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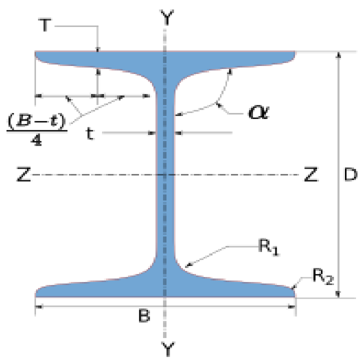
1 Input Parameters

Module	Beam Coverplate Connection
MainModule	Moment Connection
Moment(kNm)*	1.0
Shear (kN)*	89.0
Axial (kN) *	32.0

Section



Beam Section *		WPB 200x200x101	
Preferences		Outside + Inside	
Material *		E 250 (Fe 410 W)A	
Ultimate strength, fu (MPa)		410	
Yield Strength , fy (MPa)	240	R1(mm)	1.8
Mass	100.99	R2(mm)	0.0
Area(mm2) - A	12870.0	Iz(mm4)	114686000.0
D(mm)	229.0	Iy(mm4)	36645800.0
B(mm)	210.0	rz(mm)	94.4
t(mm)	14.5	ry(mm)	53.4
T(mm)	23.7	Zz(mm3)	1001620.0
FlangeSlope	90	Zy(mm3)	349010.0

Bolt Details

Diameter (mm)*	[12.0]
Grade *	[9.8]
Type *	Bearing 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

2 Design Checks

2.1 Member Capacity

Check	Required	Provided	Remarks
Axial Capacity Member Ac (kN)		$A_c = \frac{A * f_y}{\gamma_{m0} * 10^3}$ $= \frac{12870.0 * 240}{1.1 * 10^3}$ $= 2808.0$	
Shear Capacity Member Sc (kN)		$S_c = \frac{A_v * f_y}{\sqrt{3} * \gamma_{mo} * 10^3}$ $= \frac{181.6 * 14.5 * 240}{\sqrt{3} * 1.1 * 10^3}$ $= 331.7$	
Plastic Moment Capacity Pmc (kNm)		$Pmc = \frac{\beta_b * Z_p * fy}{\gamma_{mo} * 10^6}$ $= \frac{1 * 119547.28 * 240}{1.1 * 10^6}$ $= 26.08$	
Moment Deformation Criteria Mdc (kNm)		$Mdc = \frac{1.5 * Z_e * fy}{1.1 * 10^6}$ $= \frac{1.5 * 1001620.0 * 240}{1.1 * 10^6}$ $= 327.8$	
Moment Capacity Member Mc (kNm)		$M_c = min(Pmc, Mdc)$ $= min(26.08, 327.8)$ $= 26.08$	

2.2 Load Consideration

Check	Required	Provided	Remarks
Applied Axial Load Au (kN)	$Ac_{min} = 0.3 * A_c$ $= 0.3 * 2808.0$ $= 842.4$ $Ac_{max} = Ac$ $= 2808.0$	$A_u = 842.4$	Pass
Applied Shear Load Vu (kN)	$Vc_{min} = 0.6 * S_c$ $= 0.6 * 331.7$ $= 199.02$ $Vc_{max} = Sc$ $= 331.7$	$V_u = 199.02$	Pass
Applied Moment Load Mu (kNm)	$Mc_{min} = 0.5 * M_c$ $= 0.5 * 26.08$ $= 13.04$ $Mc_{max} = Mc$ $= 26.08$	$M_u = 13.04$	Pass
Forces Carried by Web		$A_w = Axial\ force\ in\ web$ $= \frac{(D - 2 * T) * t * Au}{A}$ $= \frac{(229.0 - 2 * 23.7) * 14.5 * 842.4}{12870.0}$ $= 172.35\ kN$ $M_w = Moment\ in\ web$ $= \frac{Z_w * Mu}{Z}$ $= \frac{119547.28 * 13.04}{1165460.0}$ $= 1.34\ kNm$	
Forces Carried by Flange		$A_f = Axial\ force\ in\ flange$ $= \frac{Au * B * T}{A}$ $= \frac{842.4 * 210.0 * 23.7}{12870.0}$ $= 325.77\ kN$ $M_f = Moment\ in\ flange$ $= Mu - M_w$ $= 13.04 - 1.34$ $= 11.7\ kNm$ $F_f = flange\ force$ $= \frac{M_f * 10^3}{D - T} + A_f$ $= \frac{11.7 * 10^3}{229.0 - 23.7} + 325.77$ $= 382.78\ kN$	

2.3 Initial Member Check

Check	Required	Provided	Remarks
Flange Tension Yielding Capacity (kN)	$F_f = 382.78$	$T_{dg} = \frac{l * t * f_y}{\gamma_{mo}}$ $= \frac{1 * 210.0 * 23.7 * 240}{1.1}$ $= 1131.14$	Pass
Web Tension Yielding Capacity (kN)	$A_w = 172.35$	$T_{dg} = \frac{l * t * f_y}{\gamma_{mo}}$ $= \frac{1 * 181.6 * 14.5 * 240}{1.1}$ $= 598$	Pass

2.4 Initial flange plate height check

Check	Required	Provided	Remarks
flange_plate.Height	Outer.b >= 50	$Outer.b = 210.0$	Pass
flange_plate.InnerHeight	Inner.b >= 50	$inner.b = \frac{B - t - (2 * r_1)}{2}$ $= \frac{210.0 - 14.5 - (2 * 1.8)}{2}$ $= 95.95$	Pass

2.5 Flange plate thickness

Check	Required	Provided	Remarks
Thickness (mm)*	$T = 11.85$	$t_f = 25.0$	Pass
Plate Area check (mm2)	$pt.area >= connected\ member\ area * 1.05 = 5225.85$	$outer.b = B = 210.0$ $inner.b = \frac{B - t - (2 * r_1)}{2} = \frac{210.0 - 14.5 - (2 * 1.8)}{2} = 95.95$ $pt.area = (210.0 + (2 * 95.95)) * 25.0 = 10047.5$	Pass

2.6 Web plate thickness

Check	Required	Provided	Remarks
Thickness (mm)*	$t = 7.25$	$t_w = 20.0$	Pass
Plate Area check (mm2)	$pt.area >=$ $connected\ member\ area * 1.05$ $= 1699.11$	$web\ b = D - (2 * T) - (2 * r_1)$ $= 229.0 - (2 * 23.7) - (2 * 1.8)$ $= 111.6$ $pt.area = 20.0 * 2 * 111.6$ $= 4464.0$	Pass

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2.7 Web Spacing Checks

Check	Required	Provided	Remarks
Min.Diameter (mm)		$d = 12.0$	
Min. Gauge (mm)	$p/g_{min} = 2.5\ d$ $=2.5 * 12.0 \quad = 30.0$	$g = 30\ (Row\ Limit\ (r_l) = 2)$	
Min. Edge Distance (mm)	$e/e`_{min} = [1.5\ or\ 1.7] * d_0$ $= 1.7 * 13.0 = 22.1$	25	
Spacing Check	$depth = 2 * e + (r_l - 1) * g$ $= 2 * 25 + (2.0 - 1) * 30$ $= 80.0$	111.6	Pass

2.8 Flange Spacing Checks

Check	Required	Provided	Remarks
Min.Diameter (mm)		$d = 12.0$	
Min. Gauge (mm)	$p/g_{min} = 2.5\ d$ $= 2.5 * 12.0 \quad = 30.0$	$g = 0.0$ $(Row\ Limit\ (r_l) = 1)$	
Min. Edge Distance (mm)	$e/e`_{min} = [1.5\ or\ 1.7] * d_0$ $= 1.7 * 13.0 = 22.1$	25	
Spacing Check	$depth = 2 * e + (r_l - 1) * g$ $= 2 * 25 + (1.0 - 1) * 30$ $= 50.0$	95.95	Pass

2.9 Flange Bolt Checks

Check	Required	Provided	Remarks
Diameter (mm)	Bolt Quantity Optimisation	$d = 12.0$	
Grade	Bolt Grade Optimisation	9.8	
Bolt.fu		900.0	
Bolt.fy		720.0	
Hole Diameter (mm)		$d_0 = 13.0$	
Shear Capacity (kN)		$V_{dsb} = \frac{f_{ub}\ n_n\ A_{nb}}{\sqrt{3}\ \gamma_{mb}}$ $= \frac{900.0 * 2 * 84.3}{\sqrt{3}\ *\ 1.25}$ $= 70.09$	
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5\ k_b\ d\ t\ f_u}{\gamma_{mb}}$ $= \frac{2.5\ * 0.52 * 12.0 * 23.7 * 410}{1.25}$ $= 121.27$	
Bolt Capacity (kN)		$V_{db} = min\ (V_{dsb}, V_{dpb})$ $= min\ (70.09, 121.27)$ $= 70.09$	
No of Bolts	$R_u = \sqrt{V_u^2 + A_u^2}$ $n_{trial} = R_u/V_{bolt}$ $R_u = \frac{\sqrt{0.0^2 + 382.78^2}}{70.09}$ $= 12$	16	
No of Columns		$n_c = 4$	
No of Rows		$n_r = 4$	
Min. Pitch (mm)	$p/g_{min} = 2.5\ d$ $= 2.5 * 12.0 \quad = 30.0$	30	Pass
Max. Pitch (mm)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 *\ 23.7,\ 300\ mm)$ $= 300$	30	Pass
Min. Gauge (mm)	$p/g_{min} = 2.5\ d$ $= 2.5 * 12.0 \quad = 30.0$	45	Pass
Max. Gauge (mm)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 *\ 23.7,\ 300\ mm)$ $= 300$	45	Pass
Min. End Distance (mm)	$e/e`_{min} = [1.5\ or\ 1.7] * d_0$ $= 1.7 * 13.0 = 22.1$	25	Pass

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Check	Required	Provided	Remarks
Max. End Distance (mm)	$e/e`_{max} = 12\ t\ \varepsilon$ $\varepsilon = \sqrt{\frac{250}{f_y}}$ $e/e`_{max} = 12\ * 25.0 * \sqrt{\frac{250}{250}}$ $= 300.0$	25	Pass
Min. Edge Distance (mm)	$e/e`_{min} = [1.5\ or\ 1.7] * d_0$ $= 1.7 * 13.0 = 22.1$	25.475	Pass
Max. Edge Distance (mm)	$e/e`_{max} = 12\ t\ \varepsilon$ $\varepsilon = \sqrt{\frac{250}{f_y}}$ $e/e`_{max} = 12\ * 25.0 * \sqrt{\frac{250}{250}}$ $= 300.0$	25.475	Pass
Bolt Capacity post Long Joint (kN)	$if\ l \geq 15 * d\ then\ V_{rd} = \beta_{ij} * V_{db}$ $if\ l < 15 * d\ then\ V_{rd} = V_{db}$ $where,$ $l = ((nc\ or\ nr) - 1) * (p\ or\ g)$ $\beta_{ij} = 1.075 - l/(200 * d)$ $but\ 0.75 \leq \beta_{ij} \leq 1.0$	$l\ = ((nc\ or\ nr) - 1) * (p\ or\ g)$ $lc = 2 * ((\frac{4}{2} - 1) * 30 + 25) + 10.0$ $= 120.0$ $lr = 2 * ((\frac{4}{2} - 1) * 45 + 25.475$ $+ 1.8) + 14.5 = 159.04999999999998$ $l\ = 159.04999999999998$ $15 * d = 15 * 12.0 = 180.0$ $since,\ l < 15 * d$ $then\ V_{rd} = V_{db}$ $V_{rd} = 70.09$	
Capacity (kN)	47.85	70.09	Pass

2.10 Web Bolt Checks

Check	Required	Provided	Remarks
Shear Capacity (kN)		$V_{dsb} = \frac{f_{ub}\ n_n\ A_{nb}}{\sqrt{3}\ \gamma_{mb}}$ $= \frac{900.0 * 2 * 84.3}{\sqrt{3}\ *\ 1.25}$ $= 70.09$	
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5\ k_b\ d\ t\ f_u}{\gamma_{mb}}$ $= \frac{2.5\ * 0.52 * 12.0 * 14.5 * 410}{1.25}$ $= 74.19$	
Bolt Capacity (kN)		$V_{db} = min\ (V_{dsb}, V_{dpb})$ $= min\ (70.09, 74.19)$ $= 70.09$	
No of Bolts	$R_u = \sqrt{V_u^2 + A_u^2}$ $n_{trial} = R_u/V_{bolt}$ $R_u = \frac{\sqrt{199.02^2 + 172.35^2}}{70.09}$ $= 8$	30	
No of Columns		$n_c = 10$	
No of Rows		$n_r = 3$	
Min. Pitch (mm)	$p/g_{min} = 2.5\ d$ $=2.5 * 12.0 \quad = 30.0$	30	Pass
Max. Pitch (mm)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 *\ 14.5,\ 300\ mm)$ $= 300$	30	Pass
Min. Gauge (mm)	$p/g_{min} = 2.5\ d$ $=2.5 * 12.0 \quad = 30.0$	45	Pass
Max. Gauge (mm)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 *\ 14.5,\ 300\ mm)$ $= 300$	45	Pass
Min. End Distance (mm)	$e/e`_{min} = [1.5\ or\ 1.7] * d_0$ $= 1.7 * 13.0 = 22.1$	25	Pass
Max. End Distance (mm)	$e/e`_{max} = 12\ t\ \varepsilon$ $\varepsilon = \sqrt{\frac{250}{f_y}}$ $e/e`_{max} = 12\ * 20.0 * \sqrt{\frac{250}{250}}$ $= 240.0$	25	Pass
Min. Edge Distance (mm)	$e/e`_{min} = [1.5\ or\ 1.7] * d_0$ $= 1.7 * 13.0 = 22.1$	25	Pass

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Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e/e`_{max} = 12\ t\ \varepsilon$   $\varepsilon = \sqrt{\frac{250}{f_y}}$   $e/e`_{max} = 12\ * 20.0 * \sqrt{\frac{250}{250}}$ $= 240.0$	25	Pass
Parameters required for bolt force (mm)		$l_n = length\ available$ $l_n = (n_r - 1) * g$ $= (3 - 1) * 45$ $= 90$ $y_{max} = l_n/2$ $= 90/2$ $= 45.0$ $x_{max} = p * (\frac{n_c}{2} - 1)/2$ $= 30 * (\frac{10}{2} + -1)/2$ $= 60.0$	
Moment Demand (kNm		$M_d = (V_u * ecc + M_w)$ $= \frac{(199.02 * 10^3 * 135.0 + 1.34 * 10^6)}{10^6}$ $= 28.21$	
Bolt.Force		$vbv = V_u/(n_r * n_c)$ $= \frac{199.02}{(3 * 10)}$ $= 13.27$ $tmh = \frac{M_d * y_{max}}{\Sigma r_i^2}$ $= \frac{28.21 * 45.0}{47.25}$ $= 26.86$ $tmv = \frac{M_d * x_{max}}{\Sigma r_i^2}$ $= \frac{28.21 * 60.0}{47.25}$ $= 35.82$ $abh = \frac{A_u}{(n_r * n_c)}$ $= \frac{172.35}{(3 * 10)}$ $= 11.49$ $vres = \sqrt{(vbv + tmv)^2 + (tmh + abh)^2}$ $= \sqrt{(13.27 + 35.82)^2 + (26.86 + 11.49)^2}$ $= 62.29$	

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Check	Required	Provided	Remarks
Bolt Capacity post Long Joint (kN)	$if\ l \geq 15 * d\ then\ V_{rd} = \beta_{ij} * V_{db}$ $if\ l < 15 * d\ then\ V_{rd} = V_{db}$ $where,$ $l = ((nc\ or\ nr) - 1) * (p\ or\ g)$ $\beta_{ij} = 1.075 - l/(200 * d)$ $but\ 0.75 \leq \beta_{ij} \leq 1.0$	$l = ((nc\ or\ nr) - 1) * (p\ or\ g)$ $lc = 2 * ((\frac{10}{2} - 1) * 30 + 25) + 10.0$ $= 300.0$ $lr = (3 - 1) * 45 = 90$ $l = 300.0$ $15 * d = 15 * 12.0 = 180.0$ $since,\ l \geq 15 * d$ $then\ V_{rd} = \beta_{ij} * V_{db}$ $\beta_{ij} = 1.075 - 300.0/(200 * 12.0)$ $= 0.95$ $V_{rd} = 0.95 * 70.09 = 66.58$	
Capacity (kN)	62.29	66.58	Pass

2.11 Inner and Outer flange plate Checks

Check	Required	Provided	Remarks
Min. Plate Height (mm)	$min\ flange\ plate\ ht = beam\ width$ $= 210.0$	210.0	Pass
Min. Plate Length (mm)	$2[2 * e_{min} + (\frac{bolt\ lines}{2} - 1) * p_{min})]$ $+ \frac{gap}{2}]$ $= 2 * [(2 * 22.1 + (\frac{4}{2} - 1) * 30.0$ $= + \frac{10.0}{2}]$ $= 158.4$	170.0	Pass
Min. Inner Plate Height (mm)	$= \frac{B - t - (2 * R1)}{2}$ $= \frac{210.0 - 14.5 - 2 * 1.8}{2}$ $= 95.95$	95.95	Pass
Max. Inner Plate Height (mm)	$= \frac{B - t - (2 * R1)}{2}$ $= \frac{210.0 - 14.5 - 2 * 1.8}{2}$ $= 95.95$	95.95	Pass
Min. Inner Plate Length (mm)	$2[2 * e_{min} + (\frac{bolt\ lines}{2} - 1) * p_{min})]$ $+ \frac{gap}{2}]$ $= 2 * [(2 * 22.1 + (\frac{4}{2} - 1) * 30.0$ $= + \frac{10.0}{2}]$ $= 158.4$	170.0	Pass
Min.Plate Thickness (mm)	$t_w = 11.85$	25.0	Pass

2.12 Member Checks

Check	Required	Provided	Remarks
Flange Tension Yielding Capacity (kN)		$T_{dg} = \frac{l * t * f_y}{\gamma_{mo}}$ $= \frac{1 * 210.0 * 23.7 * 240}{1.1}$ $= 1131.14$	
Flange Tension Rupture Capacity (kN)		$T_{dn} = \frac{0.9 * A_n * f_u}{\gamma_{m1}}$ $= \frac{0.9 * (210.0 - 4 * 13.0) * 23.7 * 410}{1.25}$ $= 1105.41$	
Flange Block Shear Capacity (kN)		$T_{db1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{db2} = \frac{0.9 * A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = min(T_{db1}, T_{db2}) = 1046.0$	
Flange Tension Capacity (kN)	$f_f = 382.78$	$T_d = min(T_{dg}, T_{dn}, T_{db})$ $= min(1131.14, 1105.41, 1046.0)$ $= 1046.0$	Pass
Web Tension Yielding Capacity (kN)		$T_{dg} = \frac{l * t * f_y}{\gamma_{mo}}$ $= \frac{1 * 181.6 * 14.5 * 240}{1.1}$ $= 598.45$	
Web Tension Rupture Capacity (kN)		$T_{dn} = \frac{0.9 * A_n * f_u}{\gamma_{m1}}$ $= \frac{0.9 * (181.6 - 3 * 13.0) * 14.5 * 410}{1.25}$ $= 610.39$	
Web Block Shear Capacity (kN)		$T_{db1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{db2} = \frac{0.9 * A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = min(T_{db1}, T_{db2}) = 932.72$	
Web Tension Capacity (kN)	$A_w = 172.35$	$T_d = min(T_{dg}, T_{dn}, T_{db})$ $= min(598.45, 610.39, 932.72)$ $= 598.45$	Pass

2.13 Flange Plate Capacity Checks in axial-Outside/Inside

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{dg} = \frac{l * t * f_y}{\gamma_{mo}} = \frac{1 * 401.9 * 25.0 * 250}{1.1} = 2283.52$	
Tension Rupture Capacity (kN)		$T_{dn} = \frac{0.9 * A_n * f_u}{\gamma_{m1}} = \frac{0.9 * (401.9 - 4 * 13.0) * 25.0 * 410}{1.25} = 2582.26$	
Block Shear Capacity (kN)		$T_{db1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{db2} = \frac{0.9 * A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = min(T_{db1}, T_{db2}) = 2309.59$	
Plate Tension Capacity (kN)	$f_f = 382.78$	$T_d = min(T_{dg}, T_{dn}, T_{db}) = min(2283.52, 2582.26, 2309.59) = 2283.52$	Pass

2.14 Web Plate Capacity Checks in Axial

Check	Required	Provided	Remarks
Tension Yielding Capacity (kN)		$T_{dg} = \frac{l*t*f_y}{\gamma_{mo}}$ $= \frac{1*140*20.0*250}{1.1}$ $= 734.81$	
Tension Rupture Capacity (kN)		$T_{dn} = \frac{0.9*A_n*f_u}{\gamma_{m1}}$ $= \frac{0.9*(140-3*13.0)*20.0*900.0}{1.25}$ $= 1192.61$	
Block Shear Capacity (kN)		$T_{db1} = \frac{A_{vg}f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9A_{tn}f_u}{\gamma_{m1}}$ $T_{db2} = \frac{0.9*A_{vn}f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg}f_y}{\gamma_{m0}}$ $T_{db} = min(T_{db1}, T_{db2}) = 2573.02$	
Plate Tension Capacity (kN)	$A_w = 172.35$	$T_d = min(T_{dg}, T_{dn}, T_{db})$ $= min(1272.73, 1192.61, 2573.02)$ $= 1192.61$	Pass

2.15 Web Plate Capacity Checks in Shear

Check	Required	Provided	Remarks
Shear yielding Capacity (V_dy) (kN)		$V_{dy} = \frac{A_v * f_y}{\sqrt{3} * \gamma_{mo}}$ $= \frac{1 * 140 * 20.0 * 250}{\sqrt{3} * 1.1}$ $= 734.81$	
Shear Rupture Capacity (V_dn) (kN)		$V_{dn} = \frac{0.9 * A_{vn} * f_u}{\sqrt{3} * \gamma_{m1}}$ $= \frac{0.9 * (140 - (5.0 * 13.0)) * 20.0 * 410}{\sqrt{3} * 1.25}$ $= 688.55$	
Block Shear Capacity in Shear (V_db) (kN)		$T_{db1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $T_{db2} = \frac{0.9 * A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $T_{db} = min(T_{db1}, T_{db2}) = 1880.61$	
Plate Shear Capacity (kN)	$V_u = 199.02$	$V_d = min(V_{dy}, V_{dn}, V_{db})$ $= min(734.81, 688.55, 2573.02)$ $= 688.55$	Pass

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3 3D View

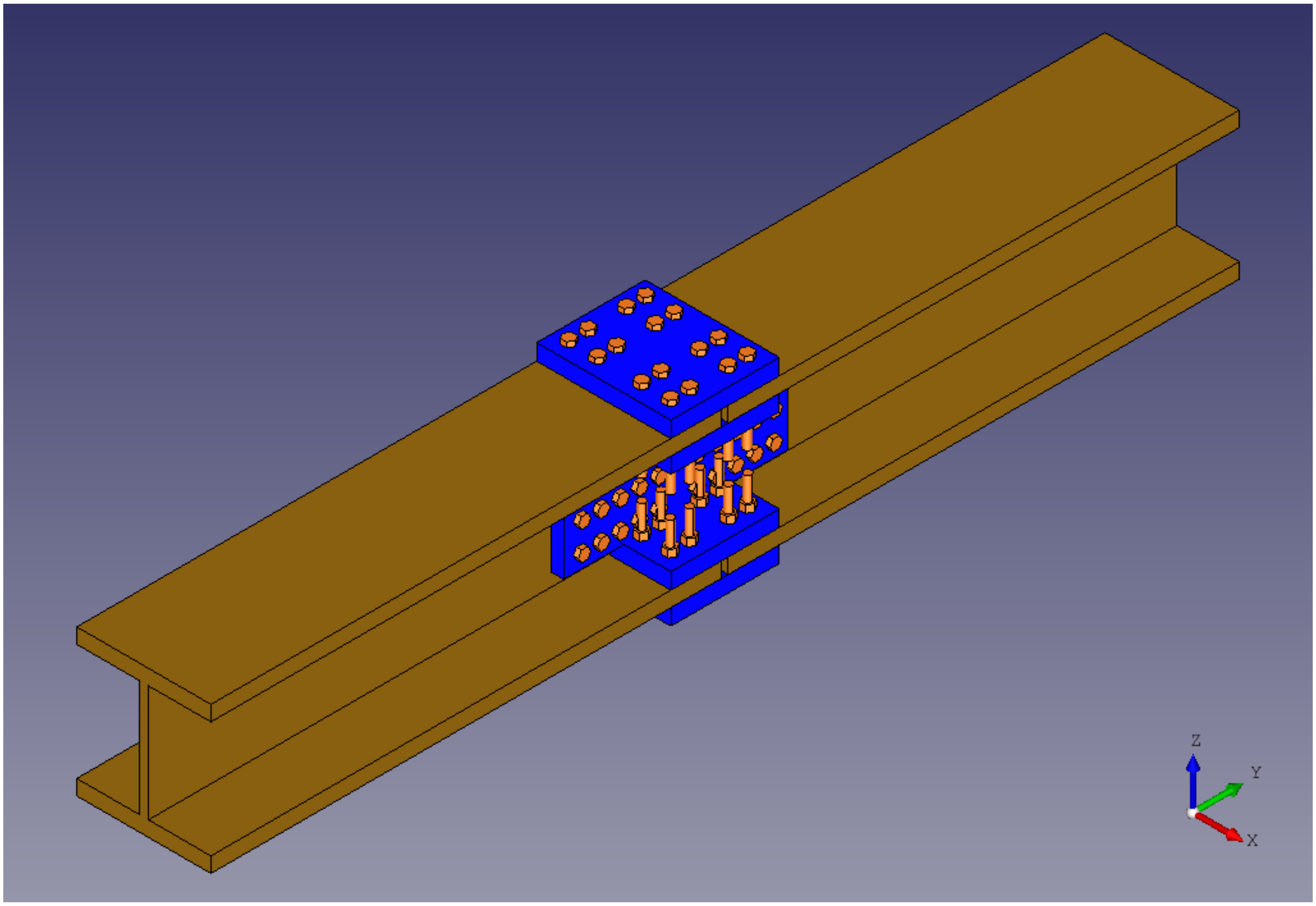

Figure 1: 3D View