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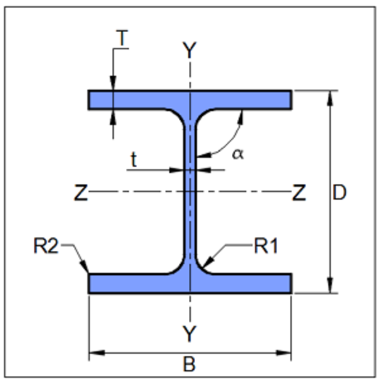
Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Fin Plate
Designer	Engineer#1	Job Number	1.1.1.2.1
Date	04 /02 /2021	Client	Mr. Yogesh D Pisal, Mumbai

1 Input Parameters

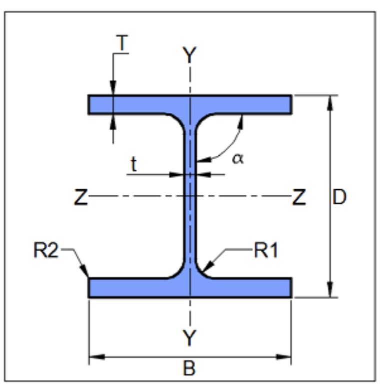
Main Module	Shear Connection
Module	Fin Plate Connection
Connectivity	Column Web-Beam Web
Shear Force (kN)	225.0
Axial Force (kN)	100.0

Supporting Section - Mechanical Properties



Supporting Section		PBP 400 X 230.9	
Material		E 350 (Fe 490)	
Ultimate Strength, F_u (MPa)		490	
Yield Strength, F_y (MPa)		330	
Mass, m (kg/m)	230.9	I_z (cm^4)	70100.0
Area, A (cm^2)	294.0	I_y(cm^4)	28200.0
D (mm)	372.0	r_z (cm)	15.4
B (mm)	402.0	r_y (cm)	9.8
t (mm)	26.0	Z_z (cm^3)	3770.0
T (mm)	26	Z_y (cm^3)	1400.0
Flange Slope	90	Z_{pz} (cm^3)	4310.0
R_1 (mm)	15.0	Z_{py} (cm^3)	2150.0
R_2 (mm)	0.0		

Supported Section - Mechanical Properties



Supported Section		NPB 350 X 250 X 79.18	
Material		E 350 (Fe 490)	
Ultimate Strength, F_u (MPa)		490	
Yield Strength, F_y (MPa)		350	
Mass, m (kg/m)	79.18	I_z (cm^4)	21500.0
Area, A (cm^2)	100.0	I_y(cm^4)	3650.0
D (mm)	340.0	r_z (cm)	14.6
B (mm)	250.0	r_y (cm)	6.01
t (mm)	9.0	Z_z (cm^3)	1260.0
T (mm)	14.0	Z_y (cm^3)	292.0
Flange Slope	90	Z_{pz} (cm^3)	1400.0
R_1 (mm)	18.0	Z_{py} (cm^3)	446.0
R_2 (mm)	0.0		

Bolt Details - Input and Design Preference	
Diameter (mm)	[12, 16, 20, 24]
Property Class	[4.6, 8.8, 10.9]
Type	Bearing Bolt
Hole Type	Over-sized
Bolt Tension	Non 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)	12.0
Are the Members Exposed to Corrosive Influences?	False
Plate Details - Input and Design Preference	
Thickness (mm)	[12, 14, 16, 18, 20, 22, 25]
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)	510.0

2 Design Checks

Design Status	Pass

2.1 Initial Section Check

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)	225.0	$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{340.0 \times 9.0 \times 350}{\sqrt{3} \times 1.1 \times 1000}$ $= 562.13$ [Ref. IS 800:2007, Cl.10.4.3]	Pass
Allowable Shear Capacity (kN)	225.0	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 562.13$ $= 337.28$ [Limited to low shear]	Pass
Tension Yielding Capacity (kN)	100.0	$T_{\text{dg}} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 340.0 \times 9.0$ $= \frac{3060.0 \times 350}{1.1 \times 10^3}$ $= 973.64$ [Ref. IS 800:2007, Cl.6.2]	Pass

2.2 Load Consideration

Check	Required	Provided	Remarks
Applied Axial Force (kN)	100.0	100.0	

Check	Required	Provided	Remarks
Applied Shear Force (kN)	225.0	$V_{y_{\min}} = \min(0.15V_{d_y},\ 40.0)$ $= \min(0.15 \times 562.13,\ 40.0)$ $= 40$ $V_u = \max(V_y,\ V_{y_{\min}})$ $= \max(225.0, 40)$ $= 225.0$ [Ref. IS 800:2007, Cl.10.7]	

2.3 Bolt Design

Check	Required	Provided	Remarks
Diameter (mm)		16.0	
Property Class		8.8	
Plate Thickness (mm)	$t_w = 9.0$	12.0	Pass
No. of Bolt Columns		2	Pass
No. of Bolt Rows		6	
Min. Pitch Distance (mm)	$p_{\min} = 2.5d$ $= 2.5 \times 16.0$ $= 40.0$ [Ref. IS 800:2007, Cl.10.2.2]	40	Pass
Max. Pitch Distance (mm)	$p/g_{\max} = \min(32t,\ 300)$ $= \min(32 \times 9.0,\ 300)$ $= \min(288.0,\ 300)$ $= 288.0$ Where, $t = \min(12.0, 9.0)$ [Ref. IS 800:2007, Cl.10.2.3]	40	Pass

Check	Required	Provided	Remarks
Min. Gauge Distance (mm)	$p_{\min} = 2.5d$ $= 2.5 \times 16.0$ $= 40.0$ [Ref. IS 800:2007, Cl.10.2.2]	40	Pass
Max. Gauge Distance (mm)	$p/g_{\max} = \min(32t,\ 300)$ $= \min(32 \times 9.0,\ 300)$ $= \min(288.0,\ 300)$ $= 288.0$ Where, $t = \min(12.0, 9.0)$ [Ref. IS 800:2007, Cl.10.2.3]	40	Pass
Min. End Distance (mm)	$e_{\min} = 1.5d_0$ $= 1.5 \times 20.0$ $= 30.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	30	Pass
Max. End Distance (mm)	$e_{\max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 12.0 \times \sqrt{\frac{250}{250}} = 144.0$ $e_2 = 12 \times 9.0 \times \sqrt{\frac{250}{350}} = 91.28$ $e_{\max} = \min(e_1,\ e_2) = 91.28$ [Ref. IS 800:2007, Cl.10.2.4.3]	30	Pass
Min. Edge Distance (mm)	$e'_{\min} = 1.5d_0$ $= 1.5 \times 20.0$ $= 30.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	30	Pass

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{\max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 12.0 \times \sqrt{\frac{250}{250}} = 144.0$ $e_2 = 12 \times 9.0 \times \sqrt{\frac{250}{350}} = 91.28$ $e'_{\max} = min(e_1,\ e_2) = 91.28$ [Ref. IS 800:2007, Cl.10.2.4.3]	30	Pass
Moment Demand (kNm)		$M_d = (V_u \times \text{ecc} + M_w)$ $\text{ecc} = \text{eccentricity}$ $M_w = \text{external moment acting on web}$ $= \frac{(225.0 \times 10^3 \times 62.0 + 0.0 \times 10^6)}{10^6}$ $= 13.95$	
Bolt Force Parameter(s) (mm)	$l_n = \text{length available}$ $l_n = p\ (n_r - 1)$ $= 40 \times (6 - 1)$ $= 200$ $y_{\max} = l_n/2$ $= 200/2$ $= 100.0$ $x_{\max} = g(n_c - 1)/2$ $= 40 \times (2 - 1)/2$ $= 20.0$		

Check	Required	Provided	Remarks
Bolt Force (kN)	$vbv = V_u/(n_r \times n_c) = \frac{225.0}{(6 \times 2)} = 18.75$ $tmh = \frac{M_d \times y_{\max}}{\Sigma r_i^2} = \frac{13.95 \times 100.0}{60.8} = 22.94$ $tmv = \frac{M_d \times x_{\max}}{\Sigma r_i^2} = \frac{13.95 \times 20.0}{60.8} = 4.59$ $abh = \frac{A_u}{(n_r \times n_c)} = \frac{100.0}{(6 \times 2)} = 8.33$ $v_{\text{res}} = \sqrt{(vbv + tmv)^2 + (tmh + abh)^2} = \sqrt{(18.75 + 4.59)^2 + (22.94 + 8.33)^2} = 39.03$		
Shear Capacity (kN)		$V_{\text{dsb}} = \frac{f_{ub} n_n A_{nb}}{\sqrt{3}\gamma_{mb}} = \frac{800.0 \times 1 \times 157}{1000 \times \sqrt{3} \times 1.25} = 58.01$ [Ref. IS 800:2007, Cl.10.3.3]	

Check	Required	Provided	Remarks
Kb		$k_b = \min\left(\frac{e}{3d_0},\ \frac{p}{3d_0} - 0.25,\ \frac{f_{ub}}{f_u},\ 1.0\right)$ $= \min\left(\frac{30}{3 \times 20.0},\ \frac{40}{3 \times 20.0} - 0.25,\ \frac{800.0}{490},\ 1.0\right)$ $= \min(0.5, 0.42, 1.63, 1.0)$ $= 0.42$ [Ref. IS 800:2007, Cl.10.3.4]	
Bearing Capacity (kN)		$V_{\text{dpb}} = \frac{2.5 k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.42 \times 16.0 \times 9.0 \times 490}{1000 \times 1.25}$ $= 41.49$ [Ref. IS 800:2007, Cl.10.3.4]	
Capacity (kN)		$V_{\text{db}} = \min\ (V_{\text{dsb}},\ V_{\text{dpb}})$ $= \min\ (58.01,\ 41.49)$ $= 41.49$ [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]	$l_j = (n_r - 1) \times p$ $= (6 - 1) \times 40 = 200$ $l = 200$ $15 \times d = 15 \times 16.0 = 240.0$ since, $l_j < 15 \times d$ then $\beta_{lj} = 1.0$ [Ref. IS 800:2007, Cl.10.3.3.1]	
Capacity (kN)	39.03	41.49	Pass

2.4 Plate Design

Check	Required	Provided	Remarks
Min. Plate Height (mm)	$0.6 \times (d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (340.0 - 2 \times 14.0 - 2 \times 18.0)$ $= 165.6$ [Ref. INSDAG, Ch.5, sec.5.2.3]	260	**Pass**
Max. Plate Height (mm)	$d_b - 2(t_{bf} + r_{b1} + \text{gap})$ $= 340.0 - 2 \times (14.0 + 18.0 + 10)$ $= 276.0$	260	**Pass**
Min. Plate Width (mm)	$2e_{\min} + (n_c - 1)p_{\min})$ $= 2 \times 30.0 + (2 - 1) \times 40.0$ $= 112.0$	112.0	**Fail**
Min. Plate Thickness (mm)	$t_w = 9.0$	12.0	**Pass**
Shear Yielding Capacity (kN)		$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{260 \times 12.0 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 409.39$ [Ref. IS 800:2007, Cl.10.4.3]	
Allowable Shear Capacity (kN)	$V = 225.0$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 409.39$ $= 245.64$ [Limited to low shear]	**Pass**
Shear Rupture Capacity (kN)		$V_{d_n} = \frac{0.75 A_{vn} f_u}{\sqrt{3}\gamma_{m1}}$ $= 1 \times \frac{(260 - (6 \times 20.0)) \times 12.0 \times 410}{\sqrt{3} \times 1.25}$ $= 516.6$ [Ref. AISC, sect. J4]	

Check	Required	Provided	Remarks
Block Shear Capacity in Shear (kN)		$V_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{\text{db}} = \min(V_{db1},\ V_{db2}) = 436.33$ [Ref. IS 800:2007, Cl.6.4]	
Shear Capacity (kN)	225.0	$V_d = \min(S_c,\ V_{d_n},\ V_{d_b})$ $= \min(245.64,\ 516.6,\ 436.33)$ $= 245.64$ [Ref. IS 800:2007, Cl.6.1]	**Pass**
Tension Yielding Capacity (kN)		$T_{\text{dg}} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 260 \times 12.0$ $= \frac{3120.0 \times 250}{1.1 \times 10^3}$ $= 709.09$ [Ref. IS 800:2007, Cl.6.2]	
Tension Rupture Capacity (kN)		$T_{\text{dn}} = \frac{0.9 A_n f_u}{\gamma_{m1}}$ $= \frac{1 \times\ 0.9 \times (260 - 6 \times 20.0) \times 12.0 \times 410}{1.25}$ $= 779.33$ [Ref. IS 800:2007, Cl.6.3.1]	

Check	Required	Provided	Remarks
Block Shear Capacity in Tension (kN)		$T_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{\text{db}} = \min(T_{db1},\ T_{db2}) = 574.68$ [Ref. IS 800:2007, Cl.6.4]	
Tension Capacity (kN)	100.0	$T_{\text{d}} = \min(T_{\text{dg}},\ T_{\text{dn}},\ T_{\text{db}})$ $= \min(709.09, 779.33, 574.68)$ $= 574.68$ [Ref.IS 800:2007, Cl.6.1]	Pass
Moment Capacity (kNm)	13.95	$M_{dz} = \frac{\beta_b Z_p f y}{\gamma_{m0} \times 10^6}$ $= \frac{1.0 \times 202800.0 \times 250}{1.1 \times 10^6}$ $= 46.09$ [Ref. IS 800:2007, Cl.8.2.1.2]	Pass
Interaction Ratio	≤ 1	$\frac{13.95}{46.09} + \frac{100.0}{574.68} = 0.48$ [Ref. IS 800:2007, Cl.10.7]	Pass

2.5 Section Design

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)		$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{340.0 \times 9.0 \times 350}{\sqrt{3} \times 1.1 \times 1000}$ $= 562.13$ [Ref. IS 800:2007, Cl.10.4.3]	

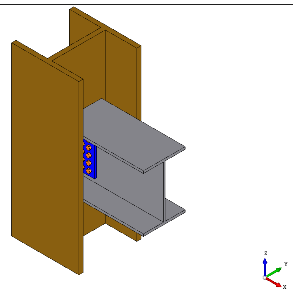
Check	Required	Provided	Remarks
Allowable Shear Capacity (kN)	$V = 225.0$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 562.13$ $= 337.28$ [Limited to low shear]	**Pass**
Shear Rupture Capacity (kN)		$V_{d_n} = \frac{0.75 A_{v_n} f_u}{\sqrt{3}\gamma_{m1}}$ $= 1 \times \frac{(340.0 - (6 \times 20.0)) \times 9.0 \times 490}{\sqrt{3} \times 1.25}$ $= 727.65$ [Ref. AISC, sect. J4]	
Block Shear Capacity in Shear (kN)		$V_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{\text{db}} = \min(V_{db1},\ V_{db2}) = 420.44$ [Ref. IS 800:2007, Cl.6.4]	
Shear Capacity (kN)	225.0	$V_d = \min(S_c,\ V_{d_n},\ V_{d_b})$ $= \min(337.28,\ 727.65,\ 420.44)$ $= 337.28$ [Ref. IS 800:2007, Cl.6.1]	**Pass**
Tension Yielding Capacity (kN)		$T_{\text{dg}} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 340.0 \times 9.0$ $= \frac{3060.0 \times 350}{1.1 \times 10^3}$ $= 973.64$ [Ref. IS 800:2007, Cl.6.2]	

Check	Required	Provided	Remarks
Tension Rupture Capacity (kN)		$T_{\text{dn}} = \frac{0.9 A_n f_u}{\gamma_{m1}}$ $= \frac{1 \times\ 0.9 \times (340.0 - 6 \times 20.0) \times 9.0 \times 490}{1.25}$ $= 698.54$ [Ref. IS 800:2007, Cl.6.3.1]	
Block Shear Capacity in Tension (kN)		$T_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{\text{db}} = \min(T_{db1},\ T_{db2}) = 548.98$ [Ref. IS 800:2007, Cl.6.4]	
Tension Capacity (kN)	100.0	$T_{\text{d}} = \min(T_{\text{dg}},\ T_{\text{dn}},\ T_{\text{db}})$ $= \min(973.64, 698.54, 548.98)$ $= 548.98$ [Ref.IS 800:2007, Cl.6.1]	**Pass**
Moment Capacity (kNm)	13.95	$M_{d_{\text{z}}} = \frac{\beta_b Z_p f y}{\gamma_{m0} \times 10^6}$ $= \frac{1.0 \times 1400000.0 \times 350}{1.1 \times 10^6}$ $= 445.45$ [Ref. IS 800:2007, Cl.8.2.1.2]	**Pass**
Interaction Ratio	≤ 1	$\frac{13.95}{445.45} + \frac{100.0}{548.98} = 0.21$ [Ref. IS 800:2007, Cl.10.7]	**Pass**

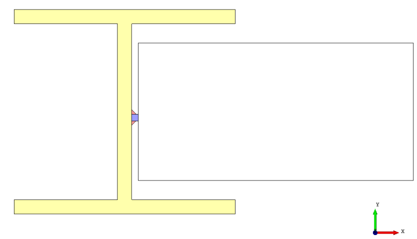
2.6 Weld Design

Check	Required	Provided	Remarks
Min. Weld Size (mm)	$t_{w_{\min}}$ based on thinner part $= \max(12,\ 12)$ $s_{\min}$ based on thicker part $= 6$ [Ref. IS 800:2007, Table 21, Cl.10.5.2.3]	8	**Pass**
Max. Weld Size (mm)	Thickness of thinner part $= \min(26,\ 12.0) = 12.0$ $s_{\max} = 12$ [Ref. IS 800:2007, Cl.10.5.3.1]	8	**Pass**
Weld Strength (N/mm)	$R_{\mathrm{w}} = \sqrt{(T_{\mathrm{wh}} + A_{\mathrm{wh}})^2 + (T_{\mathrm{wv}} + V_{\mathrm{wv}})^2}$ $T_{\mathrm{wh}} = \dfrac{M \times y_{\max}}{I_{pw}} = \dfrac{13950000.0 \times 122.0}{2421130.67}$ $T_{\mathrm{wv}} = \dfrac{M \times x_{\max}}{I_{pw}} = \dfrac{13950000.0 \times 0.0}{2421130.67}$ $V_{\mathrm{wv}} = \dfrac{V}{l_w} = \dfrac{225000.0}{488}$ $A_{\mathrm{wh}} = \dfrac{A}{l_w} = \dfrac{100000.0}{488}$ $R_{\mathrm{w}} = \sqrt{(702.94 + 204.92)^2 + (0.0 + 461.07)^2}$ $= 1018.22$	$f_w = \dfrac{t_t f_u}{\sqrt{3}\gamma_{mw}}$ $= \dfrac{5.6 \times 410}{\sqrt{3} \times 1.25}$ $= 1060.48$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	**Pass**

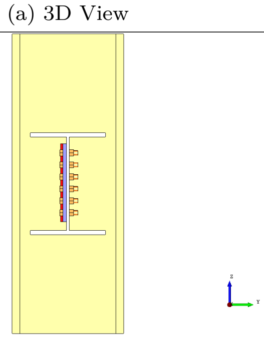
3 3D Views



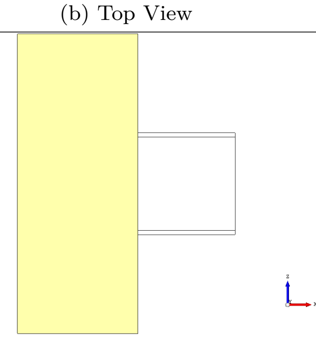
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log

2021-02-04 11:45:54 - Osdag - INFO - === End Of Design ===