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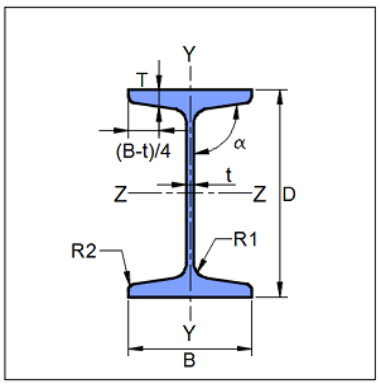
Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Fin Plate
Designer	Engineer#1	Job Number	1.1.1.1.1
Date	04 /02 /2021	Client	Prof. S R Satish Kumar, IIT Madras

1 Input Parameters

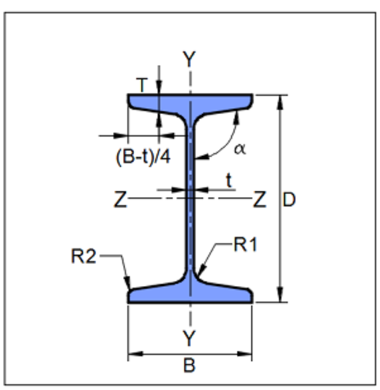
Main Module	Shear Connection
Module	Fin Plate Connection
Connectivity	Column Flange-Beam Web
Shear Force (kN)	180.0
Axial Force (kN)	50.0

Supporting Section - Mechanical Properties



Supporting Section		HB 450	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, F_u (MPa)		410	
Yield Strength, F_y (MPa)		250	
Mass, m (kg/m)	87.22	I_z (cm^4)	39200.0
Area, A (cm^2)	111.0	I_y(cm^4)	2980.0
D (mm)	450.0	r_z (cm)	18.7
B (mm)	250.0	r_y (cm)	5.18
t (mm)	9.8	Z_z (cm^3)	1740.0
T (mm)	13.7	Z_y (cm^3)	238.0
Flange Slope	94	Z_{pz} (cm^3)	1950.0
R_1 (mm)	15.0	Z_{py} (cm^3)	394.0
R_2 (mm)	7.5		

Supported Section - Mechanical Properties



Supported Section		MB 350	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, F_u (MPa)		410	
Yield Strength, F_y (MPa)		250	
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		

Bolt Details - Input and Design Preference	
Diameter (mm)	[12, 16, 20, 24, 30]
Property Class	[4.6, 4.8, 5.6, 6.8, 8.8]
Type	Friction Grip Bolt
Hole Type	Standard
Bolt Tension	Pre-tensioned
Slip Factor, (μ_f)	0.3
Detailing - Design Preference	
Edge Preparation Method	Rolled, machine-flame cut, sawn and planed
Gap Between Members (mm)	15.0
Are the Members Exposed to Corrosive Influences?	False
Plate Details - Input and Design Preference	
Thickness (mm)	[10, 12, 16, 18, 20]
Material	E 350 (Fe 490)
Ultimate Strength, Fu (MPa)	490
Yield Strength, Fy (MPa)	350
Weld Details - Input and Design Preference	
Weld Type	Fillet
Type of Weld Fabrication	Shop Weld
Material Grade Overwrite, Fu (MPa)	410.0

2 Design Checks

Design Status	**Pass**

2.1 Initial Section Check

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)	180.0	$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{350.0 \times 8.1 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 372.0$ [Ref. IS 800:2007, Cl.10.4.3]	Pass
Allowable Shear Capacity (kN)	180.0	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 372.0$ $= 223.2$ [Limited to low shear]	Pass
Tension Yielding Capacity (kN)	50.0	$T_{\text{dg}} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 350.0 \times 8.1$ $= \frac{2835.0 \times 250}{1.1 \times 10^3}$ $= 644.32$ [Ref. IS 800:2007, Cl.6.2]	Pass

2.2 Load Consideration

Check	Required	Provided	Remarks
Applied Axial Force (kN)	50.0	50.0	

Check	Required	Provided	Remarks
Applied Shear Force (kN)	180.0	$V_{y_{\min}} = \min(0.15V_{d_y},\ 40.0)$ $= \min(0.15 \times 372.0,\ 40.0)$ $= 40$ $V_u = \max(V_y,\ V_{y_{\min}})$ $= \max(180.0, 40)$ $= 180.0$ [Ref. IS 800:2007, Cl.10.7]	

2.3 Bolt Design

Check	Required	Provided	Remarks
Diameter (mm)		30.0	
Property Class		8.8	
Plate Thickness (mm)	$t_w = 8.1$	10.0	Pass
No. of Bolt Columns		2	Pass
No. of Bolt Rows		3	
Min. Pitch Distance (mm)	$p_{\min} = 2.5d$ $= 2.5 \times 30.0$ $= 75.0$ [Ref. IS 800:2007, Cl.10.2.2]	75	Pass
Max. Pitch Distance (mm)	$p/g_{\max} = \min(32t,\ 300)$ $= \min(32 \times 8.1,\ 300)$ $= \min(259.2,\ 300)$ $= 259.2$ Where, $t = \min(10.0, 8.1)$ [Ref. IS 800:2007, Cl.10.2.3]	75	Pass

Check	Required	Provided	Remarks
Min. Gauge Distance (mm)	$p_{\min} = 2.5d$ $= 2.5 \times 30.0$ $= 75.0$ [Ref. IS 800:2007, Cl.10.2.2]	75	**Pass**
Max. Gauge Distance (mm)	$p/g_{\max} = \min(32t,\ 300)$ $= \min(32 \times 8.1,\ 300)$ $= \min(259.2,\ 300)$ $= 259.2$ Where, $t = \min(10.0, 8.1)$ [Ref. IS 800:2007, Cl.10.2.3]	75	**Pass**
Min. End Distance (mm)	$e_{\min} = 1.5d_0$ $= 1.5 \times 33.0$ $= 49.5$ [Ref. IS 800:2007, Cl.10.2.4.2]	50	**Pass**
Max. End Distance (mm)	$e_{\max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 10.0 \times \sqrt{\frac{250}{350}} = 101.42$ $e_2 = 12 \times 8.1 \times \sqrt{\frac{250}{250}} = 97.2$ $e_{\max} = \min(e_1,\ e_2) = 97.2$ [Ref. IS 800:2007, Cl.10.2.4.3]	50	**Pass**
Min. Edge Distance (mm)	$e'_{\min} = 1.5d_0$ $= 1.5 \times 33.0$ $= 49.5$ [Ref. IS 800:2007, Cl.10.2.4.2]	50	**Pass**

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{\max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 10.0 \times \sqrt{\frac{250}{350}} = 101.42$ $e_2 = 12 \times 8.1 \times \sqrt{\frac{250}{250}} = 97.2$ $e'_{\max} = min(e_1,\ e_2) = 97.2$ [Ref. IS 800:2007, Cl.10.2.4.3]	50	**Pass**
Moment Demand (kNm)		$M_d = (V_u \times \text{ecc} + M_w)$ $\text{ecc} = \text{eccentricity}$ $M_w = \text{external moment acting on web}$ $= \frac{(180.0 \times 10^3 \times 102.5 + 0.0 \times 10^6)}{10^6}$ $= 18.45$	
Bolt Force Parameter(s) (mm)	$l_n = \text{length available}$ $l_n = p\ (n_r - 1)$ $= 75 \times (3 - 1)$ $= 150$ $y_{\max} = l_n/2$ $= 150/2$ $= 75.0$ $x_{\max} = g(n_c - 1)/2$ $= 75 \times (2 - 1)/2$ $= 37.5$		

Check	Required	Provided	Remarks
Bolt Force (kN)	$vbv = V_u/(n_r \times n_c) = \frac{180.0}{(3 \times 2)} = 30.0$ $tmh = \frac{M_d \times y_{\max}}{\Sigma r_i^2} = \frac{18.45 \times 75.0}{30.94} = 44.73$ $tmv = \frac{M_d \times x_{\max}}{\Sigma r_i^2} = \frac{18.45 \times 37.5}{30.94} = 22.36$ $abh = \frac{A_u}{(n_r \times n_c)} = \frac{50.0}{(3 \times 2)} = 8.33$ $v_{\text{res}} = \sqrt{(vbv + tmv)^2 + (tmh + abh)^2} = \sqrt{(30.0 + 22.36)^2 + (44.73 + 8.33)^2} = 74.55$		
Slip Resistance (kN)		$V_{dsf} = \frac{\mu_f n_e K_h F_o}{\gamma_{mf}}$ Where , $F_o = 0.7 f_{ub} A_{nb}$ $V_{dsf} = \frac{0.3 \times 1 \times 1.0 \times 0.7 \times 830.0 \times 561}{1.25 \times 10^3} = 78.23$ [Ref. IS 800:2007, Cl.10.4.3]	

Check	Required	Provided	Remarks
Long Joint Reduction Factor	if $l_j \geq 15d$ then $V_{\text{rd}} = \beta_{lj} V_{\text{db}}$ if $l_j < 15d$ then $V_{\text{rd}} = V_{\text{db}}$ where, $l_j = ((nc \text{ or } nr) - 1) \times (p \text{ or } g)$ $\beta_{lj} = 1.075 - l/(200d)$ but $0.75 \leq \beta_{lj} \leq 1.0$ [Ref. IS 800:2007, Cl.10.3.3.1]	$l_j = (n_r - 1) \times p$ $= (3 - 1) \times 75 = 150$ $l = 150$ $15 \times d = 15 \times 30.0 = 450.0$ since, $l_j < 15 \times d$ then $\beta_{lj} = 1.0$ [Ref. IS 800:2007, Cl.10.3.3.1]	
Capacity (kN)	74.55	78.23	**Pass**

2.4 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]	250	**Pass**
Max. Plate Height (mm)	$d_b - 2(t_{bf} + r_{b1} + \text{gap})$ $= 350.0 - 2 \times (14.2 + 14.0 + 10)$ $= 293.6$	250	**Pass**
Min. Plate Width (mm)	$2e_{\min} + (n_c - 1)p_{\min})$ $= 2 \times 49.5 + (2 - 1) \times 75.0$ $= 189.0$	190.0	**Pass**
Min. Plate Thickness (mm)	$t_w = 8.1$	10.0	**Pass**

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)		$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{250 \times 10.0 \times 350}{\sqrt{3} \times 1.1 \times 1000}$ $= 459.26$ [Ref. IS 800:2007, Cl.10.4.3]	
Allowable Shear Capacity (kN)	$V = 180.0$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 459.26$ $= 275.55$ [Limited to low shear]	**Pass**
Shear Rupture Capacity (kN)		$V_{d_n} = \frac{0.75 A_{v_n} f_u}{\sqrt{3}\gamma_{m1}}$ $= 1 \times \frac{(250 - (3 \times 33.0)) \times 10.0 \times 490}{\sqrt{3} \times 1.25}$ $= 554.92$ [Ref. AISC, sect. J4]	
Block Shear Capacity in Shear (kN)		$V_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{\text{db}} = \min(V_{db1},\ V_{db2}) = 633.77$ [Ref. IS 800:2007, Cl.6.4]	
Shear Capacity (kN)	180.0	$V_d = \min(S_c,\ V_{d_n},\ V_{d_b})$ $= \min(275.55,\ 554.92,\ 633.77)$ $= 275.55$ [Ref. IS 800:2007, Cl.6.1]	**Pass**

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{\text{dg}} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 250 \times 10.0$ $= \frac{2500.0 \times 350}{1.1 \times 10^3}$ $= 795.45$ [Ref. IS 800:2007, Cl.6.2]	
Tension Rupture Capacity (kN)		$T_{\text{dn}} = \frac{0.9 A_n f_u}{\gamma_{m1}}$ $= \frac{1 \times \ 0.9 \times (250 - 3 \times 33.0) \times 10.0 \times 490}{1.25}$ $= 649.15$ [Ref. IS 800:2007, Cl.6.3.1]	
Block Shear Capacity in Tension (kN)		$T_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{\text{db}} = \min(T_{db1},\ T_{db2}) = 755.61$ [Ref. IS 800:2007, Cl.6.4]	
Tension Capacity (kN)	50.0	$T_{\text{d}} = \min(T_{\text{dg}},\ T_{\text{dn}},\ T_{\text{db}})$ $= \min(795.45, 649.15, 755.61)$ $= 649.15$ [Ref.IS 800:2007, Cl.6.1]	**Pass**
Moment Capacity (kNm)	18.45	$M_{d_z} = \frac{\beta_b Z_p f y}{\gamma_{m0} \times 10^6}$ $= \frac{1.0 \times 156250.0 \times 350}{1.1 \times 10^6}$ $= 49.72$ [Ref. IS 800:2007, Cl.8.2.1.2]	**Pass**

Check	Required	Provided	Remarks
Interaction Ratio	≤ 1	$\frac{18.45}{49.72} + \frac{50.0}{649.15} = 0.45$ [Ref. IS 800:2007, Cl.10.7]	Pass

2.5 Section Design

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)		$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{350.0 \times 8.1 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 372.0$ [Ref. IS 800:2007, Cl.10.4.3]	
Allowable Shear Capacity (kN)	$V = 180.0$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 372.0$ $= 223.2$ [Limited to low shear]	Pass
Shear Rupture Capacity (kN)		$V_{d_n} = \frac{0.75 A_{vn} f_u}{\sqrt{3}\gamma_{m1}}$ $= 1 \times \frac{(350.0 - (3 \times 33.0)) \times 8.1 \times 410}{\sqrt{3} \times 1.25}$ $= 625.18$ [Ref. AISC, sect. J4]	
Block Shear Capacity in Shear (kN)		$V_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{\text{db}} = \min(V_{db1},\ V_{db2}) = 392.32$ [Ref. IS 800:2007, Cl.6.4]	

Check	Required	Provided	Remarks
Shear Capacity (kN)	180.0	$V_d = \min(S_c,\ V_{d_n},\ V_{d_b})$ $= \min(223.2,\ 625.18,\ 392.32)$ $= 223.2$ [Ref. IS 800:2007, Cl.6.1]	**Pass**
Tension Yielding Capacity (kN)		$T_{\text{dg}} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 350.0 \times 8.1$ $= \frac{2835.0 \times 250}{1.1 \times 10^3}$ $= 644.32$ [Ref. IS 800:2007, Cl.6.2]	
Tension Rupture Capacity (kN)		$T_{\text{dn}} = \frac{0.9 A_n f_u}{\gamma_{m1}}$ $= \frac{1 \times\ 0.9 \times (350.0 - 3 \times 33.0) \times 8.1 \times 410}{1.25}$ $= 600.17$ [Ref. IS 800:2007, Cl.6.3.1]	
Block Shear Capacity in Tension (kN)		$T_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{\text{db}} = \min(T_{db1},\ T_{db2}) = 466.57$ [Ref. IS 800:2007, Cl.6.4]	
Tension Capacity (kN)	50.0	$T_{\text{d}} = \min(T_{\text{dg}},\ T_{\text{dn}},\ T_{\text{db}})$ $= \min(644.32, 600.17, 466.57)$ $= 466.57$ [Ref.IS 800:2007, Cl.6.1]	**Pass**

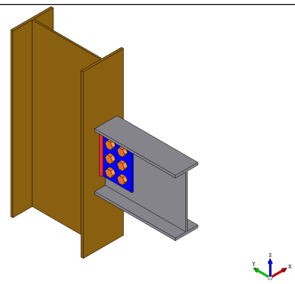
Check	Required	Provided	Remarks
Moment Capacity (kNm)	18.45	$M_{d_z} = \frac{\beta_b Z_p f y}{\gamma_{m0} \times 10^6}$ $= \frac{1.0 \times 889000.0 \times 250}{1.1 \times 10^6}$ $= 202.05$ [Ref. IS 800:2007, Cl.8.2.1.2]	Pass
Interaction Ratio	≤ 1	$\frac{18.45}{202.05} + \frac{50.0}{466.57} = 0.2$ [Ref. IS 800:2007, Cl.10.7]	Pass

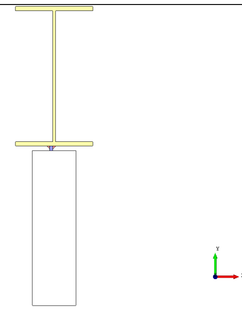
2.6 Weld Design

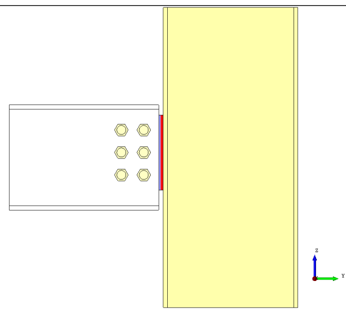
Check	Required	Provided	Remarks
Min. Weld Size (mm)	$t_{w_{\min}}$ based on thinner part $= \max(10,\ 10)$ $s_{\min}$ based on thicker part $= 5$ [Ref. IS 800:2007, Table 21, Cl.10.5.2.3]	10	Pass
Max. Weld Size (mm)	Thickness of thinner part $= \min(13.7,\ 10.0) = 10.0$ $s_{\max} = 10$ [Ref. IS 800:2007, Cl.10.5.3.1]	10	Pass

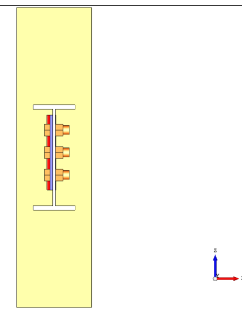
Check	Required	Provided	Remarks
Weld Strength (N/mm)	$R_{\text{w}} = \sqrt{(T_{\text{wh}} + A_{\text{wh}})^2 + (T_{\text{wv}} + V_{\text{wv}})^2}$ $T_{\text{wh}} = \frac{M \times y_{\text{max}}}{I_{pw}} = \frac{18450000.0 \times 115.0}{2027833.33}$ $T_{\text{wv}} = \frac{M \times x_{\text{max}}}{I_{pw}} = \frac{18450000.0 \times 0.0}{2027833.33}$ $V_{\text{wv}} = \frac{V}{l_w} = \frac{180000.0}{460}$ $A_{\text{wh}} = \frac{A}{l_w} = \frac{50000.0}{460}$ $R_{\text{w}} = \sqrt{(1046.31 + 108.7)^2 + (0.0 + 391.3)^2}$ $= 1219.49$	$f_w = \frac{t_t f_u}{\sqrt{3}\gamma_{mw}}$ $= \frac{7.0 \times 410}{\sqrt{3} \times 1.25}$ $= 1325.6$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	**Pass**

3 3D Views


(a) 3D View


(b) Top View


(c) Side View


(d) Front View

4 Design Log

2021-02-04 11:42:27 - Osdag - INFO - === End Of Design ===