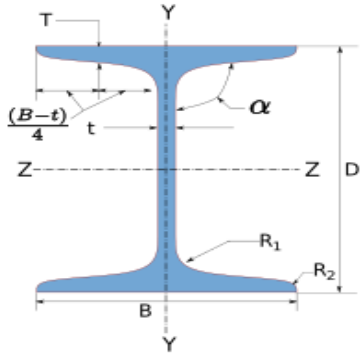


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## 1 Input Parameters

Module		Beam Coverplate Connection		
MainModule		Moment Connection		
Moment(kNm)*		5.0		
Shear (kN)*		62.0		
Axial (kN) *		151.0		
Section				
	Beam Section *		MB 450	
	Preferences		Outside + Inside	
	Material *		E 250 (Fe 410 W)A	
	Ultimate strength, fu (MPa)		410	
	Yield Strength , fy (MPa)	250	R1(mm)	15.0
	Mass	72.4	R2(mm)	7.5
	Area(mm2) - A	9220.0	Iz(mm4)	303580000.0
	D(mm)	450.0	Iy(mm4)	8070000.0
	B(mm)	150.0	rz(mm)	181.0
	t(mm)	9.4	ry(mm)	30.0
	T(mm)	17.4	Zz(mm3)	1349300.0
FlangeSlope	98	Zy(mm3)	108000.0	
Bolt Details				
Diameter (mm)*		[12.0, 16.0, 20.0, 24.0, 30.0, 36.0]		
Grade *		[3.6, 4.6, 4.8, 5.6, 5.8, 6.8, 8.8, 9.8, 10.9, 12.9]		
Type *		Friction Grip Bolt		
Bolt hole type		Standard		
Slip factor (μ_f)		0.3		
Type of edges		a - Sheared or hand flame cut		
Gap between beam and  support (mm)		10.0		
Are the members exposed to  corrosive influences		False		

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## 2 Design Checks

### 2.1 Member Capacity

Check	Required	Provided	Remarks
Axial Capacity Member Ac (kN)		$A_c = \frac{A * f_y}{\gamma_{m0} * 10^3}$ $= \frac{9220.0 * 250}{1.1 * 10^3}$ $= 2095.45$	
Shear Capacity Member Sc (kN)		$S_c = \frac{A_v * f_y}{\sqrt{3} * \gamma_{mo} * 10^3}$ $= \frac{415.2 * 9.4 * 250}{\sqrt{3} * 1.1 * 10^3}$ $= 512.12$	
Plastic Moment Capacity Pmc (kNm)		$Pmc = \frac{\beta_b * Z_p * f_y}{\gamma_{mo} * 10^6}$ $= \frac{1 * 405118.94 * 250}{1.1 * 10^6}$ $= 92.07$	
Moment Deformation Cri- teria Mdc (kNm)		$Mdc = \frac{1.5 * Z_e * f_y}{1.1 * 10^6}$ $= \frac{1.5 * 1349300.0 * 250}{1.1 * 10^6}$ $= 459.99$	
Moment Capacity Mem- ber Mc (kNm)		$M_c = \min(Pmc, Mdc)$ $= \min(92.07, 459.99)$ $= 92.07$	

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## 2.2 Load Consideration

Check	Required	Provided	Remarks
Applied Axial Load $A_u$ (kN)	$A_{c_{min}} = 0.3 * A_c$ $= 0.3 * 2095.45$ $= 628.64$ $A_{c_{max}} = A_c$ $= 2095.45$	$A_u = 628.64$	Pass
Applied Shear Load $V_u$ (kN)	$V_{c_{min}} = 0.6 * S_c$ $= 0.6 * 512.12$ $= 307.27$ $V_{c_{max}} = S_c$ $= 512.12$	$V_u = 307.27$	Pass
Applied Moment Load $M_u$ (kNm)	$M_{c_{min}} = 0.5 * M_c$ $= 0.5 * 92.07$ $= 46.04$ $M_{c_{max}} = M_c$ $= 92.07$	$M_u = 46.04$	Pass
Forces Carried by Web		$A_w = \text{Axial force in web}$ $= \frac{(D - 2 * T) * t * A_u}{A}$ $= \frac{(450.0 - 2 * 17.4) * 9.4 * 628.64}{9220.0}$ $= 266.11 \text{ kN}$ $M_w = \text{Moment in web}$ $= \frac{Z_w * M_u}{Z}$ $= \frac{405118.94 * 46.04}{1551600.0}$ $= 12.02 \text{ kNm}$	
Forces Carried by Flange		$A_f = \text{Axial force in flange}$ $= \frac{A_u * B * T}{A}$ $= \frac{628.64 * 150.0 * 17.4}{9220.0}$ $= 177.95 \text{ kN}$ $M_f = \text{Moment in flange}$ $= M_u - M_w$ $= 46.04 - 12.02$ $= 34.02 \text{ kNm}$ $F_f = \text{flange force}$ $= \frac{M_f * 10^3}{D - T} + A_f$ $= \frac{34.02 * 10^3}{450.0 - 17.4} + 177.95$ $= 256.59 \text{ kN}$	

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### 2.3 Initial Member Check

Check	Required	Provided	Remarks
Flange Tension Yielding Capacity (kN)	$F_f = 256.59$	$T_{dg} = \frac{l * t * f_y}{\gamma_{mo}}$ $= \frac{1 * 150.0 * 17.4 * 250}{1.1}$ $= 593.18$	Pass
Web Tension Yield- ing Capacity (kN)	$A_w = 266.11$	$T_{dg} = \frac{l * t * f_y}{\gamma_{mo}}$ $= \frac{1 * 415.2 * 9.4 * 250}{1.1}$ $= 887$	Pass

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## 2.4 Initial flange plate height check

Check	Required	Provided	Remarks
flange_plate.Height	Outer.b >= 50	$Outer.b = 150.0$	Pass
flange_plate.InnerHeight	Inner.b >= 50	$inner.b = \frac{B - t - (2 * r_1)}{2}$ $= \frac{150.0 - 9.4 - (2 * 15.0)}{2}$ $= 55.3$	Pass

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## 2.5 Flange plate thickness

Check	Required	Provided	Remarks
Thickness (mm)*	$T = 8.7$	$t_f = 12.0$	Pass
Plate Area check (mm <sup>2</sup> )	$pt.area \geq$ $connected\ member\ area * 1.05$ $= 2740.5$	$outer.b = B$ $= 150.0$ $inner.b = \frac{B - t - (2 * r_1)}{2}$ $= \frac{150.0 - 9.4 - (2 * 15.0)}{2}$ $= 55.3$ $pt.area = (150.0 + (2 * 55.3)) * 12.0$ $= 3127.2$	Pass

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## 2.6 Web plate thickness

Check	Required	Provided	Remarks
Thickness (mm)*	$t = 4.7$	$t_w = 6.0$	Pass
Plate Area check (mm <sup>2</sup> )	$pt.area \geq$ $connected\ member\ area * 1.05$ $= 3604.52$	$web\ b = D - (2 * T) - (2 * r_1)$ $= 450.0 - (2 * 17.4) - (2 * 15.0)$ $= 365.2$ $pt.area = 6.0 * 2 * 365.2$ $= 4382.4$	Pass

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## 2.7 Web Spacing Checks

Check	Required	Provided	Remarks
Min.Diameter (mm)		$d = 12.0$	
Min. Gauge (mm)	$p/g_{min} = 2.5 d$ $= 2.5 * 12.0 = 30.0$	$g = 30$ ( <i>Row Limit</i> ( $r_l$ ) = 2)	
Min. Edge Distance (mm)	$e/e'_{min} = [1.5 \text{ or } 1.7] * d_0$ $= 1.7 * 13.0 = 22.1$	25	
Spacing Check	$depth = 2 * e + (r_l - 1) * g$ $= 2 * 25 + (2.0 - 1) * 30$ $= 80.0$	365.2	Pass



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## 2.8 Flange Spacing Checks

Check	Required	Provided	Remarks
Min.Diameter (mm)		$d = 12.0$	
Min. Gauge (mm)	$p/g_{min} = 2.5 d$ $= 2.5 * 12.0 = 30.0$	$g = 0.0$ ( <i>Row Limit</i> ( $r_l$ ) = 1)	
Min. Edge Dis- tance (mm)	$e/e'_{min} = [1.5 \text{ or } 1.7] * d_0$ $= 1.7 * 13.0 = 22.1$	25	
Spacing Check	$depth = 2 * e + (r_l - 1) * g$ $= 2 * 25 + (1.0 - 1) * 30$ $= 50.0$	55.3	Pass

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## 2.9 Flange Bolt Checks

Check	Required	Provided	Remarks
Diameter (mm)	Bolt Quantity Optimisation	$d = 12.0$	
Grade	Bolt Grade Optimisation	12.9	
Bolt.fu		1200.0	
Bolt.fy		1080.0	
Hole Diameter (mm)		$d_0 = 13.0$	
Slip Resistance		$V_{dsf} = \frac{\mu_f n_e K_h F_o}{\gamma_{mf}}$ $\text{Where, } F_o = 0.7 * f_{ub} A_{nb}$ $V_{dsf} = \frac{0.3 * 1 * 1.0 * 0.7 * 1200.0 * 0.0}{1.25}$ $= 33.99$	
No of Bolts	$R_u = \sqrt{V_u^2 + A_u^2}$ $n_{trial} = R_u / V_{bolt}$ $R_u = \frac{\sqrt{0.0^2 + 256.59^2}}{33.99}$ $= 16$	16	
No of Columns		$n_c = 8$	
No of Rows		$n_r = 2$	
Min. Pitch (mm)	$p/g_{min} = 2.5 d$ $= 2.5 * 12.0 = 30.0$	30	Pass
Max. Pitch (mm)	$p/g_{max} = \min(32 t, 300 \text{ mm})$ $= \min(32 * 12.0, 300 \text{ mm})$ $= 300$	30	Pass
Min. Gauge (mm)	$p/g_{min} = 2.5 d$ $= 2.5 * 12.0 = 30.0$	0.0	N/A
Max. Gauge (mm)	$p/g_{max} = \min(32 t, 300 \text{ mm})$ $= \min(32 * 12.0, 300 \text{ mm})$ $= 300$	0.0	N/A
Min. End Distance (mm)	$e/e'_{min} = [1.5 \text{ or } 1.7] * d_0$ $= 1.7 * 13.0 = 22.1$	25	Pass
Max. End Distance (mm)	$e/e'_{max} = 12 t \varepsilon$ $\varepsilon = \sqrt{\frac{250}{f_y}}$ $e/e'_{max} = 12 * 12.0 * \sqrt{\frac{250}{250}}$ $= 144.0$	25	Pass
Min. Edge Distance (mm)	$e/e'_{min} = [1.5 \text{ or } 1.7] * d_0$ $= 1.7 * 13.0 = 22.1$	27.65	Pass

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Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e/e_{max} = 12 t \varepsilon$ $\varepsilon = \sqrt{\frac{250}{f_y}}$ $e/e_{max} = 12 * 12.0 * \sqrt{\frac{250}{250}}$ $= 144.0$	27.65	Pass
Bolt Capacity post Long Joint (kN)	<p>if <math>l \geq 15 * d</math> then <math>V_{rd} = \beta_{ij} * V_{db}</math>  if <math>l &lt; 15 * d</math> then <math>V_{rd} = V_{db}</math>  where,  <math>l = ((nc \text{ or } nr) - 1) * (p \text{ or } g)</math>  <math>\beta_{ij} = 1.075 - l / (200 * d)</math>  but <math>0.75 \leq \beta_{ij} \leq 1.0</math></p>	$l = ((nc \text{ or } nr) - 1) * (p \text{ or } g)$ $lc = 2 * ((\frac{8}{2} - 1) * 30 + 25) + 10.0$ $= 240.0$ $lr = 2 * ((\frac{2}{2} - 1) * 0.0 + 27.65$ $+ 15.0) + 9.4 = 94.7$ $l = 240.0$ $15 * d = 15 * 12.0 = 180.0$ <p>since, <math>l \geq 15 * d</math>  then <math>V_{rd} = \beta_{ij} * V_{db}</math>  <math>\beta_{ij} = 1.075 - 240.0 / (200 * 12.0)</math>  <math>= 0.98</math>  <math>V_{rd} = 0.98 * 33.99 = 33.31</math></p>	
Capacity (kN)	32.07	33.31	Pass

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## 2.10 Web Bolt Checks

Check	Required	Provided	Remarks
Slip Resistance		$V_{dsf} = \frac{\mu_f n_e K_h F_o}{\gamma_{mf}}$ $\text{Where, } F_o = 0.7 * f_{ub} A_{nb}$ $V_{dsf} = \frac{0.3 * 1 * 1.0 * 0.7 * 1200.0 * 84.3}{1.25}$ $= 33.99$	
No of Bolts	$R_u = \sqrt{V_u^2 + A_u^2}$ $n_{trial} = R_u / V_{bolt}$ $R_u = \frac{\sqrt{307.27^2 + 266.11^2}}{33.99}$ $= 24$	60	
No of Columns		$n_c = 6$	
No of Rows		$n_r = 10$	
Min. Pitch (mm)	$p/g_{min} = 2.5 d$ $= 2.5 * 12.0 = 30.0$	30	Pass
Max. Pitch (mm)	$p/g_{max} = \min(32 t, 300 \text{ mm})$ $= \min(32 * 6.0, 300 \text{ mm})$ $= 192.0$	30	Pass
Min. Gauge (mm)	$p/g_{min} = 2.5 d$ $= 2.5 * 12.0 = 30.0$	30	Pass
Max. Gauge (mm)	$p/g_{max} = \min(32 t, 300 \text{ mm})$ $= \min(32 * 6.0, 300 \text{ mm})$ $= 192.0$	30	Pass
Min. End Distance (mm)	$e/e'_{min} = [1.5 \text{ or } 1.7] * d_0$ $= 1.7 * 13.0 = 22.1$	25	Pass
Max. End Distance (mm)	$e/e'_{max} = 12 t \varepsilon$ $\varepsilon = \sqrt{\frac{250}{f_y}}$ $e/e'_{max} = 12 * 6.0 * \sqrt{\frac{250}{250}}$ $= 72.0$	25	Pass
Min. Edge Distance (mm)	$e/e'_{min} = [1.5 \text{ or } 1.7] * d_0$ $= 1.7 * 13.0 = 22.1$	25	Pass
Max. Edge Distance (mm)	$e/e'_{max} = 12 t \varepsilon$ $\varepsilon = \sqrt{\frac{250}{f_y}}$ $e/e'_{max} = 12 * 6.0 * \sqrt{\frac{250}{250}}$ $= 72.0$	25	Pass

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Check	Required	Provided	Remarks
Parameters required for bolt force (mm)		$l_n = \text{length available}$ $l_n = (n_r - 1) * g$ $= (10 - 1) * 30$ $= 270$ $y_{max} = l_n / 2$ $= 270 / 2$ $= 135.0$ $x_{max} = p * (\frac{n_c}{2} - 1) / 2$ $= 30 * (\frac{6}{2} + -1) / 2$ $= 30.0$	
Moment Demand (kNm)		$M_d = (V_u * ecc + M_w)$ $= \frac{(307.27 * 10^3 * 75.0 + 12.02 * 10^6)}{10^6}$ $= 35.07$	
Bolt.Force		$v_bv = V_u / (n_r * n_c)$ $= \frac{307.27}{(10 * 6)}$ $= 10.24$ $tmh = \frac{M_d * y_{max}}{\sum r_i^2}$ $= \frac{35.07 * 135.0}{240.75}$ $= 19.66$ $tmv = \frac{M_d * x_{max}}{\sum r_i^2}$ $= \frac{35.07 * 30.0}{240.75}$ $= 4.37$ $abh = \frac{A_u}{(n_r * n_c)}$ $= \frac{266.11}{(10 * 6)}$ $= 8.87$ $v_{res} = \sqrt{(v_bv + tmv)^2 + (tmh + abh)^2}$ $= \sqrt{(10.24 + 4.37)^2 + (19.66 + 8.87)^2}$ $= 32.06$	

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Check	Required	Provided	Remarks
Bolt Capacity post Long Joint (kN)	$\text{if } l \geq 15 * d \text{ then } V_{rd} = \beta_{ij} * V_{db}$ $\text{if } l < 15 * d \text{ then } V_{rd} = V_{db}$ <p>where,</p> $l = ((nc \text{ or } nr) - 1) * (p \text{ or } g)$ $\beta_{ij} = 1.075 - l / (200 * d)$ $\text{but } 0.75 \leq \beta_{ij} \leq 1.0$	$l = ((nc \text{ or } nr) - 1) * (p \text{ or } g)$ $lc = 2 * ((\frac{6}{2} - 1) * 30 + 25) + 10.0$ $= 180.0$ $lr = (10 - 1) * 30 = 270$ $l = 270$ $15 * d = 15 * 12.0 = 180.0$ <p>since, <math>l \geq 15 * d</math></p> <p>then <math>V_{rd} = \beta_{ij} * V_{db}</math></p> $\beta_{ij} = 1.075 - 270 / (200 * 12.0)$ $= 0.96$ $V_{rd} = 0.96 * 33.99 = 32.63$	
Capacity (kN)	32.06	32.63	Pass

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## 2.11 Inner and Outer flange plate Checks

Check	Required	Provided	Remarks
Min. Plate Height (mm)	$\min \text{ flange plate ht} = \text{beam width}$ $= 150.0$	150.0	Pass
Min. Plate Length (mm)	$2[2 * e_{min} + (\frac{\text{bolt lines}}{2} - 1) * p_{min}]$ $+ \frac{\text{gap}}{2}]$ $= 2 * [(2 * 22.1 + (\frac{8}{2} - 1) * 30.0$ $= + \frac{10.0}{2}]$ $= 278.4$	290.0	Pass
Min. Inner Plate Height (mm)	$= \frac{B - t - (2 * R1)}{2}$ $= \frac{150.0 - 9.4 - 2 * 15.0}{2}$ $= 55.3$	55.3	Pass
Max. Inner Plate Height (mm)	$= \frac{B - t - (2 * R1)}{2}$ $= \frac{150.0 - 9.4 - 2 * 15.0}{2}$ $= 55.3$	55.3	Pass
Min. Inner Plate Length (mm)	$2[2 * e_{min} + (\frac{\text{bolt lines}}{2} - 1) * p_{min}]$ $+ \frac{\text{gap}}{2}]$ $= 2 * [(2 * 22.1 + (\frac{8}{2} - 1) * 30.0$ $= + \frac{10.0}{2}]$ $= 278.4$	290.0	Pass
Min. Plate Thickness (mm)	$t_w = 8.7$	12.0	Pass

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## 2.12 Member Checks

Check	Required	Provided	Remarks
Flange Tension Yielding Capacity (kN)		$T_{dg} = \frac{l * t * f_y}{\gamma_{mo}}$ $= \frac{1 * 150.0 * 17.4 * 250}{1.1}$ $= 593.18$	
Flange Tension Rupture Capacity (kN)		$T_{dn} = \frac{0.9 * A_n * f_u}{\gamma_{m1}}$ $= \frac{0.9 * (150.0 - 2 * 13.0) * 17.4 * 410}{1.25}$ $= 636.92$	
Flange Block Shear Capacity (kN)		$T_{db1} = \frac{A_{vg}f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9A_{tn}f_u}{\gamma_{m1}}$ $T_{db2} = \frac{0.9 * A_{vn}f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg}f_y}{\gamma_{m0}}$ $T_{db} = \min(T_{db1}, T_{db2}) = 630.9$	
Flange Tension Capacity (kN)	$f_f = 256.59$	$T_d = \min(T_{dg}, T_{dn}, T_{db})$ $= \min(593.18, 636.92, 630.9)$ $= 593.18$	Pass
Web Tension Yielding Capacity (kN)		$T_{dg} = \frac{l * t * f_y}{\gamma_{mo}}$ $= \frac{1 * 415.2 * 9.4 * 250}{1.1}$ $= 887.02$	
Web Tension Rupture Capacity (kN)		$T_{dn} = \frac{0.9 * A_n * f_u}{\gamma_{m1}}$ $= \frac{0.9 * (415.2 - 10 * 13.0) * 9.4 * 410}{1.25}$ $= 791.4$	
Web Block Shear Capacity (kN)		$T_{db1} = \frac{A_{vg}f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9A_{tn}f_u}{\gamma_{m1}}$ $T_{db2} = \frac{0.9 * A_{vn}f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg}f_y}{\gamma_{m0}}$ $T_{db} = \min(T_{db1}, T_{db2}) = 703.61$	
Web Tension Capacity (kN)	$A_w = 266.11$	$T_d = \min(T_{dg}, T_{dn}, T_{db})$ $= \min(887.02, 791.4, 703.61)$ $= 703.61$	Pass



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### 2.13 Flange Plate Capacity Checks in axial-Outside/Inside

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{dg} = \frac{l * t * f_y}{\gamma_{mo}}$ $= \frac{1 * 260.6 * 12.0 * 250}{1.1}$ $= 710.73$	
Tension Rupture Capacity (kN)		$T_{dn} = \frac{0.9 * A_n * f_u}{\gamma_{m1}}$ $= \frac{0.9 * (260.6 - 2 * 13.0) * 12.0 * 410}{1.25}$ $= 831.05$	
Block Shear Capacity (kN)		$T_{db1} = \frac{A_{vg} f_y}{\sqrt{3} \gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{db2} = \frac{0.9 * A_{vn} f_u}{\sqrt{3} \gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = \min(T_{db1}, T_{db2}) = 977.66$	
Plate Tension Capacity (kN)	$f_f = 256.59$	$T_d = \min(T_{dg}, T_{dn}, T_{db})$ $= \min(710.73, 831.05, 977.66)$ $= 710.73$	Pass

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## 2.14 Web Plate Capacity Checks in Axial

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{dg} = \frac{l * t * f_y}{\gamma_{mo}}$ $= \frac{1 * 320 * 6.0 * 250}{1.1}$ $= 503.87$	
Tension Rupture Capacity (kN)		$T_{dn} = \frac{0.9 * A_n * f_u}{\gamma_{m1}}$ $= \frac{0.9 * (320 - 10 * 13.0) * 6.0 * 1200.0}{1.25}$ $= 673.06$	
Block Shear Capacity (kN)		$T_{db1} = \frac{A_{vg} f_y}{\sqrt{3} \gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{db2} = \frac{0.9 * A_{vn} f_u}{\sqrt{3} \gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = \min(T_{db1}, T_{db2}) = 898.23$	
Plate Tension Capacity (kN)	$A_w = 266.11$	$T_d = \min(T_{dg}, T_{dn}, T_{db})$ $= \min(503.87, 673.06, 898.23)$ $= 503.87$	Pass

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## 2.15 Web Plate Capacity Checks in Shear

Check	Required	Provided	Remarks
Shear yielding Capacity (V_dy) (kN)		$V_{dy} = \frac{A_v * f_y}{\sqrt{3} * \gamma_{mo}}$ $= \frac{1 * 320 * 6.0 * 250}{\sqrt{3} * 1.1}$ $= 503.87$	
Shear Rupture Capacity (V_dn) (kN)		$V_{dn} = \frac{0.9 * A_{vn} * f_u}{\sqrt{3} * \gamma_{m1}}$ $= \frac{0.9 * (320 - (3.0 * 13.0)) * 6.0 * 410}{\sqrt{3} * 1.25}$ $= 388.59$	
Block Shear Capacity in Shear (V_db) (kN)		$T_{db1} = \frac{A_{vg} f_y}{\sqrt{3} \gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{db2} = \frac{0.9 * A_{vn} f_u}{\sqrt{3} \gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = \min(T_{db1}, T_{db2}) = 582.57$	
Plate Shear Capacity (kN)	$V_u = 307.27$	$V_d = \min(V_{dy}, V_{dn}, V_{db})$ $= \min(503.87, 388.59, 582.57)$ $= 388.59$	Pass

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3 3D View

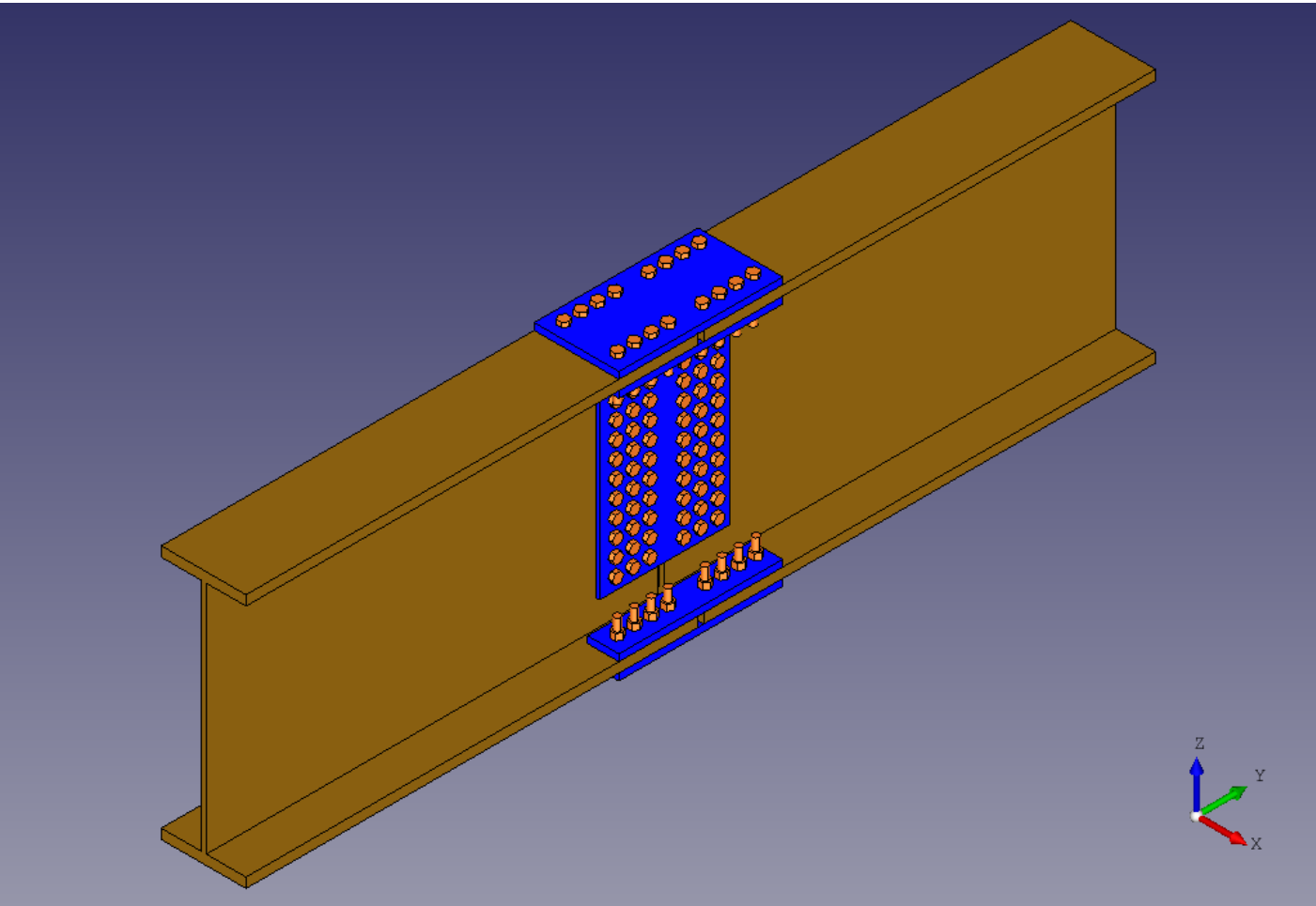


Figure 1: 3D View