^{1.5}\right]\sqrt{f_{yc}\left(T_c/t_c\right)}$ $= \left(\frac{300\times 12.0^2}{1.25}\right)\times\left[1+3\times\left(17.2/314.5\right)\times\left(12.0/18.7\right)^{1.5}\right]\times$ $\sqrt{300.0\times\left(18.7/12.0\right)}\times 10^{-3}$ $= 810.27$	**OK**
Compression Strength (kN)		$P_{cw} = min(P_{cw_1},\ P_{cw_2},\ P_{cw_3})$ $= min(611.02,\ 1238.88,\ 810.27)$ $= 611.02$	**OK**
Continuity Plate Required?	$R_c = 660.24$	$P_{cw} = 611.02$	**Yes**

2.13 Continuity Plate Design - Compression/Tension Flange

Check	Required	Provided	Remarks
Area Required (mm2)	$A_{cp} = \frac{R_c - P_{cw}}{f_{y_{cp}}\gamma_{m0}}$ $= \frac{\left(660.24-611.02\right)\times 10^3}{240\times 1.1}$ $= 186.44$		**OK**
Notch Size (mm)		$n = 24$	**OK**

Check	Required	Provided	Remarks
Length (mm)		$l_{cp1} = Outer\ length$ $l_{cp1} = D_c - 2 \times T_c$ $= 314.5 - (2 \times 18.7)$ $= 277.1$ $l_{cp2} = Inner\ length$ $l_{cp2} = D_c - 2(T_c + n)$ $= 314.5 - \left[2 \times (18.7 + 24)\right]$ $= 229.1$	**OK**
Width (mm)		$w_{cp} = \frac{B_c - T_c - 2n}{2}$ $= \frac{307.4 - 12.0 - 2 \times 24}{2}$ $= 123.0$	**OK**

Check	Required	Provided	Remarks
Thickness (mm)	$t_{cp1} = Minimum\ area\ criteria$ $t_{cp1} = \frac{A_{cp}/2}{w_{cp}}$ $= \frac{186.44/2}{123.0}$ $= 0.76$ $t_{cp2} = Limiting\ b/t\ ratio\ criteria$ $t_{cp2} = \frac{l_{cp1}}{29.3\ \epsilon_{cp}}$ $\epsilon_{cp} = \sqrt{\frac{250}{f_{y_{cp}}}}$ $= \sqrt{\frac{250}{240}}$ $= 1.02$ $= \frac{277.1}{29.3 \times 1.02}$ $= 9.27$ $t_{cp3} = Minimum\ thickness\ criteria$ $t_{cp3} = T_b$ $= 17.2$ $t_{cp} = max(t_{cp1},\ t_{cp2},\ t_{cp3})$ $= max(0.76, 9.27, 17.2)$ $= 17.2$	18	**Pass**

2.14 Weld Design - Continuity Plate

Check	Required	Provided	Remarks
Weld Strength (N/mm2)	$f_{uw} = min(f_w,\ f_{u\,cp})$ $= min(410.0,\ 410)$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.1.1]$	$f_{uw} = 410.0$	**Pass**
Total (effective) Weld Length (mm)		$L_{w\,cp} = 217.1$ $Note: Provide\ weld\ on\ one\ side\ of\ the\ continuity\ plate$	**OK**
Weld Size (mm)	$t_{w\,cp} = \frac{V_{cp}/2}{f_{uw}\ k\ L_{w\,cp}} \times \sqrt{3}\ \gamma_{mw}$ $= \frac{R_c - P_{cw}}{2 \times f_{uw}\ k\ L_{w\,cp}} \times \sqrt{3}\ \gamma_{mw}$ $= \frac{(660.24 - 611.02) \times 10^3}{2 \times 410.0 \times 0.7 \times 217.1} \times \sqrt{3} \times 1.25$ $= 0.86$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7]$	5	**Pass**
Min. Weld Size (mm)	1) $t_{w\,min}$ – *based on thickness of the thicker part* $t_{thicker} = max(18,\ 12.0)$ $= 18$ $t_{w\,min} = 5$ 2) $t_{w\,min}$ – *based on thickness of the thinner part* $t_{thinner} = min(18,\ 12.0)$ $= 12.0$ $t_{w\,min} \leq min(5,\ 12.0)$ $[Ref\ IS\ 800:2007, Table\ 21\ ,\ Cl 10.5.2.3]$	$t_w = max(t_w,\ t_{w\,min})$ $= max(0.86,\ 5)$ $= 5$	**Pass**

Check	Required	Provided	Remarks
Max. Weld Size (mm)	$t_{w\,max}$ *based on thickness of the thinner part* $t_{thinner} = min(18,\ 12.0)$ $= 12.0$ $t_{w\,max} = 12$ [*Ref. IS* 800 : 2007, *Cl.* 10.5.3.1]	$t_w \leq t_{w\,max}$ $5 \leq 12$	**Pass**

2.15 Column Web Shear Check

Check	Required	Provided	Remarks
Web Stiffener Plate Required ?	$t_{wc} = \frac{1.9 M_{ue}}{D_c\ D_b\ f_{yc}}$ $= \frac{1.9 \times 235.22}{314.5 \times 500.0 \times 300.0}$ $= 9.47$	$t_c = 12.0$	**No**

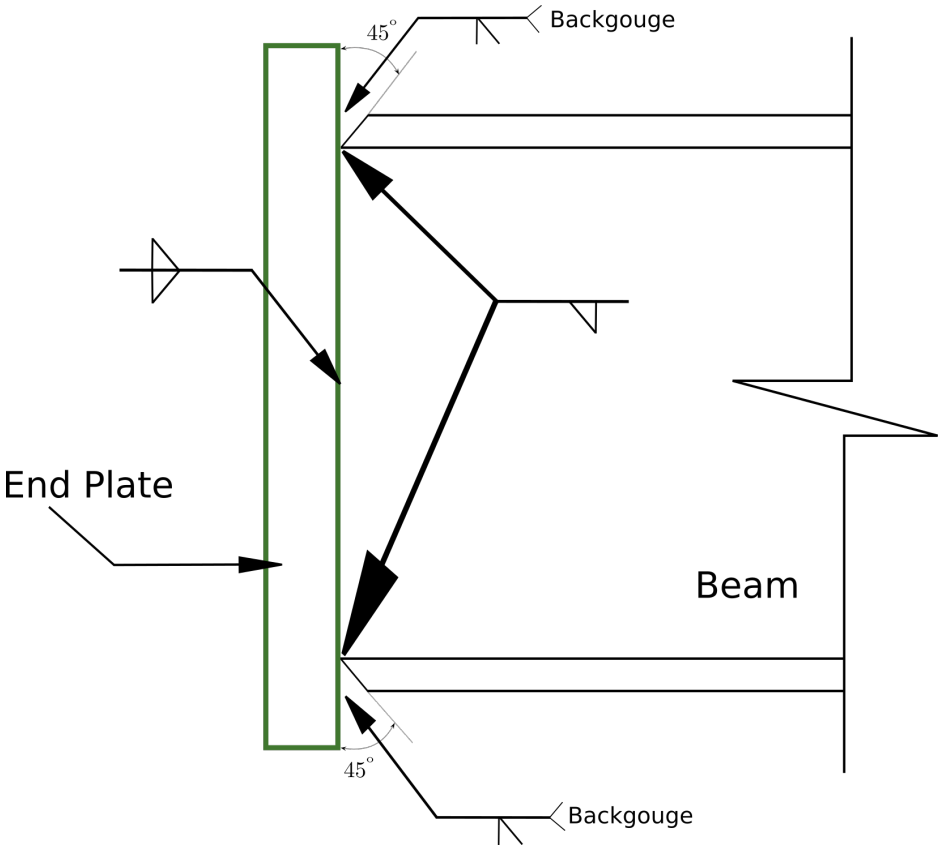


Figure 1: Typical Weld Details - Beam to End Plate Connection

3 2D Drawings (Typical)

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Beam-Column End Plate
Designer	Engineer #1	Job Number	1.2.2.1.1.1.2
Date	18 /12 /2020	Client	Manas M. Ghosh, INSDAG, Kolkata

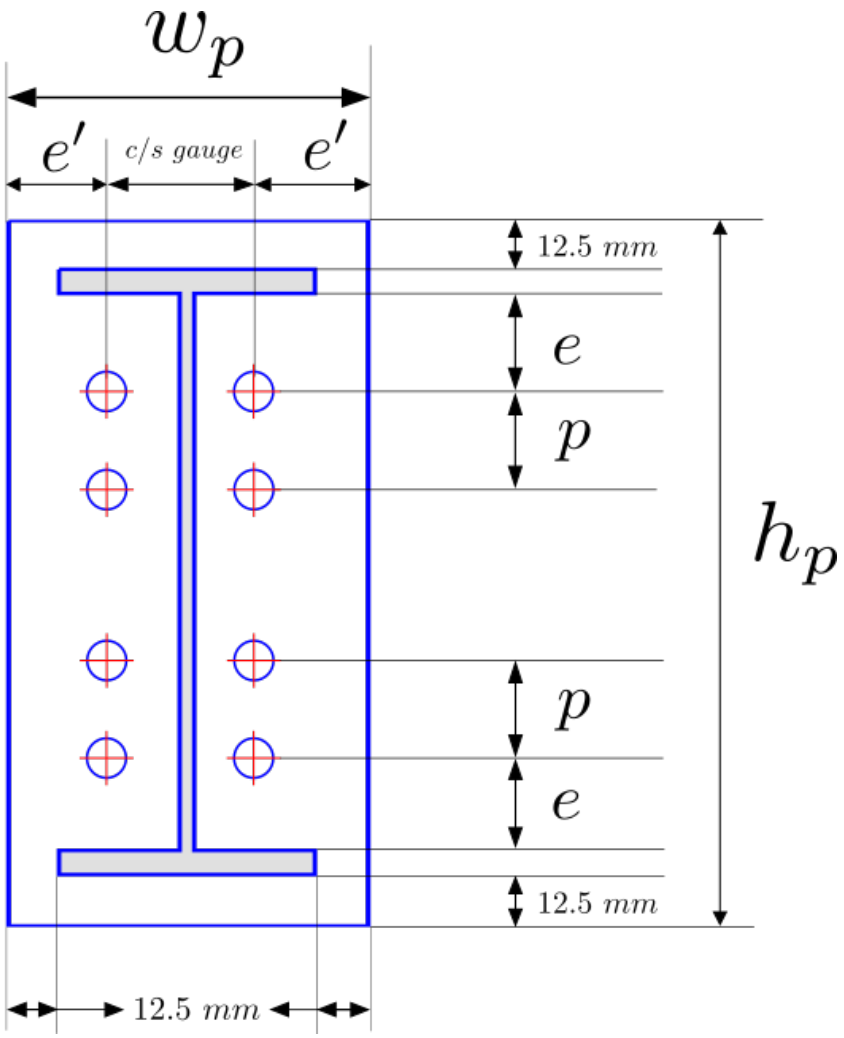


Figure 2: Typical Detailing

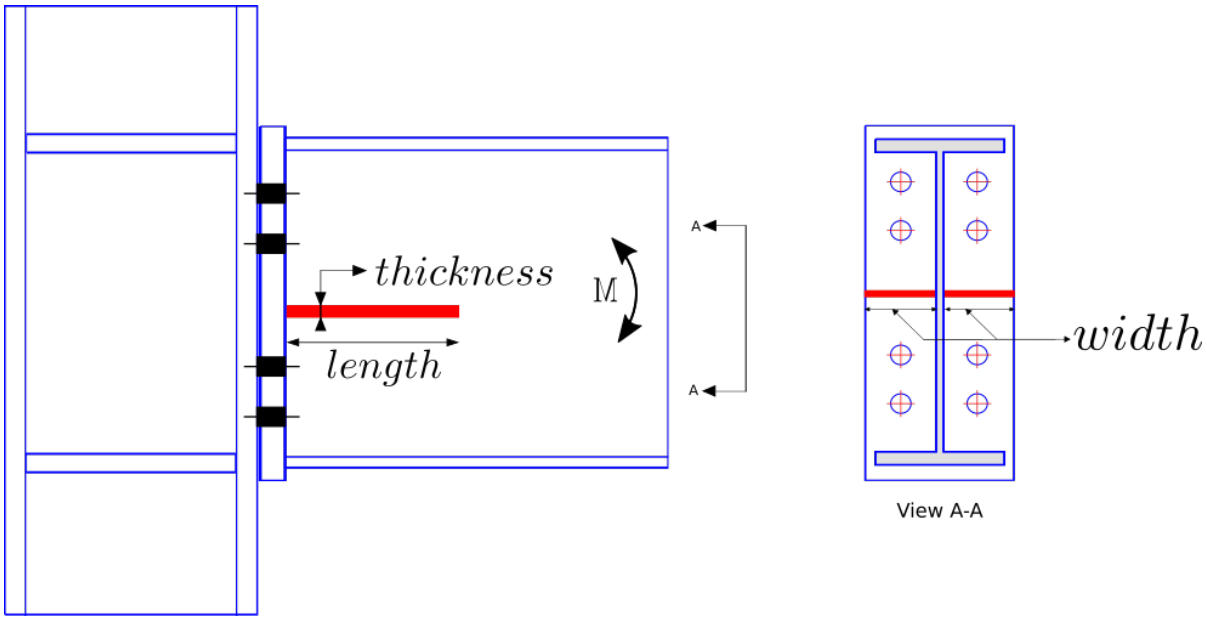
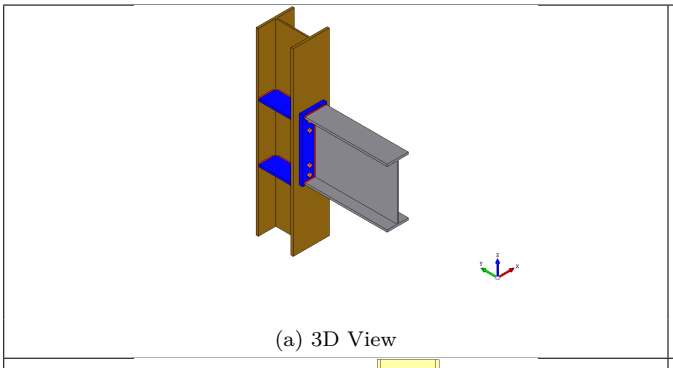
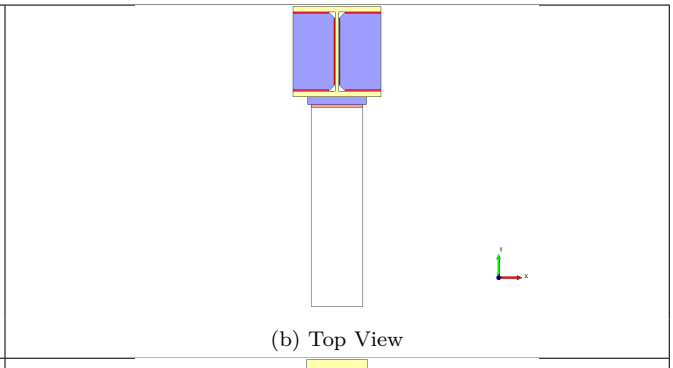


Figure 3: Typical Stiffener Details

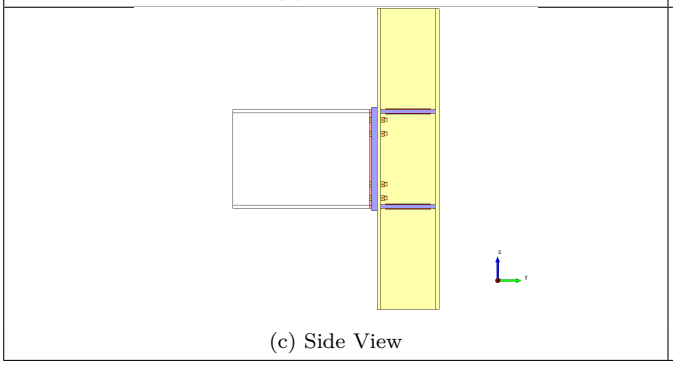
4 3D Views



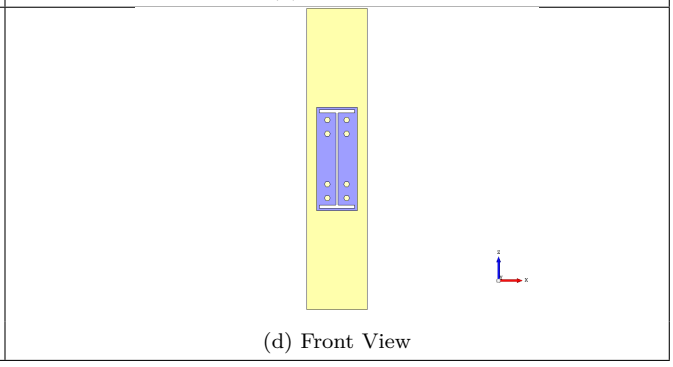
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

5 Design Log

2020-12-18 00:12:18 - Osdag - WARNING - The Load(s) defined is/are less than the minimum recommended value [Ref. IS 800:2007, Cl.10.7].
2020-12-18 00:12:18 - Osdag - WARNING - [Minimum Factored Load] The external factored bending moment (150.0 kNm) is less than 0.5 times the plastic moment capacity of the beam (470.45 kNm)
2020-12-18 00:12:18 - 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)
2020-12-18 00:12:18 - 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
2020-12-18 00:12:18 - Osdag - INFO - Designing the connection for a factored moment of 235.22 kNm
2020-12-18 00:12:18 - Osdag - INFO - [Bolt Design] Bolt diameter and grade combination ready to perform bolt design
2020-12-18 00:12:18 - Osdag - INFO - The solver has selected 1.0 combinations of bolt diameter and grade to perform optimum bolt design in an iterative manner
2020-12-18 00:12:18 - Osdag - INFO - Checking the design with the following bolt diameter-grade combination [(20.0, 12.9)]
2020-12-18 00:12:18 - Osdag - WARNING - [Column Web] The web of the column is not susceptible to shear bucking due to the reaction transferred by the beam to the column
2020-12-18 00:12:18 - Osdag - INFO - The minimum required thickness of the web i.e. 9.47 mm is satisfied
2020-12-18 00:12:18 - Osdag - INFO - Additional stiffening of the column web is not required
2020-12-18 00:12:18 - Osdag - INFO - [Optimisation] Performing the design by optimising the plate thickness, using the thin plate and large (suitable) bolt diameter approach
2020-12-18 00:12:18 - Osdag - INFO - If you wish to optimise the bolt diameter-grade combination, pass a higher value of plate thickness using the Input Dock
2020-12-18 00:12:18 - Osdag - INFO - The provided beam can accommodate a single column of bolt on either side of the web [Ref. based on detailing requirement]
2020-12-18 00:12:18 - Osdag - INFO - Performing the design with a single column of bolt on each side
2020-12-18 00:12:18 - Osdag - INFO - [Flange Strength] The reaction at the compression flange of the beam 582.98 kN is less than the flange capacity 703.64 kN. The flange strength requirement is satisfied.
2020-12-18 00:12:18 - Osdag - ERROR - [End Plate] The selected trial end plate of 28.0 mm is insufficient and fails in the moment capacity check
2020-12-18 00:12:18 - Osdag - INFO - The minimum required thickness of end plate is 31.68 mm
2020-12-18 00:12:18 - Osdag - INFO - Re-designing the connection with a plate of available higher thickness
2020-12-18 00:12:18 - Osdag - ERROR - [Bolt Design] The bolt of 20.0 mm diameter and 12.9 grade fails the tension check
2020-12-18 00:12:18 - Osdag - ERROR - Total tension demand on bolt (due to direct tension + prying action) is 325.12913966085824 kN and exceeds the bolt tension capacity (215.21 kN)
2020-12-18 00:12:18 - Osdag - INFO - Re-designing the connection with a bolt of higher grade and/or diameter
2020-12-18 00:12:18 - Osdag - ERROR - [Bolt Design] The bolt of 20.0 mm diameter and 12.9 grade fails the combined shear + tension check
2020-12-18 00:12:18 - Osdag - ERROR - The Interaction Ratio (IR) of the critical bolt is 2.361
2020-12-18 00:12:18 - Osdag - INFO - Re-designing the connection with a bolt of higher grade and/or diameter