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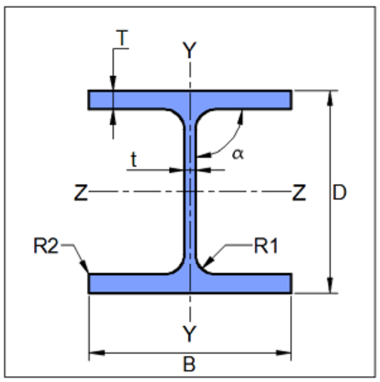
Company Name		Project Title	20 mm bolts
Group/Team Name		Subtitle	
Designer		Job Number	
Date	11 /04 /2021	Client	

1 Input Parameters

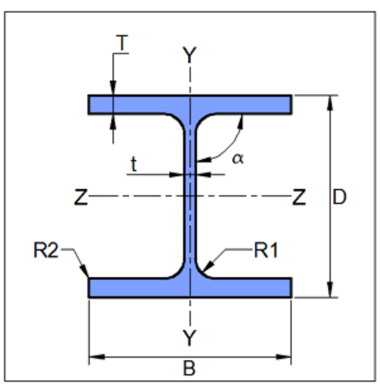
Main Module	Shear Connection
Module	Fin Plate Connection
Connectivity	Beam-Beam
Shear Force (kN)	131.628
Axial Force (kN)	147.368

Supporting Section - Mechanical Properties



Supporting Section		GROUP4	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, F_u (MPa)		410	
Yield Strength, F_y (MPa)		250	
Mass, m (kg/m)	328.22	I_z (cm^4)	511521.0
Area, A (cm^2)	419.0	I_y(cm^4)	42926.0
D (mm)	824.0	r_z (cm)	34.9
B (mm)	500.0	r_y (cm)	10.12
t (mm)	12.0	Z_z (cm^3)	13034.0
T (mm)	16.0	Z_y (cm^3)	2071.0
Flange Slope	90	Z_{pz} (cm^3)	7374.9
R_1 (mm)	20.0	Z_{py} (cm^3)	15512.0
R_2 (mm)	10.0		

Supported Section - Mechanical Properties



Supported Section		GROUP4-S1-	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, F_u (MPa)		410	
Yield Strength, F_y (MPa)		250	
Mass, m (kg/m)	324.0	I_z (cm^4)	511521.0
Area, A (cm^2)	419.0	I_y(cm^4)	42926.0
D (mm)	750.0	r_z (cm)	34.9
B (mm)	500.0	r_y (cm)	10.12
t (mm)	12.0	Z_z (cm^3)	13034.0
T (mm)	16.0	Z_y (cm^3)	2071.0
Flange Slope	90	Z_{pz} (cm^3)	6483.59
R_1 (mm)	20.0	Z_{py} (cm^3)	15464.64
R_2 (mm)	10.0		

Bolt Details - Input and Design Preference	
Diameter (mm)	[12, 14, 16, 18, 20]
Property Class	[3.6, 4.6, 4.8, 5.6, 5.8, 6.8, 8.8, 9.8, 10.9, 12.9]
Type	Friction Grip Bolt
Hole Type	Standard
Bolt Tension	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, 16, 18, 20]
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)	410.0

2 Design Checks

Design Status	Pass

2.1 Initial Section Check

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)	131.628	$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{700.0 \times 12.0 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 1102.21$ [Ref. IS 800:2007, Cl.10.4.3]	Pass
Allowable Shear Capacity (kN)	131.628	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 1102.21$ $= 661.33$ [Limited to low shear]	Pass
Tension Yielding Capacity (kN)	147.368	$T_{\mathrm{dg}} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 700.0 \times 12.0$ $= \frac{8400.0 \times 250}{1.1 \times 10^3}$ $= 1909.09$ [Ref. IS 800:2007, Cl.6.2]	Pass

2.2 Load Consideration

Check	Required	Provided	Remarks
Applied Axial Force (kN)	147.368	147.368	

Check	Required	Provided	Remarks
Applied Shear Force (kN)	131.628	$V_{y_{\min}} = \min(0.15V_{d_y},\ 40.0)$ $= \min(0.15 \times 1102.21,\ 40.0)$ $= 40$ $V_u = \max(V_y,\ V_{y_{\min}})$ $= \max(131.628, 40)$ $= 131.628$ [Ref. IS 800:2007, Cl.10.7]	

2.3 Bolt Design

Check	Required	Provided	Remarks
Diameter (mm)		20.0	
Property Class		12.9	
Plate Thickness (mm)	$t_w = 12.0$	14.0	Pass
No. of Bolt Columns		1	Pass
No. of Bolt Rows		5	
Min. Pitch Distance (mm)	$p_{\min} = 2.5d$ $= 2.5 \times 20.0$ $= 50.0$ [Ref. IS 800:2007, Cl.10.2.2]	140	Pass
Max. Pitch Distance (mm)	$p/g_{\max} = \min(32t,\ 300)$ $= \min(32 \times 12.0,\ 300)$ $= \min(384.0,\ 300)$ $= 300$ Where, $t = \min(14.0, 12.0)$ [Ref. IS 800:2007, Cl.10.2.3]	140	Pass

Check	Required	Provided	Remarks
Min. Gauge Distance (mm)	$p_{\mathrm{min}} = 2.5d$ $= 2.5 \times 20.0$ $= 50.0$ [Ref. IS 800:2007, Cl.10.2.2]	0.0	
Max. Gauge Distance (mm)	$p/g_{\mathrm{max}} = \min(32t,\ 300)$ $= \min(32 \times 12.0,\ 300)$ $= \min(384.0,\ 300)$ $= 300$ Where, $t = \min(14.0, 12.0)$ [Ref. IS 800:2007, Cl.10.2.3]	0.0	
Min. End Distance (mm)	$e_{\mathrm{min}} = 1.7d_0$ $= 1.7 \times 22.0$ $= 37.4$ [Ref. IS 800:2007, Cl.10.2.4.2]	40	**Pass**
Max. End Distance (mm)	$e_{\mathrm{max}} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 14.0 \times \sqrt{\frac{250}{250}} = 168.0$ $e_2 = 12 \times 12.0 \times \sqrt{\frac{250}{250}} = 144.0$ $e_{\mathrm{max}} = \min(e_1,\ e_2) = 144.0$ [Ref. IS 800:2007, Cl.10.2.4.3]	40	**Pass**
Min. Edge Distance (mm)	$e'_{\mathrm{min}} = 1.7d_0$ $= 1.7 \times 22.0$ $= 37.4$ [Ref. IS 800:2007, Cl.10.2.4.2]	40	**Pass**

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{\max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 14.0 \times \sqrt{\frac{250}{250}} = 168.0$ $e_2 = 12 \times 12.0 \times \sqrt{\frac{250}{250}} = 144.0$ $e'_{\max} = min(e_1,\ e_2) = 144.0$ [Ref. IS 800:2007, Cl.10.2.4.3]	40	**Pass**
Moment Demand (kNm)		$M_d = (V_u \times \text{ecc} + M_w)$ $\text{ecc} = \text{eccentricity}$ $M_w = \text{external moment acting on web}$ $= \frac{(131.63 \times 10^3 \times 50.0 + 0.0 \times 10^6)}{10^6}$ $= 6.58$	
Bolt Force Parameter(s) (mm)	$l_n = \text{length available}$ $l_n = p\ (n_r - 1)$ $= 140 \times (5 - 1)$ $= 560$ $y_{\max} = l_n/2$ $= 560/2$ $= 280.0$ $x_{\max} = g(n_c - 1)/2$ $= 0.0 \times (1 - 1)/2$ $= 0.0$		

Check	Required	Provided	Remarks
Bolt Force (kN)	$vbv = V_u/(n_r \times n_c) = \frac{131.63}{(5 \times 1)} = 26.33$ $tmh = \frac{M_d \times y_{\max}}{\Sigma r_i^2} = \frac{6.58 \times 280.0}{196.0} = 9.4$ $tmv = \frac{M_d \times x_{\max}}{\Sigma r_i^2} = \frac{6.58 \times 0.0}{196.0} = 0.0$ $abh = \frac{A_u}{(n_r \times n_c)} = \frac{147.37}{(5 \times 1)} = 29.47$ $v_{\text{res}} = \sqrt{(vbv + tmv)^2 + (tmh + abh)^2} = \sqrt{(26.33 + 0.0)^2 + (9.4 + 29.47)^2} = 46.95$		
Slip Resistance (kN)		$V_{dsf} = \frac{\mu_f n_e K_h F_o}{\gamma_{mf}}$ Where , $F_o = 0.7 f_{ub} A_{nb}$ $V_{dsf} = \frac{0.3 \times 1 \times 1.0 \times 0.7 \times 1220.0 \times 245}{1.25 \times 10^3} = 50.22$ [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]	$l_j = (n_r - 1) \times p$ $= (5 - 1) \times 140 = 560$ $l = 560$ $15 \times d = 15 \times 20.0 = 300.0$ since, $l_j \geq 15\ d$ then $V_{\text{rd}} = \beta_{lj}\ V_{\text{db}}$ $\beta_{lj} = 1.075 - 560/(200\ \times 20.0) = 0.94$ [Ref. IS 800:2007, Cl.10.3.3.1]	
Capacity (kN)	46.95	47.2	**Pass**

2.4 Plate Design

Check	Required	Provided	Remarks
Min. Plate Height (mm)	$0.6 \times (d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (750.0 - 2 \times 16.0 - 2 \times 20.0)$ $= 406.8$ [Ref. INSDAG, Ch.5, sec.5.2.3]	640	**Pass**
Max. Plate Height (mm)	$d_b - t_{bf} + r_{b1} - notch_h$ $= 750.0 - 16.0 + 20.0 - 50$ $= 664.0$	640	**Pass**
Min. Plate Width (mm)	$2e_{\text{min}} + (n_c - 1)p_{\text{min}})$ $= 2 \times 37.4 + (1 - 1) \times 50.0$ $= 84.8$	90.0	**Pass**
Min. Plate Thickness (mm)	$t_w = 12.0$	14.0	**Pass**

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)		$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{640 \times 14.0 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 1175.7$ [Ref. IS 800:2007, Cl.10.4.3]	
Allowable Shear Capacity (kN)	$V = 131.628$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 1175.7$ $= 705.42$ [Limited to low shear]	**Pass**
Shear Rupture Capacity (kN)		$V_{d_n} = \frac{0.75 A_{v_n} f_u}{\sqrt{3}\gamma_{m1}}$ $= 1 \times \frac{(640 - (5 \times 22.0)) \times 14.0 \times 410}{\sqrt{3} \times 1.25}$ $= 2281.65$ [Ref. AISC, sect. J4]	
Block Shear Capacity in Shear (kN)		$V_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{\text{db}} = \min(V_{db1},\ V_{db2}) = 1222.07$ [Ref. IS 800:2007, Cl.6.4]	
Shear Capacity (kN)	131.628	$V_d = \min(S_c,\ V_{d_n},\ V_{d_b})$ $= \min(705.42,\ 2281.65,\ 1222.07)$ $= 705.42$ [Ref. IS 800:2007, Cl.6.1]	**Pass**

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{\mathrm{dg}} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 640 \times 14.0$ $= \frac{8960.0 \times 250}{1.1 \times 10^3}$ $= 2036.36$ [Ref. IS 800:2007, Cl.6.2]	
Tension Rupture Capacity (kN)		$T_{\mathrm{dn}} = \frac{0.9 A_n f_u}{\gamma_{m1}}$ $= \frac{1 \times\ 0.9 \times (640 - 5 \times 22.0) \times 14.0 \times 410}{1.25}$ $= 2554.07$ [Ref. IS 800:2007, Cl.6.3.1]	
Block Shear Capacity in Tension (kN)		$T_{\mathrm{dbl1}} = \frac{A_{\mathrm{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{\mathrm{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{\mathrm{db}} = \min(T_{db1},\ T_{db2}) = 1920.21$ [Ref. IS 800:2007, Cl.6.4]	
Tension Capacity (kN)	147.368	$T_{\mathrm{d}} = \min(T_{\mathrm{dg}},\ T_{\mathrm{dn}},\ T_{\mathrm{db}})$ $= \min(2036.36, 2554.07, 1920.21)$ $= 1920.21$ [Ref.IS 800:2007, Cl.6.1]	Pass
Moment Capacity (kNm)	6.58	$M_{d_z} = \frac{\beta_b Z_p f y}{\gamma_{m0} \times 10^6}$ $= \frac{1.0 \times 1433600.0 \times 250}{1.1 \times 10^6}$ $= 325.82$ [Ref. IS 800:2007, Cl.8.2.1.2]	Pass

Check	Required	Provided	Remarks
Interaction Ratio	≤ 1	$\frac{6.58}{325.82} + \frac{147.368}{1920.21} = 0.1$ [Ref. IS 800:2007, Cl.10.7]	Pass

2.5 Section Design

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)		$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{700.0 \times 12.0 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 1102.21$ [Ref. IS 800:2007, Cl.10.4.3]	
Allowable Shear Capacity (kN)	$V = 131.628$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 1102.21$ $= 661.33$ [Limited to low shear]	Pass
Shear Rupture Capacity (kN)		$V_{d_n} = \frac{0.75 A_{v_n} f_u}{\sqrt{3}\gamma_{m1}}$ $= 1 \times \frac{(700.0 - (5 \times 22.0)) \times 12.0 \times 410}{\sqrt{3} \times 1.25}$ $= 2177.1$ [Ref. AISC, sect. J4]	
Block Shear Capacity in Shear (kN)		$V_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{\text{db}} = \min(V_{db1},\ V_{db2}) = 1047.48$ [Ref. IS 800:2007, Cl.6.4]	

Check	Required	Provided	Remarks
Shear Capacity (kN)	131.628	$V_d = \min(S_c,\ V_{d_n},\ V_{d_b})$ $= \min(661.33,\ 2177.1,\ 1047.48)$ $= 661.33$ [Ref. IS 800:2007, Cl.6.1]	Pass
Tension Yielding Capacity (kN)		$T_{\text{dg}} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 700.0 \times 12.0$ $= \frac{8400.0 \times 250}{1.1 \times 10^3}$ $= 1909.09$ [Ref. IS 800:2007, Cl.6.2]	
Tension Rupture Capacity (kN)		$T_{\text{dn}} = \frac{0.9 A_n f_u}{\gamma_{m1}}$ $= \frac{1 \times\ 0.9 \times (700.0 - 5 \times 22.0) \times 12.0 \times 410}{1.25}$ $= 2090.02$ [Ref. IS 800:2007, Cl.6.3.1]	
Block Shear Capacity in Tension (kN)		$T_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{\text{db}} = \min(T_{db1},\ T_{db2}) = 1645.89$ [Ref. IS 800:2007, Cl.6.4]	
Tension Capacity (kN)	147.368	$T_{\text{d}} = \min(T_{\text{dg}},\ T_{\text{dn}},\ T_{\text{db}})$ $= \min(1909.09, 2090.02, 1645.89)$ $= 1645.89$ [Ref.IS 800:2007, Cl.6.1]	Pass

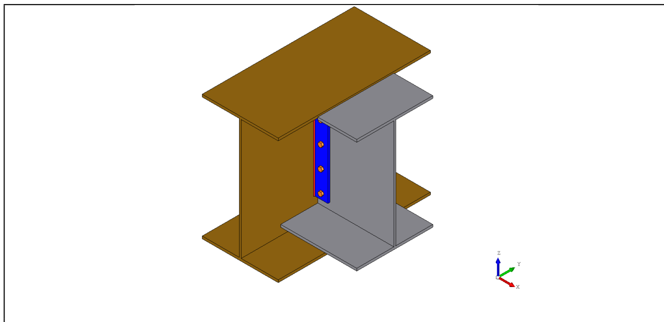
Check	Required	Provided	Remarks
Moment Capacity (kNm)	6.58	$M_{d_z} = \frac{\beta_b Z_p fy}{\gamma_{m0} \times 10^6}$ $= \frac{1.0 \times 6483590.0 \times 250}{1.1 \times 10^6}$ $= 1473.54$ [Ref. IS 800:2007, Cl.8.2.1.2]	**Pass**
Interaction Ratio	≤ 1	$\frac{6.58}{1473.54} + \frac{147.368}{1645.89} = 0.09$ [Ref. IS 800:2007, Cl.10.7]	**Pass**

2.6 Weld Design

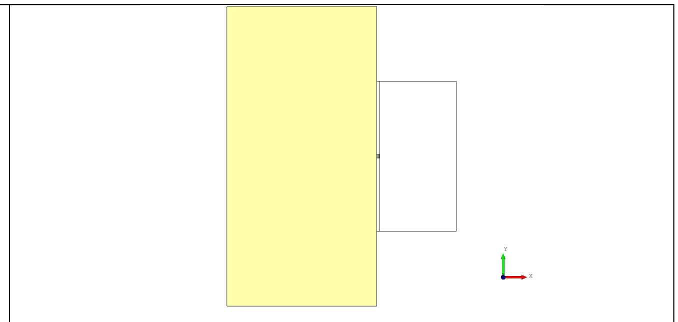
Check	Required	Provided	Remarks
Min. Weld Size (mm)	$t_{w_{\min}}$ based on thinner part $= \max(12,\ 12)$ $s_{\min}$ based on thicker part $= 5$ [Ref. IS 800:2007, Table 21, Cl.10.5.2.3]	5	**Pass**
Max. Weld Size (mm)	Thickness of thinner part $= \min(12.0,\ 14.0) = 12.0$ $s_{\max} = 12$ [Ref. IS 800:2007, Cl.10.5.3.1]	5	**Pass**

Check	Required	Provided	Remarks
Weld Strength (N/mm)	$R_{\text{w}} = \sqrt{(T_{\text{wh}} + A_{\text{wh}})^2 + (T_{\text{wv}} + V_{\text{wv}})^2}$ $T_{\text{wh}} = \frac{M \times y_{\max}}{I_{pw}} = \frac{6581400.0 \times 315.0}{41674500.0}$ $T_{\text{wv}} = \frac{M \times x_{\max}}{I_{pw}} = \frac{6581400.0 \times 0.0}{41674500.0}$ $V_{\text{wv}} = \frac{V}{l_w} = \frac{131628.0}{1260}$ $A_{\text{wh}} = \frac{A}{l_w} = \frac{147368.0}{1260}$ $R_{\text{w}} = \sqrt{(49.75 + 116.96)^2 + (0.0 + 104.47)^2}$ $= 196.73$	$f_w = \frac{t_t f_u}{\sqrt{3}\gamma_{mw}}$ $= \frac{3.5 \times 410}{\sqrt{3} \times 1.25}$ $= 662.8$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	**Pass**

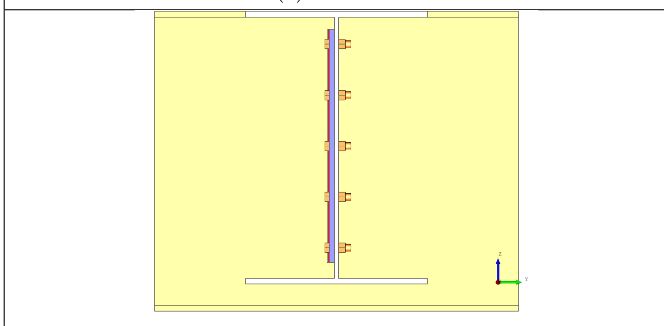
3 3D Views



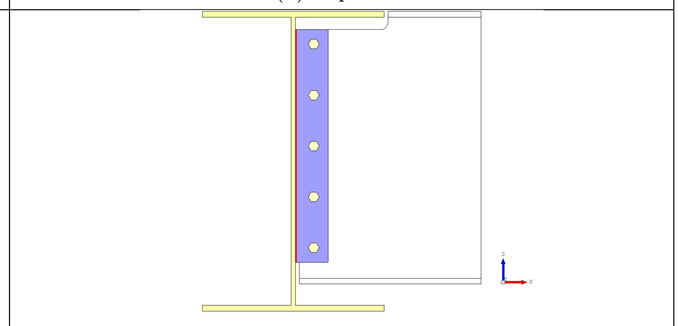
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log

2021-04-11 13:30:11 - Osdag - INFO - === End Of Design ===