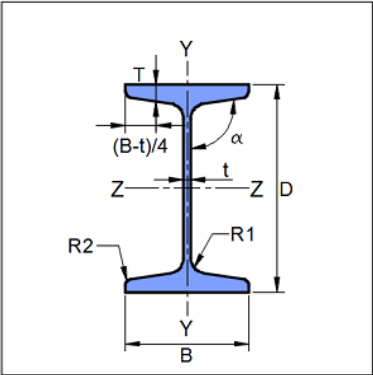
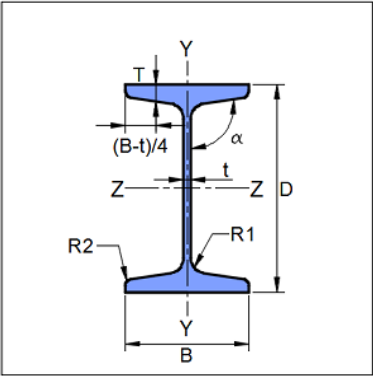




Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer#1	Job Number	1.1.2.3.1
Date	04 /02 /2021	Client	Dr. Pradyumna M, Bengaluru

## 1 Input Parameters

Main Module		Shear Connection		
Module		End Plate Connection		
Connectivity		Beam-Beam		
Shear Force (kN)		160.0		
Axial Force (kN)		20.0		
Supporting Section - Mechanical Properties				
	Supporting Section		WB 400	
	Material		E 300 (Fe 440)	
	Ultimate Strength, $F_u$ (MPa)		440	
	Yield Strength, $F_y$ (MPa)		300	
	Mass, $m$ (kg/m)	66.71	$I_z$ (cm <sup>4</sup> )	23400.0
	Area, $A$ (cm <sup>2</sup> )	85.0	$I_y$ (cm <sup>4</sup> )	1380.0
	$D$ (mm)	400.0	$r_z$ (cm)	16.6
	$B$ (mm)	200.0	$r_y$ (cm)	4.04
	$t$ (mm)	8.6	$Z_z$ (cm <sup>3</sup> )	1170.0
	$T$ (mm)	13.0	$Z_y$ (cm <sup>3</sup> )	138.0
	Flange Slope	96	$Z_{pz}$ (cm <sup>3</sup> )	1320.0
	$R_1$ (mm)	13.0	$Z_{py}$ (cm <sup>3</sup> )	234.0
	$R_2$ (mm)	6.5		
	Supported Section - Mechanical Properties			
	Supported Section		MB 350	
	Material		E 300 (Fe 440)	
	Ultimate Strength, $F_u$ (MPa)		440	
	Yield Strength, $F_y$ (MPa)		300	
	Mass, $m$ (kg/m)	52.33	$I_z$ (cm <sup>4</sup> )	13600.0
	Area, $A$ (cm <sup>2</sup> )	66.7	$I_y$ (cm <sup>4</sup> )	537.0
	$D$ (mm)	350.0	$r_z$ (cm)	14.2
	$B$ (mm)	140.0	$r_y$ (cm)	2.83
	$t$ (mm)	8.1	$Z_z$ (cm <sup>3</sup> )	779.0
	$T$ (mm)	14.2	$Z_y$ (cm <sup>3</sup> )	76.8
	Flange Slope	98	$Z_{pz}$ (cm <sup>3</sup> )	889.0
	$R_1$ (mm)	14.0	$Z_{py}$ (cm <sup>3</sup> )	129.0
	$R_2$ (mm)	7.0		



Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer#1	Job Number	1.1.2.3.1
Date	04 /02 /2021	Client	Dr. Pradyumna M, Bengaluru

Bolt Details - Input and Design Preference	
Diameter (mm)	[16, 20, 24]
Property Class	[8.8, 10.9]
Type	Friction Grip Bolt
Hole Type	Standard
Bolt Tension	Pretensioned
Slip Factor, ( $\mu_f$ )	0.48
Detailing - Design Preference	
Edge Preparation Method	Rolled, machine-flame cut, sawn and planed
Gap Between Members (mm)	10.0
Are the Members Exposed to Corrosive Influences?	False
Plate Details - Input and Design Preference	
Thickness (mm)	[16, 18, 20, 22]
Material	E 250 (Fe 410 W)A
Ultimate Strength, $F_u$ (MPa)	410
Yield Strength, $F_y$ (MPa)	250
Weld Details - Input and Design Preference	
Weld Type	Fillet
Type of Weld Fabrication	Shop Weld
Material Grade Overwrite, $F_u$ (MPa)	410.0



Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer#1	Job Number	1.1.2.3.1
Date	04 /02 /2021	Client	Dr. Pradyumna M, Bengaluru

## 2 Design Checks

Design Status	Pass
---------------	------

### 2.1 Section Design Check

Check	Required	Provided	Remarks
Shear Capacity (kN)	160.0	$V_{dy} = \frac{A_v f_y}{\sqrt{3} \gamma_{m0}}$ $= \frac{310.0 \times 8.1 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 395379.96161867736$ [Ref. IS 800:2007, Cl.10.4.3]	Pass
Tension Capacity (kN)	20.0	$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 310.0 \times 8.1$ $= \frac{2511.0 \times 300}{1.1 \times 10^3}$ $= 684818.18$ [Ref. IS 800:2007, Cl.6.2]	Pass

### 2.2 Bolt Design

Check	Required	Provided	Remarks
Diameter (mm)		16	
Property Class		10.9	
Plate Thickness (mm)		16	
No. of Bolt Columns	2	2	Pass
No. of Bolt Rows		2	Pass
Min. Pitch Distance (mm)	$p_{min} = 2.5d$ $= 2.5 \times 16$ $= 40.0$ [Ref. IS 800:2007, Cl.10.2.2]	120	Pass



Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer#1	Job Number	1.1.2.3.1
Date	04 /02 /2021	Client	Dr. Pradyumna M, Bengaluru

Check	Required	Provided	Remarks
Max. Pitch Distance (mm)	$p/g_{\max} = \min(32t, 300)$ $= \min(32 \times 8.1, 300)$ $= \min(259.2, 300)$ $= 259.2$ <p>Where, <math>t = \min(22.0, 8.1)</math></p> <p>[Ref. IS 800:2007, Cl.10.2.3]</p>	120	Pass
Min. End Distance (mm)	$e_{\min} = 1.5d_0$ $= 1.5 \times 18.0$ $= 27.0$ <p>[Ref. IS 800:2007, Cl.10.2.4.2]</p>	30	Pass
Max. End Distance (mm)	$e_{\max} = 12t\varepsilon; \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 16 \times \sqrt{\frac{250}{240}} = 195.96$ $e_2 = 12 \times 8.6 \times \sqrt{\frac{250}{300}} = 94.21$ $e_{\max} = \min(e_1, e_2) = 94.21$ <p>[Ref. IS 800:2007, Cl.10.2.4.3]</p>	30	Pass
Min. Edge Distance (mm)	$e'_{\min} = 1.5d_0$ $= 1.5 \times 18.0$ $= 27.0$ <p>[Ref. IS 800:2007, Cl.10.2.4.2]</p>	30	Pass



Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer#1	Job Number	1.1.2.3.1
Date	04 /02 /2021	Client	Dr. Pradyumna M, Bengaluru

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{\max} = 12t\epsilon; \epsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 16 \times \sqrt{\frac{250}{240}} = 195.96$ $e_2 = 12 \times 8.6 \times \sqrt{\frac{250}{300}} = 94.21$ $e'_{\max} = \min(e_1, e_2) = 94.21$ <p>[Ref. IS 800:2007, Cl.10.2.4.3]</p>	30	Pass
Min. Gauge Distance (mm)	$g_{\min} = 2(e'_{\min} + s) + t_w$ $= 2(27.0 + 5) + 8.1$ $= 72.1$	80	Pass
Slip Resistance (kN)		$V_{dsf} = \frac{\mu_f n_e K_h F_o}{\gamma_{mf}}$ <p>Where, <math>F_o = 0.7 f_{ub} A_{nb}</math></p> $V_{dsf} = \frac{0.48 \times 1 \times 1.0 \times 0.7 \times 1040.0 \times 157}{1.25 \times 10^3}$ $= 43889.664$ <p>[Ref. IS 800:2007, Cl.10.4.3]</p>	
Capacity (kN)	$V_{bv} = \frac{V}{n}$ $= \frac{160.0}{4}$ $= 40.0$	43889.664	
Long Joint Reduction Factor		$l_j = (n_r - 1) \times p$ $= (2 - 1) \times 120 = 120$ $l = 120$ $15 \times d = 15 \times 16 = 240$ <p>since, <math>l_j &lt; 15 \times d</math> then <math>\beta_{lj} = 1.0</math></p> <p>[Ref. IS 800:2007, Cl.10.3.3.1]</p>	



Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer#1	Job Number	1.1.2.3.1
Date	04 /02 /2021	Client	Dr. Pradyumna M, Bengaluru

Check	Required	Provided	Remarks
Large Grip Length Reduction Factor		$l_g = \Sigma (t_p + t_{\text{member}})$ $= 34.6$ $5d = 80$ $8d = 128$ 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 $V_{rd} = \beta_{pk} V_{db}$ $\beta_{pk} = 1.0 - 0.0125 \times 10.0 = 0.875$  [Ref. IS 800:2007, Cl.10.3.3.3]	
Bolt Capacity (post reduction factor) (kN)	40.0	$V_{rd} = \beta_{lj} \beta_{lg} \beta_{pk} V_{db}$ $= 1.0 \times 1.0 \times 1.0 \times 43.89$ $= 43.89$  [Ref. IS 800:2007, Cl.10.3.3]	
Bolt Tension Force (kN)	$T_{ba} = \frac{P}{n}$ $= \frac{20.0}{4}$ $= 5.0$		



Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer#1	Job Number	1.1.2.3.1
Date	04 /02 /2021	Client	Dr. Pradyumna M, Bengaluru

Check	Required	Provided	Remarks
Bolt Prying Force (kN)	$Q = \frac{l_v}{2l_e} \left[ T_e - \frac{\beta \eta f_o b_e t^4}{27 l_e l_v^2} \right]$ $l_v = e - \frac{R_1}{2}$ $= 30 - \frac{14.0}{2} = 30.95 \text{ mm}$ $f_o = 0.7 f_{ub}$ $= 0.7 \times 1040.0$ $= 728.0 \text{ N/mm}^2$ $l_e = \min \left( e, 1.1 t \sqrt{\frac{\beta f_o}{f_y}} \right)$ $= \min \left( 30, 1.1 \times 16 \times \sqrt{\frac{1 \times 728.0}{250}} \right)$ $= \min(30, 30.03) = 30 \text{ mm}$ $\beta = 1 \text{ (pre-tensioned bolt)}$ $\eta = 1.5$ $b_e = \frac{B}{n_c}$ $= \frac{140.0}{2} = 61.9 \text{ mm}$ $Q = \frac{30.95}{2 \times 30} \times \left[ 5.0 - \left( \frac{1 \times 1.5 \times 728.0 \times 61.9 \times 16^4}{27 \times 30 \times 30.95^2} \right) \right] \times 10^{-3}$ $Q = 0.0$ <p><i>Note : The end plate is sufficiently thick to prevent yielding of the plate. Thus, Q = 0</i></p> <p>[Ref. IS 800:2007, Cl.10.4.7]</p>		



Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer#1	Job Number	1.1.2.3.1
Date	04 /02 /2021	Client	Dr. Pradyumna M, Bengaluru

Check	Required	Provided	Remarks
Bolt Tension Force (kN)	$T_f = T_1 + Q$ $= 5.0 + 0.0$ $= 5.0$	$T_{db} = 0.90 f_{ub} A_n / \gamma_{mb}$ $< f_{yb} A_{sb} (\gamma_{mb} / \gamma_{m0})$ $= \min \left( 0.90 \times 1040.0 \times 157 / 1.25, \right.$ $\left. 1040.0 \times 201 \times (1.25/1.1) \right)$ $= \min(117.56, 237.55)$ $= 117.56$  [Ref. IS 800:2007, Cl.10.3.5]	Pass
Interaction Ratio	$\leq 1$	$\left( \frac{V_{sb}}{V_{db}} \right)^2 + \left( \frac{T_b}{T_{db}} \right)^2 \leq 1.0$ $\left( \frac{40.0}{43.89} \right)^2 + \left( \frac{5.0}{117.56} \right)^2 = 0.83$  [Ref. IS 800:2007, Cl.10.3.6]	Pass

## 2.3 Plate Design

Check	Required	Provided	Remarks
Min. Plate Height (mm)	$0.6 \times (d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (350.0 - 2 \times 14.2 - 2 \times 14.0)$ $= 176.16$  [Ref. INSDAG, Ch.5, sec.5.2.3]	180	Pass
Max. Plate Height (mm)	$d_b - t_{bf} + r_{b1} - notch_h$ $= 350.0 - 14.2 + 14.0 - 40$ $= 281.8$	180	Pass
Min. Plate Thickness (mm)	$t_w = 8.1$	16	Pass
Min. Plate Width (mm)	$w_{pmin} = g^i + e^i_{min} \ 2$ $= 80 + 27.0 \times 2$ $= 134.0$	140	Pass
Max. Plate Width (mm)	N/A	140	





Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer#1	Job Number	1.1.2.3.1
Date	04 /02 /2021	Client	Dr. Pradyumna M, Bengaluru

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)		$V_{dy} = \frac{A_v f_y}{\sqrt{3} \gamma_{m0}}$ $= \frac{180 \times 16 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 377.9$ [Ref. IS 800:2007, Cl.10.4.3]	
Block Shear Capacity in Shear (kN)		$V_{db1} = \frac{A_{vg} f_y}{\sqrt{3} \gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{db2} = \frac{0.9 A_{vn} f_u}{\sqrt{3} \gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{db} = \min(V_{db1}, V_{db2}) = 513.29$ [Ref. IS 800:2007, Cl.6.4]	
Shear Capacity (kN)	160.0	$V_d = \min(S_c, V_{db})$ $= \min(377.9, 513.29)$ $= 377.9$ [ Ref. IS 800:2007, Cl.6.1]	Pass
Moment Capacity (kNm)	$M = T_e \times ecc$ $ecc = \frac{g}{2} - \frac{t_w}{2} - s = 30.95$ $M = 5.0 \times 30.95 \times 10^{-3} = 0.15$	$M_{dz} = \frac{\beta_b Z_p f_y}{\gamma_{m0} \times 10^6}$ $= \frac{1.0 \times 11520.0 \times 250}{1.1 \times 10^6}$ $= 0.873$ [Ref. IS 800:2007, Cl.8.2.1.2]	Pass



Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer#1	Job Number	1.1.2.3.1
Date	04 /02 /2021	Client	Dr. Pradyumna M, Bengaluru

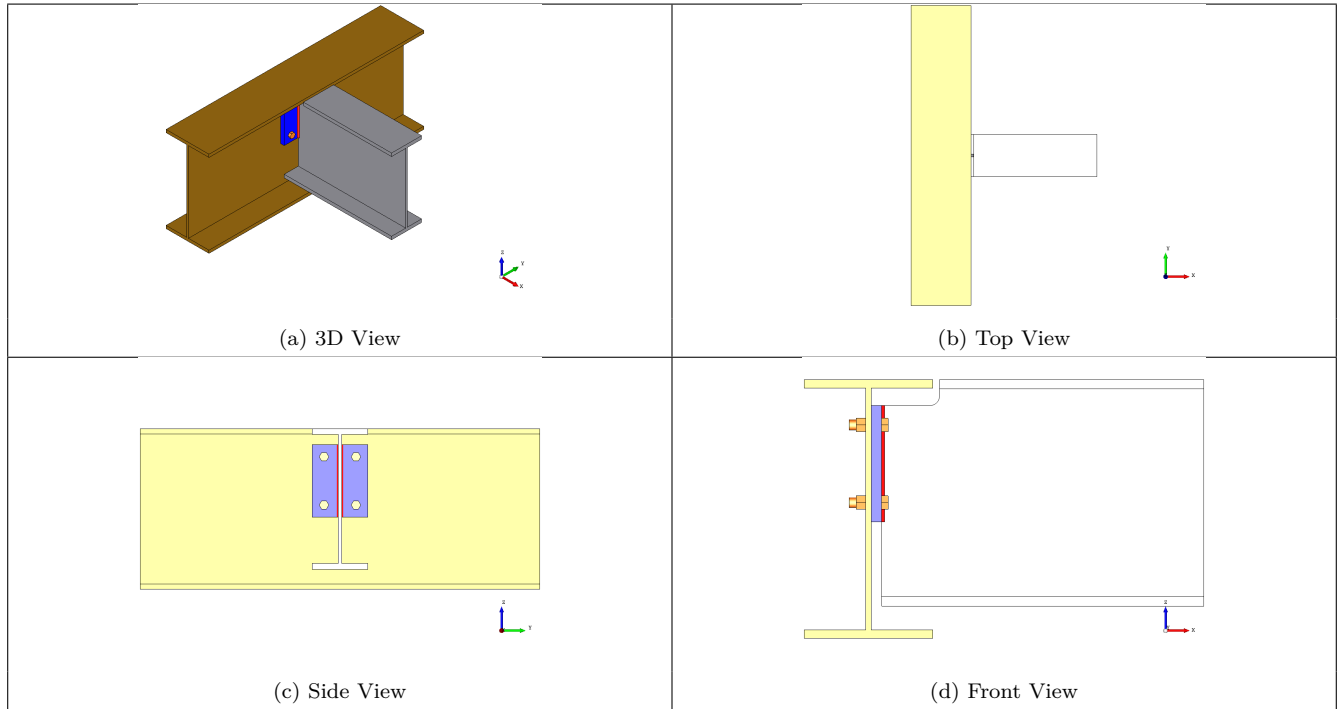
## 2.4 Weld Design

Check	Required	Provided	Remarks
Min. Weld Size (mm)	$t_{w_{min}}$ based on thinner part $= \max(8, 8)$  $s_{min}$ 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 $= \min(16, 8.1) = 8.1$ $s_{max} = 10$  [Ref. IS 800:2007, Cl.10.5.3.1]	5	Pass
Weld Strength (N/mm)	$R_w = \sqrt{(A_{wh})^2 + (V_{wv})^2}$  $V_{wv} = \frac{V}{l_w} = \frac{160000.0}{336.0}$ $A_{wh} = \frac{A}{l_w} = \frac{20000.0}{336.0}$  $R_w = \sqrt{(59.52)^2 + (476.19)^2}$ $= 474.25$	$f_w = \frac{t_t f_u}{\sqrt{3} \gamma_{mw}}$ $= \frac{4.2 \times 410}{\sqrt{3} \times 1.25}$ $= 662.8$  [Ref. IS 800:2007, Cl.10.5.7.1.1]	
Weld Strength (post long joint) (N/mm)	if $l \geq 150t_t$ , then $V_{rd} = \beta_{lw} V_{db}$  if $l < 150t_t$ , then $V_{rd} = V_{db}$  where, $l$ = plate length or height $\beta_{lw} = 1.2 - \frac{(0.2l)}{(150t_t)}$ but, $0.6 \leq \beta_{lw} \leq 1.0$  [Ref. IS 800:2007, Cl.10.5.7.3]	$l_w = h$ $= 180$  $150t_t = 150 \times 4.2 = 630.0$  since, $l < 150t_t$ then $f_{wrd} = f_w$ $f_{wrd} = 662.8$  [Ref. IS 800:2007, Cl.10.5.7.3.]	
Weld Strength (N/mm)	474.25	662.8	Pass



Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer#1	Job Number	1.1.2.3.1
Date	04 /02 /2021	Client	Dr. Pradyumna M, Bengaluru

### 3 3D Views



### 4 Design Log

2021-02-04 12:16:09 - Osdag - INFO - End plate is designed with minimum possible plate thickness.  
2021-02-04 12:16:09 - Osdag - INFO - Bolt columns are limited to two (one on each side) in shear end plate.  
2021-02-04 12:16:09 - Osdag - INFO - === End Of Design ===