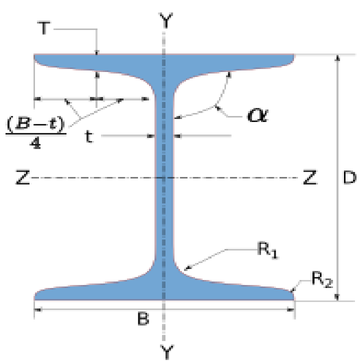
		Created with Osdag®	
Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Column-Column End Plate
Designer	Engineer #1	Job Number	1.2.3.3.1.1
Date	18 /12 /2020	Client	Meera Raghunandan, Professor, IIT Bombay

1 Input Parameters

Module	Column End Plate
Main Module	Moment Connection
Bending Moment (kNm)	0.0
Shear Force (kN)	0.0
Axial Force (kN)	350.0

Column Section - Mechanical Properties



Beam Section *		HB 250	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, Fu (MPa)		410	
Yield Strength, Fy (MPa)		250	
Mass, m (kg/m)	50.98	I_z (cm^4)	7730.0
Area, A (cm^2)	64.9	I_y(cm^4)	1960.0
D (mm)	250.0	r_z (cm)	10.9
B (mm)	250.0	r_y (cm)	5.49
t (mm)	6.9	Z_z (cm^3)	619.0
T (mm)	9.7	Z_y (cm^3)	156.0
Flange Slope	94	Z_{pz} (cm^3)	678.0
R_1 (mm)	10.0	Z_{py} (cm^3)	262.0
R_2 (mm)	5.0		

Bolt Details - Input and Design Preference	
Diameter (mm)	[24, 30]
Property Class	[8.8, 9.8, 10.9, 12.9]
Type	Bearing Bolt
Bolt Tension	Non pre-tensioned
Hole Type	Standard
Slip Factor, (mu_f)	0.3
Detailing - Design Preference	
Edge Preparation Method	Rolled, machine-flame cut, sawn and planed
Are the Members Exposed to Corrosive Influences?	False

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)	350	$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $= \frac{6490.0 \times 250}{1.1 \times 10^3}$ $= 1475.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.2]$	Pass
Shear Capacity Member (kN)	0	$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{230.6 \times 6.9 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 208.78$ $[Ref. IS\ 800:2007, Cl.10.4.3]$	
Plastic Moment Capacity (kNm)		$M_{dzz} = \frac{\beta_b \times Z_p \times fy}{\gamma_{mo} \times 10^6}$ $= \frac{0.91 \times 678000.0 \times 250}{1.1 \times 10^6}$ $= 140.68$ $[Ref.\ IS\ 800:2007,\ Cl.\ 8.2.1.2]$	
Moment Deformation Criteria (kNm)		$Mdc = \frac{1.5 \times Z_e \times fy}{1.1 \times 10^6}$ $= \frac{1.5 \times 619000.0 \times 250}{1.1 \times 10^6}$ $= 211.02$ $[Ref.\ IS\ 800:2007,\ Cl.\ 8.2.1.2]$	

Check	Required	Provided	Remarks
Moment Capacity Member (kNm)	0	$M_{dzz} = min(M_{dzz}, Mdc)$ $= min(140.68, 211.02)$ $= 140.68$ $[Ref.\ IS\ 800:2007,\ Cl.\ 8.2]$	

2.2 Load Consideration

Check	Required	Provided	Remarks
Interaction Ratio		$IR\ axial = P_x/T_{dg}$ $= 350.0/1475.0$ $= 0.24$ $IR\ moment = M_z/M_{dzz}$ $= 0.0/140.68$ $= 0.0$ $IR\ sum = IR\ axial + IR\ moment$ $= 0.24 + 0.0$ $= 0.24$	

Check	Required	Provided	Remarks
Minimum Required Load	$if\ \ IR\ axial < 0.3\ and\ IR\ moment < 0.5$ $P_{x\,min} = 0.3 \times T_{dg}$ $M_{z\,min} = 0.5 \times M_{dzz}$ $elif\ \ sum\ IR <= 1.0\ and\ IR\ moment < 0.5$ $if\ \ (0.5 - IR\ moment) < (1 - sum\ IR)$ $M_{z\,min} = 0.5 \times M_{dzz}$ $else$ $M_{z\,min} = M_z + ((1 - sum\ IR) \times M_{dzz})$ $P_{x\,min} = P_x$ $elif\ \ sum\ IR <= 1.0\ and\ IR\ axial < 0.3$ $if\ \ (0.3 - IR\ axial) < (1 - sum\ IR)$ $P_{x\,min} = 0.3 \times T_{dg}$ $else$ $P_{x\,min} = P_x + ((1 - sum\ IR) \times T_{dg})$ $M_{z\,min} = M_z$ $else$ $P_{x\,min} = P_x$ $M_{z\,min} = M_z$ $Note:\ AL =\ User\ Applied\ Load$	$M_{z\,min} = 70.34$ $P_{x\,min} = 442.5$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.7]$	
Applied Axial Force (kN)	350.0	$P_u = max(P_x,\ P_{x\,min})$ $= max(350.0, 442.5)$ $= 442.5$	

Check	Required	Provided	Remarks
Applied Shear Force (kN)	0.0	$V_{y_{min}} = min(0.15 \times V_{dy}, 40.0)$ $= min(0.15 \times 347.97, 40.0)$ $= 40.0$ $V_u = max(V_y,\ V_{y_{min}})$ $= max(0.0, 40.0)$ $= 40.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.7]$	
Applied Moment (kNm)	0.0	$M_u = max(M_z,\ M_{z_{min}})$ $= max(0.0,\ 70.34)$ $= 70.34$ $[Ref.\ IS\ 800:2007,\ Cl.\ 8.2.1.2]$	

2.3 Bolt Check

Check	Required	Provided	Remarks
Diameter (mm)	Bolt Quantity Optimization	$d = 30.0$	
Property Class	Bolt Grade Optimization	8.8	
Hole Diameter (mm)		$d_0 = 33.0$	
No. of Bolts (along one side of the web) (n)	$n_{bw} = 2 \times (\frac{D - (2 \times T_f) - (2 \times e)}{p} + 1)$ $= 2 \times (\frac{250.0 - (2 \times 9.7) - (2 \times 50)}{75.0} + 1)$ $= 4$	4	**Pass**
No. of Bolts (along one side of the flange overhang) (n)	$n_{bf} = 2 \times (\frac{b/2 - (T_w/2) - (2 \times e)}{p} + 1)$ $= 2 \times (\frac{250.0/2 - (0.5 \times 6.9) - (2 \times 50)}{75.0} + 1)$ $= 2$	2	**Pass**
Total No. of Bolts		4	

Check	Required	Provided	Remarks
Shear Capacity (kN)		$V_{dsb} = \frac{f_{ub}\ n_n\ A_{nb}}{\sqrt{3}\ \gamma_{mb}}$ $= \frac{830.0 \times 1 \times 561}{1000 \times \sqrt{3}\ \times\ 1.25}$ $= 215.07$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3]$	
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5\ k_b\ d\ t\ f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.51 \times 30.0 \times 56.0 \times 410}{1000 \times 1.25}$ $= 702.58$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.4]$	
Capacity (kN)	$V_{sb} = \frac{V}{n_{wb}}$ $= \frac{40.0}{4}$ $= 10.0$	$V_{db} = min\ (V_{dsb}, V_{dpb})$ $= min\ (215.07, 702.58)$ $= 215.07$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.2]$	**Pass**
Tension due to Moment and Axial Force (kN)	$T_1 = \frac{P}{n} + \frac{M \times y_{max}}{y_{sqr}}$ $= \frac{442.5 \times 10^3}{4} + \frac{70340.91 \times 10^6 \times 185.45}{74800.45}$ $= 285.02$		

Check	Required	Provided	Remarks
Prying force (kN)	$Q = \frac{l_v}{2 \times l_e}\left[T_e - \frac{\beta \times \eta \times f_o \times b_e \times t^4}{27 \times l_e \times l_v^2}\right]$ $l_v = e \; - \; t_w$ $= 50 \; - \; 0 = 50 \; mm$ $f_o = 0.7 \times f_{ub}$ $= 0.7 \times 830.0$ $= 581.0 \; N/mm^2$ $l_e = min\left(e, 1.1 \; t \; \sqrt{\frac{\beta \; f_o}{f_y}}\right)$ $= min\left(50, 1.1 \times 56.0 \times \sqrt{\frac{2 \times 581.0}{250}}\right)$ $= min(50, 93.91) = 50 \; mm$ $\beta = 2 \; (non \; pre-tensioned \; bolt)$ $\eta = 1.5$ $b_e = \frac{B}{n_c}$ $= \frac{250.0}{2} = 125.0 \; mm$ $Q = \frac{50}{2 \times 50} \times$ $\left[285.02 - \left(\frac{2 \times 1.5 \times 581.0 \times 125.0 \times 56.0^4}{27 \times 50 \times 50^2}\right) \times 10^{-3}\right]$ $Q = 0.0$ $Note: The \; end \; plate \; is \; sufficiently \; thick \; to$ $prevent \; yielding \; of \; the \; plate. \; Thus, \; Q \; = \; 0$ $[Ref. \; IS \; 800:2007, \; Cl. \; 10.4.7]$		**OK**

Check	Required	Provided	Remarks
Tension demand (kN)	$T_b = T_1 + Q$ $= 285 + 0$ $= 285.02$	$T_{db} = 0.90\ f_{ub}\ A_n\ /\ \gamma_{mb}$ $<\ f_{yb}\ A_{sb}\ (\gamma_{mb}\ /\ \gamma_{m0})$ $= min\Big(0.90\ \times 830.0 \times 561\ /\ 1.25,$ $660.0 \times 707.0 \times (1.25/1.1)\Big)$ $= min(335.25,\ 530.25)$ $= 335.25$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.5]$	**Pass**
Min. Pitch Distance (mm)	$p_{min} = 2.5\ d$ $= 2.5 \times 30.0$ $= 75.0$ $[Ref\ IS\ 800:2007,\ Cl.\ 10.2.2]$	75.0	**Pass**
Max. Pitch Distance (mm)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 56.0,\ 300\ mm)$ $= \min(1792.0,\ 300\ mm)$ $= 300$ $Where,\ t = min(56.0, 56.0)$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.3]$	75.0	**Pass**
Min. End Distance (mm)	$e_{min} = 1.5\ d_0$ $= 1.5 \times 33.0$ $= 49.5$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2]$	50	**Pass**

Check	Required	Provided	Remarks
Max. End Distance (mm)	$e_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 56.0 \times \sqrt{\frac{250}{250}} = 672.0$ $e_2 = 12 \times 56.0 \times \sqrt{\frac{250}{250}} = 672.0$ $e_{max} = min(e_1, e_2) = 672.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3]$	50	Pass

2.4 End Plate Checks

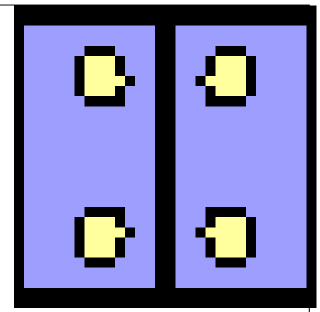
Check	Required	Provided	Remarks
Min. Plate Length (mm)	250.0	250.0	Pass
Min. Plate Height (mm)	250.0	250.0	Pass
Min. Plate Thickness (mm)	$t_p = max\left(\sqrt{\frac{4M_{cr}}{b_{eff}(f_y/\gamma_{m0})}},\ \sqrt[4]{\left(T_1 - \frac{2Ql_e}{l_v}\right) \times \left(\frac{27l_el_v^2}{\beta\eta f_o b_e}\right)}\right)$ $= max\left(\sqrt{\frac{4 \times 10.72 \times 10^6}{75 \times (250/1.1)}},\ \sqrt[4]{\left(285018.62 - \frac{2 \times 0 \times 50}{50}\right) \times \left(\frac{27 \times 50 \times 50^2}{2 \times 1.5 \times 581.0 \times 125.0}\right)}\right)$ $= 56.0$	56.0	
Moment Capacity (kNm)	$M_{ep} = max(0.5 \times Tension\ in\ First\ Bolt \times End\ dist, Tension\ in\ Second\ Bolt \times End\ dist)$ $= max(0.5 \times T_b1 \times e, T_b2 \times e)$ $= max(0.5 \times 285018.62 \times 50, 214490.06 \times 50$ $= 10.72$	$M_{dp} = \frac{b_{eff}\ t_p^2\ f_y}{4\ \gamma_{m0}}$ $= \frac{75.0 \times 56.0^2 \times 250}{4 \times 1.1}$ $= 13.36$	Pass

2.5 Bolt Checks

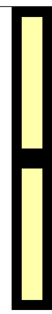
Check	Required	Provided	Remarks
Diameter (mm)	Bolt Quantity Optimisation	The number of bolts for given bolt size(s) are not sufficient to cater for the given section and loads combination.	

3 3D Views

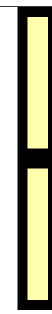
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log

2020-12-18 01:25:54 - Osdag - INFO - The Load(s) defined is/are less than the minimum recommended value [Ref. IS 800:2007, Cl.10.7].

2020-12-18 01:25:54 - Osdag - INFO - The value of load(s) is/are set at minimum recommended value as per IS 800:2007, Cl.10.7.
2020-12-18 01:25:54 - Osdag - INFO - : Overall Column End Plate connection design is SAFE
2020-12-18 01:25:54 - Osdag - INFO - :=========End Of design===========