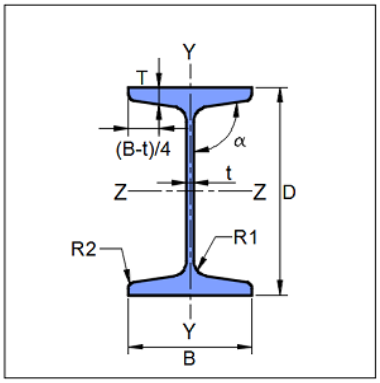
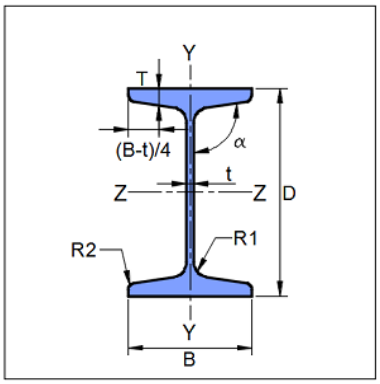
Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.1
Date	04 /02 /2021	Client	Mr. Pratip Bhattacharya, Kolkata

1 Input Parameters

Main Module		Shear Connection	
Module		Cleat Angle Connection	
Connectivity		Beam-Beam	
Shear Force (kN)		160.0	
Supporting Section - Mechanical Properties			
			
Supporting Section		WB 400	
Material		E 300 (Fe 440)	
Ultimate Strength, F_u (MPa)		440	
Yield Strength, F_y (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, F_u (MPa)		440	
Yield Strength, F_y (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, 12.9]
Type	Friction Grip Bolt
Hole Type	Standard
Slip Factor, (μ_f)	0.48
Detailing - Design Preference	
Edge Preparation Method	Rolled, machine-flame cut, sawn and planed
Gap Between Members (mm)	10.0
Are the Members Exposed to Corrosive Influences?	False

1.1 List of Input Section

Cleat Angle List	'80 x 80 x 8', '90 x 90 x 6', '90 x 90 x 8', '90 x 90 x 10', '100 x 100 x 8', '100 x 100 x 10', '110 x 110 x 10'

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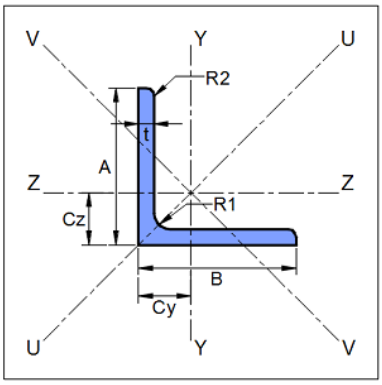
Designer	Engineer#1	Job Number	1.1.3.3.1
Date	04 /02 /2021	Client	Mr. Pratip Bhattacharya, Kolkata

2 Design Checks

Design Status	Pass

2.1 Selected Member Data



Section Size		80 x 80 x 8	
Material		E 165 (Fe 290)	
Ultimate Strength, Fu (MPa)		290	
Yield Strength, Fy (MPa)		165	
Mass, m (kg/m)	9.65	I_u (cm^4)	117.0
Area, A (cm^2)	12.3	I_v(cm^4)	30.5
A (mm)	80.0	r_z (cm)	2.45
B (mm)	80.0	r_y (cm)	2.45
t (mm)	8.0	r_u (cm)	3.09
R_1 (mm)	8.0	r_v (cm)	1.58
R_2 (mm)	0.0	Z_z (cm^3)	12.9
C_y (mm)	22.8	Z_y (cm^3)	12.9
C_z (mm)	22.8	Z_{pz} (cm^3)	23.3
I_z (cm^4)	74.0	Z_{py} (cm^3)	12.9
I_y(cm^4)	74.0		

2.2 Initial Section Check

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)	160.0	$V_{dy} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{260.0 \times 7.7 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 315.23$ [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

2.3 Load Consideration

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

2.4 Bolt Design - Connected to Beam

Check	Required	Provided	Remarks
Diameter (mm)		16	
Property Class		12.9	
Cleat Angle Connection		80 x 80 x 8	
No. of Bolt Columns		1	
No. of Bolt Rows		2	
Min. Pitch Distance (mm)	$p_{min} = 2.5d$ $= 2.5 \times 16$ $= 40.0$ [Ref. IS 800:2007, Cl.10.2.2]	120	**Pass**
Max. Pitch Distance (mm)	$p_{max} = \min(32t,\ 300)$ $= \min(32 \times 7.7,\ 300)$ $= \min(246.4,\ 300)$ $= 246.4$ Where, $t = \min(8.0, 7.7)$ [Ref. IS 800:2007, Cl.10.2.3]	120	**Pass**

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.1
Date	04 /02 /2021	Client	Mr. Pratip Bhattacharya, Kolkata

Check	Required	Provided	Remarks
Min. Gauge Distance (mm)	$g_{min} = 2.5d$ $= 2.5 \times 16$ $= 40.0$ [Ref. IS 800:2007, Cl.10.2.2]	N/A	
Max. Gauge Distance (mm)	$g_{max} = \min(32t,\ 300)$ $= \min(32 \times 7.7,\ 300)$ $= \min(246.4,\ 300)$ $= 246.4$ Where, $t = \min(8.0, 7.7)$ [Ref. IS 800:2007, Cl.10.2.3]	N/A	
Min. End Distance (mm)	$e_{min} = 1.5d_0$ $= 1.5 \times 18.0$ $= 27.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	30	**Pass**
Max. End Distance (mm)	$e_{max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 8.0 \times \sqrt{\frac{250}{165}} = 118.17$ $e_2 = 12 \times 7.7 \times \sqrt{\frac{250}{300}} = 84.35$ $e_{max} = \min(e_1,\ e_2) = 84.35$ [Ref. IS 800:2007, Cl.10.2.4.3]	30	**Pass**
Min. Edge Distance (mm)	$e'_{min} = 1.5d_0$ $= 1.5 \times 18.0$ $= 27.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	30	**Pass**

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.1
Date	04 /02 /2021	Client	Mr. Pratip Bhattacharya, Kolkata

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 8.0 \times \sqrt{\frac{250}{165}} = 118.17$ $e_2 = 12 \times 7.7 \times \sqrt{\frac{250}{300}} = 84.35$ $e'_{max} = min(e_1,\ e_2) = 84.35$ [Ref. IS 800:2007, Cl.10.2.4.3]	30	**Pass**
Moment Demand (kNm)		$M_d = (V_u \times \text{ecc} + M_w)$ ecc = eccentricity M_w = external moment acting on web $= \frac{(160.0 \times 10^3 \times 46.0 + 0.0 \times 10^6)}{10^6}$ $= 7360.0$	
Bolt Force Parameter(s) (mm)	l_n = length available $l_n = p\ (n_r - 1)$ $= 120 \times (2 - 1)$ $= 120$ $y_{max} = l_n/2$ $= 120/2$ $= 60.0$ $x_{max} = g(n_c - 1)/2$ $= 0.0 \times (1 - 1)/2$ $= 0.0$		

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.1
Date	04 /02 /2021	Client	Mr. Pratip Bhattacharya, Kolkata

Check	Required	Provided	Remarks
Bolt.Force (kN)	$vbv = V_u/(n_r \times n_c)$ $= \frac{160.0}{(2 \times 1)}$ $= 80.0$ $tmh = \frac{M_d \times y_{\max}}{\Sigma r_i^2}$ $= \frac{7360.0 \times 60.0}{7.2}$ $= 61.33$ $tmv = \frac{M_d \times x_{\max}}{\Sigma r_i^2}$ $= \frac{7360.0 \times 0.0}{7.2}$ $= 0.0$ $abh = \frac{A_u}{(n_r \times n_c)}$ $= \frac{0.0}{(2 \times 1)}$ $= 0.0$ $v_{\text{res}} = \sqrt{(vbv + tmv)^2 + (tmh + abh)^2}$ $= \sqrt{(80.0 + 0.0)^2 + (61.33 + 0.0)^2}$ $= 100.81$		
Slip Resistance		$V_{dsf} = \frac{\mu_f n_e K_h F_o}{\gamma_{mf}}$ Where , $F_o = 0.7 f_{ub} A_{nb}$ $V_{dsf} = \frac{0.48 \times 1 \times 1.0 \times 0.7 \times 1220.0 \times 157}{1.25 \times 10^3}$ $= 102.97$ [Ref. IS 800:2007, Cl.10.4.3]	

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.1
Date	04 /02 /2021	Client	Mr. Pratip Bhattacharya, Kolkata

Check	Required	Provided	Remarks
Long Joint Reduction Factor		$l_j = (n_r - 1) \times p$ $= (2 - 1) \times 120 = 120$ $l = 120$ $15 \times d = 15 \times 16 = 240$ since, $l_j < 15 \times d$ then $\beta_{lj} = 1.0$ [Ref. IS 800:2007, Cl.10.3.3.1]	
Large Grip Length Reduction Factor		$l_g = \Sigma\ (t_p + t_{\text{member}})$ $= 23.7$ $5d = 80$ $8d = 128$ since, $l_g < 5d$; $\beta_{lg} = 1.0$ [Ref. IS 800:2007, Cl.10.3.3.2]	N/A
Bolt Capacity (post reduction factor) (kN)		$V_{\text{rd}} = \beta_{lj}\beta_{lg}V_{\text{db}}$ $= 1.0 \times 1.0 \times 102.97$ $= 102.97$	
Capacity (kN)	100.81	102.97	Pass

2.5 Bolt Design - Connected to Column

Check	Required	Provided	Remarks
Diameter (mm)		16	
Property Class		12.9	
Cleat Angle Connection		80 x 80 x 8	
No. of Bolt Columns		1	
No. of Bolt Rows		2	
Min. Pitch Distance (mm)	$p_{\text{min}} = 2.5d$ $= 2.5 \times 16$ $= 40.0$ [Ref. IS 800:2007, Cl.10.2.2]	120	Pass

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.1
Date	04 /02 /2021	Client	Mr. Pratip Bhattacharya, Kolkata

Check	Required	Provided	Remarks
Max. Pitch Distance (mm)	$p_{max} = \min(32t,\ 300)$ $= \min(32 \times 8.0,\ 300)$ $= \min(256.0,\ 300)$ $= 256.0$ Where, $t = \min(8.0, 8.6)$ [Ref. IS 800:2007, Cl.10.2.3]	120	**Pass**
Min. Gauge Distance (mm)	$g_{min} = 2.5d$ $= 2.5 \times 16$ $= 40.0$ [Ref. IS 800:2007, Cl.10.2.2]	N/A	
Max. Gauge Distance (mm)	$g_{max} = \min(32t,\ 300)$ $= \min(32 \times 8.0,\ 300)$ $= \min(256.0,\ 300)$ $= 256.0$ Where, $t = \min(8.0, 8.6)$ [Ref. IS 800:2007, Cl.10.2.3]	N/A	
Min. End Distance (mm)	$e_{min} = 1.5d_0$ $= 1.5 \times 18.0$ $= 27.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	30	**Pass**

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.1
Date	04 /02 /2021	Client	Mr. Pratip Bhattacharya, Kolkata

Check	Required	Provided	Remarks
Max. End Distance (mm)	$e_{max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 8.0 \times \sqrt{\frac{250}{165}} = 118.17$ $e_2 = 12 \times 8.6 \times \sqrt{\frac{250}{300}} = 94.21$ $e_{max} = \min(e_1,\ e_2) = 94.21$ [Ref. IS 800:2007, Cl.10.2.4.3]	30	**Pass**
Min. Edge Distance (mm)	$e'_{min} = 1.5d_0$ $= 1.5 \times 18.0$ $= 27.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	30	**Pass**
Max. Edge Distance (mm)	$e'_{max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 8.0 \times \sqrt{\frac{250}{165}} = 118.17$ $e_2 = 12 \times 8.6 \times \sqrt{\frac{250}{300}} = 94.21$ $e'_{max} = min(e_1,\ e_2) = 94.21$ [Ref. IS 800:2007, Cl.10.2.4.3]	30	**Pass**
Moment Demand (kNm)		$M_d = (V_u \times \text{ecc} + M_w)$ ecc = eccentricity M_w = external moment acting on web $= \frac{(80.0 \times 10^3 \times 46.0 + 0.0 \times 10^6)}{10^6}$ $= 3680.0$	

Check	Required	Provided	Remarks
Bolt Force Parameter(s) (mm)	l_n = length available $l_n = p\ (n_r - 1)$ $= 120 \times (2 - 1)$ $= 120$ $y_{max} = l_n/2$ $= 120/2$ $= 60.0$ $x_{max} = g(n_c - 1)/2$ $= 0.0 \times (1 - 1)/2$ $= 0.0$		

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.1
Date	04 /02 /2021	Client	Mr. Pratip Bhattacharya, Kolkata

Check	Required	Provided	Remarks
Bolt.Force (kN)	$vbv = V_u/(n_r \times n_c)$ $= \frac{160.0}{(2 \times 1)}$ $= 40.0$ $tmh = \frac{M_d \times y_{\max}}{\Sigma r_i^2}$ $= \frac{3680.0 \times 60.0}{7.2}$ $= 30.67$ $tmv = \frac{M_d \times x_{\max}}{\Sigma r_i^2}$ $= \frac{3680.0 \times 0.0}{7.2}$ $= 0.0$ $abh = \frac{A_u}{(n_r \times n_c)}$ $= \frac{0.0}{(2 \times 1)}$ $= 0.0$ $v_{\text{res}} = \sqrt{(vbv + tmv)^2 + (tmh + abh)^2}$ $= \sqrt{(40.0 + 0.0)^2 + (30.67 + 0.0)^2}$ $= 50.4$		
Slip Resistance		$V_{dsf} = \frac{\mu_f n_e K_h F_o}{\gamma_{mf}}$ Where , $F_o = 0.7 f_{ub} A_{nb}$ $V_{dsf} = \frac{0.48 \times 1 \times 1.0 \times 0.7 \times 1220.0 \times 157}{1.25 \times 10^3}$ $= 51.49$ [Ref. IS 800:2007, Cl.10.4.3]	

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.1
Date	04 /02 /2021	Client	Mr. Pratip Bhattacharya, Kolkata

Check	Required	Provided	Remarks
Long Joint Reduction Factor		$l_j = (n_r - 1) \times p$ $= (2 - 1) \times 120 = 120$ $l = 120$ $15 \times d = 15 \times 16 = 240$ since, $l_j < 15 \times d$ then $\beta_{lj} = 1.0$ [Ref. IS 800:2007, Cl.10.3.3.1]	
Large Grip Length Reduction Factor		$l_g = \Sigma\ (t_p + t_{\text{member}})$ $= 16.6$ $5d = 80$ $8d = 128$ since, $l_g < 5d$; $\beta_{lg} = 1.0$ [Ref. IS 800:2007, Cl.10.3.3.2]	N/A
Bolt Capacity (post reduction factor) (kN)		$V_{\text{rd}} = \beta_{lj}\beta_{lg}V_{\text{db}}$ $= 1.0 \times 1.0 \times 51.49$ $= 51.49$	
Capacity (kN)	50.4	51.49	Pass

2.6 Cleat Angle Check

Check	Required	Provided	Remarks
Min. Cleat Angle Height	$0.6 \times (d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (300.0 - 2 \times 13.1 - 2 \times 14.0)$ $= 147.48$ [Ref. INSDAG, Ch.5, sec.5.2.3]	180	Pass
Max. Cleat Angle Height	$d_b - t_{bf} + r_{b1} - notch_h$ $= 400.0 - 13.0 + 13.0 - 0.0$ $= 232.9$	180	Pass

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.1
Date	04 /02 /2021	Client	Mr. Pratip Bhattacharya, Kolkata

Check	Required	Provided	Remarks
Min. Leg Length (mm) (on supported leg)	$\max\left(\text{gap},\ t_{\text{cleat}} + r_{r_{\text{angle}}} + 2e'_{\min} + (n_c - 1)g_{\min}\right)$ $= \max\left(10.0,\ 8.0 + 8.0 + 2 \times 27.0 + (1-1) \times 40.0\right)$ $= 70.0$	80.0	Pass
Min. Leg Length (mm) (on supporting leg)	$t_{\text{cleat}} + r_{r_{\text{angle}}} + 2e'_{\min} + (n_c - 1)g_{\min}$ $= 8.0 + 8.0 + 2 \times 27.0 + (1-1) \times 40.0$ $= 70.0$	80.0	Pass
Min. Cleat Angle Thickness (mm)	$t_w = 0.5 \times 7.7 = 3.85$	8.0	Pass
Shear Yielding Capacity (kN)		$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{2 \times 180 \times 8.0 \times 165}{\sqrt{3} \times 1.1 \times 1000}$ $= 249.42$ [Ref. IS 800:2007, Cl.10.4.3]	
Block Shear Capacity in Shear (kN)		$V_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9A_{tn} f_u}{\gamma_{m1}}$ $V_{\text{dbl2}} = \frac{0.9A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{\text{db}} = \min(V_{db1},\ V_{db2}) = 278.0$ [Ref. IS 800:2007, Cl.6.4]	
Shear Capacity (kN)	160.0	$V_d = \min(V_{d_y},\ V_{d_b})$ $= \min(249.42, 278.0)$ $= 249.42$ [Ref. IS 800:2007, Cl.6.1]	Pass

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Designer	Engineer#1	Job Number	1.1.3.3.1
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Check	Required	Provided	Remarks
Moment Capacity (kNm)	7.36	$M_{dz} = \frac{\beta_b Z_p fy}{\gamma_{m0} \times 10^6}$ $= \frac{1.0 \times 129600.0 \times 165}{1.1 \times 10^6}$ $= 19.44$ [Ref. IS 800:2007, Cl.8.2.1.2]	**Pass**

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.1
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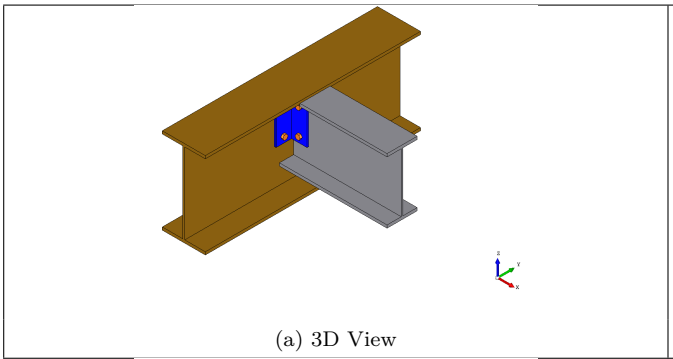
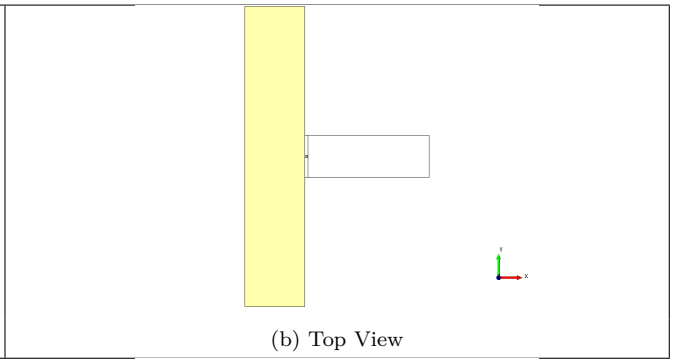
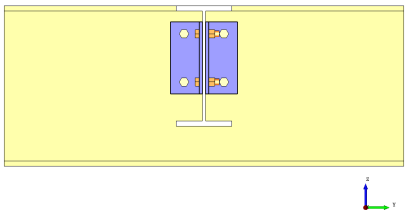
3 3D Views



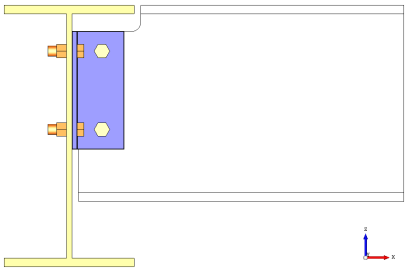
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log