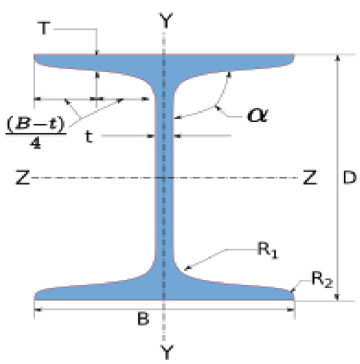
		Created with Osdag®	
Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Column-Column End Plate
Designer	Engineer #1	Job Number	1.2.3.3.2.1
Date	18 /12 /2020	Client	Manas M. Ghosh, INSDAG, Kolkata

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 over-hang) (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		8	

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)		$V_{dpb} = \frac{2.5\ k_b\ d\ t\ f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.51 \times 30.0 \times 45.0 \times 410}{1000 \times 1.25}$ $= 564.57$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.4]$	
Capacity (kN)	$V_{sb} = \frac{V}{n_{wb}}$ $= \frac{40.0}{4}$ $= 5.0$	$V_{db} = min\ (V_{dsb}, V_{dpb})$ $= min\ (215.07, 564.57)$ $= 215.07$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.2]$	**Pass**
Tension due to Moment and Axial Force (kN)	$T_1 = \frac{P}{n} + \frac{M \times y_{max}}{y_{sqr}}$ $= \frac{442.5 \times 10^3}{8} + \frac{70340.91 \times 10^6 \times 295.15}{249027.49}$ $= 138.68$		

Check	Required	Provided	Remarks
Prying force (kN)	$Q = \frac{l_v}{2 \times l_e}\left[T_e - \frac{\beta \times \eta \times f_o \times b_e \times t^4}{27 \times l_e \times l_v^2}\right]$ $l_v = e\ -\ t_w$ $= 50\ -\ 0 = 50\ mm$ $f_o = 0.7 \times f_{ub}$ $= 0.7 \times 830.0$ $= 581.0\ N/mm^2$ $l_e = min\left(e, 1.1\ t\ \sqrt{\frac{\beta\ f_o}{f_y}}\right)$ $= min\left(50, 1.1 \times 45.0 \times \sqrt{\frac{2 \times 581.0}{250}}\right)$ $= min(50, 75.46) = 50\ mm$ $\beta = 2\ (non\ pre-tensioned\ bolt)$ $\eta = 1.5$ $b_e = \frac{B}{n_c}$ $= \frac{250.0}{2} = 125.0\ mm$ $Q = \frac{50}{2 \times 50} \times$ $\left[138.68 - \left(\frac{2 \times 1.5 \times 581.0 \times 125.0 \times 45.0^4}{27 \times 50 \times 50^2}\right) \times 10^{-3}\right]$ $Q = 6.55$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.4.7]$		**OK**

Check	Required	Provided	Remarks
Tension demand (kN)	$T_b = T_1 + Q$ $= 139 + 6.55$ $= 145.23$	$T_{db} = 0.90\ f_{ub}\ A_n\ /\ \gamma_{mb}$ $<\ f_{yb}\ A_{sb}\ (\gamma_{mb}\ /\ \gamma_{m0})$ $= min\Big(0.90\ \times 830.0 \times 561\ /\ 1.25,$ $660.0 \times 707.0 \times (1.25/1.1)\Big)$ $= min(335.25,\ 530.25)$ $= 335.25$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.5]$	**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)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 45.0,\ 300\ mm)$ $= \min(1440.0,\ 300\ mm)$ $= 300$ $Where,\ t = min(45.0, 45.0)$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.3]$	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)	$e_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 45.0 \times \sqrt{\frac{250}{250}} = 540.0$ $e_2 = 12 \times 45.0 \times \sqrt{\frac{250}{250}} = 540.0$ $e_{max} = min(e_1, e_2) = 540.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3]$	50	**Pass**

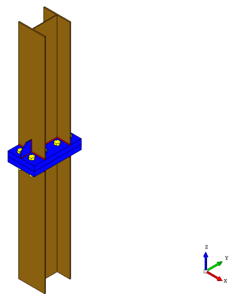
2.4 End Plate Checks

Check	Required	Provided	Remarks
Min. Plate Length (mm)	$D + 4e$ $= 250.0 + 4 \times 50$ $= 450.0$	450.0	**Pass**
Min. Plate Height (mm)	250.0	250.0	**Pass**
Min. Plate Thickness (mm)	$t_p = max\left(\sqrt{\frac{4M_{cr}}{b_{eff}(f_y/\gamma_{m0})}}, \sqrt[4]{\left(T_1 - \frac{2Ql_e}{l_v}\right) \times \left(\frac{27l_el_v^2}{\beta\eta f_o b_e}\right)}\right)$ $= max\left(\sqrt{\frac{4 \times 6.93 \times 10^6}{75 \times (250/1.1)}}, \sqrt[4]{\left(138681.28 - \frac{2 \times 6.55 \times 50}{50}\right) \times \left(\frac{27 \times 50 \times 50^2}{2 \times 1.5 \times 581.0 \times 125.0}\right)}\right)$ $= 45.0$	45.0	
Moment Capacity (kNm)	$M_{ep} = Tension\ in\ Bolt \times End\ dist$ $= T_b \times e$ $= 138681.28 \times 50$ $= 6.93$	$M_{dp} = \frac{b_{eff}\ t_p^2\ f_y}{4\ \gamma_{m0}}$ $= \frac{75.0 \times 45.0^2 \times 250}{4 \times 1.1}$ $= 8.63$	**Pass**

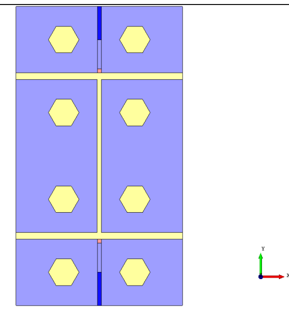
2.5 Stiffener Details

Check	Required	Provided	Remarks
Height (mm)	$h_s = 14\ ts$ $= 100$	100	
Width (mm)	$w_s = 2\ e$ $= 2 \times 50$ $= 100$	100	
Thickness (mm)		6	
Type		Groove Weld	
Weld Between Stiffener and End plate		Groove Weld	

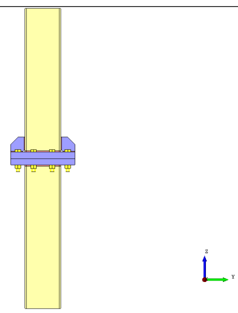
3 3D Views



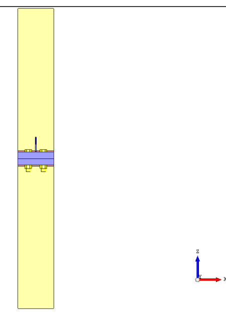
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log

2020-12-18 01:32:02 - Osdag - INFO - The Load(s) defined is/are less than the minimum recommended value [Ref. IS 800:2007, Cl.10.7].

2020-12-18 01:32:02 - 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 01:32:02 - Osdag - INFO - : Overall Column End Plate connection design is SAFE
2020-12-18 01:32:02 - Osdag - INFO - :=========End Of design===========