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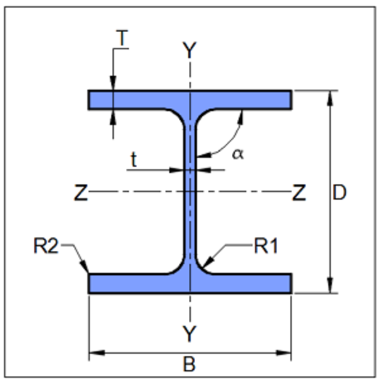
Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Fin Plate
Designer	Engineer#1	Job Number	1.1.1.1.2
Date	04 /02 /2021	Client	Dr. Pradyumna M, Bengaluru

1 Input Parameters

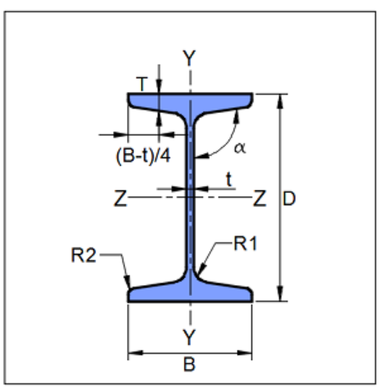
Main Module	Shear Connection
Module	Fin Plate Connection
Connectivity	Column Flange-Beam Web
Shear Force (kN)	175.0
Axial Force (kN)	35.0

Supporting Section - Mechanical Properties



Supporting Section		PBP 320 X 88.48	
Material		E 300 (Fe 440)	
Ultimate Strength, F_u (MPa)		440	
Yield Strength, F_y (MPa)		300	
Mass, m (kg/m)	88.48	I_z (cm^4)	18700.0
Area, A (cm^2)	112.0	I_y(cm^4)	5630.0
D (mm)	303.0	r_z (cm)	12.8
B (mm)	304.0	r_y (cm)	7.07
t (mm)	12.0	Z_z (cm^3)	1230.0
T (mm)	12	Z_y (cm^3)	370.0
Flange Slope	90	Z_{pz} (cm^3)	1370.0
R_1 (mm)	27.0	Z_{py} (cm^3)	572.0
R_2 (mm)	0.0		

Supported Section - Mechanical Properties



Supported Section		WB 300	
Material		E 300 (Fe 440)	
Ultimate Strength, F_u (MPa)		440	
Yield Strength, F_y (MPa)		300	
Mass, m (kg/m)	48.12	I_z (cm^4)	9820.0
Area, A (cm^2)	61.3	I_y(cm^4)	990.0
D (mm)	300.0	r_z (cm)	12.6
B (mm)	200.0	r_y (cm)	4.01
t (mm)	7.4	Z_z (cm^3)	654.0
T (mm)	10.0	Z_y (cm^3)	99.0
Flange Slope	96	Z_{pz} (cm^3)	731.0
R_1 (mm)	11.0	Z_{py} (cm^3)	171.0
R_2 (mm)	5.5		

Bolt Details - Input and Design Preference	
Diameter (mm)	[20]
Property Class	[6.8]
Type	Bearing Bolt
Hole Type	Standard
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 300 (Fe 440)
Ultimate Strength, Fu (MPa)	440
Yield Strength, Fy (MPa)	300
Weld Details - Input and Design Preference	
Weld Type	Fillet
Type of Weld Fabrication	Shop Weld
Material Grade Overwrite, Fu (MPa)	440.0

2 Design Checks

Design Status	**Pass**

2.1 Initial Section Check

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)	175.0	$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{300.0 \times 7.4 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 349.56$ [Ref. IS 800:2007, Cl.10.4.3]	Pass
Allowable Shear Capacity (kN)	175.0	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 349.56$ $= 209.74$ [Limited to low shear]	Pass
Tension Yielding Capacity (kN)	35.0	$T_{\rm dg} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 300.0 \times 7.4$ $= \frac{2220.0 \times 300}{1.1 \times 10^3}$ $= 605.45$ [Ref. IS 800:2007, Cl.6.2]	Pass

2.2 Load Consideration

Check	Required	Provided	Remarks
Applied Axial Force (kN)	35.0	35.0	

Check	Required	Provided	Remarks
Applied Shear Force (kN)	175.0	$V_{y_{\min}} = \min(0.15V_{d_y},\ 40.0)$ $= \min(0.15 \times 349.56,\ 40.0)$ $= 40$ $V_u = \max(V_y,\ V_{y_{\min}})$ $= \max(175.0, 40)$ $= 175.0$ [Ref. IS 800:2007, Cl.10.7]	

2.3 Bolt Design

Check	Required	Provided	Remarks
Diameter (mm)		20.0	
Property Class		6.8	
Plate Thickness (mm)	$t_w = 7.4$	14.0	Pass
No. of Bolt Columns		2	Pass
No. of Bolt Rows		3	
Min. Pitch Distance (mm)	$p_{\min} = 2.5d$ $= 2.5 \times 20.0$ $= 50.0$ [Ref. IS 800:2007, Cl.10.2.2]	65	Pass
Max. Pitch Distance (mm)	$p/g_{\max} = \min(32t,\ 300)$ $= \min(32 \times 7.4,\ 300)$ $= \min(236.8,\ 300)$ $= 236.8$ Where, $t = \min(14.0, 7.4)$ [Ref. IS 800:2007, Cl.10.2.3]	65	Pass

Check	Required	Provided	Remarks
Min. Gauge Distance (mm)	$p_{\text{min}} = 2.5d$ $= 2.5 \times 20.0$ $= 50.0$ [Ref. IS 800:2007, Cl.10.2.2]	50	**Pass**
Max. Gauge Distance (mm)	$p/g_{\text{max}} = \min(32t,\ 300)$ $= \min(32 \times 7.4,\ 300)$ $= \min(236.8,\ 300)$ $= 236.8$ Where, $t = \min(14.0, 7.4)$ [Ref. IS 800:2007, Cl.10.2.3]	50	**Pass**
Min. End Distance (mm)	$e_{\text{min}} = 1.7d_0$ $= 1.7 \times 22.0$ $= 37.4$ [Ref. IS 800:2007, Cl.10.2.4.2]	40	**Pass**
Max. End Distance (mm)	$e_{\text{max}} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 14.0 \times \sqrt{\frac{250}{300}} = 153.36$ $e_2 = 12 \times 7.4 \times \sqrt{\frac{250}{300}} = 81.06$ $e_{\text{max}} = \min(e_1,\ e_2) = 81.06$ [Ref. IS 800:2007, Cl.10.2.4.3]	40	**Pass**
Min. Edge Distance (mm)	$e'_{\text{min}} = 1.7d_0$ $= 1.7 \times 22.0$ $= 37.4$ [Ref. IS 800:2007, Cl.10.2.4.2]	40	**Pass**

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{\max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 14.0 \times \sqrt{\frac{250}{300}} = 153.36$ $e_2 = 12 \times 7.4 \times \sqrt{\frac{250}{300}} = 81.06$ $e'_{\max} = min(e_1,\ e_2) = 81.06$ [Ref. IS 800:2007, Cl.10.2.4.3]	40	**Pass**
Moment Demand (kNm)		$M_d = (V_u \times \text{ecc} + M_w)$ $\text{ecc} = \text{eccentricity}$ $M_w = \text{external moment acting on web}$ $= \frac{(175.0 \times 10^3 \times 75.0 + 0.0 \times 10^6)}{10^6}$ $= 13.12$	
Bolt Force Parameter(s) (mm)	$l_n = \text{length available}$ $l_n = p\ (n_r - 1)$ $= 65 \times (3 - 1)$ $= 130$ $y_{\max} = l_n/2$ $= 130/2$ $= 65.0$ $x_{\max} = g(n_c - 1)/2$ $= 50 \times (2 - 1)/2$ $= 25.0$		

Check	Required	Provided	Remarks
Bolt Force (kN)	$vbv = V_u/(n_r \times n_c) = \frac{175.0}{(3 \times 2)} = 29.17$ $tmh = \frac{M_d \times y_{\max}}{\Sigma r_i^2} = \frac{13.12 \times 65.0}{20.65} = 41.31$ $tmv = \frac{M_d \times x_{\max}}{\Sigma r_i^2} = \frac{13.12 \times 25.0}{20.65} = 15.89$ $abh = \frac{A_u}{(n_r \times n_c)} = \frac{35.0}{(3 \times 2)} = 5.83$ $v_{\text{res}} = \sqrt{(vbv + tmv)^2 + (tmh + abh)^2} = \sqrt{(29.17 + 15.89)^2 + (41.31 + 5.83)^2} = 65.21$		
Shear Capacity (kN)		$V_{\text{dsb}} = \frac{f_{ub} n_n A_{nb}}{\sqrt{3}\gamma_{mb}} = \frac{600.0 \times 1 \times 245}{1000 \times \sqrt{3} \times 1.25} = 67.9$ [Ref. IS 800:2007, Cl.10.3.3]	

Check	Required	Provided	Remarks
Kb		$k_b = \min\left(\frac{e}{3d_0}, \frac{p}{3d_0} - 0.25, \frac{f_{ub}}{f_u}, 1.0\right)$ $= \min\left(\frac{40}{3 \times 22.0}, \frac{65}{3 \times 22.0} - 0.25, \frac{600.0}{440}, 1.0\right)$ $= \min(0.61, 0.73, 1.36, 1.0)$ $= 0.61$ [Ref. IS 800:2007, Cl.10.3.4]	
Bearing Capacity (kN)		$V_{\text{dpb}} = \frac{2.5 k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.61 \times 20.0 \times 7.4 \times 440}{1000 \times 1.25}$ $= 79.45$ [Ref. IS 800:2007, Cl.10.3.4]	
Capacity (kN)		$V_{\text{db}} = \min\ (V_{\text{dsb}},\ V_{\text{dpb}})$ $= \min\ (67.9,\ 79.45)$ $= 67.9$ [Ref. IS 800:2007, Cl.10.3.2]	
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]	$l_j = (n_r - 1) \times p$ $= (3 - 1) \times 65 = 130$ $l = 130$ $15 \times d = 15 \times 20.0 = 300.0$ since, $l_j < 15 \times d$ then $\beta_{lj} = 1.0$ [Ref. IS 800:2007, Cl.10.3.3.1]	
Capacity (kN)	65.21	67.9	**Pass**

2.4 Plate Design

Check	Required	Provided	Remarks
Min. Plate Height (mm)	$0.6 \times (d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (300.0 - 2 \times 10.0 - 2 \times 11.0)$ $= 154.8$ [Ref. INSDAG, Ch.5, sec.5.2.3]	210	Pass
Max. Plate Height (mm)	$d_b - 2(t_{bf} + r_{b1} + \text{gap})$ $= 300.0 - 2 \times (10.0 + 11.0 + 10)$ $= 258.0$	210	Pass
Min. Plate Width (mm)	$2e_{\min} + (n_c - 1)p_{\min})$ $= 2 \times 37.4 + (2 - 1) \times 50.0$ $= 134.8$	140.0	Pass
Min. Plate Thickness (mm)	$t_w = 7.4$	14.0	Pass
Shear Yielding Capacity (kN)		$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{210 \times 14.0 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 462.93$ [Ref. IS 800:2007, Cl.10.4.3]	
Allowable Shear Capacity (kN)	$V = 175.0$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 462.93$ $= 277.76$ [Limited to low shear]	Pass
Shear Rupture Capacity (kN)		$V_{d_n} = \frac{0.75 A_{vn} f_u}{\sqrt{3}\gamma_{m1}}$ $= 1 \times \frac{(210 - (3 \times 22.0)) \times 14.0 \times 440}{\sqrt{3} \times 1.25}$ $= 665.28$ [Ref. AISC, sect. J4]	

Check	Required	Provided	Remarks
Block Shear Capacity in Shear (kN)		$V_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{\text{db}} = \min(V_{db1},\ V_{db2}) = 627.56$ [Ref. IS 800:2007, Cl.6.4]	
Shear Capacity (kN)	175.0	$V_d = \min(S_c,\ V_{d_n},\ V_{d_b})$ $= \min(277.76,\ 665.28,\ 627.56)$ $= 277.76$ [Ref. IS 800:2007, Cl.6.1]	**Pass**
Tension Yielding Capacity (kN)		$T_{\text{dg}} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 210 \times 14.0$ $= \frac{2940.0 \times 300}{1.1 \times 10^3}$ $= 801.82$ [Ref. IS 800:2007, Cl.6.2]	
Tension Rupture Capacity (kN)		$T_{\text{dn}} = \frac{0.9 A_n f_u}{\gamma_{m1}}$ $= \frac{1 \times\ 0.9 \times (210 - 3 \times 22.0) \times 14.0 \times 440}{1.25}$ $= 736.24$ [Ref. IS 800:2007, Cl.6.3.1]	

Check	Required	Provided	Remarks
Block Shear Capacity in Tension (kN)		$T_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{\text{db}} = \min(T_{db1},\ T_{db2}) = 778.22$ [Ref. IS 800:2007, Cl.6.4]	
Tension Capacity (kN)	35.0	$T_{\text{d}} = \min(T_{\text{dg}},\ T_{\text{dn}},\ T_{\text{db}})$ $= \min(801.82, 736.24, 778.22)$ $= 736.24$ [Ref.IS 800:2007, Cl.6.1]	Pass
Moment Capacity (kNm)	13.12	$M_{dz} = \frac{\beta_b Z_p f y}{\gamma_{m0} \times 10^6}$ $= \frac{1.0 \times 154350.0 \times 300}{1.1 \times 10^6}$ $= 42.1$ [Ref. IS 800:2007, Cl.8.2.1.2]	Pass
Interaction Ratio	≤ 1	$\frac{13.12}{42.1} + \frac{35.0}{736.24} = 0.36$ [Ref. IS 800:2007, Cl.10.7]	Pass

2.5 Section Design

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)		$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{300.0 \times 7.4 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 349.56$ [Ref. IS 800:2007, Cl.10.4.3]	

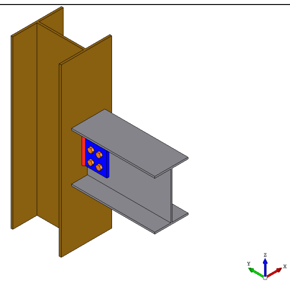
Check	Required	Provided	Remarks
Allowable Shear Capacity (kN)	$V = 175.0$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 349.56$ $= 209.74$ [Limited to low shear]	Pass
Shear Rupture Capacity (kN)		$V_{d_n} = \frac{0.75 A_{vn} f_u}{\sqrt{3}\gamma_{m1}}$ $= 1 \times \frac{(300.0 - (3 \times 22.0)) \times 7.4 \times 440}{\sqrt{3} \times 1.25}$ $= 571.43$ [Ref. AISC, sect. J4]	
Block Shear Capacity in Shear (kN)		$V_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{\text{db}} = \min(V_{db1},\ V_{db2}) = 331.71$ [Ref. IS 800:2007, Cl.6.4]	
Shear Capacity (kN)	175.0	$V_d = \min(S_c,\ V_{d_n},\ V_{d_b})$ $= \min(209.74,\ 571.43,\ 331.71)$ $= 209.74$ [Ref. IS 800:2007, Cl.6.1]	Pass
Tension Yielding Capacity (kN)		$T_{\text{dg}} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 300.0 \times 7.4$ $= \frac{2220.0 \times 300}{1.1 \times 10^3}$ $= 605.45$ [Ref. IS 800:2007, Cl.6.2]	

Check	Required	Provided	Remarks
Tension Rupture Capacity (kN)		$T_{\text{dn}} = \frac{0.9 A_n f_u}{\gamma_{m1}}$ $= \frac{1\times\ 0.9\times(300.0-3\times22.0)\times7.4\times440}{1.25}$ $= 548.57$ [Ref. IS 800:2007, Cl.6.3.1]	
Block Shear Capacity in Tension (kN)		$T_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{\text{db}} = \min(T_{db1},\ T_{db2}) = 411.35$ [Ref. IS 800:2007, Cl.6.4]	
Tension Capacity (kN)	35.0	$T_{\text{d}} = \min(T_{\text{dg}},\ T_{\text{dn}},\ T_{\text{db}})$ $= \min(605.45, 548.57, 411.35)$ $= 411.35$ [Ref.IS 800:2007, Cl.6.1]	**Pass**
Moment Capacity (kNm)	13.12	$M_{d_{\text{z}}} = \frac{\beta_b Z_p f y}{\gamma_{m0}\times10^6}$ $= \frac{1.0\times731000.0\times300}{1.1\times10^6}$ $= 199.36$ [Ref. IS 800:2007, Cl.8.2.1.2]	**Pass**
Interaction Ratio	≤ 1	$\frac{13.12}{199.36} + \frac{35.0}{411.35} = 0.15$ [Ref. IS 800:2007, Cl.10.7]	**Pass**

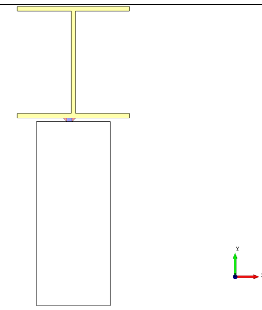
2.6 Weld Design

Check	Required	Provided	Remarks
Min. Weld Size (mm)	$t_{w_{\min}}$ based on thinner part $= \max(12,\ 12)$ $s_{\min}$ 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 $= \min(12,\ 14.0) = 12$ $s_{\max} = 12$ [Ref. IS 800:2007, Cl.10.5.3.1]	10	Pass
Weld Strength (N/mm)	$R_{\mathrm{w}} = \sqrt{(T_{\mathrm{wh}} + A_{\mathrm{wh}})^2 + (T_{\mathrm{wv}} + V_{\mathrm{wv}})^2}$ $T_{\mathrm{wh}} = \frac{M \times y_{\max}}{I_{pw}} = \frac{13125000.0 \times 95.0}{1143166.67}$ $T_{\mathrm{wv}} = \frac{M \times x_{\max}}{I_{pw}} = \frac{13125000.0 \times 0.0}{1143166.67}$ $V_{\mathrm{wv}} = \frac{V}{l_w} = \frac{175000.0}{380}$ $A_{\mathrm{wh}} = \frac{A}{l_w} = \frac{35000.0}{380}$ $R_{\mathrm{w}} = \sqrt{(1090.72 + 92.11)^2 + (0.0 + 460.53)^2}$ $= 1269.32$	$f_w = \frac{t_t f_u}{\sqrt{3}\gamma_{mw}}$ $= \frac{7.0 \times 440}{\sqrt{3} \times 1.25}$ $= 1422.59$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	Pass

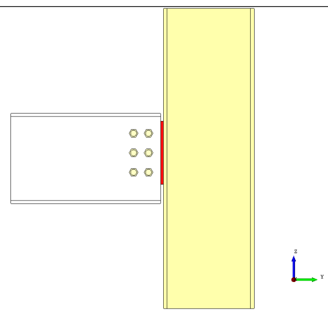
3 3D Views



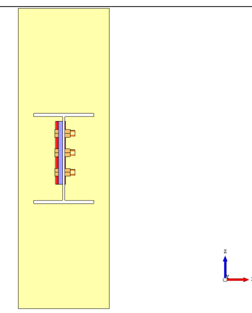
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log

2021-02-04 11:43:59 - Osdag - INFO - === End Of Design ===