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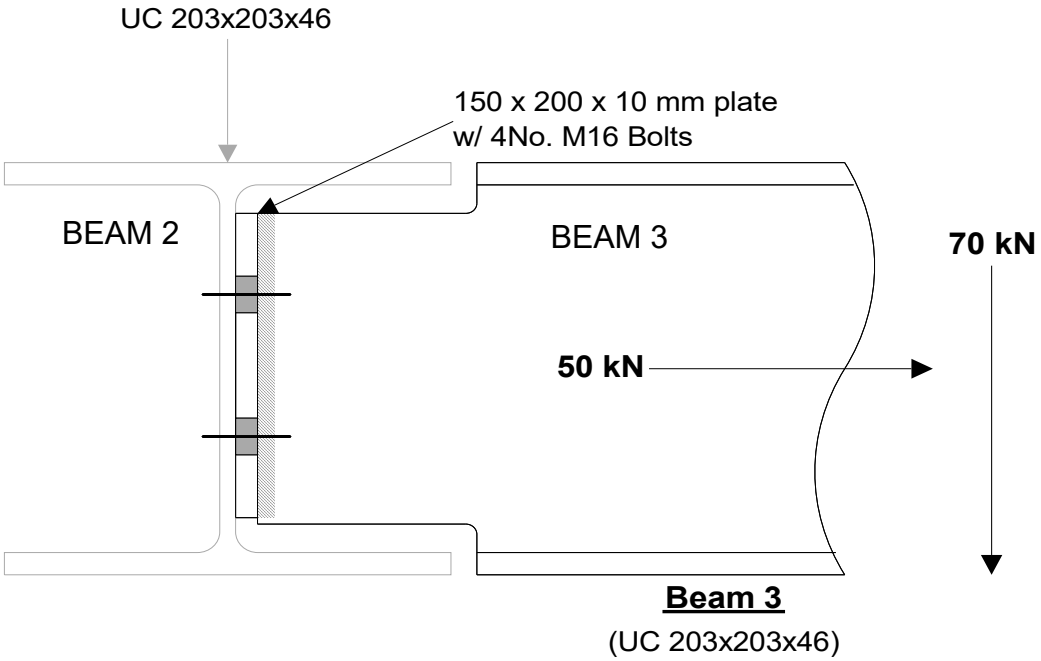
Project				Job no.	
CONNECTION 1 - 150x200x10mm plate S275				2023-7459	
Calcs for				Start page no./Revision	
Mr Colin Williams, 59 Oakhill Road, Horsham RH13 5LE				1	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
SB	12/10/2023	DB	12/10/2023	Sb	12/10/2023

STEEL CONNECTION DESIGN

In accordance with EN1993-1-1:2005 incorporating Corrigenda February 2006 and April 2009, and EN1993-1-8:2005 incorporating Corrigenda December 2005, September 2006 and July 2009, and the UK National Annex.

Tedds calculation version 1.0.00



Connection details

Connection type	**Partial depth end plate**
Number of supported beams	**1 supported beam**

Partial factors

Resistance of cross-section	γ_{M0} = **1.00**
Resistance of members to instability	γ_{M1} = **1.00**
Cross-sections in tension to fracture	$\gamma_{M2,c}$ = **1.10**
Resistance of bolts	$\gamma_{M2,b}$ = **1.25**
Structural integrity	$\gamma_{M,u}$ = **1.10**

Supporting beam details

Section name	**UC 203x203x46**
Steel grade	**S275**
Yield strength	f_y = **275** N/mm^2
Ultimate strength	f_u =**410** N/mm^2

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Mr Colin Williams, 59 Oakhill Road, Horsham RH13 5LE				2	
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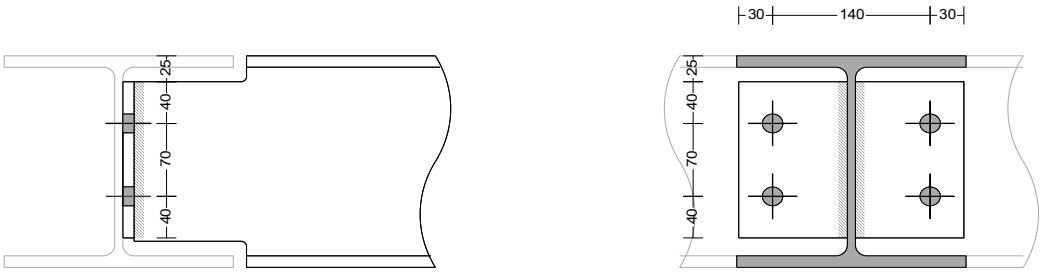
Supported Beam 3



Summary Table

Check	Description	Units	Design Force	Design Resistance	Utilisation	
1	Recommended detailing practices					PASS
2	Supported beam - Welds	kN	43	212.7	0.202	PASS
4	Supported beam - Web in shear	kN	70	154.3	0.454	PASS
5	Supported beam - Resistance at notch	kNm	7.7	7.7	0.994	PASS
6	Supported beam - Local stability notch					PASS
8	Connection - Bolt group	kN	70	192.9	0.363	PASS
9	Connection - End plate in shear	kN	70	310.6	0.225	PASS
10	Supporting beam - Shear	kN	35	232.3	0.151	PASS
11	Tying resistance - Plate and bolts	kN	50	105.1	0.476	PASS
12	Tying resistance - Supported beam web	kN	50	402.5	0.124	PASS

Design forces

Design shear V_{Ed1} = **70** kN
Design tying force F_{Ed1} = **50** kN

Supported beam details

Section name **UC 203x203x46**
Steel grade **S275**
Yield strength $f_{y,b}$ = **275** N/mm^2
Ultimate strength $f_{u,b}$ = **410** N/mm^2
Correlation factor $\beta_{w,b}$ = **0.85**

End plate details

Plate height h_p = **150** mm
Plate width b_p = **200** mm
Plate thickness t_p = **10** mm
Plate grade **S275**
Yield strength $f_{y,p}$ = **275** N/mm^2
Ultimate strength $f_{u,p}$ = **410** N/mm^2
Correlation factor $\beta_{w,p}$ = **0.85**

Bolt details

Number of bolt rows	$n_{1,1}$ = **2**
Total number of bolts	n_b = **4**
End distance	e_1 = **40** mm
Edge distance	e_2 = **30** mm
Pitch	p_1 = **70** mm
Gauge	p_3 = **140** mm
Bolt hole	d_0 = **18** mm
Bolt size	**M16**
Bolt grade	**8.8**
Yield strength	$f_{y,bolt}$ = **640** N/mm^2
Ultimate strength	$f_{u,bolt}$ = **800** N/mm^2

Check 1: Recommended detailing practice

Minimum plate height	0.6 × h_b = **121.9** mm
Actual plate height	h_p = **150** mm
Maximum depth to plate	**50 mm**
Actual depth to plate	d_p = **25** mm
Maximum plate thickness	**10 mm**
Actual plate thickness	t_p = **10** mm
Minimum bolt gauge	**90 mm**
Actual bolt gauge	p_3 = **140** mm

Top Notch

Depth of notch	d_{nt} = **25** mm
Length of notch	l_n = **100** mm
Minimum vertical clearance	Max($t_{f,b}$ + r_b, t_f + r) = **21.2** mm
Actual vertical clearance	d_{nt} = **25** mm
Minimum horizontal clearance	**10 mm**
Actual horizontal clearance	l_n - (b - t_w) / 2 + t_p = **11.8** mm

Bottom Notch

Depth of notch	d_{nb} = **25** mm
Length of notch	l_n = **100** mm
Minimum vertical clearance	Max($t_{f,b}$ + r_b, t_f + r) = **21.2** mm
Actual vertical clearance	d_{nb} = **25** mm

PASS - Recommended detailing practices are met

Check 2: Supported beam - Welds

Weld leg size	s_w = **8.0** mm
Minimum weld throat thickness	0.4 × $t_{w,b}$ = **2.9** mm
Effective weld throat thickness	a_w = 0.7 × s_w = **5.6** mm
Correlation factor	β_w = Min($\beta_{w,b}$, $\beta_{w,p}$) = **0.85**
Design shear strength	$f_{vw,d}$ = Min($f_{u,b}$,$f_{u,p}$) / √(3) / (β_w × $\gamma_{M2,c}$) = **253.17** N/mm^2
Design resistance	$F_{w,Rd}$ = $f_{vw,d}$ × a_w × h_p = **212.66** kN
Design weld force	$F_{w,Ed}$ = √(V_{Ed1}^2 + F_{Ed1}^2) / 2 = **43.01** kN
Utilisation	$F_{w,Ed}$ / $F_{w,Rd}$ = **0.202**

PASS - Weld throat thickness greater than required

Check 4: Supported beam - Web in shear

Shear area	A_v = 0.9 × h_p × $t_{w,b}$ = **972** mm^2

Plastic shear resistance of beam web	$V_{pl,Rd} = A_v \times (f_{y,b} / \sqrt{(3)}) / \gamma_{M0}$ = **154.33** kN
Design shear resistance	$V_{c,Rd} = V_{pl,Rd}$ = **154.33** kN
Utilisation	$V_{Ed1} / V_{c,Rd}$ = **0.454**

PASS - Web shear resistance greater than design shear

Check 5: Supported beam - Resistance at notch

Double Notch (low shear, $V_{Ed} <= 0.5V_{pl,DN,Rd}$)

Shear area at notch	$A_{v,DN} = 0.9 \times (h_b - d_{nt} - d_{nb}) \times t_{w,b}$ = **993** mm^2
Shear resistance at notch	$V_{pl,DN,Rd} = (A_{v,DN} \times f_{y,b}) / (\sqrt{(3)} \times \gamma_{M0})$ = **157.62** kN
Moment resistance at notch	$M_{v,DN,Rd} = f_{y,b} \times t_{w,b} / (6 \times \gamma_{M0}) \times (h_b - d_{nt} - d_{nb})^2$ = **7.75** kNm
Design moment at notch	$M_{v,Ed} = V_{Ed1} \times (t_p + l_n)$ = **7.7** kNm
Utlilisation	$M_{v,Ed} / M_{v,N,Rd}$ = 0.994

PASS - Notch resistance is greater than design force

Check 6: Supported beam - Local stability of notched beam

Double notch

Maximum notch depth	$h_b / 5$ = **40.6** mm
Actual notch depth	$Max(d_{nt}, d_{nb})$ = **25** mm
Maximum notch length ($h_b/t_{w,b}$ <= 54.3)	h_b = **203.2** mm
Actual notch length	l_n = **100** mm

PASS - Local stability is accounted for

Check 8: Connection - Bolt group

Bolt tensile stress area	A_s = **157** mm^2
Bolt shear stress factor	α_v = **0.6**
Bolt shear resistance	$F_{v,Rd} = \alpha_v \times f_{u,bolt} \times A_s / \gamma_{M2,b}$ = **60.29** kN
For the end plate	$\alpha_{b,p} = Min(e_1 / (3 \times d_0), p_1 / (3 \times d_0) - 1/4, f_{u,bolt} / f_{u,p}, 1)$ = **0.74**
	$k_{1,p} = Min(2.8 \times e_2 / d_0 - 1.7, 1.4 \times p_3 / d_0 - 1.7, 2.5)$ = **2.5**
For the supporting member	$\alpha_{b,2} = Min(p_1 / (3 \times d_0) - 1/4, f_{u,bolt} / f_u, 1)$ = **1**
	$k_{1,2} = Min(1.4 \times p_3 / d_0 - 1.7, 2.5)$ = **2.5**
Bearing on the end plate	$F_{b,Rd,p} = k_{1,p} \times \alpha_{b,p} \times f_{u,p} \times d_b \times t_p / \gamma_{M2,b}$ = **97.19** kN
Bearing on the supporting member	$F_{b,Rd,2} = k_{1,2} \times \alpha_{b,2} \times f_u \times d_b \times t_w / \gamma_{M2,b}$ = **94.46** kN
Minimum bearing resistance	$F_{b,Rd1} = Min(F_{b,Rd,p}, F_{b,Rd,2})$ = **94.46** kN
Resistance of the bolt group	$F_{Rd} = 0.8 \times n_b \times F_{v,Rd}$ = **192.92** kN
Utilisation	V_{Ed1} / F_{Rd} = **0.363**

PASS - Bolt group resistance is greater than design force

Check 9: Connection - End plate in shear

Net shear area	$A_{v,net} = t_p \times (h_p - n_{1,1} \times d_0)$ = **1140** mm^2
Edge shear area	$A_{nt} = t_p \times (e_2 - d_0 / 2)$ = **210** mm^2
Shear area from end bolt	$A_{nv} = t_p \times (h_p - e_1 - (n_{1,1} - 0.5) \times d_0)$ = **830** mm^2
Gross section shear resistance	$V_{Rd,g} = (2 \times h_p \times t_p) / 1.27 \times f_{y,p} / (\sqrt{(3)} \times \gamma_{M0})$ = **375.05** kN
Net section shear resistance	$V_{Rd,n} = 2 \times A_{v,net,A\_c1} \times f_{u,plate,A\_c1} / (\sqrt{(3)} \times \gamma_{M2,c})$ = **490.64** kN
Block tearing resistance	$V_{Rd,b} = 2 \times (0.5 \times f_{u,p} \times A_{nt} / \gamma_{M2,c} + f_{y,p} \times A_{nv} / (\sqrt{(3)} \times \gamma_{M0}))$ = **341.83** kN
End plate in-plane bending resistance	$V_{Rd,ip} = 2 \times t_{p,A\_c1} \times h_{p,A\_c1}^2 \times f_{y,plate,A\_c1} / (3 \times (p_{3\_c1} - t_{w,b,A\_c1}) \times \gamma_{M0})$ = **310.62** kN
End plate shear resistance	$V_{Rd,pl,min} = Min(V_{Rd,g}, V_{Rd,n}, V_{Rd,b}, V_{Rd,ip})$ = **310.62** kN
Utilisation	_PlateShearUtilisationA_c1 = **0.225**

PASS - Shear resistance of end plate greater than design force

Check 10: Supporting beam - Shear

Distance from top bolt to flange	$e_{1,t}$ = **65** mm
Distance from bottom bolt to flange	$e_{1,b}$ = **68** mm
Minimum top distance	$e_t = Min(e_{1,t}, 5 \times d_b)$ = **65** mm
Minimum bottom distance	$e_b = Min(e_{1,b}, p_3 / 2, 5 \times d_b)$ = **68** mm
Shear area of supporting member	$A_v = t_w \times (e_t + (n_{1,1} - 1) \times p_1 + e_b)$ = **1463** mm^2
Net shear area of supporting member	$A_{v,net} = A_v - n_{1,1} \times d_0 \times t_w$ = **1204** mm^2
Local shear resistance	$V_{Rd,min} = Min(A_v \times f_y / (\sqrt{(3)} \times \gamma_{M0}), A_{v,net} \times f_u / (\sqrt{(3)} \times \gamma_{M2,c}))$ = **232.29** kN
Utilisation	$V_{Ed1}/2 / V_{Rd,min}$ = **0.151**

PASS - Beam shear resistance is greater than design force

Check 11: Tying resistance - Plate and bolts

Effective end distance	$e_{1A} = Min(e_1, 0.5 \times (p_3 - t_{w,b} - 2 \times a_w \times \sqrt{(2)}) + d_0/2)$ = **40** mm
Effective bolt pitch	$p_{1A} = Min(p_1, p_3 - t_{w,b} - 2 \times a_w \times \sqrt{(2)} + d_0)$ = **70** mm
Minimum end distance	$e_{min} = e_2$ = **30** mm
Bolt factor	k_2 = **0.9**
Distance from weld throat to bolt	$m_w = (p_3 - t_{w,b} - 2 \times 0.8 \times a_w \times \sqrt{(2)}) / 2$ = **60.1** mm
	$n_w = Min(e_{min}, 1.25 \times m_w)$ = **30** mm
Width across bolt head points	d_w = **26** mm
	$e_w = d_w / 4$ = **6.5** mm
Effective length of equivalent T-stub	$\Sigma l_{eff} = 2 \times e_{1A} + (n_{1,1} - 1) \times p_{1A}$ = **150.0** mm
Moment resistance of plate	$M_{pl,1,Rd,u} = (0.25 \times \Sigma l_{eff} \times t_p^2 \times f_{u,p}) / \gamma_{M,u}$ = **1.4** kNm
	$M_{pl,2,Rd,u} = M_{pl,1,Rd,u}$ = **1.4** kNm
Mode 1 plate failure	$F_{Rd,u,1} = (8 \times n_w - 2 \times e_w) \times M_{pl,1,Rd,u} / (2 \times m_w \times n_w - e_w \times (m_w + n_w))$ = **105.12** kN
Individual bolt resistance	$F_{t,Rd,u} = k_2 \times f_{u,bolt} \times A_s / \gamma_{M,u}$ = **102.76** kN
Group bolt resistance	$\Sigma F_{t,Rd,u} = n_b \times F_{t,Rd,u}$ = **411.05** kN
Mode 2 bolt and plate failure	$F_{Rd,u,2} = (2 \times M_{pl,2,Rd,u} + n_w \times \Sigma F_{t,Rd,u}) / (m_w + n_w)$ = **167.96** kN
Mode 3 bolt failure	$F_{Rd,u,3} = \Sigma F_{t,Rd,u}$ = **411.05** kN
Minimum resistance	$F_{Rd,u,min} = Min(F_{Rd,u,1}, F_{Rd,u,2}, F_{Rd,u,3})$ = **105.12** kN
Utilisation	$F_{Ed1} / F_{Rd,u,min}$ = **0.476**

PASS - Tying resistance of plate and bolts is greater than design force

Check 12: Tying resistance - Supported beam web

Web resistance	$F_{Rd,u} = (t_{w,b} \times h_p \times f_{u,b}) / \gamma_{M,u}$ = **402.55** kN
Utilisation	$F_{Ed1} / F_{Rd,u}$ = **0.124**

PASS - Supported beam web tying resistance is greater than design force