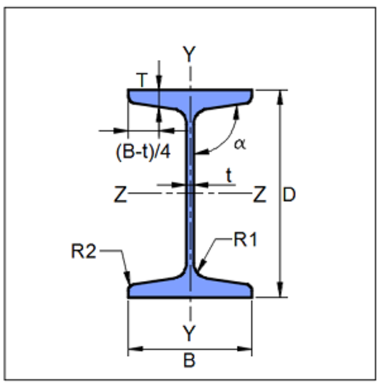
	Created with Osdag®

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Cover Plate Welded
Designer	Engineer #1	Job Number	1.2.1.3.2
Date	18 /12 /2020	Client	Meera Raghunandan, Professor, IIT Bombay

1 Input Parameters

Module	Beam Cover Plate - Welded
Main Module	Moment Connection
Bending Moment (kNm)	150.0
Shear Force (kN)	80.0
Axial Force (kN)	0.0

Beam Section - Mechanical Properties



Beam Section		WB 400	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, f_u (MPa)		410	
Yield Strength, f_y (MPa)		250	
Mass, m (kg/m)	66.71	I_z (cm^4)	23400.0
Area, A (cm^2)	8500.0	I_y(cm^4)	1380.0
D (mm)	400.0	r_z (cm)	16.6
B (mm)	200.0	r_y (cm)	4.04
t (mm)	8.6	Z_z (cm^3)	1170.0
T (mm)	13.0	Z_y (cm^3)	138.0
Flange Slope	96	Z_{pz} (cm^3)	1320.0
R_1 (mm)	13.0	Z_{py} (cm^3)	234.0
R_2 (mm)	6.5		

Weld Details - Input and Design Preference

Weld Type	Fillet
Type of Weld Fabrication	Shop Weld
Material Grade Overwrite, Fu (MPa)	450.0

Plate Details - Input and Design Preference

Preference	Outside
Ultimate Strength, Fu (MPa)	440
Yield Strength, Fy (MPa)	300
Material	E 300 (Fe 440)
Thickness (mm)	[12]

2 Design Checks

Design Status	**Pass**

2.1 Member Capacity

Check	Required	Provided	Remarks
Section Classification		$Plastic$ $[Ref: Table\ 2, Cl.3.7.2\ and\ 3.7.4\ IS\ 800:2007]$	
Axial Capacity Member (kN)	$P_x = 0.0$	$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $= \frac{8500.0 \times 250}{1.1 \times 10^3}$ $= 1931.82$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.2]$	
Shear Capacity Member (kN)		$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{374.0 \times 8.6 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 422.04$ $[Ref. IS\ 800:2007, Cl.10.4.3]$	
Allowable Shear Capacity (kN)	$V_y = 80.0$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 422.04$ $= 253.23$ $[Limited\ to\ low\ shear]$	Pass
Plastic Moment Capacity (kNm)		$M_{dzz} = \frac{\beta_b \times Z_p \times fy}{\gamma_{mo} \times 10^6}$ $= \frac{1 \times 1320000.0 \times 250}{1.1 \times 10^6}$ $= 300.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 8.2.1.2]$	

Check	Required	Provided	Remarks
Moment Deformation Criteria (kNm)		$Mdc = \frac{1.5 \times Z_e \times fy}{1.1 \times 10^6}$ $= \frac{1.5 \times 1170000.0 \times 250}{1.1 \times 10^6}$ $= 398.86$ [$Ref.\ IS$ 800 : 2007, $Cl.$ 8.2.1.2]	
Moment Capacity Member (kNm)	$M_z = 150.0$	$M_{dzz} = min(M_{dzz}, Mdc)$ $= min(300.0, 398.86)$ $= 300.0$ [$Ref.\ IS$ 800 : 2007, $Cl.$ 8.2]	

2.2 Load Consideration

Check	Required	Provided	Remarks
Interaction Ratio		$IR\ axial = P_x/T_{dg}$ $= 0.0/1931.82$ $= 0.0$ $IR\ moment = M_z/M_{dzz}$ $= 150.0/300.0$ $= 0.5$ $IR\ sum = IR\ axial + IR\ moment$ $= 0.0 + 0.5$ $= 0.5$	

Check	Required	Provided	Remarks
Minimum Required Load	$if\ \ IR\ axial < 0.3\ and\ IR\ moment < 0.5$ $P_{x\,min} = 0.3 \times T_{dg}$ $M_{z\,min} = 0.5 \times M_{dzz}$ $elif\ \ sum\ IR <= 1.0\ and\ IR\ moment < 0.5$ $if\ \ (0.5 - IR\ moment) < (1 - sum\ IR)$ $M_{z\,min} = 0.5 \times M_{dzz}$ $else$ $M_{z\,min} = M_z + ((1 - sum\ IR) \times M_{dzz})$ $P_{x\,min} = P_x$ $elif\ \ sum\ IR <= 1.0\ and\ IR\ axial < 0.3$ $if\ \ (0.3 - IR\ axial) < (1 - sum\ IR)$ $P_{x\,min} = 0.3 \times T_{dg}$ $else$ $P_{x\,min} = P_x + ((1 - sum\ IR) \times T_{dg})$ $M_{z\,min} = M_z$ $else$ $P_{x\,min} = P_x$ $M_{z\,min} = M_z$ $Note:\ \ AL =\ \ User\ Applied\ Load$	$M_{z\,min} = 150.0$ $P_{x\,min} = 579.55$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.7]$	
Applied Axial Force (kN)	$P_x = 0.0$	$P_u = max(P_x,\ P_{x\,min})$ $= max(0.0, 579.55)$ $= 579.55$	

Check	Required	Provided	Remarks
Applied Shear Force (kN)	$V_y = 80.0$	$V_{y_{min}} = min(0.15 \times V_{dy}, 40.0)$ $= min(0.15 \times 422.04, 40.0)$ $= 40.0$ $V_u = max(V_y,\ V_{y_{min}})$ $= max(80.0, 40.0)$ $= 80.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.7]$	
Applied Moment (kNm)	$M_z = 150.0$	$M_u = max(M_z,\ M_{z_{min}})$ $= max(150.0,\ 150.0)$ $= 150.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 8.2.1.2]$	
Force Carried by Web		$A_w = Axial\ force\ in\ web$ $= \frac{(D-2T)\ t\ Au}{A}$ $= \frac{(400.0 - 2 \times 13.0) \times 8.6 \times 579.55}{8500.0}$ $= 219.3\ kN$ $M_w = Moment\ in\ web$ $= \frac{Z_w \times Mu}{Z}$ $= \frac{300733.4 \times 150.0}{1320000.0}$ $= 34.17\ kNm$	

Check	Required	Provided	Remarks
Force Carried by Flange		$A_f = Axial\ force\ in\ flange$ $= \frac{Au\ B\ T}{A}$ $= \frac{579.55 \times 200.0 \times 13.0}{8500.0}$ $= 177.27\ kN$ $M_f = Moment\ in\ flange$ $= Mu - M_w$ $= 150.0 - 34.17$ $= 115.83\ kNm$ $F_f = flange\ force$ $= \frac{M_f \times 10^3}{D - T} + A_f$ $= \frac{115.83 \times 10^3}{400.0 - 13.0} + 177.27$ $= 476.56\ kN$	

2.3 Flange Weld Design

Check	Required	Provided	Remarks
Min. Flange Plate Thickness (mm)	$T = 13.0$	$t_{fp} = 18.0$	**Pass**
Min. Weld Size (mm)	$t_{w_{min}}\ based\ on\ thinner\ part$ $= 13\ or\ 13$ $s_{min}\ based\ on\ thicker\ part = 5$ $[Ref\ IS\ 800:2007, Table\ 21\ (Cl 10.5.2.3)]$	$t_w = 11$	**Pass**
Max. Weld Size (mm)	$Thickness\ of\ thinner\ part$ $= min(13.0, 18.0) = 13.0$ $s_{max} = 13.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.3.1]$	$t_w = 11$	**Pass**

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)		$l_{eff} = (2 \times l_w) + B_{fp} - 2 \times t_w$ $= (2 \times 200) + 165 - 2 \times 11$ $= 545$	
Flange Weld Strength (N/mm)	$Stress = \frac{F_f \times 10^3}{l_{eff}}$ $= \frac{476.56 \times 10^3}{545}$ $= 872.83$	$f_w = \frac{t_t\ f_u}{\sqrt{3}\ \gamma_{mw}}$ $= \frac{7.7 \times 410}{\sqrt{3} \times 1.25}$ $= 1458.16$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.1.1]$	**Pass**
Weld Strength (post long joint) (N/mm)	$if\ l \geq 150 t_t\ then\ V_{rd} = \beta_{l_w} V_{db}$ $if\ l < 150 t_t\ then\ V_{rd} = V_{db}$ $where,$ $l\ = pt.length\ or\ pt.height$ $\beta_{l_w} = 1.2 - \frac{(0.2 l)}{(150 t_t)}$ $but\ 0.6 \leq \beta_{l_w} \leq 1.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.3]$	$l\ = pt.length\ or\ pt.height$ $l_l = 2(200 + (2 \times 11)) + 8.0$ $= 452.0$ $l_h = 165$ $l\ = 452.0$ $150 \times t_t = 150 \times 7.7 = 1155.0$ $since,\ l < 150 \times t_t$ $then\ V_{rd} = V_{db}$ $V_{rd} = 1458.16$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.3]$	
Weld Strength (N/mm)	872.83	1458.16	**Pass**

2.4 Flange Plate Dimension Check - Outside

Check	Required	Provided	Remarks
Min. Flange Plate Width (mm)	50	$B_{fp} = B - 2sp$ $= 200.0 - 2 \times 16$ $= 165$	Pass
Max. Flange Plate Width (mm)	$B_{fp} = B - 2sp$ $= 200.0 - 2 \times 16$ $= 165$	165	Pass
Min. Flange Plate Length (mm)	400.0	$L_{fp} = [2 \times (l_w + 2 \times t_w) + g]$ $= [2 \times (200 + 2 \times 11) + 8.0]$ $= 452.0$	Pass
Min. Flange Plate Thickness (mm)	$T = 13.0$	$t_{fp} = 18.0$	Pass
Plate Area Check (mm2)	$pt.area >=$ $connected\ member\ area \times 1.05$ $= 2730.0$ $[Ref : Cl.8.6.3.2\ IS\ 800 : 2007]$	$pt.area = B_{fp} \times t_{ifp}$ $= 165 \times 18.0$ $= 2970.0$	Pass

2.5 Web Weld Design

Check	Required	Provided	Remarks
Min. Web Plate Thickness (mm)	$t = 4.3$	$t_{wp} = 12.0$	Pass
Min. Weld Size (mm)	$t_{w_{min}}\ based\ on\ thinner\ part$ $= 8\ or\ 8$ $s_{min}\ based\ on\ thicker\ part = 5$ $[Ref\ IS\ 800 : 2007, Table\ 21\ (Cl10.5.2.3)]$	$t_w = 7$	Pass
Max. Weld Size (mm)	$Thickness\ of\ thinner\ part$ $= min(8.6, 12.0) = 8.6$ $s_{max} = 8.6$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.5.3.1]$	$t_w = 7$	Pass

Check	Required	Provided	Remarks
Effective Length (mm)		$l_{eff} = (2 \times l_w) + W_{wp} - 2 \times t_w$ $= (2 \times 100) + 315 - 2 \times 7$ $= 505$	
Clearance (mm)	$sp = max(15, (t_w + 5))$ $= max(15, (7 + 5))$ $= 15$	$sp = 15$	**Pass**
Throat Thickness (mm)	$t_t \geq 3$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.3.1]$	$t_t = 0.7 t_w$ $= 0.7 \times 7$ $= 4.9$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.3.1]$	**Pass**
Moment Demand (kNm)	$M_d = (V_u \times ecc + M_w)$ $ecc = eccentricity$ $M_w = external\ moment\ acting\ on\ web$ $= \frac{(40.0 \times 10^3 \times 80.04 + 17.09 \times 10^6)}{10^6}$ $= 20.29$		

Check	Required	Provided	Remarks
Web Weld Strength (N/mm)	$R_w = \sqrt{(T_{wh} + A_{wh})^2 + (T_{wv} + V_{wv})^2}$ $T_{wh} = \frac{M_d \times y_{max}}{Ipw} = \frac{20288721.81 \times 19.96}{7269690.95}$ $T_{wv} = \frac{M_d \times x_{max}}{Ipw} = \frac{20288721.81 \times 150.5}{7269690.95}$ $V_{wv} = \frac{V_u}{l_{eff}} = \frac{40000.0}{505}$ $A_{wh} = \frac{A_u}{l_{eff}} = \frac{109650.0}{505}$ $R_w = \sqrt{(55.71 + 217.13)^2 + (420.03 + 79.21)^2} = 568.92$	$f_w = \frac{t_t\ f_u}{\sqrt{3}\ \gamma_{mw}} = \frac{4.9 \times 410}{\sqrt{3} \times 1.25} = 927.92$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.1.1]$	**Pass**

Check	Required	Provided	Remarks
Weld Strength (post long joint) (N/mm)	$if\ l \geq 150t_t\ then\ V_{rd} = \beta_{l_w} V_{db}$ $if\ l < 150t_t\ then\ V_{rd} = V_{db}$ $where,$ $l\ = pt.length\ or\ pt.height$ $\beta_{l_w} = 1.2 - \frac{(0.2l)}{(150t_t)}$ $but\ 0.6 \leq \beta_{l_w} \leq 1.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.3]$	$l\ = pt.length\ or\ pt.height$ $l_l = 2(100 + (2 \times 7)) + 8.0$ $= 236.0$ $l_h = 315$ $l\ = 315$ $150 \times t_t = 150 \times 4.9 = 735.0$ $since,\ l < 150 \times t_t$ $then\ V_{rd} = V_{db}$ $V_{rd} = 927.92$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.3]$	
Weld Strength (N/mm)	568.92	927.92	**Pass**

2.6 Web Plate Dimension Check

Check	Required	Provided	Remarks
Min. Web Plate Height (mm)	$= 0.6 \times D$ $= 0.6 \times 400.0$ $= 208.8$ $[Ref: INSDAG - Chp\ 5,$ $Sect.5.2.3]$	$W_{wp} = D - 2T - 2R1 - 2sp$ $= 400.0 - 2 \times 13.0 - (2 \times 13.0) - 2 \times 15$ $= 315$	**Pass**
Min. Web Plate Width (mm)	200.0	$L_{wp} = [2 \times (l_w + 2 \times t_w) + g]$ $= [2 \times (100 + 2 \times 7) + 8.0]$ $= 240$	**Pass**
Min. Web Plate Thickness (mm)	$t = 4.3$	$t_{wp} = 12.0$	**Pass**

Check	Required	Provided	Remarks
Plate Area Check (mm2)	$pt.area >=$ $connected\ member\ area \times 1.05$ $= 3377.22$ $[Ref: Cl.8.6.3.2\ IS\ 800:2007]$	$pt.area = 2 \times W_{wp} \times t_{wp}$ $= 2 \times 315 \times 12.0$ $= 7560.0$	**Pass**

2.7 Member Check

Check	Required	Provided	Remarks
Flange Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $A_g = l \times t = 200.0 \times 13.0$ $= \frac{2600.0 \times 250}{1.1 \times 10^3}$ $= 590.91$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.2]$	
Flange Tension Capacity (kN)	$F_f = 476.56$	$T_d = T_{dg}$ $= 590.91$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.1]$	**Pass**
Web Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $A_g = l \times t = 374.0 \times 8.6$ $= \frac{3216.4 \times 250}{1.1 \times 10^3}$ $= 731.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.2]$	

Check	Required	Provided	Remarks
Web Block Shear Capacity (kN)		$T_{dbl1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{dbl2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = min(T_{db1}, T_{db2}) = 952.8$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.4]$	
Web Tension Capacity (kN)	$A_w = 219.3$	$T_d = min(T_{dg}, T_{dn}, T_{db})$ $= min(731.0, 949.48, 952.8)$ $= 731.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.1]$	**Pass**

2.8 Flange Plate Capacity Checks in Axial-Outside

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $A_g = l \times t = 165 \times 18.0$ $= \frac{2970.0 \times 300}{1.1 \times 10^3}$ $= 810.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.2]$	
Flange Plate Tension Capacity (kN)	$F_f = 476.56$	$T_d = T_{dg}$ $= 810.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.1]$	**Pass**

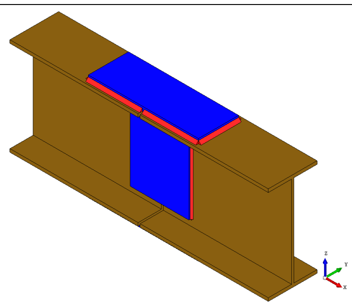
2.9 Web Plate Capacity Check for Axial Load

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $A_g = 2l \times t = 2 \times 315 \times 12.0$ $= \frac{3780.0 \times 300}{1.1 \times 10^3}$ $= 2061.82$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.2]$	
Web Plate Tension Capacity (kN)	$A_w = 219.3$	$T_d = T_{dg}$ $= 2061.82$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.1]$	Pass

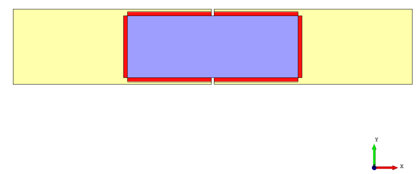
2.10 Web Plate Capacity Check for Shear Load

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)		$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{2 \times 315 \times 12.0 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 1190.39$ $[Ref. IS\ 800:2007, Cl.10.4.3]$	
Allowable Shear Capacity (kN)	$V = 80.0$	$V_d = 0.6\ V_{dy}$ $= 0.6 \times 1190.39$ $= 714.23$ *[Limited to low shear]*	Pass
Web Plate Shear Capacity (kN)	$V_u = 80.0$	$V_d = S_c$ $= 714.23$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.1]$	Pass

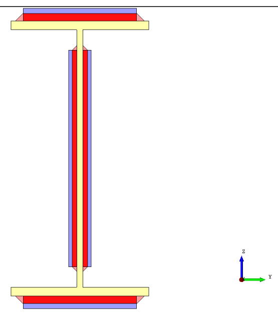
3 3D Views



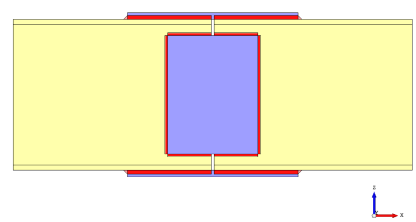
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log

2020-12-18 00:07:04 - Osdag - INFO - The value of axial force is less than the minimum recommended value [Ref. IS 800:2007, Cl.10.7].

2020-12-18 00:07:04 - Osdag - INFO - The value of axial force is set at 579.55 kN.
2020-12-18 00:07:04 - Osdag - INFO - : Overall beam cover plate welded connection design is safe.