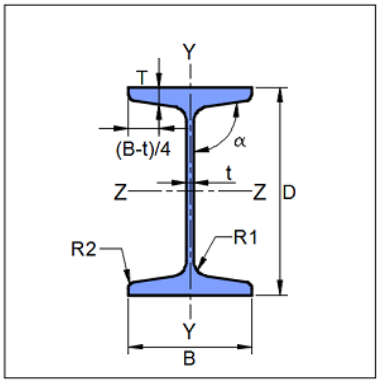
Company Name	IIT Bombay	Project Title	Moment Connection
Group/Team Name	Osdag	Subtitle	Column-to-Column Cover Plate (welded)
Designer	Engineer#1	Job Number	1.2.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

1 Input Parameters

Module			Column-to-Column Cover Plate Welded Connection	
Main Module			Moment Connection	
Bending Moment (kNm)			50.0	
Shear Force (kN)			30.0	
Axial Force (kN)			480.0	
Column Section - Mechanical Properties				
	Beam Section *		HB 400	
	Material		E 250 (Fe 410 W)A	
	Ultimate Strength, F_u (MPa)		410	
	Yield Strength, F_y (MPa)		250	
	Mass, m (kg/m)	77.43	I_z (cm^4)	28000.0
	Area, A (cm^2)	98.6	I_y(cm^4)	2720.0
	D (mm)	400.0	r_z (cm)	16.8
	B (mm)	250.0	r_y (cm)	5.25
	t (mm)	9.1	Z_z (cm^3)	1400.0
	T (mm)	12.7	Z_y (cm^3)	218.0
	Flange Slope	94	Z_{pz} (cm^3)	1560.0
	R_1 (mm)	14.0	Z_{py} (cm^3)	360.0
	R_2 (mm)	7.0		
Weld Details - Input and Design Preference				
Weld Type			Fillet	
Type of Weld Fabrication			Field weld	
Material Grade Overwrite, F_u (MPa)			510.0	
Plate Details - Input and Design Preference				
Preference			Outside	
Ultimate Strength, F_u (MPa)			410	
Yield Strength, F_y (MPa)			250	
Material			E 250 (Fe 410 W)A	
Thickness (mm)			[14]	

2 Design Checks

Design Status	Pass

2.1 Member Capacity

Check	Required	Provided	Remarks
Section Classification		Compact [Ref: Table 2, Cl.3.7.2 and 3.7.4, IS 800:2007]	
Axial Capacity Member (kN)	$P_x = 480.0$	$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ $= \frac{9860.0 \times 250}{1.1 \times 10^3}$ $= 2240.91$ [Ref. IS 800:2007, Cl.6.2]	
Shear Capacity Member (kN)		$V_{d_y} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{374.6 \times 9.1 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 447.3$ [Ref. IS 800:2007, Cl.10.4.3]	
Allowable Shear Capacity (kN)	$V_y = 30.0$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 447.3$ $= 268.38$ [Limited to low shear]	Pass
Plastic Moment Capacity (kNm)		$M_{d_z} = \frac{\beta_b Z_p f y}{\gamma_{m0} \times 10^6}$ $= \frac{1 \times 1560000.0 \times 250}{1.1 \times 10^6}$ $= 354.55$ [Ref. IS 800:2007, Cl.8.2.1.2]	

Check	Required	Provided	Remarks
Moment Deformation Criteria (kNm)		$M_{dc} = \frac{1.5 Z_e f y}{\gamma_{m0} \times 10^6}$ $= \frac{1.5 \times 1400000.0 \times 250}{1.1 \times 10^6}$ $= 477.27$ [Ref. IS 800:2007, Cl.8.2.1.2]	
Moment Capacity Member (kNm)	$M_z = 50.0$	$M_{dz} = \min(M_{dz},\ M_{dc})$ $= \min(354.55, 477.27)$ $= 354.55$ [Ref. IS 800:2007, Cl.8.2]	

2.2 Load Consideration

Check	Required	Provided	Remarks
Interaction Ratio		I.R. axial $= P_x/T_{dg}$ $= 480.0/2240.91$ $= 0.2142$ I.R. moment $= M_z/M_{dz}$ $= 50.0/354.55$ $= 0.141$ I.R. sum $=$ I.R. axial + I.R. moment $= 0.2142 + 0.141$ $= 0.3552$	

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	$M_{z\min} = 177.27$ $P_{x\min} = 672.27$ [Ref. IS 800:2007, Cl.10.7]	
Applied Axial Force (kN)	$P_x = 480.0$	$P_u = \max(P_x, P_{x\min})$ $= \max(480.0, 672.27)$ $= 672.27$	

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Designer	Engineer#1	Job Number	1.2.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

Check	Required	Provided	Remarks
Applied Shear Force (kN)	$V_y = 30.0$	$V_{y_{\min}} = \min(0.15V_{d_y},\ 40.0)$ $= \min(0.15 \times 447.3,\ 40.0)$ $= 40.0$ $V_u = \max(V_y,\ V_{y_{\min}})$ $= \max(30.0, 40.0)$ $= 40.0$ [Ref. IS 800:2007, Cl.10.7]	
Applied Moment (kNm)	$M_z = 50.0$	$M_u = \max(M_z,\ M_{z\min})$ $= \max(50.0,\ 177.27)$ $= 177.27$ [Ref. IS 800:2007, Cl.8.2.1.2]	
Force Carried by Web		$A_w =$ Axial force in web $= \frac{(D-2T)tAu}{A}$ $= \frac{(400.0 - 2 \times 12.7) \times 9.1 \times 672.27}{9860.0}$ $= 232.42$ kN $M_w =$ Moment in web $= \frac{Z_w Mu}{Z}$ $= \frac{319239.74 \times 177.27}{1560000.0}$ $= 36.28$ kNm	

Check	Required	Provided	Remarks
Force Carried by Flange		A_f = Axial force in flange $= \frac{AuBT}{A}$ $= \frac{672.27 \times 250.0 \times 12.7}{9860.0}$ $= 216.48$ kN M_f = Moment in flange $= Mu - M_w$ $= 177.27 - 36.28$ $= 141.0$ kNm F_f = flange force $= \frac{M_f \times 10^3}{D - T} + A_f$ $= \frac{141.0 \times 10^3}{400.0 - 12.7} + 216.48$ $= 580.52$ kN	

2.3 Flange Weld Design

Check	Required	Provided	Remarks
Min. Flange Plate Thickness (mm)	$T = 12.7$	$t_{fp} = 18.0$	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]	$t_w = 11$	Pass
Max. Weld Size (mm)	Thickness of thinner part $= \min(12.7,\ 18.0) = 12.7$ $s_{max} = 12.7$ [Ref. IS 800:2007, Cl.10.5.3.1]	$t_w = 11$	Pass

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Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

Check	Required	Provided	Remarks
Clearance (mm)	$sp = \max(15,\ (t_w + 5))$ $= \max(15,\ (11 + 5))$ $= 16$	$sp = 16$	**Pass**
Throat Thickness (mm)	$t_t \geq 3$ [Ref. IS 800:2007, Cl.10.5.3.1]	$t_t = 0.7 t_w$ $= 0.7 \times 11$ $= 7.7$ [Ref. IS 800:2007, Cl.10.5.3.1]	**Pass**
Effective Length (mm)		$l_{\text{eff}} = (2 l_w) + B_{fp} - 2 t_w$ $= (2 \times 250) + 215 - 2 \times 11$ $= 695$	
Flange Weld Strength (N/mm)	$\text{Stress} = \dfrac{F_f \times 10^3}{l_{\text{eff}}}$ $= \dfrac{580.52 \times 10^3}{695}$ $= 834.09$	$f_w = \dfrac{t_t f_u}{\sqrt{3}\gamma_{mw}}$ $= \dfrac{7.7 \times 410}{\sqrt{3} \times 1.5}$ $= 1458.16$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	**Pass**
Weld Strength (post long joint) (N/mm)	if $l \geq 150 t_t$, then $V_{\text{rd}} = \beta_{l_w} V_{\text{db}}$ if $l < 150 t_t$, *then* $V_{\text{rd}} = V_{\text{db}}$ where, l = plate length or height $\beta_{l_w} = 1.2 - \dfrac{(0.2 l)}{(150 t_t)}$ but, $0.6 \leq \beta_{l_w} \leq 1.0$ [Ref. IS 800:2007, Cl.10.5.7.3]	l = plate length or height $l_l = 2(250 + (2 \times 11)) + 5.0$ $= 549.0$ $l_h = 215$ $l = 549.0$ $150 \times t_t = 150 \times 7.7 = 1155.0$ since, $l < 150 \times t_t$ then $V_{\text{rd}} = V_{\text{db}}$ $V_{\text{rd}} = 1458.16$ [Ref. IS 800:2007, Cl.10.5.7.3]	
Weld Strength (N/mm)	834.09	1458.16	**Pass**

2.4 Flange Plate Dimension Check - Outside

Check	Required	Provided	Remarks
Min. Flange Plate Width (mm)	50	$B_{fp} = B - 2sp$ $= 250.0 - 2 \times 16$ $= 215$	Pass
Max. Flange Plate Width (mm)	$B_{fp} = B - 2sp$ $= 250.0 - 2 \times 16$ $= 215$	215	Pass
Min. Flange Plate Length (mm)	500.0	$L_{fp} = [2 \times (l_w + 2 \times t_w) + g]$ $= [2 \times (250 + 2 \times 11) + 5.0]$ $= 549.0$	Pass
Min. Flange Plate Thickness (mm)	$T = 12.7$	$t_{fp} = 18.0$	Pass
Plate Area Check (mm2)	plate area >= 1.05 X connected member area $= 3333.75$ [Ref: Cl.8.6.3.2, IS 800:2007]	plate area $= B_{fp} \times t_{ifp}$ $= 215 \times 18.0$ $= 3870.0$	Pass

2.5 Web Weld Design

Check	Required	Provided	Remarks
Min. Web Plate Thickness (mm)	$t = 4.55$	$t_{wp} = 14.0$	Pass
Min. Weld Size (mm)	$t_{w_{\min}}$ based on thinner part $= \max(9,\ 9)$ $s_{\min}$ based on thicker part $= 5$ [Ref. IS 800:2007, Table 21, Cl.10.5.2.3]	$t_w = 7$	Pass
Max. Weld Size (mm)	Thickness of thinner part $= \min(9.1,\ 14.0) = 9.1$ $s_{\max} = 9.1$ [Ref. IS 800:2007, Cl.10.5.3.1]	$t_w = 7$	Pass

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Designer	Engineer#1	Job Number	1.2.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

Check	Required	Provided	Remarks
Effective Length (mm)		$l_{\text{eff}} = (2l_w) + W_{wp} - 2t_w$ $= (2 \times 125) + 315 - 2 \times 7$ $= 555$	
Clearance (mm)	$sp = \max(15,\ (t_w + 5))$ $= \max(15,\ (7 + 5))$ $= 15$	$sp = 15$	**Pass**
Throat Thickness (mm)	$t_t \geq 3$ [Ref. IS 800:2007, Cl.10.5.3.1]	$t_t = 0.7t_w$ $= 0.7 \times 7$ $= 4.9$ [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 $= \frac{(20.0 \times 10^3 \times 96.64 + 18.14 \times 10^6)}{10^6}$ $= 20.07$	

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Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

Check	Required	Provided	Remarks
Web Weld Strength (N/mm)	$R_{\mathrm{w}} = \sqrt{(T_{\mathrm{wh}} + A_{\mathrm{wh}})^2 + (T_{\mathrm{wv}} + V_{\mathrm{wv}})^2}$ $T_{\mathrm{wh}} = \frac{M_d \times y_{\max}}{Ipw}$ $= \frac{20071470.95 \times 28.36}{8794134.48}$ $T_{\mathrm{wv}} = \frac{M_d \times x_{\max}}{Ipw}$ $= \frac{20071470.95 \times 150.5}{8794134.48}$ $V_{\mathrm{wv}} = \frac{V_u}{l_{\mathrm{eff}}}$ $= \frac{20000.0}{555}$ $A_{\mathrm{wh}} = \frac{A_u}{l_{\mathrm{eff}}}$ $= \frac{116211.14}{555}$ $R_{\mathrm{w}} = \sqrt{(64.73 + 209.39)^2 + (343.5 + 36.04)^2}$ $= 469.27$	$f_w = \frac{t_t f_u}{\sqrt{3}\gamma_{mw}}$ $= \frac{4.9 \times 410}{\sqrt{3} \times 1.5}$ $= 927.92$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	**Pass**

Company Name	IIT Bombay	Project Title	Moment Connection
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Designer	Engineer#1	Job Number	1.2.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

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 $l_l = 2(125 + (2 \times 7)) + 5.0$ $= 283.0$ $l_h = 315$ $l = 315$ $150 \times t_t = 150 \times 4.9 = 735.0$ since, $l < 150 \times t_t$ then $V_{rd} = V_{db}$ $V_{rd} = 927.92$ [Ref. IS 800:2007, Cl.10.5.7.3]	
Weld Strength (N/mm)	469.27	927.92	**Pass**

2.6 Web Plate Dimension Check

Check	Required	Provided	Remarks
Min. Web Plate Height (mm)	$0.6 \times (d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (400.0 - 2 \times 12.7 - 2 \times 14.0)$ $= 240.0$ [Ref. INSDAG, Ch.5, sec.5.2.3]	$W_{wp} = D - 2T - 2R1 - 2sp$ $= 400.0 - 2 \times 12.7 - (2 \times 14.0) - 2 \times 15$ $= 315$	**Pass**
Min. Web Plate Width (mm)	250.0	$L_{wp} = [2 \times (l_w + 2 \times t_w) + g]$ $= [2 \times (125 + 2 \times 7) + 5.0]$ $= 285$	**Pass**
Min. Web Plate Thickness (mm)	$t = 4.55$	$t_{wp} = 14.0$	**Pass**

Check	Required	Provided	Remarks
Plate Area Check (mm2)	plate area >= 1.05 X connected member area = 3579.3 [Ref: Cl.8.6.3.2, IS 800:2007]	plate area $= 2 \times W_{wp} \times t_{wp}$ $= 2 \times 315 \times 14.0$ $= 8820.0$	**Pass**

2.7 Member Check

Check	Required	Provided	Remarks
Flange Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 250.0 \times 12.7$ $= \frac{3175.0 \times 250}{1.1 \times 10^3}$ $= 721.59$ [Ref. IS 800:2007, Cl.6.2]	
Flange Tension Capacity (kN)	$F_f = 580.52$	$T_d = T_{dg}$ $= 721.59$ [Ref.IS 800:2007, Cl.6.1]	**Pass**
Web Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 374.6 \times 9.1$ $= \frac{3408.86 \times 250}{1.1 \times 10^3}$ $= 774.74$ [Ref. IS 800:2007, Cl.6.2]	

Check	Required	Provided	Remarks
Web Block Shear Capacity (kN)		$T_{\text{dbl1}} = \frac{A_{\text{vg}} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{\text{dbl2}} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{\text{db}} = \min(T_{db1},\ T_{db2}) = 1039.21$ [Ref. IS 800:2007, Cl.6.4]	
Web Tension Capacity (kN)	$A_w = 232.42$	$T_{\text{d}} = \min(T_{\text{dg}},\ T_{\text{db}})$ $= \min(774.74, 1039.21)$ $= 774.74$ [Ref.IS 800:2007, Cl.6.1]	**Pass**

2.8 Flange Plate Capacity Check for Axial Load - Outside

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{\text{dg}} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 215 \times 18.0$ $= \frac{3870.0 \times 250}{1.1 \times 10^3}$ $= 879.55$ [Ref. IS 800:2007, Cl.6.2]	
Flange Plate Tension Capacity (kN)	$F_f = 580.52$	$T_{\text{d}} = T_{\text{dg}}$ $= 879.55$ [Ref.IS 800:2007, Cl.6.1]	**Pass**

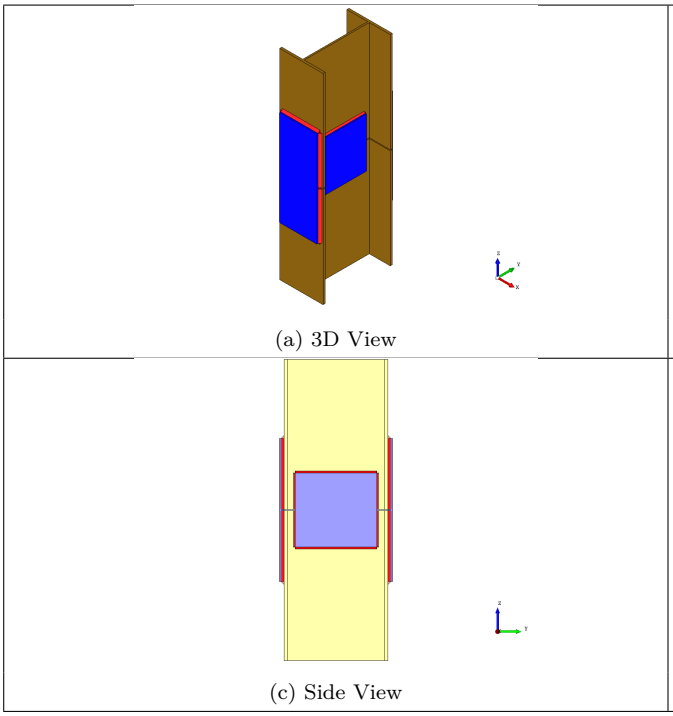
2.9 Web Plate Capacity Check for Axial Load

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = 2lt = 2 \times 315 \times 14.0$ $= \frac{4410.0 \times 250}{1.1 \times 10^3}$ $= 2004.55$ [Ref. IS 800:2007, Cl.6.2]	
Web Plate Tension Capacity (kN)	$A_w = 232.42$	$T_d = T_{dg}$ $= 2004.55$ [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)		$V_{dy} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$ $= \frac{2 \times 315 \times 14.0 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 1157.32$ [Ref. IS 800:2007, Cl.10.4.3]	
Allowable Shear Capacity (kN)	$V = 30.0$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 1157.32$ $= 694.39$ [Limited to low shear]	**Pass**
Web Plate Shear Capacity (kN)	$V_u = 40.0$	$V_d = S_c$ $= 694.39$ [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 14:53:53 - Osdag - WARNING - The defined factored load(s) are less than the minimum recommended value [Cl.10.7, IS 800:2007]

2021-02-04 14:53:53 - Osdag - INFO - The load values have been set as per the minimum recommendations of Cl.10.7, IS 800:2007

2021-02-04 14:53:53 - Osdag - INFO - : Overall Column Cover Plate Welded member design is SAFE

2021-02-04 14:53:53 - Osdag - INFO - : ==========End of Design==========