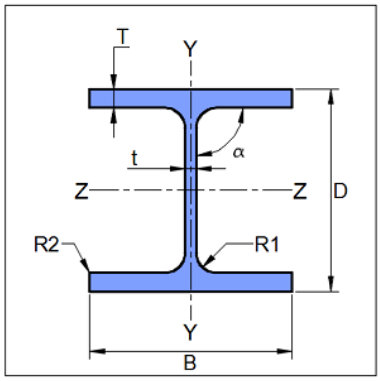
Company Name	IIT Bombay	Project Title	Moment Connection
Group/Team Name	Osdag	Subtitle	Column-to-Column Cover Plate (welded)
Designer	Engineer#1	Job Number	1.2.3.2.1
Date	04 /02 /2021	Client	Mr. Yogesh D Pisal, Mumbai

1 Input Parameters

Module			Column-to-Column Cover Plate Welded Connection	
Main Module			Moment Connection	
Bending Moment (kNm)			127.0	
Shear Force (kN)			0.0	
Axial Force (kN)			370.0	
Column Section - Mechanical Properties				
	Beam Section *		PBP 400 X 140.2	
	Material		E 300 (Fe 440)	
	Ultimate Strength, F_u (MPa)		440	
	Yield Strength, F_y (MPa)		300	
	Mass, m (kg/m)	140.2	I_z (cm^4)	40200.0
	Area, A (cm^2)	178.0	I_y(cm^4)	16000.0
	D (mm)	352.0	r_z (cm)	15.0
	B (mm)	392.0	r_y (cm)	9.5
	t (mm)	16.0	Z_z (cm^3)	2280.0
	T (mm)	16	Z_y (cm^3)	820.0
	Flange Slope	90	Z_{pz} (cm^3)	2540.0
	R_1 (mm)	15.0	Z_{py} (cm^3)	1250.0
	R_2 (mm)	0.0		
Weld Details - Input and Design Preference				
Weld Type			Fillet	
Type of Weld Fabrication			Field weld	
Material Grade Overwrite, F_u (MPa)			540.0	
Plate Details - Input and Design Preference				
Preference			Outside + Inside	
Ultimate Strength, F_u (MPa)			440	
Yield Strength, F_y (MPa)			300	
Material			E 300 (Fe 440)	
Thickness (mm)			[8, 10, 12, 14, 16, 18, 20, 22, 25, 28, 32, 36, 40, 45, 50, 56, 63, 75, 80, 90, 100, 110, 120]	

2 Design Checks

Design Status	Pass

2.1 Member Capacity

Check	Required	Provided	Remarks
Section Classification		Semi-Compact [Ref: Table 2, Cl.3.7.2 and 3.7.4, IS 800:2007]	
Axial Capacity Member (kN)	$P_x = 370.0$	$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ $= \frac{17800.0 \times 300}{1.1 \times 10^3}$ $= 4854.55$ [Ref. IS 800:2007, Cl.6.2]	
Shear Capacity Member (kN)		$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{320.0 \times 16.0 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 806.19$ [Ref. IS 800:2007, Cl.10.4.3]	
Allowable Shear Capacity (kN)	$V_y = 0.0$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 806.19$ $= 483.71$ [Limited to low shear]	
Plastic Moment Capacity (kNm)		$M_{d_z} = \frac{\beta_b Z_p f y}{\gamma_{m0} \times 10^6}$ $= \frac{0.9 \times 2540000.0 \times 300}{1.1 \times 10^6}$ $= 621.82$ [Ref. IS 800:2007, Cl.8.2.1.2]	

Check	Required	Provided	Remarks
Moment Deformation Criteria (kNm)		$M_{dc} = \frac{1.5 Z_e f y}{\gamma_{m0} \times 10^6}$ $= \frac{1.5 \times 2280000.0 \times 300}{1.1 \times 10^6}$ $= 932.73$ [Ref. IS 800:2007, Cl.8.2.1.2]	
Moment Capacity Member (kNm)	$M_z = 127.0$	$M_{dz} = \min(M_{dz},\ M_{dc})$ $= \min(621.82, 932.73)$ $= 621.82$ [Ref. IS 800:2007, Cl.8.2]	

2.2 Load Consideration

Check	Required	Provided	Remarks
Interaction Ratio		I.R. axial $= P_x/T_{dg}$ $= 370.0/4854.55$ $= 0.0762$ I.R. moment $= M_z/M_{dz}$ $= 127.0/621.82$ $= 0.2042$ I.R. sum $=$ I.R. axial + I.R. moment $= 0.0762 + 0.2042$ $= 0.2804$	

Check	Required	Provided	Remarks
Minimum Required Load	if I.R. axial < 0.3 and I.R. moment < 0.5 $P_{x\min} = 0.3T_{dg}$ $M_{z\min} = 0.5M_{dz}$ elif sum I.R. $<= 1.0$ and I.R. moment < 0.5 if $(0.5 - \text{I.R. moment}) < (1 - \text{sum I.R.})$ $M_{z\min} = 0.5 \times M_{dz}$ else $M_{z\min} = M_z + ((1 - \text{sum I.R.}) \times M_{dz})$ $P_{x\min} = P_x$ elif sum I.R. $<= 1.0$ and I.R. axial < 0.3 if $(0.3 - \text{I.R. axial}) < (1 - \text{sum I.R.})$ $P_{x\min} = 0.3T_{dg}$ else $P_{x\min} = P_x + ((1 - \text{sum I.R.}) \times T_{dg})$ $M_{z\min} = M_z$ else $P_{x\min} = P_x$ $M_{z\min} = M_z$ Note: AL is the user input for load	$M_{z\min} = 310.91$ $P_{x\min} = 1456.36$ [Ref. IS 800:2007, Cl.10.7]	
Applied Axial Force (kN)	$P_x = 370.0$	$P_u = \max(P_x, P_{x\min})$ $= \max(370.0, 1456.36)$ $= 1456.36$	

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Group/Team Name	Osdag	Subtitle	Column-to-Column Cover Plate (welded)
Designer	Engineer#1	Job Number	1.2.3.2.1
Date	04 /02 /2021	Client	Mr. Yogesh D Pisal, Mumbai

Check	Required	Provided	Remarks
Applied Shear Force (kN)	$V_y = 0.0$	$V_{y_{min}} = \min(0.15V_{d_y},\ 40.0)$ $= \min(0.15 \times 806.19,\ 40.0)$ $= 40.0$ $V_u = \max(V_y,\ V_{y_{min}})$ $= \max(0.0, 40.0)$ $= 40.0$ [Ref. IS 800:2007, Cl.10.7]	
Applied Moment (kNm)	$M_z = 127.0$	$M_u = \max(M_z,\ M_{z_{min}})$ $= \max(127.0,\ 310.91)$ $= 310.91$ [Ref. IS 800:2007, Cl.8.2.1.2]	
Force Carried by Web		$A_w =$ Axial force in web $= \frac{(D-2T)tAu}{A}$ $= \frac{(352.0 - 2 \times 16) \times 16.0 \times 1456.36}{17800.0}$ $= 418.91$ kN $M_w =$ Moment in web $= \frac{Z_w Mu}{Z}$ $= \frac{273066.67 \times 310.91}{2540000.0}$ $= 33.42$ kNm	

Check	Required	Provided	Remarks
Force Carried by Flange		A_f = Axial force in flange $= \frac{AuBT}{A}$ $= \frac{1456.36 \times 392.0 \times 16}{17800.0}$ $= 513.16$ kN M_f = Moment in flange $= Mu - M_w$ $= 310.91 - 33.42$ $= 277.48$ kNm F_f = flange force $= \frac{M_f \times 10^3}{D - T} + A_f$ $= \frac{277.48 \times 10^3}{352.0 - 16} + 513.16$ $= 1339.01$ kN	

2.3 Flange Weld Design

Check	Required	Provided	Remarks
Min. Flange Plate Thickness (mm)	$T = 8.0$	$t_{fp} = 12.0$	**Pass**
Min. Weld Size (mm)	$t_{w_{min}}$ based on thinner part $= \max(12,\ 12)$ s_{min} based on thicker part = 5 [Ref. IS 800:2007, Table 21, Cl.10.5.2.3]	$t_w = 10$	**Pass**
Max. Weld Size (mm)	Thickness of thinner part $= \min(16,\ 12.0) = 12.0$ $s_{max} = 12.0$ [Ref. IS 800:2007, Cl.10.5.3.1]	$t_w = 10$	**Pass**

Company Name	IIT Bombay	Project Title	Moment Connection
Group/Team Name	Osdag	Subtitle	Column-to-Column Cover Plate (welded)
Designer	Engineer#1	Job Number	1.2.3.2.1
Date	04 /02 /2021	Client	Mr. Yogesh D Pisal, Mumbai

Check	Required	Provided	Remarks
Clearance (mm)	$sp = \max(15,\ (t_w + 5))$ $= \max(15,\ (10 + 5))$ $= 15$	$sp = 15$	**Pass**
Throat Thickness (mm)	$t_t \geq 3$ [Ref. IS 800:2007, Cl.10.5.3.1]	$t_t = 0.7 t_w$ $= 0.7 \times 10$ $= 7.0$ [Ref. IS 800:2007, Cl.10.5.3.1]	**Pass**
EffLength. Outer+Inner flange		$l_{eff} = (6 \times l_w) + B_{fp} + (2 \times B_{ifp}) - 6 \times t_w$ $= (6 \times 395) + 360 + 2 \times 140 - 6 \times 10$ $= 2960$	
Flange Weld Strength (N/mm)	Stress $= \dfrac{F_f \times 10^3}{l_{\text{eff}}}$ $= \dfrac{1339.01 \times 10^3}{2960}$ $= 452.67$	$f_w = \dfrac{t_t f_u}{\sqrt{3}\gamma_{mw}}$ $= \dfrac{7.0 \times 440}{\sqrt{3} \times 1.5}$ $= 1422.59$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	**Pass**
Weld Strength (post long joint) (N/mm)	if $l \geq 150t_t$, then $V_{\text{rd}} = \beta_{l_w} V_{\text{db}}$ if $l < 150t_t$, *then* $V_{\text{rd}} = V_{\text{db}}$ where, l = plate length or height $\beta_{l_w} = 1.2 - \dfrac{(0.2l)}{(150t_t)}$ but, $0.6 \leq \beta_{l_w} \leq 1.0$ [Ref. IS 800:2007, Cl.10.5.7.3]	l = plate length or height $l_l = 2(395 + (2 \times 10)) + 3.0$ $= 833.0$ $l_h = 360$ $l = 833.0$ $150 \times t_t = 150 \times 7.0 = 1050.0$ since, $l < 150 \times t_t$ then $V_{\text{rd}} = V_{\text{db}}$ $V_{\text{rd}} = 1422.59$ [Ref. IS 800:2007, Cl.10.5.7.3]	
Weld Strength (N/mm)	452.67	1422.59	**Pass**

2.4 Flange Plate Dimension Check - Outside/Inside

Check	Required	Provided	Remarks
Min. Flange Plate Width (mm)	50	$B_{fp} = B - 2sp$ $= 392.0 - 2 \times 15$ $= 360$	Pass
Max. Flange Plate Width (mm)	$B_{fp} = B - 2sp$ $= 392.0 - 2 \times 15$ $= 360$	360	Pass
Min. Flange Plate Length (mm)	784.0	$L_{fp} = [2 \times (l_w + 2 \times t_w) + g]$ $= [2 \times (395 + 2 \times 10) + 3.0]$ $= 833.0$	Pass
Min. Inner Plate Width (mm)	>=50	140	Pass
Max. Inner Plate Width (mm)	$B_{ifp} = \frac{B - 4sp - t - 2R1}{2}$ $= \frac{392.0 - 4 \times 15 - 16.0 - 2 \times 15.0}{2}$ $= 140$	140	Pass
Min. Inner Plate Length (mm)	784.0	$L_{fp} = [2 \times (l_w + 2 \times t_w) + g]$ $= [2 \times (395 + 2 \times 10) + 3.0]$ $= 833.0$	Pass
Min. Flange Plate Thickness (mm)	$T = 8.0$	$t_{fp} = 12.0$	Pass
Plate Area Check (mm2)	plate area >= 1.05 X connected member area = 6585.6 [Ref: Cl.8.6.3.2, IS 800:2007]	plate area $= (B_{fp} + (2 \times B_{ifp})) \times t_{ifp}$ $= (360 + (2 \times 140)) \times 12.0$ $= 7680.0$	Pass

2.5 Web Weld Design

Check	Required	Provided	Remarks
Min. Web Plate Thickness (mm)	$t = 8.0$	$t_{wp} = 14.0$	**Pass**
Min. Weld Size (mm)	$t_{w_{\min}}$ based on thinner part $= \max(14,\ 14)$ $s_{\min}$ based on thicker part $= 5$ [Ref. IS 800:2007, Table 21, Cl.10.5.2.3]	$t_w = 12$	**Pass**
Max. Weld Size (mm)	Thickness of thinner part $= \min(16.0,\ 14.0) = 14.0$ $s_{\max} = 14.0$ [Ref. IS 800:2007, Cl.10.5.3.1]	$t_w = 12$	**Pass**
Effective Length (mm)		$l_{\text{eff}} = (2l_w) + W_{wp} - 2t_w$ $= (2 \times 195) + 255 - 2 \times 12$ $= 625$	
Clearance (mm)	$sp = \max(15,\ (t_w + 5))$ $= \max(15,\ (12 + 5))$ $= 17$	$sp = 17$	**Pass**
Throat Thickness (mm)	$t_t \geq 3$ [Ref. IS 800:2007, Cl.10.5.3.1]	$t_t = 0.7t_w$ $= 0.7 \times 12$ $= 8.4$ [Ref. IS 800:2007, Cl.10.5.3.1]	**Pass**
Moment Demand (kNm)		$M_d = (V_u \times \text{ecc} + M_w)$ ecc = eccentricity M_w = external moment acting on web $= \frac{(20.0 \times 10^3 \times 133.77 + 16.71 \times 10^6)}{10^6}$ $= 19.39$	

Company Name	IIT Bombay	Project Title	Moment Connection
Group/Team Name	Osdag	Subtitle	Column-to-Column Cover Plate (welded)
Designer	Engineer#1	Job Number	1.2.3.2.1
Date	04 /02 /2021	Client	Mr. Yogesh D Pisal, Mumbai

Check	Required	Provided	Remarks
Web Weld Strength (N/mm)	$R_{\mathrm{w}} = \sqrt{(T_{\mathrm{wh}} + A_{\mathrm{wh}})^2 + (T_{\mathrm{wv}} + V_{\mathrm{wv}})^2}$ $T_{\mathrm{wh}} = \frac{M_d \times y_{\max}}{Ipw}$ $= \frac{19387746.2 \times 61.23}{8844804.36}$ $T_{\mathrm{wv}} = \frac{M_d \times x_{\max}}{Ipw}$ $= \frac{19387746.2 \times 115.5}{8844804.36}$ $V_{\mathrm{wv}} = \frac{V_u}{l_{\mathrm{eff}}}$ $= \frac{20000.0}{625}$ $A_{\mathrm{wh}} = \frac{A_u}{l_{\mathrm{eff}}}$ $= \frac{209454.55}{625}$ $R_{\mathrm{w}} = \sqrt{(134.22 + 335.13)^2 + (253.18 + 32.0)^2}$ $= 551.14$	$f_w = \frac{t_t f_u}{\sqrt{3}\gamma_{mw}}$ $= \frac{8.4 \times 440}{\sqrt{3} \times 1.5}$ $= 1707.11$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	**Pass**

Check	Required	Provided	Remarks
Weld Strength (post long joint) (N/mm)	if $l \geq 150t_t$, then $V_{rd} = \beta_{l_w} V_{db}$ if $l < 150t_t$, *then* $V_{rd} = V_{db}$ where, l = plate length or height $\beta_{l_w} = 1.2 - \frac{(0.2l)}{(150t_t)}$ but, $0.6 \leq \beta_{l_w} \leq 1.0$ [Ref. IS 800:2007, Cl.10.5.7.3]	l = plate length or height $l_l = 2(195 + (2 \times 12)) + 3.0$ $= 441.0$ $l_h = 255$ $l = 441.0$ $150 \times t_t = 150 \times 8.4 = 1260.0$ since, $l < 150 \times t_t$ then $V_{rd} = V_{db}$ $V_{rd} = 1707.11$ [Ref. IS 800:2007, Cl.10.5.7.3]	
Weld Strength (N/mm)	551.14	1707.11	**Pass**

2.6 Web Plate Dimension Check

Check	Required	Provided	Remarks
Min. Web Plate Height (mm)	$0.6 \times (d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (352.0 - 2 \times 16 - 2 \times 15.0)$ $= 211.2$ [Ref. INSDAG, Ch.5, sec.5.2.3]	$W_{wp} = D - 2T - 2R1 - 2sp$ $= 352.0 - 2 \times 16 - (2 \times 15.0) - 2 \times 17$ $= 255$	**Pass**
Min. Web Plate Width (mm)	392.0	$L_{wp} = [2 \times (l_w + 2 \times t_w) + g]$ $= [2 \times (195 + 2 \times 12) + 3.0]$ $= 445$	**Pass**
Min. Web Plate Thickness (mm)	$t = 8.0$	$t_{wp} = 14.0$	**Pass**

Check	Required	Provided	Remarks
Plate Area Check (mm2)	plate area >= 1.05 X connected member area = 5376.0 [Ref: Cl.8.6.3.2, IS 800:2007]	plate area $= 2 \times W_{wp} \times t_{wp}$ $= 2 \times 255 \times 14.0$ $= 7140.0$	**Pass**

2.7 Member Check

Check	Required	Provided	Remarks
Flange Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 392.0 \times 16$ $= \frac{6272.0 \times 300}{1.1 \times 10^3}$ $= 1710.55$ [Ref. IS 800:2007, Cl.6.2]	
Flange Tension Capacity (kN)	$F_f = 1339.01$	$T_d = T_{dg}$ $= 1710.55$ [Ref.IS 800:2007, Cl.6.1]	**Pass**
Web Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 320.0 \times 16.0$ $= \frac{5120.0 \times 300}{1.1 \times 10^3}$ $= 1396.36$ [Ref. IS 800:2007, Cl.6.2]	

Check	Required	Provided	Remarks
Web Block Shear Capacity (kN)		$T_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{\text{db}} = \min(T_{db1},\ T_{db2}) = 2254.05$ [Ref. IS 800:2007, Cl.6.4]	
Web Tension Capacity (kN)	$A_w = 418.91$	$T_{\text{d}} = \min(T_{\text{dg}},\ T_{\text{db}})$ $= \min(1396.36, 2254.05)$ $= 1396.36$ [Ref.IS 800:2007, Cl.6.1]	**Pass**

2.8 Flange Plate Capacity Check for Axial Load - Outside/Inside

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{\text{dg}} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 640 \times 12.0$ $= \frac{7680.0 \times 300}{1.1 \times 10^3}$ $= 2094.55$ [Ref. IS 800:2007, Cl.6.2]	
Flange Plate Tension Capacity (kN)	$F_f = 1339.01$	$T_{\text{d}} = T_{\text{dg}}$ $= 2094.55$ [Ref.IS 800:2007, Cl.6.1]	**Pass**

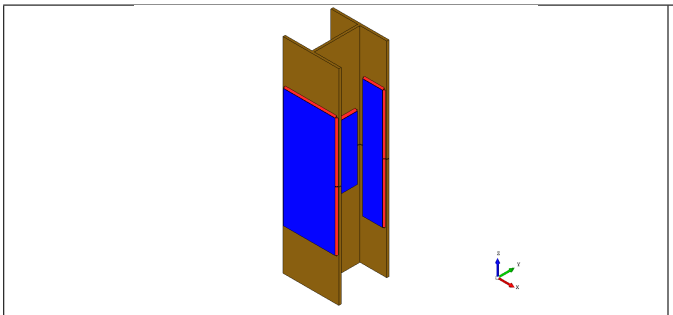
2.9 Web Plate Capacity Check for Axial Load

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = 2lt = 2 \times 255 \times 14.0$ $= \frac{3570.0 \times 300}{1.1 \times 10^3}$ $= 1947.27$ [Ref. IS 800:2007, Cl.6.2]	
Web Plate Tension Capacity (kN)	$A_w = 418.91$	$T_d = T_{dg}$ $= 1947.27$ [Ref.IS 800:2007, Cl.6.1]	Pass

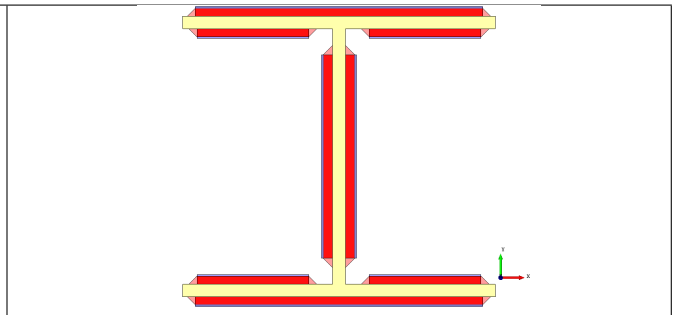
2.10 Web Plate Capacity Check for Shear Load

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)		$V_{dy} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{2 \times 255 \times 14.0 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 1124.26$ [Ref. IS 800:2007, Cl.10.4.3]	
Allowable Shear Capacity (kN)	$V = 0.0$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 1124.26$ $= 674.56$ [Limited to low shear]	
Web Plate Shear Capacity (kN)	$V_u = 40.0$	$V_d = S_c$ $= 674.56$ [Ref. IS 800:2007, Cl.6.1]	Pass

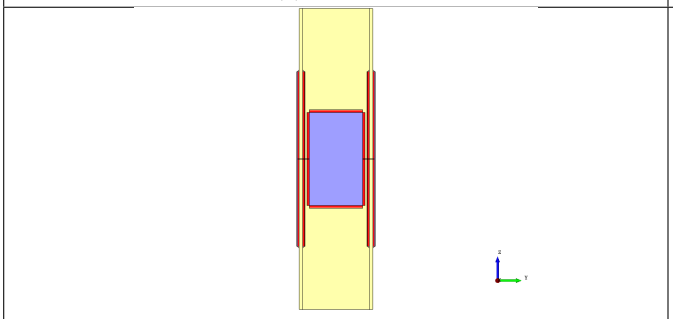
3 3D Views



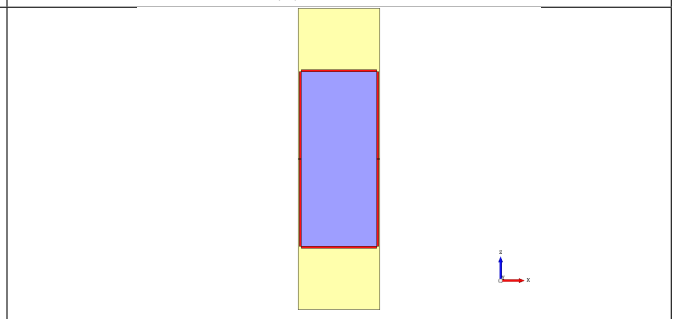
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log

2021-02-04 14:50:59 - Osdag - WARNING - The defined factored load(s) are less than the minimum recommended value [Cl.10.7, IS 800:2007]

2021-02-04 14:50:59 - Osdag - INFO - The load values have been set as per the minimum recommendations of Cl.10.7, IS 800:2007

2021-02-04 14:50:59 - Osdag - INFO - : Overall Column Cover Plate Welded member design is SAFE

2021-02-04 14:50:59 - Osdag - INFO - : ==========End of Design==========