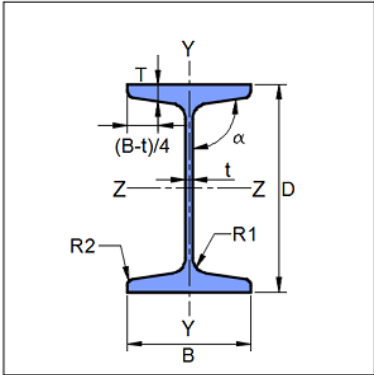




Company Name	IIT Bombay	Project Title	Moment Connection
Group/Team Name	Osdag	Subtitle	Beam-to-Beam Cover Plate (welded)
Designer	Engineer#1	Job Number	1.2.1.3.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

## 1 Input Parameters

Module		Beam-to-Beam Cover Plate Welded Connection		
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 <sup>4</sup> )	23400.0
	Area, $A$ (cm <sup>2</sup> )	8500.0	$I_y$ (cm <sup>4</sup> )	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 <sup>3</sup> )	1170.0
	$T$ (mm)	13.0	$Z_y$ (cm <sup>3</sup> )	138.0
	Flange Slope	96	$Z_{pz}$ (cm <sup>3</sup> )	1320.0
	$R_1$ (mm)	13.0	$Z_{py}$ (cm <sup>3</sup> )	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, $F_u$ (MPa)		450.0		
Plate Details - Input and Design Preference				
Preference		Outside		
Ultimate Strength, $F_u$ (MPa)		440		
Yield Strength, $F_y$ (MPa)		300		
Material		E 300 (Fe 440)		
Thickness (mm)		[12]		



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## 2 Design Checks

Design Status	Pass
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### 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)	$P_x = 0.0$	$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ $= \frac{8500.0 \times 250}{1.1 \times 10^3}$ $= 1931.82$ [Ref. IS 800:2007, Cl.6.2]	
Shear Capacity Member (kN)		$V_{dy} = \frac{A_v f_y}{\sqrt{3} \gamma_{m0}}$ $= \frac{374.0 \times 8.6 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 422.04$ [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)		$M_{dz} = \frac{\beta_b Z_p f_y}{\gamma_{m0} \times 10^6}$ $= \frac{1 \times 1320000.0 \times 250}{1.1 \times 10^6}$ $= 300.0$ [Ref. IS 800:2007, Cl.8.2.1.2]	



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Check	Required	Provided	Remarks
Moment Deformation Criteria (kNm)		$M_{dc} = \frac{1.5Z_e f_y}{\gamma_{m0} \times 10^6}$ $= \frac{1.5 \times 1170000.0 \times 250}{1.1 \times 10^6}$ $= 398.86$ [Ref. IS 800:2007, Cl.8.2.1.2]	
Moment Capacity Member (kNm)	$M_z = 150.0$	$M_{dz} = \min(M_{dz}, M_{dc})$ $= \min(300.0, 398.86)$ $= 300.0$ [Ref. IS 800:2007, Cl.8.2]	

## 2.2 Load Consideration

Check	Required	Provided	Remarks
Interaction Ratio		<p>I.R. axial = <math>P_x / T_{dg}</math></p> $= 0.0 / 1931.82$ $= 0.0$ <p>I.R. moment = <math>M_z / M_{dz}</math></p> $= 150.0 / 300.0$ $= 0.5$ <p>I.R. sum = I.R. axial + I.R. moment</p> $= 0.0 + 0.5$ $= 0.5$	



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Check	Required	Provided	Remarks
Minimum Required Load	<p>if I.R. axial <math>&lt; 0.3</math> and I.R. moment <math>&lt; 0.5</math></p> $P_{x\min} = 0.3T_{dg}$ $M_{z\min} = 0.5M_{dz}$ <p>elif sum I.R. <math>\leq 1.0</math> and I.R. moment <math>&lt; 0.5</math></p> <p>if <math>(0.5 - \text{I.R. moment}) &lt; (1 - \text{sum I.R.})</math></p> $M_{z\min} = 0.5 \times M_{dz}$ <p>else</p> $M_{z\min} = M_z + ((1 - \text{sum I.R.}) \times M_{dz})$ $P_{x\min} = P_x$ <p>elif sum I.R. <math>\leq 1.0</math> and I.R. axial <math>&lt; 0.3</math></p> <p>if <math>(0.3 - \text{I.R. axial}) &lt; (1 - \text{sum I.R.})</math></p> $P_{x\min} = 0.3T_{dg}$ <p>else</p> $P_{x\min} = P_x + ((1 - \text{sum I.R.}) \times T_{dg})$ $M_{z\min} = M_z$ <p>else</p> $P_{x\min} = P_x$ $M_{z\min} = M_z$ <p>Note: AL is the user input for load</p>	$M_{z\min} = 150.0$ $P_{x\min} = 579.55$  [Ref. IS 800:2007, Cl.10.7]	
Applied Axial Force (kN)	$P_x = 0.0$	$P_u = \max(P_x, P_{x\min})$ $= \max(0.0, 579.55)$ $= 579.55$	



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Check	Required	Provided	Remarks
Applied Shear Force (kN)	$V_y = 80.0$	$V_{y\min} = \min(0.15V_{dy}, 40.0)$ $= \min(0.15 \times 422.04, 40.0)$ $= 40.0$ $V_u = \max(V_y, V_{y\min})$ $= \max(80.0, 40.0)$ $= 80.0$ [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		$A_w = \text{Axial force in web}$ $= \frac{(D - 2T)tA_u}{A}$ $= \frac{(400.0 - 2 \times 13.0) \times 8.6 \times 579.55}{8500.0}$ $= 219.3 \text{ kN}$ $M_w = \text{Moment in web}$ $= \frac{Z_w M_u}{Z}$ $= \frac{300733.4 \times 150.0}{1320000.0}$ $= 34.17 \text{ kNm}$	



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

## 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 $= \max(13, 13)$  $s_{\min}$ 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



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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]	$t_t = 0.7t_w$ $= 0.7 \times 11$ $= 7.7$  [Ref. IS 800:2007, Cl.10.5.3.1]	Pass
Effective Length (mm)		$l_{\text{eff}} = (2l_w) + B_{fp} - 2t_w$ $= (2 \times 200) + 165 - 2 \times 11$ $= 545$	
Flange Weld Strength (N/mm)	$\text{Stress} = \frac{F_f \times 10^3}{l_{\text{eff}}}$ $= \frac{476.56 \times 10^3}{545}$ $= 872.83$	$f_w = \frac{t_t f_u}{\sqrt{3} \gamma_{mw}}$ $= \frac{7.7 \times 410}{\sqrt{3} \times 1.25}$ $= 1458.16$  [Ref. IS 800:2007, Cl.10.5.7.1.1]	Pass
Weld Strength (post long joint) (N/mm)	<p>if <math>l \geq 150t_t</math>, then <math>V_{rd} = \beta_{lw} V_{db}</math></p> <p>if <math>l &lt; 150t_t</math>, then <math>V_{rd} = V_{db}</math></p> <p>where,</p> <p><math>l</math> = plate length or height</p> $\beta_{lw} = 1.2 - \frac{(0.2l)}{(150t_t)}$ but, $0.6 \leq \beta_{lw} \leq 1.0$  [Ref. IS 800:2007, Cl.10.5.7.3]	<p><math>l</math> = plate length or height</p> $l_l = 2(200 + (2 \times 11)) + 8.0$ $= 452.0$  $l_h = 165$  $l = 452.0$  $150 \times t_t = 150 \times 7.7 = 1155.0$ 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



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## 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 (mm <sup>2</sup> )	plate area $\geq$ 1.05 X connected member area $= 2730.0$ [Ref: Cl.8.6.3.2, IS 800:2007]	plate 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 $= \max(8, 8)$ $s_{min}$ 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 $= \min(8.6, 12.0) = 8.6$ $s_{max} = 8.6$ [Ref. IS 800:2007, Cl.10.5.3.1]	$t_w = 7$	Pass





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Check	Required	Provided	Remarks
Effective Length (mm)		$l_{\text{eff}} = (2l_w) + W_{wp} - 2t_w$ $= (2 \times 100) + 315 - 2 \times 7$ $= 505$	
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]	$t_t = 0.7t_w$ $= 0.7 \times 7$ $= 4.9$  [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  $= \frac{(40.0 \times 10^3 \times 80.04 + 17.09 \times 10^6)}{10^6}$ $= 20.29$		



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



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

## 2.6 Web Plate Dimension Check

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



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Check	Required	Provided	Remarks
Plate Area Check (mm <sup>2</sup> )	plate area $\geq$ $1.05 \times \text{connected member area}$ $= 3377.22$ [Ref: Cl.8.6.3.2, IS 800:2007]	$\text{plate area} = 2 \times W_{wp} \times t_{wp}$ $= 2 \times 315 \times 12.0$ $= 7560.0$	Pass

## 2.7 Member Check

Check	Required	Provided	Remarks
Flange Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 200.0 \times 13.0$ $= \frac{2600.0 \times 250}{1.1 \times 10^3}$ $= 590.91$ [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)		$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 374.0 \times 8.6$ $= \frac{3216.4 \times 250}{1.1 \times 10^3}$ $= 731.0$ [Ref. IS 800:2007, Cl.6.2]	



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Check	Required	Provided	Remarks
Web Block Shear Capacity (kN)		$T_{dbl1} = \frac{A_{vg}f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9A_{tn}f_u}{\gamma_{m1}}$ $T_{dbl2} = \frac{0.9A_{vn}f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg}f_y}{\gamma_{m0}}$ $T_{db} = \min(T_{db1}, T_{db2}) = 952.8$ [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)		$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = lt = 165 \times 18.0$ $= \frac{2970.0 \times 300}{1.1 \times 10^3}$ $= 810.0$ [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



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## 2.9 Web Plate Capacity Check for Axial Load

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ $A_g = 2lt = 2 \times 315 \times 12.0$ $= \frac{3780.0 \times 300}{1.1 \times 10^3}$ $= 2061.82$ <p>[Ref. IS 800:2007, Cl.6.2]</p>	
Web Plate Tension Capacity (kN)	$A_w = 219.3$	$T_d = T_{dg}$ $= 2061.82$ <p>[Ref.IS 800:2007, Cl.6.1]</p>	Pass

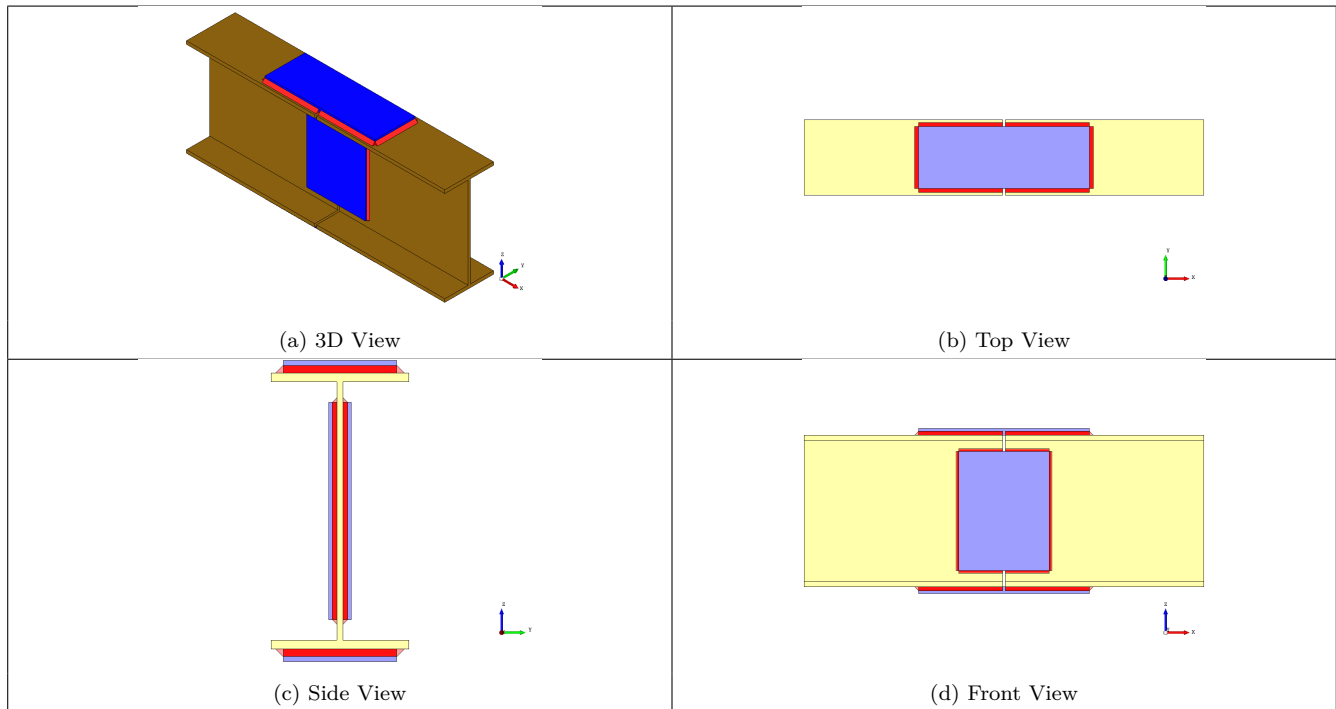
## 2.10 Web Plate Capacity Check for Shear Load

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)		$V_{dy} = \frac{A_v f_y}{\sqrt{3} \gamma_{m0}}$ $= \frac{2 \times 315 \times 12.0 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 1190.39$ <p>[Ref. IS 800:2007, Cl.10.4.3]</p>	
Allowable Shear Capacity (kN)	$V = 80.0$	$V_d = 0.6 V_{dy}$ $= 0.6 \times 1190.39$ $= 714.23$ <p>[Limited to low shear]</p>	Pass
Web Plate Shear Capacity (kN)	$V_u = 80.0$	$V_d = S_c$ $= 714.23$ <p>[Ref. IS 800:2007, Cl.6.1]</p>	Pass



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### 3 3D Views



### 4 Design Log

2021-02-04 13:39:15 - Osdag - INFO - The value of axial force is less than the minimum recommended value [Ref. IS 800:2007, Cl.10.7].

2021-02-04 13:39:15 - Osdag - INFO - The value of axial force is set at 579.55 kN.

2021-02-04 13:39:15 - Osdag - INFO - : Overall beam cover plate welded connection design is safe.

2021-02-04 13:39:15 - Osdag - INFO - :=====End Of design=====