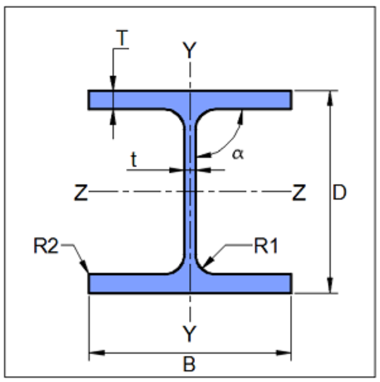
Created with

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer#1	Job Number	1.1.2.3.2
Date	04 /02 /2021	Client	Mr. Yogesh D Pisal, Mumbai

1 Input Parameters

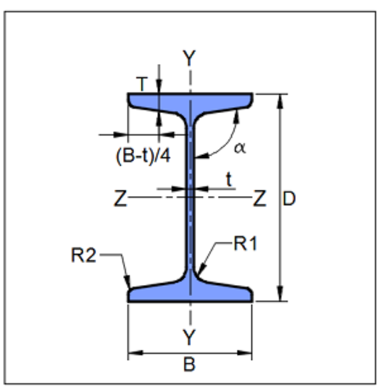
Main Module	Shear Connection
Module	End Plate Connection
Connectivity	Beam-Beam
Shear Force (kN)	100.0
Axial Force (kN)	0.0

Supporting Section - Mechanical Properties



Supporting Section		UB 305 x 102 x 33	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, F_u (MPa)		410	
Yield Strength, F_y (MPa)		250	
Mass, m (kg/m)	32.8	I_z (cm^4)	6501.0
Area, A (cm^2)	41.8	I_y(cm^4)	194.0
D (mm)	313.0	r_z (cm)	12.5
B (mm)	102.4	r_y (cm)	2.2
t (mm)	6.6	Z_z (cm^3)	416.0
T (mm)	10.8	Z_y (cm^3)	38.0
Flange Slope	90	Z_{pz} (cm^3)	481.0
R_1 (mm)	7.6	Z_{py} (cm^3)	60.0
R_2 (mm)	0.0		

Supported Section - Mechanical Properties



Supported Section		MB 300	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, F_u (MPa)		410	
Yield Strength, F_y (MPa)		250	
Mass, m (kg/m)	46.02	I_z (cm^4)	8990.0
Area, A (cm^2)	58.6	I_y(cm^4)	486.0
D (mm)	300.0	r_z (cm)	12.3
B (mm)	140.0	r_y (cm)	2.87
t (mm)	7.7	Z_z (cm^3)	599.0
T (mm)	13.1	Z_y (cm^3)	69.4
Flange Slope	98	Z_{pz} (cm^3)	681.0
R_1 (mm)	14.0	Z_{py} (cm^3)	117.0
R_2 (mm)	7.0		

Bolt Details - Input and Design Preference	
Diameter (mm)	[16]
Property Class	[5.8]
Type	Bearing Bolt
Hole Type	Over-sized
Bolt Tension	Non pre-tensioned
Slip Factor, (μ_f)	0.3
Detailing - Design Preference	
Edge Preparation Method	Sheared or hand flame cut
Gap Between Members (mm)	10.0
Are the Members Exposed to Corrosive Influences?	False
Plate Details - Input and Design Preference	
Thickness (mm)	[14]
Material	E 250 (Fe 410 W)A
Ultimate Strength, Fu (MPa)	410
Yield Strength, Fy (MPa)	250
Weld Details - Input and Design Preference	
Weld Type	Fillet
Type of Weld Fabrication	Shop Weld
Material Grade Overwrite, Fu (MPa)	450.0

2 Design Checks

Design Status	Pass

2.1 Section Design Check

Check	Required	Provided	Remarks
Shear Capacity (kN)	100.0	$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{260.0 \times 7.7 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 262694.3724812797$ [Ref. IS 800:2007, Cl.10.4.3]	Pass
Tension Capacity (kN)	0.0	$T_{\text{dg}} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 260.0 \times 7.7$ $= \frac{2002.0 \times 250}{1.1 \times 10^3}$ $= 455000.0$ [Ref. IS 800:2007, Cl.6.2]	

2.2 Bolt Design

Check	Required	Provided	Remarks
Diameter (mm)		16	
Property Class		5.8	
Plate Thickness (mm)		14	
No. of Bolt Columns	2	2	Pass
No. of Bolt Rows		2	Pass
Min. Pitch Distance (mm)	$p_{\text{min}} = 2.5d$ $= 2.5 \times 16$ $= 40.0$ [Ref. IS 800:2007, Cl.10.2.2]	80	Pass

Check	Required	Provided	Remarks
Max. Pitch Distance (mm)	$p/g_{\max} = \min(32t,\ 300)$ $= \min(32 \times 7.7,\ 300)$ $= \min(246.4,\ 300)$ $= 246.4$ Where, $t = \min(14.0, 7.7)$ [Ref. IS 800:2007, Cl.10.2.3]	80	**Pass**
Min. End Distance (mm)	$e_{\min} = 1.7 d_0$ $= 1.7 \times 20.0$ $= 34.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	35	**Pass**
Max. End Distance (mm)	$e_{\max} = 12 t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 14 \times \sqrt{\frac{250}{250}} = 168.0$ $e_2 = 12 \times 6.6 \times \sqrt{\frac{250}{250}} = 79.2$ $e_{\max} = \min(e_1,\ e_2) = 79.2$ [Ref. IS 800:2007, Cl.10.2.4.3]	35	**Pass**
Min. Edge Distance (mm)	$e'_{\min} = 1.7 d_0$ $= 1.7 \times 20.0$ $= 34.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	35	**Pass**

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{\max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 14 \times \sqrt{\frac{250}{250}} = 168.0$ $e_2 = 12 \times 6.6 \times \sqrt{\frac{250}{250}} = 79.2$ $e'_{\max} = min(e_1,\ e_2) = 79.2$ [Ref. IS 800:2007, Cl.10.2.4.3]	35	Pass
Min. Gauge Distance (mm)	$g_{min} = 2(e`_{min} + s) + t_w$ $= 2(34.0 + 5) + 7.7$ $= 85.7$	88	Pass
Shear Capacity (kN)		$V_{\text{dsb}} = \frac{f_{ub} n_n A_{nb}}{\sqrt{3}\gamma_{mb}}$ $= \frac{520.0 \times 1 \times 157}{1000 \times \sqrt{3} \times 1.25}$ $= 37.71$ [Ref. IS 800:2007, Cl.10.3.3]	
Kb		$k_b = \min\left(\frac{e}{3d_0}, \frac{p}{3d_0} - 0.25, \frac{f_{ub}}{f_u}, 1.0\right)$ $= \min\left(\frac{35}{3 \times 20.0}, \frac{80}{3 \times 20.0} - 0.25, \frac{520.0}{410}, 1.0\right)$ $= \min(0.58, 1.08, 1.27, 1.0)$ $= 0.58$ [Ref. IS 800:2007, Cl.10.3.4]	
Bearing Capacity (kN)		$V_{\text{dpb}} = \frac{2.5 k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.58 \times 16 \times 6.6 \times 410}{1000 \times 1.25}$ $= 35.16$ [Ref. IS 800:2007, Cl.10.3.4]	

Check	Required	Provided	Remarks
Capacity (kN)	$V_{bv} = \frac{V}{n}$ $= \frac{100.0}{4}$ $= 25.0$	$V_{\rm db} = \min\ (V_{\rm dsb},\ V_{\rm dpb})$ $= \min\ (37.71,\ 35.16)$ $= 35156.35199999999$ [Ref. IS 800:2007, Cl.10.3.2]	
Long Joint Reduction Factor		$l_j = (n_r - 1) \times p$ $= (2 - 1) \times 80 = 80$ $l = 88$ $15 \times d = 15 \times 16 = 240$ since, $l_j < 15 \times d$ then $\beta_{lj} = 1.0$ [Ref. IS 800:2007, Cl.10.3.3.1]	
Large Grip Length Reduction Factor		$l_g = \Sigma\ (t_p + t_{\rm member})$ $= 30.6$ $5d = 80$ $8d = 128$ since, $l_g < 5d$; $\beta_{lg} = 1.0$ [Ref. IS 800:2007, Cl.10.3.3.2]	
Packing Plate Reduction Factor		$t_{pk} = \text{gap}$ $= 10.0\text{mm}$ since, $t_{pk} \geq 6\text{mm},$ then $V_{\rm rd} = \beta_{pk}\ V_{\rm db}$ $\beta_{pk} = 1.0 - 0.0125 \times 10.0 = 0.875$ [Ref. IS 800:2007, Cl.10.3.3.3]	
Bolt Capacity (post reduction factor) (kN)	25.0	$V_{\rm rd} = \beta_{lj}\ \beta_{lg} \beta_{pk} V_{\rm db}$ $= 1.0 \times 1.0 \times 0.875 \times 35.16$ $= 30.76$ [Ref. IS 800:2007, Cl.10.3.3]	

Check	Required	Provided	Remarks
Bolt Tension Force (kN)	$T_{ba} = \frac{P}{n} = \frac{0.0}{4} = 0.0$		

Check	Required	Provided	Remarks
Bolt Prying Force (kN)	$Q = \frac{l_v}{2l_e}\left[T_e - \frac{\beta\eta f_o b_e t^4}{27 l_e l_v^2}\right]$ $l_v = e - \frac{R_1}{2} = 35 - \frac{14.0}{2} = 35.15$ mm $f_o = 0.7 f_{ub} = 0.7 \times 520.0 = 364.0\ \mathrm{N/mm^2}$ $l_e = \min\left(e, 1.1t\sqrt{\frac{\beta f_o}{f_y}}\right) = \min\left(35, 1.1 \times 14 \times \sqrt{\frac{2 \times 364.0}{250}}\right) = \min(35,\ 26.28) = 26.28$ mm $\beta = 2$ (non pre-tensioned bolt) $\eta = 1.5$ $b_e = \frac{B}{n_c} = \frac{140.0}{2} = 70.3$ mm $Q = \frac{35.15}{2 \times 26.28} \times \left[0.0 - \left(\frac{2 \times 1.5 \times 364.0 \times 70.3 \times 14^4}{27 \times 26.28 \times 35.15^2}\right) \times 10^{-3}\right]$ $Q = 0.0$ *Note : The end plate is sufficiently thick to prevent yielding of the plate. Thus,* $Q = 0$ [Ref. IS 800:2007, Cl.10.4.7]		

Check	Required	Provided	Remarks
Bolt Tension Force (kN)	$T_f = T_1 + Q$ $= 0.0 + 0.0$ $= 0.0$	$T_{\text{db}} = 0.90 f_{ub} A_n \ / \ \gamma_{mb}$ $< \ f_{yb} A_{sb} (\gamma_{mb} \ / \ \gamma_{m0})$ $= \min\Big(0.90 \times 520.0 \times 157 \ / \ 1.25,$ $520.0 \times 201 \times (1.25/1.1)\Big)$ $= \min(58.78, \ 118.77)$ $= 58.78$ [Ref. IS 800:2007, Cl.10.3.5]	
Interaction Ratio	≤ 1	$\left(\frac{V_{sb}}{V_{\text{db}}}\right)^2 + \left(\frac{T_{\text{b}}}{T_{\text{db}}}\right)^2 \leq 1.0$ $\left(\frac{25.0}{30.76}\right)^2 + \left(\frac{0.0}{58.78}\right)^2 = 0.66$ [Ref. IS 800:2007, Cl.10.3.6]	Pass

2.3 Plate Design

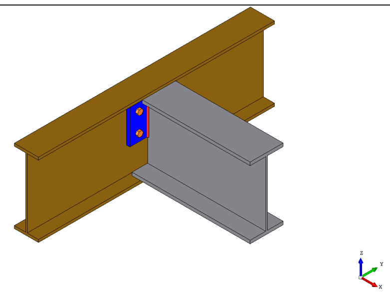
Check	Required	Provided	Remarks
Min. Plate Height (mm)	$0.6 \times (d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (300.0 - 2 \times 13.1 - 2 \times 14.0)$ $= 147.48$ [Ref. INSDAG, Ch.5, sec.5.2.3]	150	Pass
Max. Plate Height (mm)	$d_b - t_{bf} + r_{b1} - notch_h$ $= 300.0 - 13.1 + 14.0 - 40$ $= 232.9$	150	Pass
Min. Plate Thickness (mm)	$t_w = 7.7$	14	Pass
Min. Plate Width (mm)	$w_{p_{\min}} = g` + e`_{\min} \ 2$ $= 88 + 34.0 \times 2$ $= 156.0$	158	Pass
Max. Plate Width (mm)	N/A	158	

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)		$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{150 \times 14 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 275.55$ [Ref. IS 800:2007, Cl.10.4.3]	
Block Shear Capacity in Shear (kN)		$V_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{\text{db}} = \min(V_{db1},\ V_{db2}) = 417.9$ [Ref. IS 800:2007, Cl.6.4]	
Shear Capacity (kN)	100.0	$V_d = \min(S_c,\ V_{d_b})$ $= \min(275.55, 417.9)$ $= 275.55$ [Ref. IS 800:2007, Cl.6.1]	**Pass**
Moment Capacity (kNm)	$M = T_e \times \text{ecc}$ $ecc = \frac{g}{2} - \frac{t_w}{2} - s = 35.15$ $M = 0.0 \times 35.15 \times 10^{-3} = 0.0$	$M_{d_z} = \frac{\beta_b Z_p fy}{\gamma_{m0} \times 10^6}$ $= \frac{1.0 \times 7350.0 \times 250}{1.1 \times 10^6}$ $= 0.78$ [Ref. IS 800:2007, Cl.8.2.1.2]	

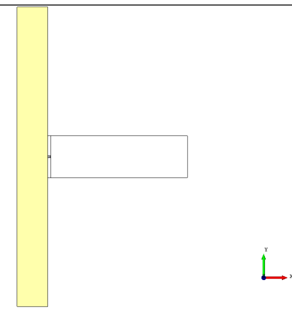
2.4 Weld Design

Check	Required	Provided	Remarks
Min. Weld Size (mm)	$t_{w_{\min}}$ based on thinner part $= \max(7,\ 7)$ $s_{\min}$ based on thicker part $= 5$ [Ref. IS 800:2007, Table 21, Cl.10.5.2.3]	5	**Pass**
Max. Weld Size (mm)	Thickness of thinner part $= \min(14,\ 7.7) = 7.7$ $s_{\max} = 8$ [Ref. IS 800:2007, Cl.10.5.3.1]	5	**Pass**
Weld Strength (N/mm)	$R_{\mathrm{w}} = \sqrt{(A_{\mathrm{wh}})^2 + (V_{\mathrm{wv}})^2}$ $V_{\mathrm{wv}} = \frac{V}{l_w} = \frac{100000.0}{280.0}$ $A_{\mathrm{wh}} = \frac{A}{l_w} = \frac{0.0}{280.0}$ $R_{\mathrm{w}} = \sqrt{(0.0)^2 + (357.14)^2}$ $= 357.14$	$f_w = \frac{t_t f_u}{\sqrt{3}\gamma_{mw}}$ $= \frac{3.5 \times 410}{\sqrt{3} \times 1.25}$ $= 662.8$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	
Weld Strength (post long joint) (N/mm)	if $l \geq 150t_t$, then $V_{\mathrm{rd}} = \beta_{l_w} V_{\mathrm{db}}$ if $l < 150t_t$, *then* $V_{\mathrm{rd}} = V_{\mathrm{db}}$ where, l = plate length or height $\beta_{l_w} = 1.2 - \frac{(0.2l)}{(150t_t)}$ but, $0.6 \leq \beta_{l_w} \leq 1.0$ [Ref. IS 800:2007, Cl.10.5.7.3]	$l_w = h$ $= 150$ $150t_t = 150 \times 3.5 = 525.0$ since, $l < 150t_t$ *then* $f_{\mathrm{wrd}} = f_{\mathrm{w}}$ $f_{\mathrm{wrd}} = 662.8$ [Ref. IS 800:2007, Cl.10.5.7.3.]	
Weld Strength (N/mm)	357.14	662.8	**Pass**

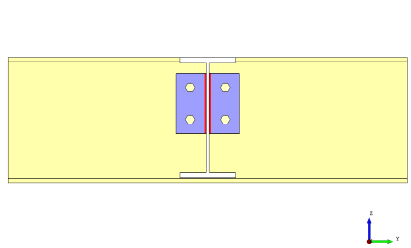
3 3D Views



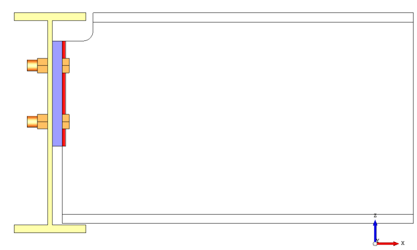
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log

2021-02-04 12:18:42 - Osdag - INFO - End plate is designed with minimum possible plate thickness.

2021-02-04 12:18:42 - Osdag - INFO - Bolt columns are limited to two (one on each side) in shear end plate.

2021-02-04 12:18:42 - Osdag - INFO - === End Of Design ===