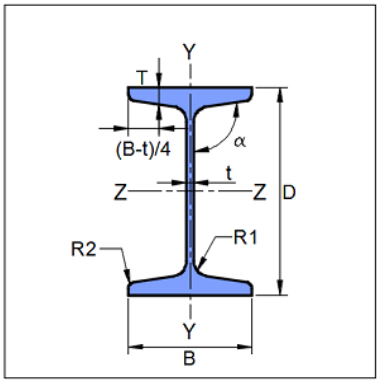
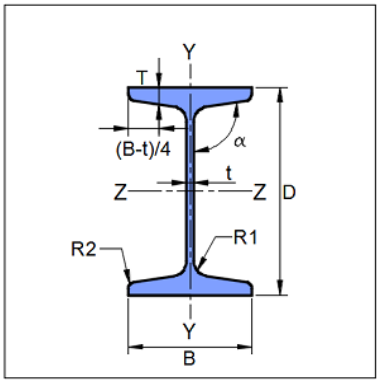
Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer #1	Job Number	1.1.2.3.1
Date	17 /12 /2020	Client	Pradyumna M, Independent Consultant, Bengaluru

1 Input Parameters

Main Module		Shear Connection	
Module		End Plate	
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, Fu (MPa)		440	
Yield Strength, Fy (MPa)		300	
Mass, m (kg/m)	66.71	I_z (cm^4)	23400.0
Area, A (cm^2)	85.0	I_y(cm^4)	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^3)	1170.0
T (mm)	13.0	Z_y (cm^3)	138.0
Flange Slope	96	Z_{pz} (cm^3)	1320.0
R_1 (mm)	13.0	Z_{py} (cm^3)	234.0
R_2 (mm)	6.5		
Supported Section - Mechanical Properties			
			
Supported Section		MB 350	
Material		E 300 (Fe 440)	
Ultimate Strength, Fu (MPa)		440	
Yield Strength, Fy (MPa)		300	
Mass, m (kg/m)	52.33	I_z (cm^4)	13600.0
Area, A (cm^2)	66.7	I_y(cm^4)	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^3)	779.0
T (mm)	14.2	Z_y (cm^3)	76.8
Flange Slope	98	Z_{pz} (cm^3)	889.0
R_1 (mm)	14.0	Z_{py} (cm^3)	129.0
R_2 (mm)	7.0		

Company Name	IIT Bombay	Project Title	Sample Connection Design
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Designer	Engineer #1	Job Number	1.1.2.3.1
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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, 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)	410.0

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer #1	Job Number	1.1.2.3.1
Date	17 /12 /2020	Client	Pradyumna M, Independent Consultant, Bengaluru

2 Design Checks

Design Status	Pass

2.1 Section Design Check

Check	Required	Provided	Remarks
Shear Capacity (kN)	160.0	$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{310.0 \times 8.1 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 395379.96161867736$ [$Ref. IS$ 800 : 2007, $Cl.$10.4.3]	Pass
Tension Capacity (kN)	20.0	$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $A_g = l \times t = 310.0 \times 8.1$ $= \frac{2511.0 \times 300}{1.1 \times 10^3}$ $= 684818.18$ [$Ref.\ IS$ 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)	$p_{min} = 2.5\ d$ $= 2.5 \times 16$ $= 40.0$ [$Ref\ IS$ 800 : 2007, $Cl.$ 10.2.2]	120	Pass

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Designer	Engineer #1	Job Number	1.1.2.3.1
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Check	Required	Provided	Remarks
Max. Pitch Distance (mm)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 8.1,\ 300\ mm)$ $= \min(259.2,\ 300\ mm)$ $= 259.2$ $Where,\ t = min(22.0, 8.1)$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.2.3]$	120	**Pass**
Min. End Distance (mm)	$e_{min} = 1.5\ d_0$ $= 1.5 \times 18.0$ $= 27.0$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.2.4.2]$	30	**Pass**
Max. End Distance (mm)	$e_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 16 \times \sqrt{\frac{250}{240}} = 195.96$ $e_2 = 12 \times 8.6 \times \sqrt{\frac{250}{300}} = 94.21$ $e_{max} = min(e_1, e_2) = 94.21$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.2.4.3]$	30	**Pass**
Min. Edge Distance (mm)	$e'_{min} = 1.5\ d_0$ $= 1.5 \times 18.0$ $= 27.0$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.2.4.2]$	30	**Pass**

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Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer #1	Job Number	1.1.2.3.1
Date	17 /12 /2020	Client	Pradyumna M, Independent Consultant, Bengaluru

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

Check	Required	Provided	Remarks
Large Grip Length Reduction Factor		$l_g = \Sigma\ (t_p + t_{member})$ $= 34.6$ $5d = 80$ $8d = 128$ $since,\ l_g < 5d\ ;\ \beta_{lg} = 1.0$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.3.3.2]$	
Packing Plate Reduction Factor		$t_{pk} = gap$ $= 10.0mm$ $since,\ t_{pk} \geq 6mm\ then\ V_{rd} = \beta_{pk}\ V_{db}$ $\beta_{pk} = 1.0 - 0.0125 \times 10.0 = 0.875$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.3.3.3]$	
Bolt Capacity (post reduction factor) (kN)	40.0	$V_{rd} = \beta_{lj}\ \beta_{lg}\beta_{pk} \times V_{db}$ $= 1.0 \times 1.0 \times 1.0 \times 43.89$ $= 43.89$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.3.3]$	
Bolt Tension Force (kN)	$T_{ba} = \frac{P}{n}$ $= \frac{20.0}{4}$ $= 5.0$		

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer #1	Job Number	1.1.2.3.1
Date	17 /12 /2020	Client	Pradyumna M, Independent Consultant, Bengaluru

Check	Required	Provided	Remarks
Bolt Prying Force (kN)	$Q = \frac{l_v}{2 \times l_e}\left[T_e - \frac{\beta \times \eta \times f_o \times b_e \times t^4}{27 \times l_e \times l_v^2}\right]$ $l_v = e - \frac{R_1}{2}$ $= 30 - \frac{14.0}{2} = 30.95\ mm$ $f_o = 0.7 \times f_{ub}$ $= 0.7 \times 1040.0$ $= 728.0\ N/mm^2$ $l_e = min\left(e, 1.1\ t\ \sqrt{\frac{\beta\ f_o}{f_y}}\right)$ $= min\left(30, 1.1 \times 16 \times \sqrt{\frac{1 \times 728.0}{250}}\right)$ $= min(30, 30.03) = 30\ mm$ $\beta = 1\ (pre - tensioned\ bolt)$ $\eta = 1.5$ $b_e = \frac{B}{n_c}$ $= \frac{140.0}{2} = 61.9\ mm$ $Q = \frac{30.95}{2 \times 30} \times$ $\left[5.0 - \left(\frac{1 \times 1.5 \times 728.0 \times 61.9 \times 16^4}{27 \times 30 \times 30.95^2}\right) \times 10^{-3}\right]$ $Q = 0.0$ *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)	$T_f = T_1 + Q$ $= 5.0 + 0.0$ $= 5.0$	$T_{db} = 0.90\ f_{ub}\ A_n\ /\ \gamma_{mb}$ $<\ f_{yb}\ A_{sb}\ (\gamma_{mb}\ /\ \gamma_{m0})$ $= min\Big(0.90\ \times 1040.0 \times 157\ /\ 1.25,$ $1040.0 \times 201 \times (1.25/1.1)\Big)$ $= min(117.56,\ 237.55)$ $= 117.56$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.5]$	**Pass**
Interaction Ratio	≤ 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)	$0.6\times(d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (350.0 - 2 \times 14.2 - 2 \times 14.0)$ $= 176.16$ $[Ref.\ INSDAG - Chpt.5,\ Sect.5.2.3]$	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)	$w_{p_{min}} = g' + e'_{min}\ 2$ $= 80 + 27.0 \times 2$ $= 134.0$	140	**Pass**
Max. Plate Width (mm)	N/A	140	

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Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)		$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{180 \times 16 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 377.9$ $[Ref. IS\ 800:2007, Cl.10.4.3]$	
Block Shear Capacity in Shear (kN)		$V_{dbl1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{dbl2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{db} = min(V_{db1}, V_{db2}) = 513.29$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.4]$	
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)	$M = T_e \times ecc$ $ecc = \frac{g}{2} - \frac{t_w}{2} - s \quad = 30.95$ $M = 5.0 \times 30.95 \times 10^{-3} \quad = 0.15$	$M_{dzz} = \frac{\beta_b \times Z_p \times fy}{\gamma_{mo} \times 10^6}$ $= \frac{1.0 \times 11520.0 \times 250}{1.1 \times 10^6}$ $= 0.873$ $[Ref.\ IS\ 800:2007,\ Cl.\ 8.2.1.2]$	**Pass**

2.4 Weld Design

Check	Required	Provided	Remarks
Min. Weld Size (mm)	$t_{w_{min}}$ *based on thinner part* $= 8$ *or* 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* $V_{rd} = \beta_{l_w} V_{db}$ *if* $l < 150t_t$ *then* $V_{rd} = V_{db}$ *where,* l = *pt.length or pt.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]	$l_w = h$ $= 180$ $150t_t = 150 \times 4.2 = 630.0$ *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**

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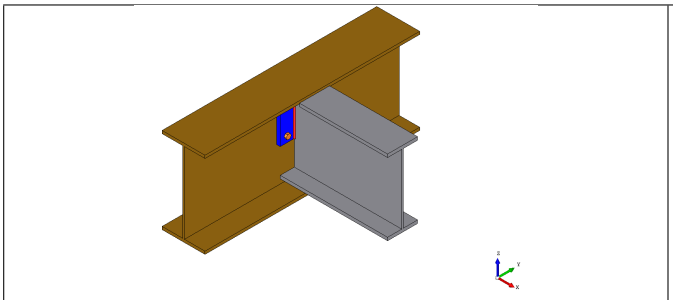
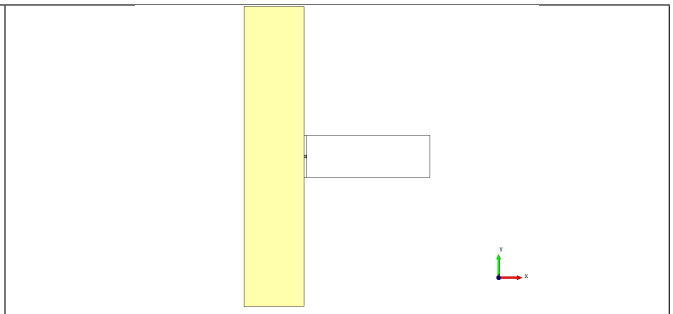
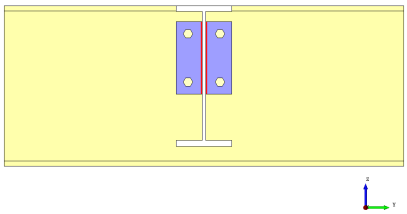
3 3D Views



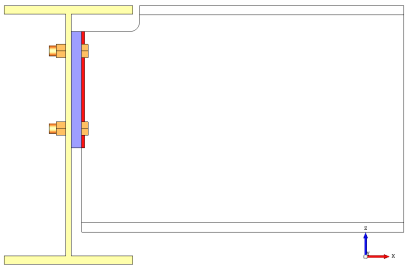
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log