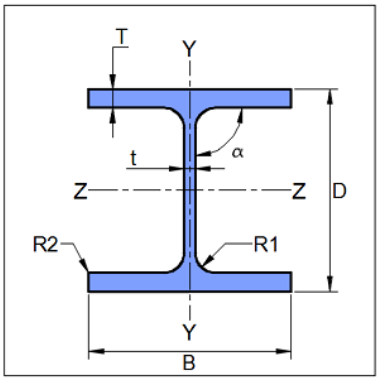
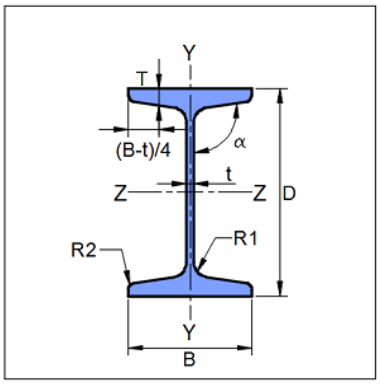
Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.2
Date	04 /02 /2021	Client	Dr. Harshvardhan Subbarao, Mumbai

1 Input Parameters

Main Module		Shear Connection	
Module		Cleat Angle Connection	
Connectivity		Beam-Beam	
Shear Force (kN)		100.0	
Supporting Section - Mechanical Properties			
			
Supporting Section		UB 305 x 102 x 33	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, F_u (MPa)		410	
Yield Strength, F_y (MPa)		250	
Mass, m (kg/m)	32.8	I_z (cm^4)	6501.0
Area, A (cm^2)	41.8	I_y(cm^4)	194.0
D (mm)	313.0	r_z (cm)	12.5
B (mm)	102.4	r_y (cm)	2.2
t (mm)	6.6	Z_z (cm^3)	416.0
T (mm)	10.8	Z_y (cm^3)	38.0
Flange Slope	90	Z_{pz} (cm^3)	481.0
R_1 (mm)	7.6	Z_{py} (cm^3)	60.0
R_2 (mm)	0.0		
Supported Section - Mechanical Properties			
			
Supported Section		MB 300	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, F_u (MPa)		410	
Yield Strength, F_y (MPa)		250	
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]
Property Class	[5.8]
Type	Bearing Bolt
Hole Type	Over-sized
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

1.1 List of Input Section

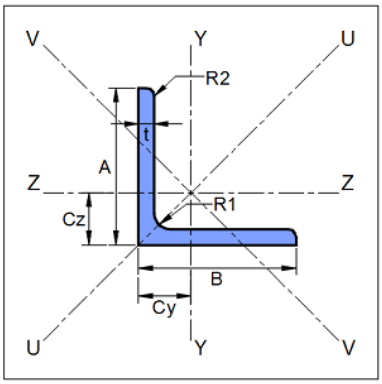
Cleat Angle List	'130 x130 x 10'

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.2
Date	04 /02 /2021	Client	Dr. Harshvardhan Subbarao, Mumbai

2 Design Checks

Design Status	Pass

2.1 Selected Member Data



Section Size		130 x130 x 10	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, Fu (MPa)		410	
Yield Strength, Fy (MPa)		250	
Mass, m (kg/m)	19.72	I_u (cm^4)	644.0
Area, A (cm^2)	25.1	I_v(cm^4)	165.0
A (mm)	130.0	r_z (cm)	4.02
B (mm)	130.0	r_y (cm)	4.02
t (mm)	10.0	r_u (cm)	5.07
R_1 (mm)	10.0	r_v (cm)	2.57
R_2 (mm)	4.8	Z_z (cm^3)	43.1
C_y (mm)	35.9	Z_y (cm^3)	43.1
C_z (mm)	35.9	Z_{pz} (cm^3)	77.8
I_z (cm^4)	405.0	Z_{py} (cm^3)	43.1
I_y(cm^4)	405.0		

2.2 Initial Section Check

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)	100.0	$V_{dy} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{260.0 \times 7.7 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 262.69$ [Ref. IS 800:2007, Cl.10.4.3]	Pass
Allowable Shear Capacity (kN)	100.0	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 262.69$ $= 157.62$ [Limited to low shear]	Pass

2.3 Load Consideration

Check	Required	Provided	Remarks
Applied Shear Force (kN)	100.0	$V_{y_{min}} = \min(0.15V_{d_y},\ 40.0)$ $= \min(0.15 \times 262.69,\ 40.0)$ $= 40$ $V_u = \max(V_y,\ V_{y_{min}})$ $= \max(100.0, 40)$ $= 100.0$ [Ref. IS 800:2007, Cl.10.7]	

2.4 Bolt Design - Connected to Beam

Check	Required	Provided	Remarks
Diameter (mm)		16	
Property Class		5.8	
Cleat Angle Connection		130 x130 x 10	
No. of Bolt Columns		2	
No. of Bolt Rows		4	
Min. Pitch Distance (mm)	$p_{min} = 2.5d$ $= 2.5 \times 16$ $= 40.0$ [Ref. IS 800:2007, Cl.10.2.2]	45	**Pass**
Max. Pitch Distance (mm)	$p_{max} = \min(32t,\ 300)$ $= \min(32 \times 7.7,\ 300)$ $= \min(246.4,\ 300)$ $= 246.4$ Where, $t = \min(10.0, 7.7)$ [Ref. IS 800:2007, Cl.10.2.3]	45	**Pass**

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.2
Date	04 /02 /2021	Client	Dr. Harshvardhan Subbarao, Mumbai

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]	40	Pass
Max. Gauge Distance (mm)	$g_{max} = \min(32t,\ 300)$ $= \min(32 \times 7.7,\ 300)$ $= \min(246.4,\ 300)$ $= 246.4$ Where, $t = \min(10.0, 7.7)$ [Ref. IS 800:2007, Cl.10.2.3]	40	Pass
Min. End Distance (mm)	$e_{min} = 1.7d_0$ $= 1.7 \times 20.0$ $= 34.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	35	Pass
Max. End Distance (mm)	$e_{max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 10.0 \times \sqrt{\frac{250}{250}} = 120.0$ $e_2 = 12 \times 7.7 \times \sqrt{\frac{250}{250}} = 92.4$ $e_{max} = \min(e_1,\ e_2) = 92.4$ [Ref. IS 800:2007, Cl.10.2.4.3]	35	Pass
Min. Edge Distance (mm)	$e'_{min} = 1.7d_0$ $= 1.7 \times 20.0$ $= 34.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	35	Pass

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.2
Date	04 /02 /2021	Client	Dr. Harshvardhan Subbarao, Mumbai

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 10.0 \times \sqrt{\frac{250}{250}} = 120.0$ $e_2 = 12 \times 7.7 \times \sqrt{\frac{250}{250}} = 92.4$ $e'_{max} = min(e_1,\ e_2) = 92.4$ [Ref. IS 800:2007, Cl.10.2.4.3]	35	**Pass**
Moment Demand (kNm)		$M_d = (V_u \times \text{ecc} + M_w)$ ecc = eccentricity M_w = external moment acting on web $= \frac{(100.0 \times 10^3 \times 75.0 + 0.0 \times 10^6)}{10^6}$ $= 7500.0$	
Bolt Force Parameter(s) (mm)	l_n = length available $l_n = p\ (n_r - 1)$ $= 45 \times (4 - 1)$ $= 135$ $y_{max} = l_n/2$ $= 135/2$ $= 67.5$ $x_{max} = g(n_c - 1)/2$ $= 40 \times (2 - 1)/2$ $= 20.0$		

Check	Required	Provided	Remarks
Bolt.Force (kN)	$vbv = V_u/(n_r \times n_c)$ $= \frac{100.0}{(4 \times 2)}$ $= 12.5$ $tmh = \frac{M_d \times y_{max}}{\Sigma r_i^2}$ $= \frac{7500.0 \times 67.5}{23.45}$ $= 21.59$ $tmv = \frac{M_d \times x_{max}}{\Sigma r_i^2}$ $= \frac{7500.0 \times 20.0}{23.45}$ $= 6.4$ $abh = \frac{A_u}{(n_r \times n_c)}$ $= \frac{0.0}{(4 \times 2)}$ $= 0.0$ $v_{res} = \sqrt{(vbv + tmv)^2 + (tmh + abh)^2}$ $= \sqrt{(12.5 + 6.4)^2 + (21.59 + 0.0)^2}$ $= 28.69$		
Shear Capacity (kN)		$V_{dsb} = \frac{f_{ub} n_n A_{nb}}{\sqrt{3}\gamma_{mb}}$ $= \frac{520.0 \times 2 \times 157}{1000 \times \sqrt{3} \times 1.25}$ $= 75.42$ [Ref. IS 800:2007, Cl.10.3.3]	

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.2
Date	04 /02 /2021	Client	Dr. Harshvardhan Subbarao, Mumbai

Check	Required	Provided	Remarks
Kb		$k_b = \min\left(\frac{e}{3d_0},\ \frac{p}{3d_0} - 0.25,\ \frac{f_{ub}}{f_u},\ 1.0\right)$ $= \min\left(\frac{35}{3 \times 20.0},\ \frac{45}{3 \times 20.0} - 0.25,\ \frac{520.0}{410},\ 1.0\right)$ $= \min(0.58, 0.5, 1.27, 1.0)$ $= 0.5$ [Ref. IS 800:2007, Cl.10.3.4]	
Bearing Capacity (kN)		$V_{\text{dpb}} = \frac{2.5 k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.5 \times 16 \times 7.7 \times 410}{1000 \times 1.25}$ $= 35.36$ [Ref. IS 800:2007, Cl.10.3.4]	
Capacity (kN)		$V_{\text{db}} = \min\ (V_{\text{dsb}},\ V_{\text{dpb}})$ $= \min\ (75.42,\ 35.36)$ $= 35.36$ [Ref. IS 800:2007, Cl.10.3.2]	
Long Joint Reduction Factor		$l_j = (n_r - 1) \times p$ $= (4 - 1) \times 45 = 135$ $l = 135$ $15 \times d = 15 \times 16 = 240$ 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		$l_g = \Sigma\ (t_p + t_{\text{member}})$ $= 27.7$ $5d = 80$ $8d = 128$ since, $l_g < 5d$; $\beta_{lg} = 1.0$ [Ref. IS 800:2007, Cl.10.3.3.2]	Pass

Check	Required	Provided	Remarks
Bolt Capacity (post reduction factor) (kN)		$V_{rd} = \beta_{lj}\beta_{lg}V_{db}$ $= 1.0 \times 1.0 \times 35.36$ $= 35.36$	
Capacity (kN)	28.69	35.36	Pass

2.5 Bolt Design - Connected to Column

Check	Required	Provided	Remarks
Diameter (mm)		16	
Property Class		5.8	
Cleat Angle Connection		130 x130 x 10	
No. of Bolt Columns		1	
No. of Bolt Rows		4	
Min. Pitch Distance (mm)	$p_{min} = 2.5d$ $= 2.5 \times 16$ $= 40.0$ [Ref. IS 800:2007, Cl.10.2.2]	45	Pass
Max. Pitch Distance (mm)	$p_{max} = \min(32t,\ 300)$ $= \min(32 \times 6.6,\ 300)$ $= \min(211.2,\ 300)$ $= 211.2$ Where, $t = \min(10.0, 6.6)$ [Ref. IS 800:2007, Cl.10.2.3]	45	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	

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.2
Date	04 /02 /2021	Client	Dr. Harshvardhan Subbarao, Mumbai

Check	Required	Provided	Remarks
Max. Gauge Distance (mm)	$g_{max} = \min(32t,\ 300)$ $= \min(32 \times 6.6,\ 300)$ $= \min(211.2,\ 300)$ $= 211.2$ Where, $t = \min(10.0, 6.6)$ [Ref. IS 800:2007, Cl.10.2.3]	N/A	
Min. End Distance (mm)	$e_{min} = 1.7d_0$ $= 1.7 \times 20.0$ $= 34.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	35	**Pass**
Max. End Distance (mm)	$e_{max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 10.0 \times \sqrt{\frac{250}{250}} = 120.0$ $e_2 = 12 \times 6.6 \times \sqrt{\frac{250}{250}} = 79.2$ $e_{max} = \min(e_1,\ e_2) = 79.2$ [Ref. IS 800:2007, Cl.10.2.4.3]	35	**Pass**
Min. Edge Distance (mm)	$e'_{min} = 1.7d_0$ $= 1.7 \times 20.0$ $= 34.0$ [Ref. IS 800:2007, Cl.10.2.4.2]	35	**Pass**

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.2
Date	04 /02 /2021	Client	Dr. Harshvardhan Subbarao, Mumbai

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 10.0 \times \sqrt{\frac{250}{250}} = 120.0$ $e_2 = 12 \times 6.6 \times \sqrt{\frac{250}{250}} = 79.2$ $e'_{max} = min(e_1,\ e_2) = 79.2$ [Ref. IS 800:2007, Cl.10.2.4.3]	35	**Pass**
Moment Demand (kNm)		$M_d = (V_u \times \text{ecc} + M_w)$ ecc = eccentricity M_w = external moment acting on web $= \frac{(50.0 \times 10^3 \times 55.0 + 0.0 \times 10^6)}{10^6}$ $= 2750.0$	
Bolt Force Parameter(s) (mm)	l_n = length available $l_n = p\ (n_r - 1)$ $= 45 \times (4 - 1)$ $= 135$ $y_{max} = l_n/2$ $= 135/2$ $= 67.5$ $x_{max} = g(n_c - 1)/2$ $= 0.0 \times (1 - 1)/2$ $= 0.0$		

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.3.2
Date	04 /02 /2021	Client	Dr. Harshvardhan Subbarao, Mumbai

Check	Required	Provided	Remarks
Bolt.Force (kN)	$vbv = V_u/(n_r \times n_c)$ $= \frac{100.0}{(4 \times 1)}$ $= 12.5$ $tmh = \frac{M_d \times y_{\max}}{\Sigma r_i^2}$ $= \frac{2750.0 \times 67.5}{10.12}$ $= 18.33$ $tmv = \frac{M_d \times x_{\max}}{\Sigma r_i^2}$ $= \frac{2750.0 \times 0.0}{10.12}$ $= 0.0$ $abh = \frac{A_u}{(n_r \times n_c)}$ $= \frac{0.0}{(4 \times 1)}$ $= 0.0$ $v_{\text{res}} = \sqrt{(vbv + tmv)^2 + (tmh + abh)^2}$ $= \sqrt{(12.5 + 0.0)^2 + (18.33 + 0.0)^2}$ $= 22.19$		
Shear Capacity (kN)		$V_{\text{dsb}} = \frac{f_{ub} n_n A_{nb}}{\sqrt{3}\gamma_{mb}}$ $= \frac{520.0 \times 1 \times 157}{1000 \times \sqrt{3} \times 1.25}$ $= 37.71$ [Ref. IS 800:2007, Cl.10.3.3]	

Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
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Check	Required	Provided	Remarks
Kb		$k_b = \min\left(\frac{e}{3d_0},\ \frac{p}{3d_0} - 0.25,\ \frac{f_{ub}}{f_u},\ 1.0\right)$ $= \min\left(\frac{35}{3 \times 20.0},\ \frac{45}{3 \times 20.0} - 0.25,\ \frac{520.0}{410},\ 1.0\right)$ $= \min(0.58, 0.5, 1.27, 1.0)$ $= 0.5$ [Ref. IS 800:2007, Cl.10.3.4]	
Bearing Capacity (kN)		$V_{\text{dpb}} = \frac{2.5 k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.5 \times 16 \times 7.7 \times 410}{1000 \times 1.25}$ $= 30.31$ [Ref. IS 800:2007, Cl.10.3.4]	
Capacity (kN)		$V_{\text{db}} = \min\ (V_{\text{dsb}},\ V_{\text{dpb}})$ $= \min\ (37.71,\ 30.31)$ $= 30.31$ [Ref. IS 800:2007, Cl.10.3.2]	
Long Joint Reduction Factor		$l_j = (n_r - 1) \times p$ $= (4 - 1) \times 45 = 135$ $l = 135$ $15 \times d = 15 \times 16 = 240$ 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]	Pass

Check	Required	Provided	Remarks
Bolt Capacity (post reduction factor) (kN)		$V_{\text{rd}} = \beta_{lj}\beta_{lg}V_{\text{db}}$ $= 1.0 \times 1.0 \times 30.31$ $= 30.31$	
Capacity (kN)	22.19	30.31	**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]	205	**Pass**
Max. Cleat Angle Height	$d_b - t_{bf} + r_{b1} - notch_h$ $= 313.0 - 10.8 + 7.6 - 0.0$ $= 232.9$	205	**Pass**
Min. Leg Length (mm) (on supported leg)	$\max\left(\text{gap},\ t_{\text{cleat}} + r_{r_{\text{angle}}} + 2e'_{\text{min}} + (n_c - 1)g_{\text{min}}\right)$ $= \max\left(10.0,\ 10.0 + 10.0 + 2 \times 34.0 + (2 - 1) \times 40.0\right)$ $= 128.0$	130.0	**Pass**
Min. Leg Length (mm) (on supporting leg)	$t_{\text{cleat}} + r_{r_{\text{angle}}} + 2e'_{\text{min}} + (n_c - 1)g_{\text{min}}$ $= 10.0 + 10.0 + 2 \times 34.0 + (1 - 1) \times 40.0$ $= 128.0$	130.0	**Pass**
Min. Cleat Angle Thickness (mm)	$t_w = 0.5 \times 7.7 = 3.85$	10.0	**Pass**
Shear Yielding Capacity (kN)		$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{2 \times 205 \times 10.0 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 537.99$ [Ref. IS 800:2007, Cl.10.4.3]	

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Group/Team Name	Osdag	Subtitle	Cleat Angle
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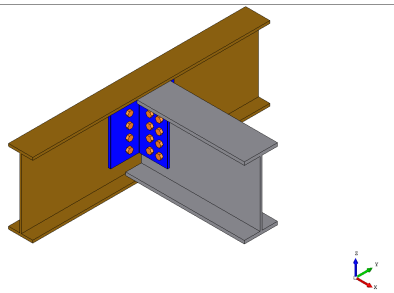
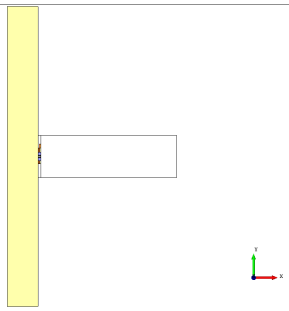
Check	Required	Provided	Remarks
Block Shear Capacity in Shear (kN)		$V_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{\text{db}} = \min(V_{db1},\ V_{db2}) = 681.78$ [Ref. IS 800:2007, Cl.6.4]	
Shear Capacity (kN)	100.0	$V_d = \min(V_{d_y},\ V_{d_b})$ $= \min(537.99, 681.78)$ $= 537.99$ [Ref. IS 800:2007, Cl.6.1]	**Pass**
Moment Capacity (kNm)	7.5	$M_{dz} = \frac{\beta_b Z_p f y}{\gamma_{m0} \times 10^6}$ $= \frac{1.0 \times 210125.0 \times 250}{1.1 \times 10^6}$ $= 47.76$ [Ref. IS 800:2007, Cl.8.2.1.2]	**Pass**

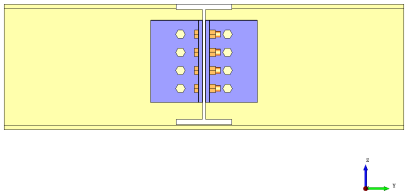
3 3D Views



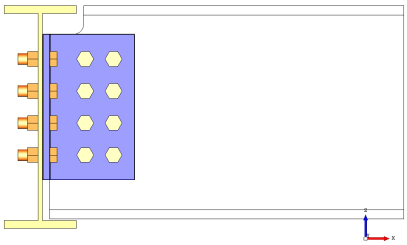
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log