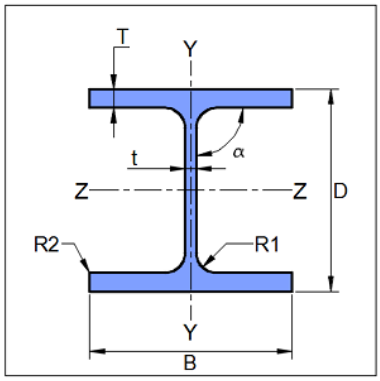
Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Column-Column Cover Plate Bolted
Designer	Engineer #1	Job Number	1.2.3.1.2
Date	18 /12 /2020	Client	Pradyumna M, Independent Consultant, Bengaluru

1 Input Parameters

Module			Column Cover Plate - Bolted	
Main Module			Moment Connection	
Bending Moment (kNm)			60.0	
Shear Force (kN)			40.0	
Axial Force (kN)			520.0	
Column Section - Mechanical Properties				
	Beam Section *		PBP 400 X 176.1	
	Material		E 300 (Fe 440)	
	Ultimate Strength, Fu (MPa)		440	
	Yield Strength, Fy (MPa)		290	
	Mass, m (kg/m)	176.1	I_z (cm^4)	51700.0
	Area, A (cm^2)	224.0	I_y(cm^4)	20700.0
	D (mm)	360.0	r_z (cm)	15.2
	B (mm)	396.0	r_y (cm)	9.6
	t (mm)	20.0	Z_z (cm^3)	2870.0
	T (mm)	20	Z_y (cm^3)	1040.0
	Flange Slope	90	Z_{pz} (cm^3)	3230.0
	R_1 (mm)	15.0	Z_{py} (cm^3)	1600.0
	R_2 (mm)	0.0		
Bolt Details - Input and Design Preference				
Diameter (mm)			[24]	
Property Class			[8.8]	
Type			Friction Grip Bolt	
Bolt Tension			Pre-tensioned	
Hole Type			Standard	
Slip Factor, (mu_f)			0.52	
Detailing - Design Preference				
Edge Preparation Method			Rolled, machine-flame cut, sawn and planed	
Gap Between Columns (mm)			0.0	
Are the Members Exposed to Corrosive Influences?			True	
Plate Details - Input and Design Preference				
Preference			Outside	

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Material	E 300 (Fe 440)
Ultimate Strength, Fu (MPa)	440
Yield Strength, Fy (MPa)	290
Thickness (mm)	[16]

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2 Design Checks

Design Status	Fail

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)	$P_x = 520.0$	$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $= \frac{22400.0 \times 290}{1.1 \times 10^3}$ $= 5905.45$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.2]$	
Shear Capacity Member (kN)		$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{320.0 \times 20.0 \times 290}{\sqrt{3} \times 1.1 \times 1000}$ $= 974.15$ $[Ref. IS\ 800:2007, Cl.10.4.3]$	
Allowable Shear Capacity (kN)	$V_y = 40.0$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 974.15$ $= 584.49$ $[Limited\ to\ low\ shear]$	Pass
Plastic Moment Capacity (kNm)		$M_{dzz} = \frac{\beta_b \times Z_p \times fy}{\gamma_{mo} \times 10^6}$ $= \frac{0.89 \times 3230000.0 \times 290}{1.1 \times 10^6}$ $= 756.64$ $[Ref.\ IS\ 800:2007,\ Cl.\ 8.2.1.2]$	

Check	Required	Provided	Remarks
Moment Deformation Criteria (kNm)		$Mdc = \frac{1.5 \times Z_e \times fy}{1.1 \times 10^6}$ $= \frac{1.5 \times 2870000.0 \times 290}{1.1 \times 10^6}$ $= 1134.95$ [$Ref.\ IS\ 800:2007,\ Cl.\ 8.2.1.2$]	
Moment Capacity Member (kNm)	$M_z = 60.0$	$M_{dzz} = min(M_{dzz}, Mdc)$ $= min(756.64, 1134.95)$ $= 756.64$ [$Ref.\ IS\ 800:2007,\ Cl.\ 8.2$]	

2.2 Load Consideration

Check	Required	Provided	Remarks
Interaction Ratio		$IR\ axial = P_x/T_{dg}$ $= 520.0/5905.45$ $= 0.0881$ $IR\ moment = M_z/M_{dzz}$ $= 60.0/756.64$ $= 0.0793$ $IR\ sum = IR\ axial + IR\ moment$ $= 0.0881 + 0.0793$ $= 0.1674$	

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Check	Required	Provided	Remarks
Minimum Required Load	*if* $IR\ axial < 0.3\ and\ IR\ moment < 0.5$ $P_{x\,min} = 0.3 \times T_{dg}$ $M_{z\,min} = 0.5 \times M_{dzz}$ *elif* $sum\ IR <= 1.0\ and\ IR\ moment < 0.5$ *if* $(0.5 - IR\ moment) < (1 - sum\ IR)$ $M_{z\,min} = 0.5 \times M_{dzz}$ *else* $M_{z\,min} = M_z + ((1 - sum\ IR) \times M_{dzz})$ $P_{x\,min} = P_x$ *elif* $sum\ IR <= 1.0\ and\ IR\ axial < 0.3$ *if* $(0.3 - IR\ axial) < (1 - sum\ IR)$ $P_{x\,min} = 0.3 \times T_{dg}$ *else* $P_{x\,min} = P_x + ((1 - sum\ IR) \times T_{dg})$ $M_{z\,min} = M_z$ *else* $P_{x\,min} = P_x$ $M_{z\,min} = M_z$ $Note:\ AL =\ User\ Applied\ Load$	$M_{z\,min} = 378.32$ $P_{x\,min} = 1771.64$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.7]$	
Applied Axial Force (kN)	$P_x = 520.0$	$P_u = max(P_x,\ P_{x\,min})$ $= max(520.0, 1771.64)$ $= 1771.64$	

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Check	Required	Provided	Remarks
Applied Shear Force (kN)	$V_y = 40.0$	$V_{y_{min}} = min(0.15 \times V_{dy}, 40.0)$ $= min(0.15 \times 974.15, 40.0)$ $= 40.0$ $V_u = max(V_y,\ V_{y_{min}})$ $= max(40.0, 40.0)$ $= 40.0$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.7]$	
Applied Moment (kNm)	$M_z = 60.0$	$M_u = max(M_z,\ M_{z_{min}})$ $= max(60.0,\ 378.32)$ $= 378.32$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 8.2.1.2]$	
Force Carried by Web		$A_w = Axial\ force\ in\ web$ $= \frac{(D - 2T)\ t\ Au}{A}$ $= \frac{(360.0 - 2 \times 20) \times 20.0 \times 1771.64}{22400.0}$ $= 506.18\ kN$ $M_w = Moment\ in\ web$ $= \frac{Z_w \times Mu}{Z}$ $= \frac{341333.33 \times 378.32}{3230000.0}$ $= 39.98\ kNm$	

Check	Required	Provided	Remarks
Force Carried by Flange		$A_f = Axial\ force\ in\ flange$ $= \frac{Au\ B\ T}{A}$ $= \frac{1771.64 \times 396.0 \times 20}{22400.0}$ $= 626.4\ kN$ $M_f = Moment\ in\ flange$ $= Mu - M_w$ $= 378.32 - 39.98$ $= 338.34\ kNm$ $F_f = flange\ force$ $= \frac{M_f \times 10^3}{D - T} + A_f$ $= \frac{338.34 \times 10^3}{360.0 - 20} + 626.4$ $= 1621.51\ kN$	

2.3 Initial Member Check

Check	Required	Provided	Remarks
Flange Tension Yielding Capacity (kN)	$F_f = 1621.51$	$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $A_g = l \times t = 396.0 \times 20$ $= \frac{7920.0 \times 290}{1.1 \times 10^3}$ $= 2088.0$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 6.2]$	**Pass**

Check	Required	Provided	Remarks
Web Tension Yielding Capacity (kN)	$A_w = 506.18$	$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $A_g = l \times t = 320.0 \times 20.0$ $= \frac{6400.0 \times 290}{1.1 \times 10^3}$ $= 1687$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.2]$	**Pass**

2.4 Initial Flange Plate Height Check

Check	Required	Provided	Remarks
Width (mm)	Bfp >= 50	$B_{fp} = 396.0$	**Pass**

2.5 Flange Plate Thickness

Check	Required	Provided	Remarks
Thickness (mm)	$T = 20$	$t_{fp} = 20.0$	**Fail**

2.6 Initial Web Plate Height Check

Check	Required	Provided	Remarks
Height (mm)	$= 0.6 \times D$ $= 0.6 \times 360.0$ $= 216.0$ $[Ref: INSDAG - Chp\ 5,\ Sect.5.2.3]$	$W_{wp} = D - (2 \times T) - (2 \times R1)$ $= 360.0 - (2 \times 20) - (2 \times 15.0)$ $= 290.0$	**Pass**

2.7 Web Plate Thickness

Check	Required	Provided	Remarks
Thickness (mm)	$t = 10.0$	$t_{wp} = 16.0$	**Pass**
Plate Area Check (mm2)	$pt.area >=$ $connected\ member\ area \times 1.05$ $= 6720.0$ $[Ref : Cl.8.6.3.2\ IS\ 800 : 2007]$	$pt.area = t_{wp} \times 2 \times W_{wp}$ $= 16.0 \times 2 \times 216.0$ $= 6912.0$	**Pass**

3 Design Log

2020-12-18 01:17:22 - Osdag - WARNING - The defined factored load(s) are less than the minimum recommended value [Cl.10.7, IS 800:2007]
2020-12-18 01:17:22 - Osdag - INFO - The load values have been set as per the minimum recommendations of Cl.10.7, IS 800:2007
2020-12-18 01:17:22 - Osdag - WARNING - : Area of the Flange Plate is less than the area of the flange
2020-12-18 01:17:22 - Osdag - INFO - : Area of the Flange Plate should be greater than 1.05 times the area of the flange, 8316.0 mm2
2020-12-18 01:17:22 - Osdag - INFO - : Increase the thickness of the Flange Plate
2020-12-18 01:17:22 - Osdag - ERROR - : Design is UNSAFE