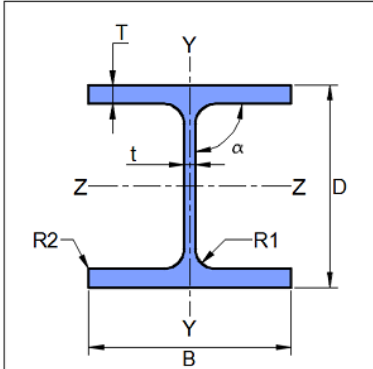
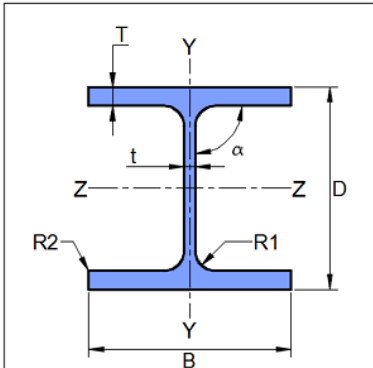




Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.2.1
Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

1 Input Parameters

Main Module		Shear Connection		
Module		Cleat Angle Connection		
Connectivity		Column Web-Beam Web		
Shear Force (kN)		170.0		
Supporting Section - Mechanical Properties				
	Supporting Section		PBP 300 X 95	
	Material		E 250 (Fe 410 W)A	
	Ultimate Strength, F_u (MPa)		410	
	Yield Strength, F_y (MPa)		250	
	Mass, m (kg/m)	95.0	I_z (cm ⁴)	20000.0
	Area, A (cm ²)	121.0	I_y (cm ⁴)	6540.0
	D (mm)	304.0	r_z (cm)	12.8
	B (mm)	309.0	r_y (cm)	7.36
	t (mm)	13.3	Z_z (cm ³)	1320.0
	T (mm)	13.3	Z_y (cm ³)	423.0
	Flange Slope	90	Z_{pz} (cm ³)	1470.0
	R_1 (mm)	15.0	Z_{py} (cm ³)	649.0
	R_2 (mm)	0.0		
Supported Section - Mechanical Properties				
	Supported Section		WPB 250 X 250 X 85.04	
	Material		E 250 (Fe 410 W)A	
	Ultimate Strength, F_u (MPa)		410	
	Yield Strength, F_y (MPa)		250	
	Mass, m (kg/m)	85.04	I_z (cm ⁴)	12100.0
	Area, A (cm ²)	108.0	I_y (cm ⁴)	3910.0
	D (mm)	253.0	r_z (cm)	10.5
	B (mm)	255.0	r_y (cm)	6.0
	t (mm)	14.0	Z_z (cm ³)	961.0
	T (mm)	14.1	Z_y (cm ³)	306.0
	Flange Slope	90	Z_{pz} (cm ³)	1080.0
	R_1 (mm)	24.0	Z_{py} (cm ³)	475.0
	R_2 (mm)	0.0		
Bolt Details - Input and Design Preference				



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Diameter (mm)	[16, 20, 24]
Property Class	[6.8, 8.8, 9.8]
Type	Bearing Bolt
Hole Type	Standard
Slip Factor, (μ_f)	0.3
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	'50 x 50 x 3', '50 x 50 x 4', '50 x 50 x 5', '50 x 50 x 6', '55 x 55 x 4', '55 x 55 x 5', '55 x 55 x 6', '55 x 55 x 8', '60 x 60 x 4', '60 x 60 x 5', '60 x 60 x 6', '60 x 60 x 8', '65 x 65 x 4', '65 x 65 x 5', '65 x 65 x 6', '65 x 65 x 8', '70 x 70 x 5', '70 x 70 x 6', '70 x 70 x 8', '70 x 70 x 10', '75 x 75 x 5', '75 x 75 x 6', '75 x 75 x 8', '75 x 75 x 10', '80 x 80 x 6', '80 x 80 x 8', '80 x 80 x 10', '80 x 80 x 12', '90 x 90 x 6', '90 x 90 x 8', '90 x 90 x 10', '90 x 90 x 12', '100 x 100 x 6', '100 x 100 x 8', '100 x 100 x 10', '100 x 100 x 12', '110 x 110 x 8', '110 x 110 x 10', '110 x 110 x 12', '110 x 110 x 16', '130 x 130 x 8', '130 x 130 x 10', '130 x 130 x 12', '130 x 130 x 16', '150 x 150 x 10', '150 x 150 x 12', '150 x 150 x 16', '150 x 150 x 20', '200 x 200 x 12', '200 x 200 x 16', '200 x 200 x 20', '200 x 200 x 25', '50 x 50 x 7', '50 x 50 x 8', '55 x 55 x 10', '60 x 60 x 10', '65 x 65 x 10', '70 x 70 x 7', '100 x 100 x 7', '100 x 100 x 15', '120 x 120 x 8', '120 x 120 x 10', '120 x 120 x 12', '120 x 120 x 15', '130 x 130 x 9', '150 x 150 x 15', '150 x 150 x 18', '180 x 180 x 15', '180 x 180 x 18', '180 x 180 x 20', '200 x 200 x 24'
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2 Design Checks

Design Status	Pass
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2.1 Selected Member Data

	Section Size		75 x 75 x 8	
	Material		E 250 (Fe 410 W)A	
	Ultimate Strength, F_u (MPa)		410	
	Yield Strength, F_y (MPa)		250	
	Mass, m (kg/m)	9.0	I_u (cm ⁴)	95.7
	Area, A (cm ²)	11.4	I_v (cm ⁴)	24.9
	A (mm)	75.0	r_z (cm)	2.29
	B (mm)	75.0	r_y (cm)	2.29
	t (mm)	8.0	r_u (cm)	2.89
	R_1 (mm)	7.0	r_v (cm)	1.47
	R_2 (mm)	0.0	Z_z (cm ³)	11.3
	C_y (mm)	21.6	Z_y (cm ³)	11.3
	C_z (mm)	21.6	Z_{pz} (cm ³)	20.3
	I_z (cm ⁴)	60.3	Z_{py} (cm ³)	11.3
	I_y (cm ⁴)	60.3		

2.2 Initial Section Check

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)	170.0	$V_{dy} = \frac{A_v f_y}{\sqrt{3} \gamma_{m0}}$ $= \frac{253.0 \times 14.0 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 464.77$ [Ref. IS 800:2007, Cl.10.4.3]	Pass
Allowable Shear Capacity (kN)	170.0	$V_d = 0.6 V_{dy}$ $= 0.6 \times 464.77$ $= 278.86$ [Limited to low shear]	Pass



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2.3 Load Consideration

Check	Required	Provided	Remarks
Applied Shear Force (kN)	170.0	$V_{y_{min}} = \min(0.15V_{dy}, 40.0)$ $= \min(0.15 \times 464.77, 40.0)$ $= 40$ $V_u = \max(V_y, V_{y_{min}})$ $= \max(170.0, 40)$ $= 170.0$ [Ref. IS 800:2007, Cl.10.7]	

2.4 Bolt Design - Connected to Beam

Check	Required	Provided	Remarks
Diameter (mm)		16	
Property Class		8.8	
Cleat Angle Connection		75 x 75 x 8	
No. of Bolt Columns		1	
No. of Bolt Rows		3	
Min. Pitch Distance (mm)	$p_{min} = 2.5d$ $= 2.5 \times 16$ $= 40.0$ [Ref. IS 800:2007, Cl.10.2.2]	55	Pass
Max. Pitch Distance (mm)	$p_{max} = \min(32t, 300)$ $= \min(32 \times 8.0, 300)$ $= \min(256.0, 300)$ $= 256.0$ Where, $t = \min(8.0, 14.0)$ [Ref. IS 800:2007, Cl.10.2.3]	55	Pass



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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)	$g_{\max} = \min(32t, 300)$ $= \min(32 \times 8.0, 300)$ $= \min(256.0, 300)$ $= 256.0$ Where, $t = \min(8.0, 14.0)$ [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)	$e_{\max} = 12t\varepsilon; \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 8.0 \times \sqrt{\frac{250}{250}} = 96.0$ $e_2 = 12 \times 14.0 \times \sqrt{\frac{250}{250}} = 168.0$ $e_{\max} = \min(e_1, e_2) = 96.0$ [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



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Designer	Engineer#1	Job Number	1.1.3.2.1
Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{\max} = 12t\epsilon; \epsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 8.0 \times \sqrt{\frac{250}{250}} = 96.0$ $e_2 = 12 \times 14.0 \times \sqrt{\frac{250}{250}} = 168.0$ $e'_{\max} = \min(e_1, e_2) = 96.0$ <p>[Ref. IS 800:2007, Cl.10.2.4.3]</p>	30	Pass
Moment Demand (kNm)		$M_d = (V_u \times ecc + M_w)$ <p>$ecc = \text{eccentricity}$ $M_w = \text{external moment acting on web}$</p> $= \frac{(170.0 \times 10^3 \times 45.0 + 0.0 \times 10^6)}{10^6}$ $= 7650.0$	
Bolt Force Parameter(s) (mm)	$l_n = \text{length available}$ $l_n = p (n_r - 1)$ $= 55 \times (3 - 1)$ $= 110$ $y_{\max} = l_n / 2$ $= 110 / 2$ $= 55.0$ $x_{\max} = g(n_c - 1) / 2$ $= 0.0 \times (1 - 1) / 2$ $= 0.0$		



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Check	Required	Provided	Remarks
Bolt.Force (kN)	$v_b v_c = V_u / (n_r \times n_c)$ $= \frac{170.0}{(3 \times 1)}$ $= 56.67$ $t_m h = \frac{M_d \times y_{\max}}{\sum r_i^2}$ $= \frac{7650.0 \times 55.0}{6.05}$ $= 69.55$ $t_m v = \frac{M_d \times x_{\max}}{\sum r_i^2}$ $= \frac{7650.0 \times 0.0}{6.05}$ $= 0.0$ $a_b h = \frac{A_u}{(n_r \times n_c)}$ $= \frac{0.0}{(3 \times 1)}$ $= 0.0$ $v_{\text{res}} = \sqrt{(v_b v_c + t_m v)^2 + (t_m h + a_b h)^2}$ $= \sqrt{(56.67 + 0.0)^2 + (69.55 + 0.0)^2}$ $= 89.71$		
Shear Capacity (kN)		$V_{\text{dsb}} = \frac{f_{ub} n_n A_{nb}}{\sqrt{3} \gamma_{mb}}$ $= \frac{800.0 \times 2 \times 157}{1000 \times \sqrt{3} \times 1.25}$ $= 116.02$ [Ref. IS 800:2007, Cl.10.3.3]	



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Check	Required	Provided	Remarks
Kb		$k_b = \min \left(\frac{e}{3d_0}, \frac{p}{3d_0} - 0.25, \frac{f_{ub}}{f_u}, 1.0 \right)$ $= \min \left(\frac{30}{3 \times 18.0}, \frac{55}{3 \times 18.0} - 0.25, \frac{800.0}{410}, 1.0 \right)$ $= \min(0.56, 0.77, 1.95, 1.0)$ $= 0.56$ <p>[Ref. IS 800:2007, Cl.10.3.4]</p>	
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.56 \times 16 \times 14.0 \times 410}{1000 \times 1.25}$ $= 102.86$ <p>[Ref. IS 800:2007, Cl.10.3.4]</p>	
Capacity (kN)		$V_{db} = \min (V_{dsb}, V_{dpb})$ $= \min (116.02, 102.86)$ $= 102.86$ <p>[Ref. IS 800:2007, Cl.10.3.2]</p>	
Long Joint Reduction Factor		$l_j = (n_r - 1) \times p$ $= (3 - 1) \times 55 = 110$ $l = 110$ $15 \times d = 15 \times 16 = 240$ <p>since, $l_j < 15 \times d$ then $\beta_{lj} = 1.0$</p> <p>[Ref. IS 800:2007, Cl.10.3.3.1]</p>	
Large Grip Length Reduction Factor		$l_g = \Sigma (t_p + t_{member})$ $= 30.0$ $5d = 80$ $8d = 128$ <p>since, $l_g < 5d$; $\beta_{lg} = 1.0$</p> <p>[Ref. IS 800:2007, Cl.10.3.3.2]</p>	Pass



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Check	Required	Provided	Remarks
Bolt Capacity (post reduction factor) (kN)		$V_{rd} = \beta_{lj} \beta_{lg} V_{db}$ $= 1.0 \times 1.0 \times 102.86$ $= 102.86$	
Capacity (kN)	89.71	102.86	Pass

2.5 Bolt Design - Connected to Column

Check	Required	Provided	Remarks
Diameter (mm)		16	
Property Class		8.8	
Cleat Angle Connection		75 x 75 x 8	
No. of Bolt Columns		1	
No. of Bolt Rows		3	
Min. Pitch Distance (mm)	$p_{min} = 2.5d$ $= 2.5 \times 16$ $= 40.0$ [Ref. IS 800:2007, Cl.10.2.2]	55	Pass
Max. Pitch Distance (mm)	$p_{max} = \min(32t, 300)$ $= \min(32 \times 8.0, 300)$ $= \min(256.0, 300)$ $= 256.0$ Where, $t = \min(8.0, 13.3)$ [Ref. IS 800:2007, Cl.10.2.3]	55	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	



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Check	Required	Provided	Remarks
Max. Gauge Distance (mm)	$g_{\max} = \min(32t, 300)$ $= \min(32 \times 8.0, 300)$ $= \min(256.0, 300)$ $= 256.0$ <p>Where, $t = \min(8.0, 13.3)$</p> <p>[Ref. IS 800:2007, Cl.10.2.3]</p>	N/A	
Min. End Distance (mm)	$e_{\min} = 1.5d_0$ $= 1.5 \times 18.0$ $= 27.0$ <p>[Ref. IS 800:2007, Cl.10.2.4.2]</p>	30	Pass
Max. End Distance (mm)	$e_{\max} = 12t\varepsilon; \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 8.0 \times \sqrt{\frac{250}{250}} = 96.0$ $e_2 = 12 \times 13.3 \times \sqrt{\frac{250}{250}} = 159.6$ $e_{\max} = \min(e_1, e_2) = 96.0$ <p>[Ref. IS 800:2007, Cl.10.2.4.3]</p>	30	Pass
Min. Edge Distance (mm)	$e'_{\min} = 1.5d_0$ $= 1.5 \times 18.0$ $= 27.0$ <p>[Ref. IS 800:2007, Cl.10.2.4.2]</p>	30	Pass



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Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{\max} = 12t\varepsilon; \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 8.0 \times \sqrt{\frac{250}{250}} = 96.0$ $e_2 = 12 \times 13.3 \times \sqrt{\frac{250}{250}} = 159.6$ $e'_{\max} = \min(e_1, e_2) = 96.0$ <p>[Ref. IS 800:2007, Cl.10.2.4.3]</p>	30	Pass
Moment Demand (kNm)		$M_d = (V_u \times ecc + M_w)$ <p>ecc = eccentricity M_w = external moment acting on web</p> $= \frac{(85.0 \times 10^3 \times 45.0 + 0.0 \times 10^6)}{10^6}$ $= 3825.0$	
Bolt Force Parameter(s) (mm)	$l_n = \text{length available}$ $l_n = p (n_r - 1)$ $= 55 \times (3 - 1)$ $= 110$ $y_{\max} = l_n / 2$ $= 110 / 2$ $= 55.0$ $x_{\max} = g(n_c - 1) / 2$ $= 0.0 \times (1 - 1) / 2$ $= 0.0$		



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Check	Required	Provided	Remarks
Bolt.Force (kN)	$v_{bv} = V_u / (n_r \times n_c)$ $= \frac{170.0}{(3 \times 1)}$ $= 28.33$ $t_{mh} = \frac{M_d \times y_{\max}}{\sum r_i^2}$ $= \frac{3825.0 \times 55.0}{6.05}$ $= 34.77$ $t_{mv} = \frac{M_d \times x_{\max}}{\sum r_i^2}$ $= \frac{3825.0 \times 0.0}{6.05}$ $= 0.0$ $a_{bh} = \frac{A_u}{(n_r \times n_c)}$ $= \frac{0.0}{(3 \times 1)}$ $= 0.0$ $v_{\text{res}} = \sqrt{(v_{bv} + t_{mv})^2 + (t_{mh} + a_{bh})^2}$ $= \sqrt{(28.33 + 0.0)^2 + (34.77 + 0.0)^2}$ $= 44.85$		
Shear Capacity (kN)		$V_{\text{dsb}} = \frac{f_{ub} n_n A_{nb}}{\sqrt{3} \gamma_{mb}}$ $= \frac{800.0 \times 1 \times 157}{1000 \times \sqrt{3} \times 1.25}$ $= 58.01$ [Ref. IS 800:2007, Cl.10.3.3]	



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Check	Required	Provided	Remarks
Kb		$k_b = \min \left(\frac{e}{3d_0}, \frac{p}{3d_0} - 0.25, \frac{f_{ub}}{f_u}, 1.0 \right)$ $= \min \left(\frac{30}{3 \times 18.0}, \frac{55}{3 \times 18.0} - 0.25, \frac{800.0}{410}, 1.0 \right)$ $= \min(0.56, 0.77, 1.95, 1.0)$ $= 0.56$ <p>[Ref. IS 800:2007, Cl.10.3.4]</p>	
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.56 \times 16 \times 14.0 \times 410}{1000 \times 1.25}$ $= 58.78$ <p>[Ref. IS 800:2007, Cl.10.3.4]</p>	
Capacity (kN)		$V_{db} = \min (V_{dsb}, V_{dpb})$ $= \min (58.01, 58.78)$ $= 58.01$ <p>[Ref. IS 800:2007, Cl.10.3.2]</p>	
Long Joint Reduction Factor		$l_j = (n_r - 1) \times p$ $= (3 - 1) \times 55 = 110$ $l = 110$ $15 \times d = 15 \times 16 = 240$ <p>since, $l_j < 15 \times d$ then $\beta_{lj} = 1.0$</p> <p>[Ref. IS 800:2007, Cl.10.3.3.1]</p>	
Large Grip Length Reduction Factor		$l_g = \Sigma (t_p + t_{member})$ $= 21.3$ $5d = 80$ $8d = 128$ <p>since, $l_g < 5d$; $\beta_{lg} = 1.0$</p> <p>[Ref. IS 800:2007, Cl.10.3.3.2]</p>	Pass



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Check	Required	Provided	Remarks
Bolt Capacity (post reduction factor) (kN)		$V_{rd} = \beta_{lj} \beta_{lg} V_{db}$ $= 1.0 \times 1.0 \times 58.01$ $= 58.01$	
Capacity (kN)	44.85	58.01	Pass

2.6 Cleat Angle Check

Check	Required	Provided	Remarks
Min. Cleat Angle Height	$0.6 \times (d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (253.0 - 2 \times 14.1 - 2 \times 24.0)$ $= 106.08$ [Ref. INSDAG, Ch.5, sec.5.2.3]	170	Pass
Max. Cleat Angle Height	$d_b - 2(t_{bf} + r_{b1} + \text{gap})$ $= 304.0 - 2 \times (13.3 + 15.0 + 10)$ $= 176.8$	170	Pass
Min. Leg Length (mm) (on supported leg)	$\max(\text{gap}, t_{\text{cleat}} + r_{\text{angle}} + 2e'_{\min} + (n_c - 1)g_{\min})$ $= \max(10.0, 8.0 + 7.0 + 2 \times 27.0 + (1 - 1) \times 40.0)$ $= 69.0$	75.0	Pass
Min. Leg Length (mm) (on supporting leg)	$t_{\text{cleat}} + r_{\text{angle}} + 2e'_{\min} + (n_c - 1)g_{\min}$ $= 8.0 + 7.0 + 2 \times 27.0 + (1 - 1) \times 40.0$ $= 69.0$	75.0	Pass
Min. Cleat Angle Thickness (mm)	$t_w = 0.5 \times 14.0 = 7.0$	8.0	Pass
Shear Yielding Capacity (kN)		$V_{dy} = \frac{A_v f_y}{\sqrt{3} \gamma_{m0}}$ $= \frac{2 \times 170 \times 8.0 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 356.91$ [Ref. IS 800:2007, Cl.10.4.3]	



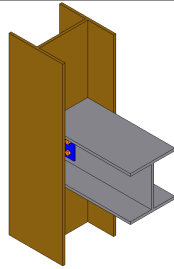
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Check	Required	Provided	Remarks
Block Shear Capacity in Shear (kN)		$V_{db1} = \frac{A_{vg}f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9A_{tn}f_u}{\gamma_{m1}}$ $V_{db2} = \frac{0.9A_{vn}f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg}f_y}{\gamma_{m0}}$ $V_{db} = \min(V_{db1}, V_{db2}) = 368.15$ <p>[Ref. IS 800:2007, Cl.6.4]</p>	
Shear Capacity (kN)	170.0	$V_d = \min(V_{dy}, V_{db})$ $= \min(356.91, 368.15)$ $= 356.91$ <p>[Ref. IS 800:2007, Cl.6.1]</p>	Pass
Moment Capacity (kNm)	7.65	$M_{dz} = \frac{\beta_b Z_p f_y}{\gamma_{m0} \times 10^6}$ $= \frac{1.0 \times 115600.0 \times 250}{1.1 \times 10^6}$ $= 26.27$ <p>[Ref. IS 800:2007, Cl.8.2.1.2]</p>	Pass

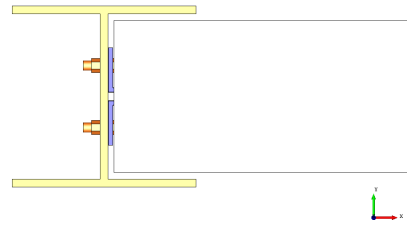


Company Name	IIT Bombay	Project Title	Shear Connection
Group/Team Name	Osdag	Subtitle	Cleat Angle
Designer	Engineer#1	Job Number	1.1.3.2.1
Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

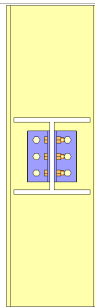
3 3D Views



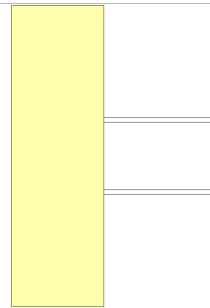
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log