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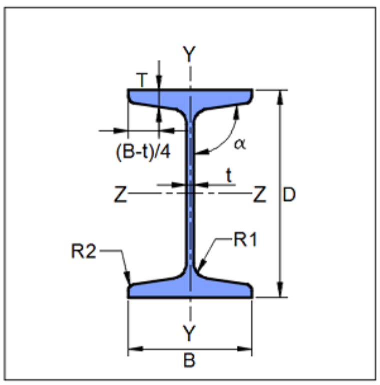
Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Fin Plate
Designer	Engineer #1	Job Number	1.1.1.3.1
Date	17 /12 /2020	Client	Somnath Mukherjee, MN Dastur, Kolkata

1 Input Parameters

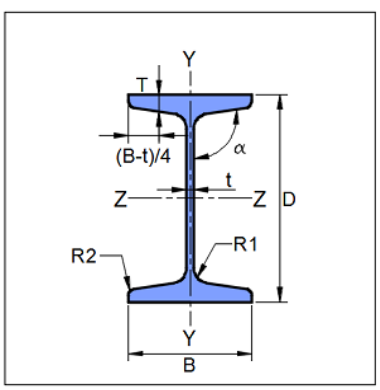
Main Module	Shear Connection
Module	Fin Plate
Connectivity	Beam-Beam
Shear Force (kN)	160.0
Axial Force (kN)	20.0

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 300	
Material		E 300 (Fe 440)	
Ultimate Strength, Fu (MPa)		440	
Yield Strength, Fy (MPa)		300	
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, 20, 24]
Property Class	[8.8, 10.9]
Type	Friction Grip Bolt
Hole Type	Standard
Bolt Tension	Pre-tensioned
Slip Factor, (mu_f)	0.48
Detailing - Design Preference	
Edge Preparation Method	Rolled, machine-flame cut, sawn and planed
Gap Between Members (mm)	5.0
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)	440.0

2 Design Checks

Design Status	Pass

2.1 Initial Section Check

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)	160.0	$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{260.0 \times 7.7 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 315.23$ $[Ref. IS\ 800:2007, Cl. 10.4.3]$	Pass
Allowable Shear Capacity (kN)	160.0	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 315.23$ $= 189.14$ [*Limited to low shear*]	Pass
Tension Yielding Capacity (kN)	20.0	$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $A_g = l \times t = 260.0 \times 7.7$ $= \frac{2002.0 \times 300}{1.1 \times 10^3}$ $= 546.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.2]$	Pass

2.2 Load Consideration

Check	Required	Provided	Remarks

Check	Required	Provided	Remarks
Applied Shear Force (kN)	160.0	$V_{y_{min}} = min(0.15 \times V_{dy}, 40.0)$ $= min(0.15 \times 315.23, 40.0)$ $= 40$ $V_u = max(V_y,\ V_{y_{min}})$ $= max(160.0, 40)$ $= 160.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.7]$	
Applied Axial Force (kN)	20.0	20.0	

2.3 Bolt Design

Check	Required	Provided	Remarks
Diameter (mm)		24.0	
Property Class		10.9	
Plate Thickness (mm)	$t_w = 7.7$	16.0	**Pass**
No. of Bolt Columns		1	**Pass**
No. of Bolt Rows		3	
Min. Pitch Distance (mm)	$p_{min} = 2.5\ d$ $= 2.5 \times 24.0$ $= 60.0$ $[Ref\ IS\ 800:2007,\ Cl.\ 10.2.2]$	60	**Pass**
Max. Pitch Distance (mm)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 7.7,\ 300\ mm)$ $= \min(246.4,\ 300\ mm)$ $= 246.4$ $Where,\ t = min(16.0, 7.7)$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.3]$	60	**Pass**

Check	Required	Provided	Remarks
Min. Gauge Distance (mm)	$p_{min} = 2.5\ d$ $= 2.5 \times 24.0$ $= 60.0$ $[Ref\ IS\ 800:2007,\ Cl.\ 10.2.2]$	0.0	
Max. Gauge Distance (mm)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 7.7,\ 300\ mm)$ $= \min(246.4,\ 300\ mm)$ $= 246.4$ $Where,\ t = min(16.0, 7.7)$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.3]$	0.0	
Min. End Distance (mm)	$e_{min} = 1.5\ d_0$ $= 1.5 \times 26.0$ $= 39.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2]$	40	**Pass**
Max. End Distance (mm)	$e_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 16.0 \times \sqrt{\frac{250}{250}} = 192.0$ $e_2 = 12 \times 7.7 \times \sqrt{\frac{250}{300}} = 84.35$ $e_{max} = min(e_1, e_2) = 84.35$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3]$	40	**Pass**
Min. Edge Distance (mm)	$e'_{min} = 1.5\ d_0$ $= 1.5 \times 26.0$ $= 39.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2]$	40	**Pass**

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 16.0 \times \sqrt{\frac{250}{250}} = 192.0$ $e_2 = 12 \times 7.7 \times \sqrt{\frac{250}{300}} = 84.35$ $e'_{max} = min(e_1, e_2) = 84.35$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3]$	40	**Pass**
Moment Demand (kNm)		$M_d = (V_u \times ecc + M_w)$ $ecc = eccentricity$ $M_w = external\ moment\ acting\ on\ web$ $= \frac{(160.0 \times 10^3 \times 45.0 + 0.0 \times 10^6)}{10^6}$ $= 7.2$	
Bolt Force Parameter(s) (mm)	$l_n = length\ available$ $l_n = p\ (n_r - 1)$ $= 60 \times (3 - 1)$ $= 120$ $y_{max} = l_n/2$ $= 120/2$ $= 60.0$ $x_{max} = g(n_c - 1)/2$ $= 0.0 \times (1 - 1)/2$ $= 0.0$		

Check	Required	Provided	Remarks
Bolt Force (kN)	$vbv = V_u/(n_r \times n_c) = \frac{160.0}{(3 \times 1)} = 53.33$ $tmh = \frac{M_d \times y_{max}}{\Sigma r_i^2} = \frac{7.2 \times 60.0}{7.2} = 60.0$ $tmv = \frac{M_d \times x_{max}}{\Sigma r_i^2} = \frac{7.2 \times 0.0}{7.2} = 0.0$ $abh = \frac{A_u}{(n_r \times n_c)} = \frac{20.0}{(3 \times 1)} = 6.67$ $vres = \sqrt{(vbv + tmv)^2 + (tmh + abh)^2} = \sqrt{(53.33 + 0.0)^2 + (60.0 + 6.67)^2} = 85.37$		
Slip Resistance (kN)		$V_{dsf} = \frac{\mu_f \ n_e \ K_h \ F_o}{\gamma_{mf}}$ $Where\ , F_o = 0.7 f_{ub} A_{nb}$ $V_{dsf} = \frac{0.48 \times 1 \times 1.0 \times 0.7 \times 1040.0 \times 353}{1.25 \times 10^3} = 98.68$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.4.3]$	

Check	Required	Provided	Remarks
Long Joint Reduction Factor	$if\ l_j \geq 15d\ then\ V_{rd} = \beta_{lj} V_{db}$ $if\ l_j < 15d\ then\ V_{rd} = V_{db}$ $where,$ $l_j = ((nc\ or\ nr) - 1) \times (p\ or\ g)$ $\beta_{lj} = 1.075 - l/(200d)$ $but\ 0.75 \leq \beta_{lj} \leq 1.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3.1]$	$l_j = (n_r - 1) \times p$ $= (3 - 1) \times 60 = 120$ $l = 120$ $15 \times d = 15 \times 24.0 = 360.0$ $since,\ l_j < 15 \times d\ then\ \beta_{lj} = 1.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3.1]$	
Capacity (kN)	85.37	98.68	Pass

2.4 Plate Design

Check	Required	Provided	Remarks
Min. Plate Height (mm)	$0.6 \times (d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (300.0 - 2 \times 13.1 - 2 \times 14.0)$ $= 147.48$ $[Ref.\ INSDAG - Chpt.5,\ Sect.5.2.3]$	200	Pass
Max. Plate Height (mm)	$d_b - t_{bf} + r_{b1} - notch_h$ $= 300.0 - 13.1 + 14.0 - 40$ $= 222.9$	200	Pass
Min. Plate Width (mm)	$2e_{min} + (n_c - 1)p_{min})$ $= 2 \times 39.0 + (1 - 1) \times 60.0$ $= 83.0$	85.0	Pass
Min. Plate Thickness (mm)	$t_w = 7.7$	16.0	Pass
Shear Yielding Capacity (kN)		$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{200 \times 16.0 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 419.89$ $[Ref. IS\ 800:2007, Cl.10.4.3]$	

Check	Required	Provided	Remarks
Allowable Shear Capacity (kN)	$V = 160.0$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 419.89$ $= 251.93$ [*Limited to low shear*]	**Pass**
Shear Rupture Capacity (kN)		$V_{dn} = \frac{0.75\ A_{vn}\ f_u}{\sqrt{3}\ \gamma_{m1}}$ $= 1 \times \frac{(200 - (3 \times 26.0)) \times 16.0 \times 410}{\sqrt{3} \times 1.25}$ $= 600.24$ $[Ref.AISC\ \ Sect.J4]$	
Block Shear Capacity in Shear (kN)		$V_{dbl1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{dbl2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{db} = min(V_{db1}, V_{db2}) = 404.51$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.4]$	
Shear Capacity (kN)	160.0	$V_d = min(S_c, V_{dn}, V_{db})$ $= min(251.93, 600.24, 404.51)$ $= 251.93$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.1]$	**Pass**
Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $A_g = l \times t = 200 \times 16.0$ $= \frac{3200.0 \times 250}{1.1 \times 10^3}$ $= 727.27$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.2]$	

Check	Required	Provided	Remarks
Tension Rupture Capacity (kN)		$T_{dn} = \frac{0.9A_n f_u}{\gamma_{m1}}$ $= \frac{1 \times\ 0.9 \times (200 - 3 \times 26.0) \times 16.0 \times 410}{1.25}$ $= 821.84$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.3.1]$	
Block Shear Capacity in Tension (kN)		$T_{dbl1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9A_{tn} f_u}{\gamma_{m1}}$ $T_{dbl2} = \frac{0.9A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = min(T_{db1}, T_{db2}) = 489.13$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.4]$	
Tension Capacity (kN)	20.0	$T_d = min(T_{dg}, T_{dn}, T_{db})$ $= min(727.27, 821.84, 489.13)$ $= 489.13$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.1]$	**Pass**
Moment Capacity (kNm)	7.2	$M_{dzz} = \frac{\beta_b \times Z_p \times fy}{\gamma_{mo} \times 10^6}$ $= \frac{1.0 \times 160000.0 \times 250}{1.1 \times 10^6}$ $= 36.36$ $[Ref.\ IS\ 800:2007,\ Cl.\ 8.2.1.2]$	**Pass**
Interaction Ratio	≤ 1	$\frac{7.2}{36.36} + \frac{20.0}{489.13} = 0.24$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.7]$	**Pass**

2.5 Section Design

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)		$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{260.0 \times 7.7 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 315.23$ $[Ref. IS\ 800:2007, Cl. 10.4.3]$	
Allowable Shear Capacity (kN)	$V = 160.0$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 315.23$ $= 189.14$ $[Limited\ to\ low\ shear]$	**Pass**
Shear Rupture Capacity (kN)		$V_{dn} = \frac{0.75\ A_{vn}\ f_u}{\sqrt{3}\ \gamma_{m1}}$ $= 1 \times \frac{(260.0 - (3 \times 26.0)) \times 7.7 \times 440}{\sqrt{3} \times 1.25}$ $= 462.46$ $[Ref. AISC\ \ Sect. J4]$	
Block Shear Capacity in Shear (kN)		$V_{dbl1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{dbl2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{db} = min(V_{db1}, V_{db2}) = 217.79$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.4]$	
Shear Capacity (kN)	160.0	$V_d = min(S_c, V_{dn}, V_{db})$ $= min(189.14, 462.46, 217.79)$ $= 189.14$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.1]$	**Pass**

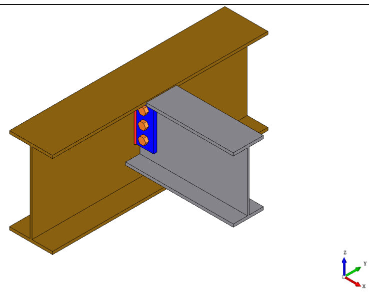
Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $A_g = l \times t = 260.0 \times 7.7$ $= \frac{2002.0 \times 300}{1.1 \times 10^3}$ $= 546.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.2]$	
Tension Rupture Capacity (kN)		$T_{dn} = \frac{0.9 A_n f_u}{\gamma_{m1}}$ $= \frac{1 \times\ 0.9 \times (260.0 - 3 \times 26.0) \times 7.7 \times 440}{1.25}$ $= 443.96$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.3.1]$	
Block Shear Capacity in Tension (kN)		$T_{dbl1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{dbl2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = min(T_{db1}, T_{db2}) = 262.87$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.4]$	
Tension Capacity (kN)	20.0	$T_d = min(T_{dg}, T_{dn}, T_{db})$ $= min(546.0, 443.96, 262.87)$ $= 262.87$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.1]$	**Pass**
Moment Capacity (kNm)	7.2	$M_{dzz} = \frac{\beta_b \times Z_p \times fy}{\gamma_{mo} \times 10^6}$ $= \frac{1.0 \times 681000.0 \times 300}{1.1 \times 10^6}$ $= 185.73$ $[Ref.\ IS\ 800:2007,\ Cl.\ 8.2.1.2]$	**Pass**

Check	Required	Provided	Remarks
Interaction Ratio	≤ 1	$\frac{7.2}{185.73} + \frac{20.0}{262.87} = 0.11$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.7]$	**Pass**

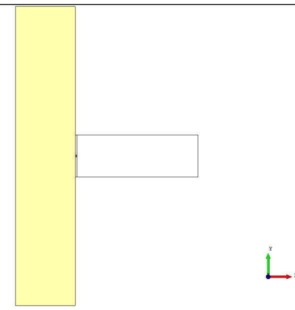
2.6 Weld Design

Check	Required	Provided	Remarks
Min. Weld Size (mm)	$t_{w_{min}}\ based\ on\ thinner\ part$ $= 8\ or\ 8$ $s_{min}\ based\ on\ thicker\ part = 5$ $[Ref\ IS\ 800:2007, Table\ 21\ (Cl10.5.2.3)]$	6	**Pass**
Max. Weld Size (mm)	$Thickness\ of\ thinner\ part$ $= min(8.6, 16.0) = 8.6$ $s_{max} = 10$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.3.1]$	6	**Pass**
Weld Strength (N/mm)	$R_w = \sqrt{(T_{wh} + A_{wh})^2 + (T_{wv} + V_{wv})^2}$ $T_{wh} = \frac{M \times y_{max}}{Ipw} = \frac{7200000.0 \times 94.0}{1107445.33}$ $T_{wv} = \frac{M \times x_{max}}{Ipw} = \frac{7200000.0 \times 0.0}{1107445.33}$ $V_{wv} = \frac{V}{l_w} = \frac{160000.0}{376}$ $A_{wh} = \frac{A}{l_w} = \frac{20000.0}{376}$ $R_w = \sqrt{(611.14 + 53.19)^2 + (0.0 + 425.53)^2}$ $= 788.93$	$f_w = \frac{t_t\ f_u}{\sqrt{3}\ \gamma_{mw}}$ $= \frac{4.2 \times 410}{\sqrt{3} \times 1.25}$ $= 795.36$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.1.1]$	**Pass**

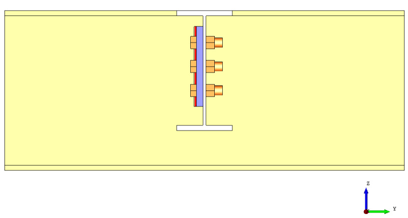
3 3D Views



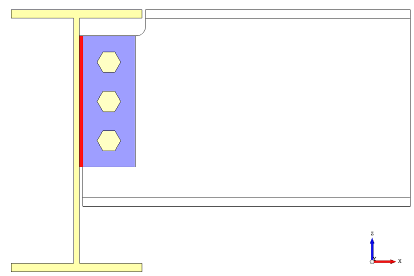
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log