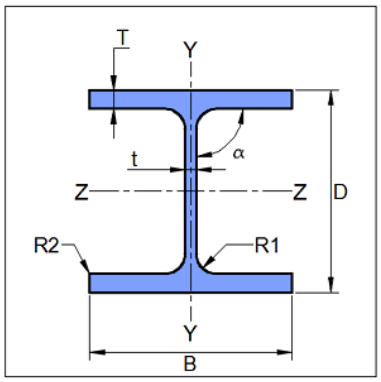
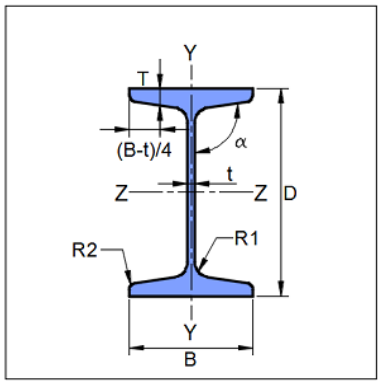
Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer #1	Job Number	1.1.3.1.2
Date	17 /12 /2020	Client	Meera Raghunandan, Professor, IIT Bombay

1 Input Parameters

Main Module		Shear Connection	
Module		Cleat Angle	
Connectivity		Column Flange-Beam Web	
Shear Force (kN)		240.0	
Supporting Section - Mechanical Properties			
			
Supporting Section		UC 305 x 305 x 118	
Material		E 300 (Fe 440)	
Ultimate Strength, Fu (MPa)		440	
Yield Strength, Fy (MPa)		300	
Mass, m (kg/m)	117.9	I_z (cm^4)	27672.0
Area, A (cm^2)	150.2	I_y(cm^4)	9058.0
D (mm)	314.5	r_z (cm)	13.6
B (mm)	307.4	r_y (cm)	7.77
t (mm)	12.0	Z_z (cm^3)	1760.0
T (mm)	18.7	Z_y (cm^3)	589.0
Flange Slope	90	Z_{pz} (cm^3)	1958.0
R_1 (mm)	15.2	Z_{py} (cm^3)	895.0
R_2 (mm)	0.0		
Supported Section - Mechanical Properties			
			
Supported Section		MB 450	
Material		E 300 (Fe 440)	
Ultimate Strength, Fu (MPa)		440	
Yield Strength, Fy (MPa)		300	
Mass, m (kg/m)	72.38	I_z (cm^4)	30400.0
Area, A (cm^2)	92.2	I_y(cm^4)	834.0
D (mm)	450.0	r_z (cm)	18.1
B (mm)	150.0	r_y (cm)	3.0
t (mm)	9.4	Z_z (cm^3)	1350.0
T (mm)	17.4	Z_y (cm^3)	111.0
Flange Slope	98	Z_{pz} (cm^3)	1550.0
R_1 (mm)	15.0	Z_{py} (cm^3)	187.0
R_2 (mm)	7.5		
Bolt Details - Input and Design Preference			

Diameter (mm)	[20]
Property Class	[12.9]
Type	Friction Grip Bolt
Hole Type	Standard
Slip Factor, (mu_f)	0.33
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	'120 x 120 x 8'

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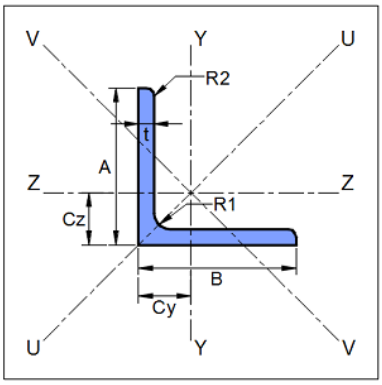
2 Design Checks

Design Status	Pass

2.1 Selected Member Data



Section Size		120 x 120 x 8	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, Fu (MPa)		410	
Yield Strength, Fy (MPa)		250	
Mass, m (kg/m)	14.66	I_u (cm^4)	410.0
Area, A (cm^2)	18.6	I_v(cm^4)	105.0
A (mm)	120.0	r_z (cm)	3.72
B (mm)	120.0	r_y (cm)	3.72
t (mm)	8.0	r_u (cm)	4.69
R_1 (mm)	10.0	r_v (cm)	2.38
R_2 (mm)	4.8	Z_z (cm^3)	29.5
C_y (mm)	32.5	Z_y (cm^3)	29.5
C_z (mm)	32.5	Z_{pz} (cm^3)	53.4
I_z (cm^4)	258.0	Z_{py} (cm^3)	29.5
I_y(cm^4)	258.0		

2.2 Initial Section Check

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)	240.0	$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{450.0 \times 9.4 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 666.05$ [$Ref. IS$ 800 : 2007, $Cl.$10.4.3]	Pass
Allowable Shear Capacity (kN)	240.0	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 666.05$ $= 399.63$ [*Limited to low shear*]	Pass

2.3 Load Consideration

Check	Required	Provided	Remarks
Applied Shear Force (kN)	240.0	$V_{y_{min}} = min(0.15 \times V_{dy}, 40.0)$ $= min(0.15 \times 666.05, 40.0)$ $= 40$ $V_u = max(V_y,\ V_{y_{min}})$ $= max(240.0, 40)$ $= 240.0$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.7]$	

2.4 Bolt Design - Connected to Beam

Check	Required	Provided	Remarks
Diameter (mm)		20	
Property Class		12.9	
Cleat Angle		120 x 120 x 8	
No. of Bolt Columns		1	
No. of Bolt Rows		3	
Min. Pitch Distance (mm)	$p_{min} = 2.5\ d$ $= 2.5 \times 20$ $= 50.0$ $[Ref\ IS\ 800 : 2007,\ Cl.\ 10.2.2]$	85	**Pass**
Max. Pitch Distance (mm)	$p_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 8.0,\ 300\ mm)$ $= \min(256.0,\ 300\ mm)$ $= 256.0$ $Where,\ t = min(8.0, 9.4)$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.2.3]$	85	**Pass**

Company Name	IIT Bombay	Project Title	Sample Connection Design
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Designer	Engineer #1	Job Number	1.1.3.1.2
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Check	Required	Provided	Remarks
Min. Gauge Distance (mm)	$g_{min} = 2.5\ d$ $= 2.5 \times 20$ $= 50.0$ [$Ref\ IS\ 800:2007,\ Cl.\ 10.2.2$]	N/A	
Max. Gauge Distance (mm)	$g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 8.0,\ 300\ mm)$ $= \min(256.0,\ 300\ mm)$ $= 256.0$ $Where,\ t = min(8.0, 9.4)$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.2.3$]	N/A	
Min. End Distance (mm)	$e_{min} = 1.5\ d_0$ $= 1.5 \times 22.0$ $= 33.0$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2$]	35	**Pass**
Max. End Distance (mm)	$e_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 8.0 \times \sqrt{\frac{250}{250}} = 96.0$ $e_2 = 12 \times 9.4 \times \sqrt{\frac{250}{300}} = 102.97$ $e_{max} = min(e_1, e_2) = 96.0$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3$]	35	**Pass**
Min. Edge Distance (mm)	$e'_{min} = 1.5\ d_0$ $= 1.5 \times 22.0$ $= 33.0$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2$]	35	**Pass**

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer #1	Job Number	1.1.3.1.2
Date	17 /12 /2020	Client	Meera Raghunandan, Professor, IIT Bombay

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 8.0 \times \sqrt{\frac{250}{250}} = 96.0$ $e_2 = 12 \times 9.4 \times \sqrt{\frac{250}{300}} = 102.97$ $e'_{max} = min(e_1, e_2) = 96.0$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.2.4.3]$	35	**Pass**
Moment Demand (kNm)		$M_d = (V_u \times ecc + M_w)$ $ecc = eccentricity$ $M_w = external\ moment\ acting\ on\ web$ $= \frac{(240.0 \times 10^3 \times 53.0 + 0.0 \times 10^6)}{10^6}$ $= 12720.0$	
Bolt Force Parameter(s) (mm)	$l_n = length\ available$ $l_n = p\ (n_r - 1)$ $= 85 \times (3 - 1)$ $= 170$ $y_{max} = l_n/2$ $= 170/2$ $= 85.0$ $x_{max} = g(n_c - 1)/2$ $= 0.0 \times (1 - 1)/2$ $= 0.0$		

Check	Required	Provided	Remarks
Bolt.Force (kN)	$vbv = V_u/(n_r \times n_c)$ $= \frac{240.0}{(3 \times 1)}$ $= 80.0$ $tmh = \frac{M_d \times y_{max}}{\Sigma r_i^2}$ $= \frac{12720.0 \times 85.0}{14.45}$ $= 74.82$ $tmv = \frac{M_d \times x_{max}}{\Sigma r_i^2}$ $= \frac{12720.0 \times 0.0}{14.45}$ $= 0.0$ $abh = \frac{A_u}{(n_r \times n_c)}$ $= \frac{0.0}{(3 \times 1)}$ $= 0.0$ $vres = \sqrt{(vbv + tmv)^2 + (tmh + abh)^2}$ $= \sqrt{(80.0 + 0.0)^2 + (74.82 + 0.0)^2}$ $= 109.54$		
Slip Resistance		$V_{dsf} = \frac{\mu_f \ n_e \ K_h \ F_o}{\gamma_{mf}}$ $Where \ , F_o = 0.7 f_{ub} A_{nb}$ $V_{dsf} = \frac{0.33 \times 1 \times 1.0 \times 0.7 \times 1220.0 \times 245}{1.25 \times 10^3}$ $= 110.47$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.4.3]$	

Check	Required	Provided	Remarks
Long Joint Reduction Factor		$l_j = (n_r - 1) \times p$ $= (3 - 1) \times 85 = 170$ $l = 170$ $15 \times d = 15 \times 20 = 300$ $since,\ l_j < 15 \times d\ then\ \beta_{lj} = 1.0$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.3.3.1]$	
Large Grip Length Reduction Factor		$l_g = \Sigma\ (t_p + t_{member})$ $= 25.4$ $5d = 100$ $8d = 160$ $since,\ l_g < 5d\ ;\ \beta_{lg} = 1.0$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.3.3.2]$	**N/A**
Bolt Capacity (post reduction factor) (kN)		$V_{rd} = \beta_{lj}\beta_{lg}V_{db}$ $= 1.0 \times 1.0 \times 110.47$ $= 110.47$	
Capacity (kN)	109.54	110.47	**Pass**

2.5 Bolt Design - Connected to Column

Check	Required	Provided	Remarks
Diameter (mm)		20	
Property Class		12.9	
Cleat Angle		120 x 120 x 8	
No. of Bolt Columns		1	
No. of Bolt Rows		3	
Min. Pitch Distance (mm)	$p_{min} = 2.5\ d$ $= 2.5 \times 20$ $= 50.0$ $[Ref\ IS\ 800 : 2007,\ Cl.\ 10.2.2]$	85	**Pass**

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer #1	Job Number	1.1.3.1.2
Date	17 /12 /2020	Client	Meera Raghunandan, Professor, IIT Bombay

Check	Required	Provided	Remarks
Max. Pitch Distance (mm)	$p_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 8.0,\ 300\ mm)$ $= \min(256.0,\ 300\ mm)$ $= 256.0$ $Where,\ t = min(8.0, 18.7)$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.3]$	85	**Pass**
Min. Gauge Distance (mm)	$g_{min} = 2.5\ d$ $= 2.5 \times 20$ $= 50.0$ $[Ref\ IS\ 800:2007,\ Cl.\ 10.2.2]$	N/A	
Max. Gauge Distance (mm)	$g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 8.0,\ 300\ mm)$ $= \min(256.0,\ 300\ mm)$ $= 256.0$ $Where,\ t = min(8.0, 18.7)$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.3]$	N/A	
Min. End Distance (mm)	$e_{min} = 1.5\ d_0$ $= 1.5 \times 22.0$ $= 33.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2]$	35	**Pass**

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer #1	Job Number	1.1.3.1.2
Date	17 /12 /2020	Client	Meera Raghunandan, Professor, IIT Bombay

Check	Required	Provided	Remarks
Max. End Distance (mm)	$e_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 8.0 \times \sqrt{\frac{250}{250}} = 96.0$ $e_2 = 12 \times 18.7 \times \sqrt{\frac{250}{300}} = 204.85$ $e_{max} = min(e_1, e_2) = 96.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3]$	35	**Pass**
Min. Edge Distance (mm)	$e'_{min} = 1.5\ d_0$ $= 1.5 \times 22.0$ $= 33.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2]$	35	**Pass**
Max. Edge Distance (mm)	$e'_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 8.0 \times \sqrt{\frac{250}{250}} = 96.0$ $e_2 = 12 \times 18.7 \times \sqrt{\frac{250}{300}} = 204.85$ $e'_{max} = min(e_1, e_2) = 96.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3]$	35	**Pass**
Moment Demand (kNm)		$M_d = (V_u \times ecc + M_w)$ $ecc = eccentricity$ $M_w = external\ moment\ acting\ on\ web$ $= \frac{(120.0 \times 10^3 \times 53.0 + 0.0 \times 10^6)}{10^6}$ $= 6360.0$	

Check	Required	Provided	Remarks
Bolt Force Parameter(s) (mm)	$l_n = length\ available$ $l_n = p\ (n_r - 1)$ $= 85 \times (3 - 1)$ $= 170$ $y_{max} = l_n/2$ $= 170/2$ $= 85.0$ $x_{max} = g(n_c - 1)/2$ $= 0.0 \times (1 - 1)/2$ $= 0.0$		

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Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer #1	Job Number	1.1.3.1.2
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Check	Required	Provided	Remarks
Bolt.Force (kN)	$vbv = V_u/(n_r \times n_c)$ $= \frac{240.0}{(3 \times 1)}$ $= 40.0$ $tmh = \frac{M_d \times y_{max}}{\Sigma r_i^2}$ $= \frac{6360.0 \times 85.0}{14.45}$ $= 37.41$ $tmv = \frac{M_d \times x_{max}}{\Sigma r_i^2}$ $= \frac{6360.0 \times 0.0}{14.45}$ $= 0.0$ $abh = \frac{A_u}{(n_r \times n_c)}$ $= \frac{0.0}{(3 \times 1)}$ $= 0.0$ $vres = \sqrt{(vbv + tmv)^2 + (tmh + abh)^2}$ $= \sqrt{(40.0 + 0.0)^2 + (37.41 + 0.0)^2}$ $= 54.77$		
Slip Resistance		$V_{dsf} = \frac{\mu_f \ n_e \ K_h \ F_o}{\gamma_{mf}}$ $Where \ , F_o = 0.7 f_{ub} A_{nb}$ $V_{dsf} = \frac{0.33 \times 1 \times 1.0 \times 0.7 \times 1220.0 \times 245}{1.25 \times 10^3}$ $= 55.24$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.4.3]$	

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Check	Required	Provided	Remarks
Long Joint Reduction Factor		$l_j = (n_r - 1) \times p$ $= (3 - 1) \times 85 = 170$ $l = 170$ $15 \times d = 15 \times 20 = 300$ $since,\ l_j < 15 \times d\ then\ \beta_{lj} = 1.0$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.3.3.1]$	
Large Grip Length Reduction Factor		$l_g = \Sigma\ (t_p + t_{member})$ $= 26.7$ $5d = 100$ $8d = 160$ $since,\ l_g < 5d\ ;\ \beta_{lg} = 1.0$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.3.3.2]$	**N/A**
Bolt Capacity (post reduction factor) (kN)		$V_{rd} = \beta_{lj}\beta_{lg}V_{db}$ $= 1.0 \times 1.0 \times 55.24$ $= 55.24$	
Capacity (kN)	54.77	55.24	**Pass**

2.6 Cleat Angle Check

Check	Required	Provided	Remarks
Min. Cleat Angle Height	$0.6\times(d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (450.0 - 2 \times 17.4 - 2 \times 15.0)$ $= 231.12$ $[Ref.\ INSDAG - Chpt.5,\ Sect.5.2.3]$	240	**Pass**
Max. Cleat Angle Height	$d_b - 2(t_{bf} + r_{b1} + gap)$ $= 314.5 - 2 \times (18.7 + 15.2 + 10)$ $= 385.2$	240	**Pass**
Min. Leg Length (mm) on supported leg	$max(gap, t_{cleat} + r_{r-angle}) + 2e`_{min} + (n_c - 1)g_{min}$ $= max(10.0,\ 8.0 + 10.0) + 2 \times 33.0 + (1 - 1) \times 50.0$ $= 84.0$	120.0	**Pass**

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Check	Required	Provided	Remarks
Min. Leg Length (mm) on supporting leg	$t_{cleat} + r_{r-angle} + 2e`_{min} + (n_c - 1)g_{min}$ $= 8.0 + 10.0 + 2 \times 33.0 + (1 - 1) \times 50.0$ $= 84.0$	120.0	**Pass**
Min. Cleat Angle Thickness (mm)	$t_w = 0.5 * 9.4 = 4.7$	8.0	**Pass**
Shear Yielding Capacity (kN)		$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{2 \times 240 \times 8.0 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 503.87$ $[Ref. IS\ 800 : 2007, Cl. 10.4.3]$	
Block Shear Capacity in Shear (kN)		$V_{dbl1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{dbl2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{db} = min(V_{db1}, V_{db2}) = 536.31$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 6.4]$	
Shear Capacity (kN)	240.0	$V_d = min(V_{dy}, V_{db})$ $= min(503.87, 536.31)$ $= 503.87$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 6.1]$	**Pass**
Moment Capacity (kNm)	12.72	$M_{dzz} = \frac{\beta_b \times Z_p \times fy}{\gamma_{mo} \times 10^6}$ $= \frac{1.0 \times 230400.0 \times 250}{1.1 \times 10^6}$ $= 52.36$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 8.2.1.2]$	**Pass**

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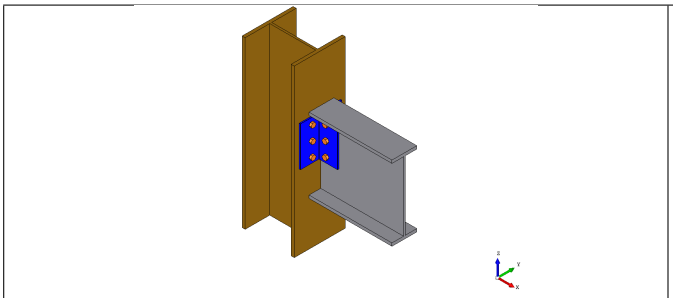
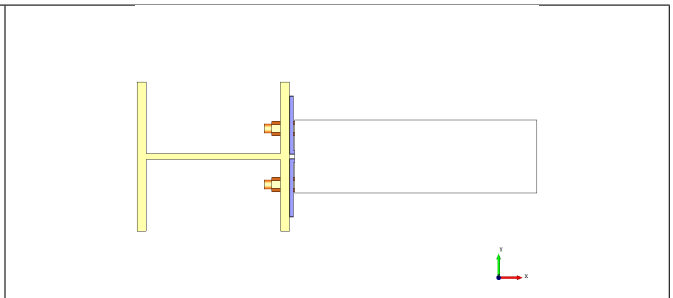
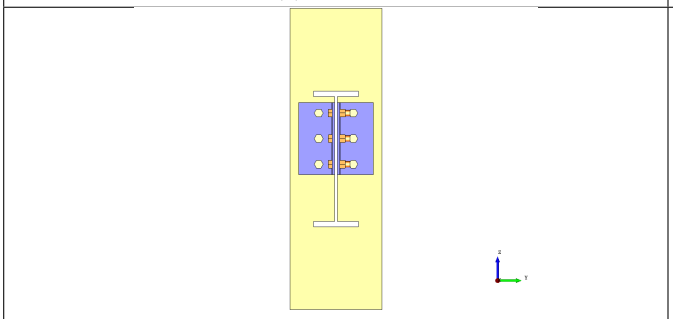
3 3D Views



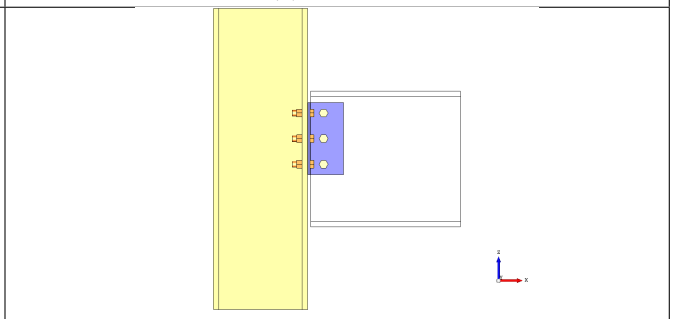
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log