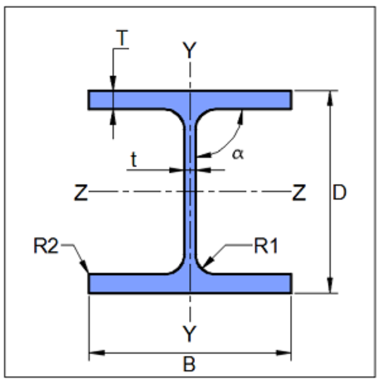
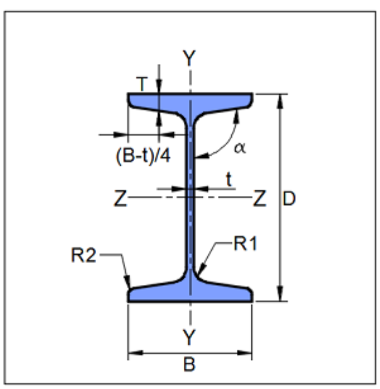
	Created with Osdag®		
Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer #1	Job Number	1.1.2.3.2
Date	17 /12 /2020	Client	Yogesh D Pisal, Aker Powergas, Mumbai

1 Input Parameters

Main Module		Shear Connection		
Module		End Plate		
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, Fu (MPa)		410	
	Yield Strength, Fy (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, Fu (MPa)		410	
	Yield Strength, Fy (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, (mu_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	$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{260.0 \times 7.7 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 262694.3724812797$ $[Ref. IS\ 800:2007, Cl. 10.4.3]$	Pass
Tension Capacity (kN)	0.0	$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $A_g = l \times t = 260.0 \times 7.7$ $= \frac{2002.0 \times 250}{1.1 \times 10^3}$ $= 455000.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.2]$	

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)	$p_{min} = 2.5\ d$ $= 2.5 \times 16$ $= 40.0$ $[Ref\ IS\ 800:2007,\ Cl.\ 10.2.2]$	80	Pass

Check	Required	Provided	Remarks
Max. Pitch Distance (mm)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 7.7,\ 300\ mm)$ $= \min(246.4,\ 300\ mm)$ $= 246.4$ $Where,\ t = min(14.0, 7.7)$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.3]$	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)	$e'_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 14 \times \sqrt{\frac{250}{250}} = 168.0$ $e_2 = 12 \times 6.6 \times \sqrt{\frac{250}{250}} = 79.2$ $e'_{max} = min(e_1, e_2) = 79.2$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3]$	35	**Pass**
Min. Gauge Distance (mm)	$g_{min} = 2(e`_{min} + s) + t_w$ $= 2(34.0 + 5) + 7.7$ $= 85.7$	88	**Pass**
Shear Capacity (kN)		$V_{dsb} = \frac{f_{ub}\ n_n\ A_{nb}}{\sqrt{3}\ \gamma_{mb}}$ $= \frac{520.0 \times 1 \times 157}{1000 \times \sqrt{3}\ \times\ 1.25}$ $= 37.71$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3]$	
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)		$V_{dpb} = \frac{2.5\ k_b\ d\ t\ f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.58 \times 16 \times 6.6 \times 410}{1000 \times 1.25}$ $= 35.16$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.4]$	

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

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

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

2.3 Plate Design

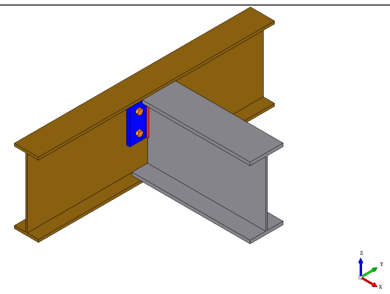
Check	Required	Provided	Remarks
Min. Plate Height (mm)	$0.6\times(d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (300.0 - 2 \times 13.1 - 2 \times 14.0)$ $= 147.48$ $[Ref.\ INSDAG - Chpt.5,\ Sect.5.2.3]$	150	**Pass**
Max. Plate Height (mm)	$d_b - t_{bf} + r_{b1} - notch_h$ $= 300.0 - 13.1 + 14.0 - 40$ $= 232.9$	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)		$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{150 \times 14 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 275.55$ [$Ref. IS$ 800 : 2007, $Cl.$10.4.3]	
Block Shear Capacity in Shear (kN)		$V_{dbl1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{dbl2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{db} = min(V_{db1}, V_{db2}) = 417.9$ [$Ref.\ IS$ 800 : 2007, $Cl.$ 6.4]	
Shear Capacity (kN)	100.0	$V_d = min(S_c, V_{db})$ $= min(275.55, 417.9)$ $= 275.55$ [$Ref.\ IS$ 800 : 2007, $Cl.$ 6.1]	**Pass**
Moment Capacity (kNm)	$M = T_e \times ecc$ $ecc = \frac{g}{2} - \frac{t_w}{2} - s$ $= 35.15$ $M = 0.0 \times 35.15 \times 10^{-3}$ $= 0.0$	$M_{dzz} = \frac{\beta_b \times Z_p \times fy}{\gamma_{mo} \times 10^6}$ $= \frac{1.0 \times 7350.0 \times 250}{1.1 \times 10^6}$ $= 0.78$ [$Ref.\ IS$ 800 : 2007, $Cl.$ 8.2.1.2]	

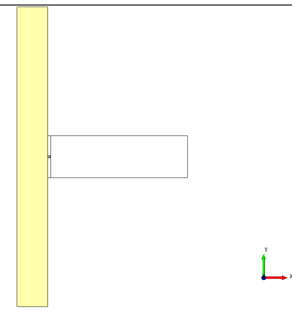
2.4 Weld Design

Check	Required	Provided	Remarks
Min. Weld Size (mm)	$t_{w_{min}}$ $based\ on\ thinner\ part$ $= 7\ or\ 7$ s_{min} $based\ on\ thicker\ part = 5$ $[Ref\ IS\ 800:2007, Table\ 21\ (Cl10.5.2.3)]$	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)	$R_w = \sqrt{(A_{wh})^2 + (V_{wv})^2}$ $V_{wv} = \frac{V}{l_w} = \frac{100000.0}{280.0}$ $A_{wh} = \frac{A}{l_w} = \frac{0.0}{280.0}$ $R_w = \sqrt{(0.0)^2 + (357.14)^2}$ $= 357.14$	$f_w = \frac{t_t\ f_u}{\sqrt{3}\ \gamma_{mw}}$ $= \frac{3.5 \times 410}{\sqrt{3} \times 1.25}$ $= 662.8$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.1.1]$	
Weld Strength (post long joint) (N/mm)	$if\ l \geq 150t_t\ then\ V_{rd} = \beta_{l_w} V_{db}$ $if\ l < 150t_t\ then\ V_{rd} = V_{db}$ $where,$ $l\ = pt.length\ or\ pt.height$ $\beta_{l_w} = 1.2 - \frac{(0.2l)}{(150t_t)}$ $but\ 0.6 \leq \beta_{l_w} \leq 1.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.3]$	$l_w\ = h$ $= 150$ $150t_t = 150 \times 3.5 = 525.0$ $since,\ l < 150t_t$ $then\ f_{wrd} = f_w$ $f_{wrd} = 662.8$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.3]$	
Weld Strength (N/mm)	357.14	662.8	**Pass**

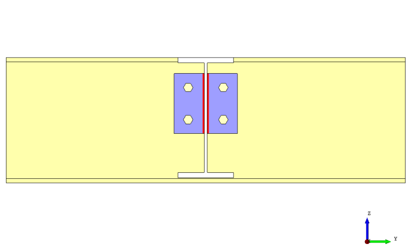
3 3D Views



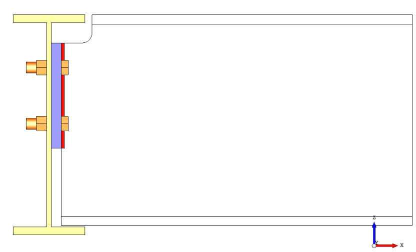
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log