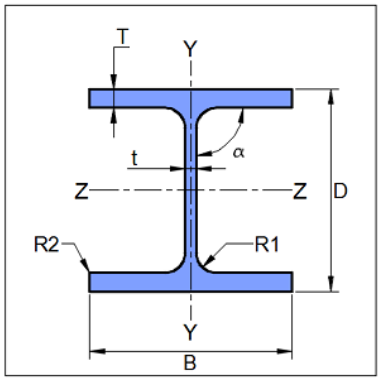
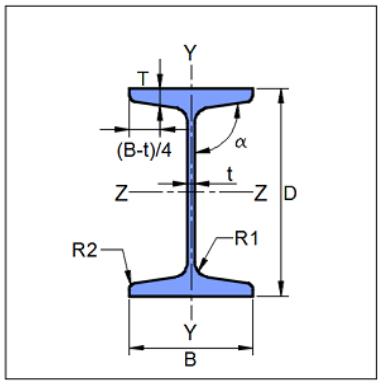
Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Seated Angle
Designer	Engineer #1	Job Number	1.1.4.1.1
Date	17 /12 /2020	Client	V Kalyanaraman, Retd. Professor, IIT Madras

1 Input Parameters

Module		Seated Angle	
Main Module		Shear Connection	
Connectivity		Column Flange-Beam Web	
Shear Force (kN)		210.0	
Supporting Section - Mechanical Properties			
	Supporting Section	PBP 360 X 152.2	
	Material	E 250 (Fe 410 W)A	
	Ultimate Strength, Fu (MPa)	410	
	Yield Strength, Fy (MPa)	250	
	Mass, m (kg/m) 152.2	I_z (cm^4)	43800.0
	Area, A (cm^2) 193.0	I_y(cm^4)	15800.0
	D (mm) 356.0	r_z (cm)	15.0
	B (mm) 376.0	r_y (cm)	9.0
	t (mm) 18.0	Z_z (cm^3)	2460.0
	T (mm) 17.9	Z_y (cm^3)	844.0
	Flange Slope 90	Z_{pz} (cm^3)	2760.0
	R_1 (mm) 15.0	Z_{py} (cm^3)	1290.0
	R_2 (mm) 0.0		
Supported Section - Mechanical Properties			
	Supported Section	WB 400	
	Material	E 250 (Fe 410 W)A	
	Ultimate Strength, Fu (MPa)	410	
	Yield Strength, Fy (MPa)	250	
	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		
Bolt Details - Input and Design Preference			

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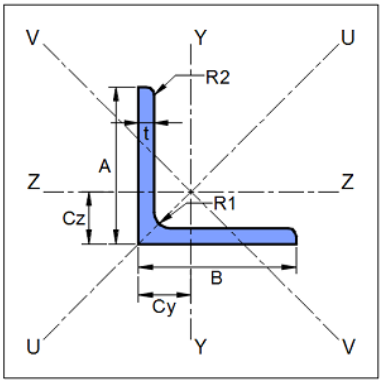
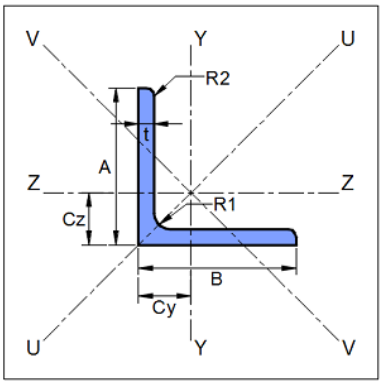
Diameter (mm)	[20, 24, 30]
Property Class	[4.6, 4.8, 5.6, 5.8, 6.8, 8.8, 9.8]
Type	Bearing Bolt
Hole Type	Standard
Slip Factor, (mu_f)	0.3
Detailing - Design Preference	
Edge Preparation Method	Rolled, machine-flame cut, sawn and planed
Gap Between Members (mm)	10.0
Are the Members Exposed to Corrosive Influences?	False
Seated and Top Angle Details	



Section Size*		150 x 150 x 20	
Material		E 300 (Fe 440)	
Ultimate Strength, Fu (MPa)		440	
Yield Strength, Fy (MPa)		300	
Mass, m (kg/m)	2.34	I_u (cm^4)	11.4
Area, A (cm^2)	2.99	I_v(cm^4)	3.01
A (mm)	50.0	r_z (cm)	1.55
B (mm)	50.0	r_y (cm)	1.55
t (mm)	3.0	r_u (cm)	1.96
R_1 (mm)	6.0	r_v (cm)	1.0
R_2 (mm)	0.0	Z_z (cm^3)	1.97
C_y (mm)	13.4	Z_y (cm^3)	1.97
C_z (mm)	13.4	Z_{pz} (cm^3)	3.53
I_z (cm^4)	7.21	Z_{py} (cm^3)	1.97
I_y(cm^4)	7.21		



Section Size*		100 x 100 x 10	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, Fu (MPa)		410	
Yield Strength, Fy (MPa)		250	
Mass, m (kg/m)	15.04	I_u (cm^4)	286.0
Area, A (cm^2)	19.1	I_v(cm^4)	74.3
A (mm)	100.0	r_z (cm)	3.07
B (mm)	100.0	r_y (cm)	3.07
t (mm)	10.0	r_u (cm)	3.87

R_1 (mm)	8.5	r_v (cm)	1.97
R_2 (mm)	0.0	Z_z (cm^3)	25.3
C_y (mm)	28.5	Z_y (cm^3)	25.3
C_z (mm)	28.5	Z_{pz} (cm^3)	45.4
I_z (cm^4)	180.0	Z_{py} (cm^3)	25.3
I_y(cm^4)	180.0		

1.1 List of Input Section

Seated 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 x130 x 10', '130 x130 x 12', '130 x130 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'

1.2 List of Input Section

Top 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 x130 x 10', '130 x130 x 12', '130 x130 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

2.1 Section Design

Check	Required	Provided	Remarks
Shear Capacity (kN)		$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{400.0 \times 8.6 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 752304.9$ [$Ref. IS\ 800 : 2007, Cl. 10.4.3$]	
Allowable Shear Capacity (kN)	210.0	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 752304.9$ $= 451382.937730071$ [*Limited to low shear*]	Pass

2.2 Load Consideration

Check	Required	Provided	Remarks
Applied Shear Force (kN)	210.0	$V_{y_{min}} = min(0.15 \times V_{dy}, 40.0)$ $= min(0.15 \times 752304.9, 40.0)$ $= 40$ $V_u = max(V_y,\ V_{y_{min}})$ $= max(210.0, 40)$ $= 210.0$ [$Ref.\ IS\ 800 : 2007,\ Cl.\ 10.7$]	

2.3 Bolt Design Checks on Column

Check	Required	Provided	Remarks
Diameter (mm)		24	
Property Class		8.8	
Plate Thickness (mm)		20.0	
Large Grip Length Reduction Factor	$if\ l_g \geq 5\ d\ then\ V_{rd} = \beta_{lg}\ V_{db}$ $if\ l_g < 5d\ then\ V_{rd} = V_{db}$ $l_g \leq 8d$ $where,$ $l_g = \Sigma(t_{ep} + t_{member})$ $\beta_{lg} = 8d/(3d + l_g)$ $but\ \beta_{lg} \leq \beta_{lj}$ [$Ref.\ IS$ 800 : 2007, $Cl.$ 10.3.3.2]	$l_g = \Sigma\ (t_p + t_{member})$ $= 37.9$ $5d = 120$ $8d = 192$ $since,\ l_g < 5d\ ;\ \beta_{lg} = 1.0$ [$Ref.\ IS$ 800 : 2007, $Cl.$ 10.3.3.2]	**Pass**
No. of Bolt Columns		2	
No. of Bolt Rows	$1 \leq n_r \leq 2$	1	**Pass**
Min. Pitch Distance (mm)	$p_{min} = 2.5\ d$ $= 2.5 \times 24$ $= 60.0$ [$Ref\ IS$ 800 : 2007, $Cl.$ 10.2.2]	60	**Pass**
Max. Pitch Distance (mm)	$p_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 17.9,\ 300\ mm)$ $= \min(572.8,\ 300\ mm)$ $= 300$ $Where,\ t = min(20.0, 17.9)$ [$Ref.\ IS$ 800 : 2007, $Cl.$ 10.2.3]	60	**Pass**

Check	Required	Provided	Remarks
Min. End Distance (mm)	$e_{min} = 1.5\ d_0$ $= 1.5 \times 26.0$ $= 39.0$ [*Ref. IS* 800 : 2007, *Cl.* 10.2.4.2]	78	**Pass**
Max. End Distance (mm)	$e_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 20.0 \times \sqrt{\frac{250}{240}} = 244.95$ $e_2 = 12 \times 17.9 \times \sqrt{\frac{250}{250}} = 214.8$ $e_{max} = min(e_1, e_2) = 214.8$ [*Ref. IS* 800 : 2007, *Cl.* 10.2.4.3]	78	**Pass**
Min. Edge Distance (mm)	$e'_{min} = 1.5\ d_0$ $= 1.5 \times 26.0$ $= 39.0$ [*Ref. IS* 800 : 2007, *Cl.* 10.2.4.2]	40.0	**Pass**
Max. Edge Distance (mm)	$e'_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 20.0 \times \sqrt{\frac{250}{240}} = 244.95$ $e_2 = 12 \times 17.9 \times \sqrt{\frac{250}{250}} = 214.8$ $e'_{max} = min(e_1, e_2) = 214.8$ [*Ref. IS* 800 : 2007, *Cl.* 10.2.4.3]	40.0	**Pass**
Shear Capacity (kN)		$V_{dsb} = \frac{f_{ub}\ n_n\ A_{nb}}{\sqrt{3}\ \gamma_{mb}}$ $= \frac{830.0 \times 1 \times 353}{1000 \times \sqrt{3}\ \times\ 1.25}$ $= 135.33$ [*Ref. IS* 800 : 2007, *Cl.* 10.3.3]	

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Check	Required	Provided	Remarks
Kb		$k_b = min\left(\frac{e}{3d_0},\ \frac{p}{3d_0} - 0.25,\ \frac{f_{ub}}{f_u},1.0\right)$ $= min\left(\frac{40}{3 \times 26.0},\ \frac{60}{3 \times 26.0} - 0.25,\ \frac{830.0}{410},\ 1.0\right)$ $= min(0.51, 0.52, 2.02, 1.0)$ $= 0.51$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.4]$	
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5\ k_b\ d\ t\ f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.51 \times 24 \times 17.9 \times 410}{1000 \times 1.25}$ $= 183.18$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.4]$	
Capacity (kN)	$V_{bv} = \frac{V}{n}$ $= \frac{210.0}{2}$ $= 105.0$	$V_{db} = min\ (V_{dsb}, V_{dpb})$ $= min\ (135.33, 183.18)$ $= 135.33$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.2]$	
Capacity (kN)	105.0	135.33	**Pass**

2.4 Detailing Check

Check	Required	Provided	Remarks
Minimum Width (mm)On Column	208.0	376.0	**Pass**
Minimum Width (mm)On Beam	194.6	200.0	**Pass**
Min. Leg Length (mm)On Column	112.0	150.0	**Pass**

2.5 Seated Angle Checks

Check	Required	Provided	Remarks
Designation		150 x 150 x 20	
Shear Capacity (kN)	210.0	$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{288 \times 20.0 \times 240}{\sqrt{3} \times 1.1 \times 1000}$ $= 725.572$ $[Ref. IS\ 800:2007, Cl.10.4.3]$	
Allowable Shear Capacity (kN)	210.0	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 725.572$ $= 435.34$ $[Limited\ to\ low\ shear]$	**Pass**
Bearing Length		$b_{lreq} = \frac{V \times \gamma_m 0}{t_w \times f_y} - t_f - r_r$ $= \frac{210.0 \times 1.1}{8.6 \times 250} - 13.0 - 13.0$ $= 81.44$ $k = t_f + r_r$ $k = 13.0 + 13.0 = 26.0$ $b_1 = max(b_{1req}, k) = 81.44$ $b_2 = b_1 + gap - t - r_{ra}$ $b_2 = 81.44 + 10.0 - 20.0 - 12.0$ $b_2 = max(b_2, 0) = 59.44$	
Minimum Leg Length (mm)	$b_1 + gap = 91.44$	150.0	**Pass**

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Check	Required	Provided	Remarks
Moment Capacity (kNm)	$M = V \times ecc$ $if\ b_2 \leq b_1, ecc = \frac{b_2}{b_1} \times \frac{b_2}{2}$ $ecc = \frac{59.44}{81.44} \times \frac{59.44}{2}$ $= 21.69$ $M = 210.0 \times 21.69 \times 10^{-3}$ $= 4.555$	$M_{dzz} = \frac{\beta_b \times Z_p \times fy}{\gamma_{mo} \times 10^6}$ $= \frac{1.0 \times 22000.0 \times 240}{1.1 \times 10^6}$ $= 4.8$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 8.2.1.2]$	**Pass**

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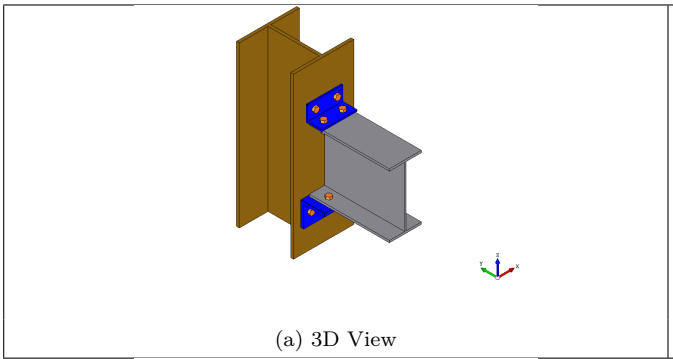
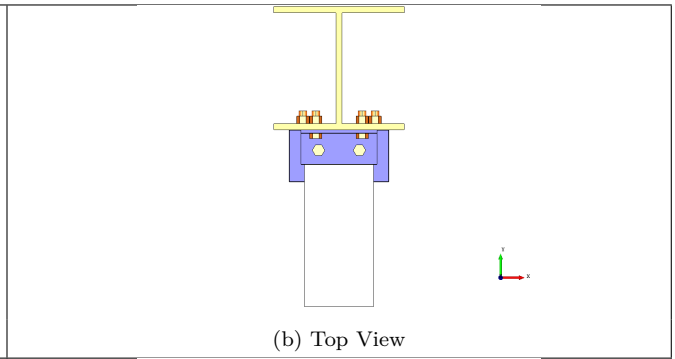
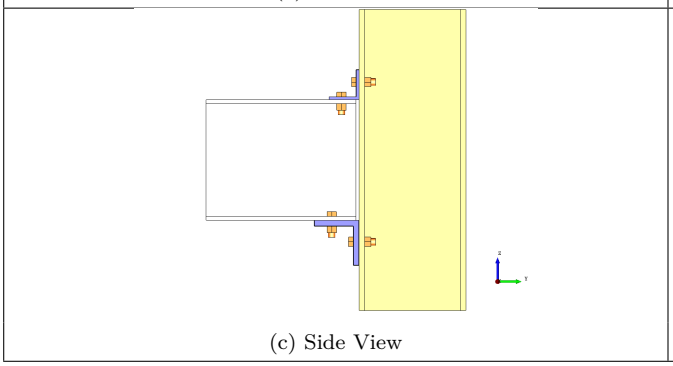
3 3D Views



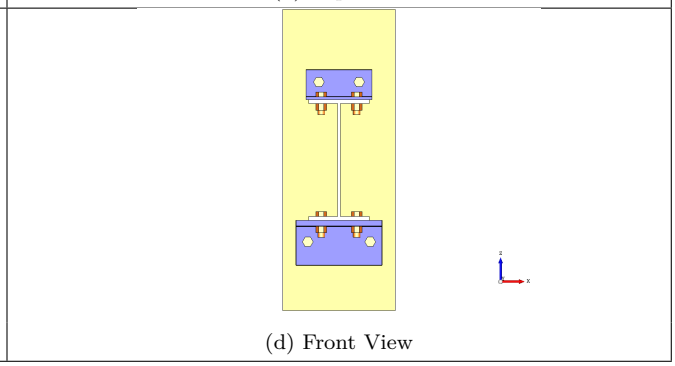
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log

2020-12-17 23:22:01 - Osdag - INFO - The required seated angle thickness is available. Fetching angle leg size.
2020-12-17 23:22:01 - Osdag - INFO - : Based on the thumb rules, a minimum top angle leg size of 100.0 mm and a thickness of 10 mm is required to provide stability to WB 400.