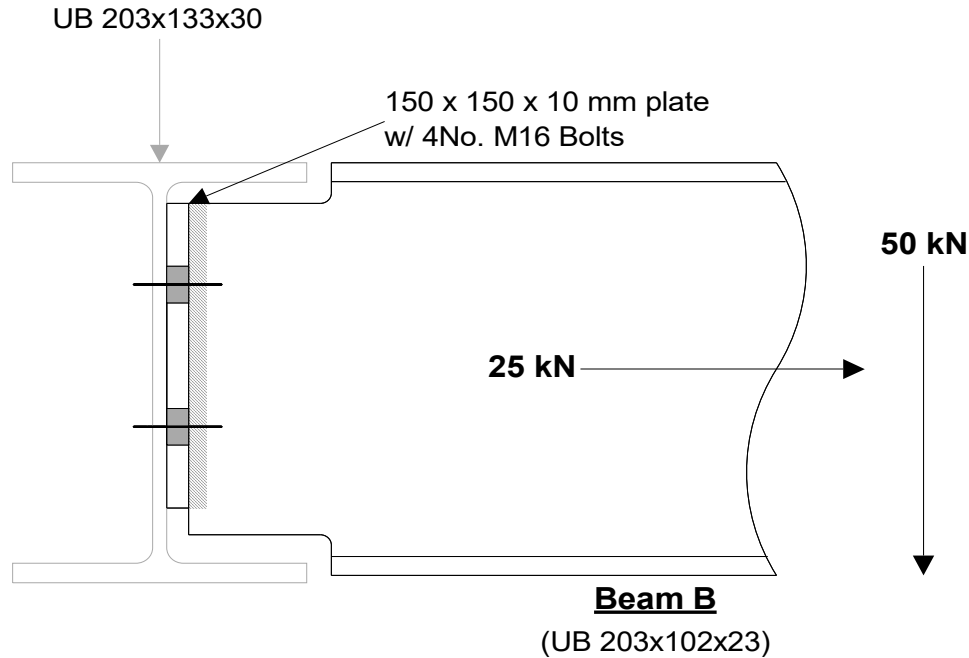


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STEEL CONNECTION DESIGN

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 1.2.01



Connection details

Connection type
Number of supported beams

Partial depth end plate
1 supported beam

Partial factors

Resistance of cross-section
Resistance of members to instability
Cross-sections in tension to fracture
Resistance of bolts
Structural integrity

$\gamma_{M0} = 1.00$
 $\gamma_{M1} = 1.00$
 $\gamma_{M2,c} = 1.10$
 $\gamma_{M2,b} = 1.25$
 $\gamma_{M,u} = 1.10$

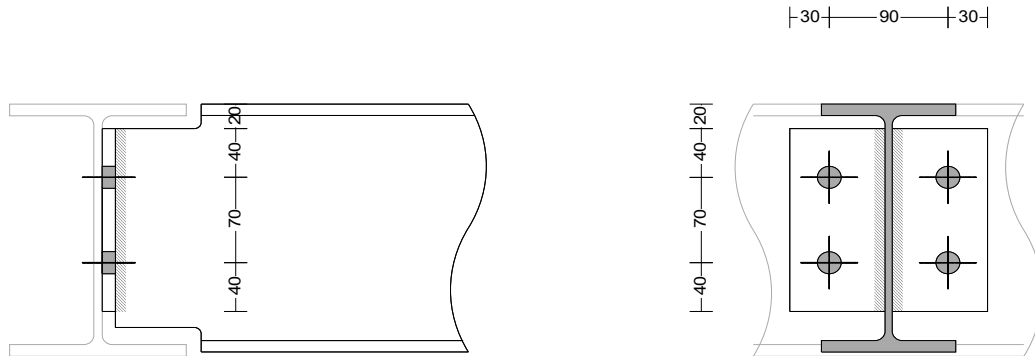
Supporting beam details

Section name
Steel grade
Yield strength
Ultimate strength

UB 203x133x30
S275
 $f_y = 275 \text{ N/mm}^2$
 $f_u = 410 \text{ N/mm}^2$

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Supported Beam B



Summary Results

Check	Description	Units	Design Force	Design Resistance	Utilisation	
1	Recommended detailing practices					PASS
2	Supported beam - Welds	kN	28	212.7	0.131	PASS
4	Supported beam - Web in shear	kN	50	115.7	0.432	PASS
5	Supported beam - Resistance at notch	kNm	3.8	6.6	0.569	PASS
6	Supported beam - Local stability notch					PASS
8	Connection - Bolt group	kN	50	192.9	0.259	PASS
9	Connection - End plate in shear	kN	50	375.1	0.133	PASS
10	Supporting beam - Shear	kN	25	177.8	0.141	PASS
11	Tying resistance - Plate and bolts	kN	25	183.5	0.136	PASS
12	Tying resistance - Supported beam web	kN	25	301.9	0.083	PASS

Design forces

Design shear $V_{Ed1} = 50$ kN

Design tying force $F_{Ed1} = 25$ kN

Supported beam details

Section name **UB 203x102x23**
 Steel grade **S275**
 Yield strength $f_{y,b} = 275$ N/mm²
 Ultimate strength $f_{u,b} = 410$ N/mm²
 Correlation factor $\beta_{w,b} = 0.85$

End plate details

Plate height $h_p = 150$ mm
 Plate width $b_p = 150$ mm
 Plate thickness $t_p = 10$ mm
 Plate grade **S275**
 Yield strength $f_{y,p} = 275$ N/mm²

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Ultimate strength $f_{u,p} = 410 \text{ N/mm}^2$
 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 $e_1 = 40 \text{ mm}$
 Edge distance $e_2 = 30 \text{ mm}$
 Pitch $p_1 = 70 \text{ mm}$
 Gauge $p_3 = 90 \text{ mm}$
 Bolt hole $d_0 = 18 \text{ mm}$
 Bolt size **M16**
 Bolt grade **8.8**
 Yield strength $f_{y,bolt} = 640 \text{ N/mm}^2$
 Ultimate strength $f_{u,bolt} = 800 \text{ N/mm}^2$

Check 1: Recommended detailing practice

Minimum plate height $0.6 \times h_b = 121.9 \text{ mm}$
 Actual plate height $h_p = 150 \text{ mm}$
 Maximum depth to plate **50 mm**
 Actual depth to plate $d_p = 20 \text{ mm}$
 Maximum plate thickness **10 mm**
 Actual plate thickness $t_p = 10 \text{ mm}$
 Minimum bolt gauge **90 mm**
 Actual bolt gauge $p_3 = 90 \text{ mm}$

Top Notch

Depth of notch $d_{nt} = 20 \text{ mm}$
 Length of notch $l_n = 65 \text{ mm}$
 Minimum vertical clearance $\text{Max}(t_{f,b} + r_b, t_f + r) = 17.2 \text{ mm}$
 Actual vertical clearance $d_{nt} = 20 \text{ mm}$
 Minimum horizontal clearance **10 mm**
 Actual horizontal clearance $l_n - (b - t_w) / 2 + t_p = 11.2 \text{ mm}$

Bottom Notch

Depth of notch $d_{nb} = 20 \text{ mm}$
 Length of notch $l_n = 65 \text{ mm}$
 Minimum vertical clearance $t_{f,b,A_c1} + r_b = 16.9 \text{ mm}$
 Actual vertical clearance $d_{nb} = 20 \text{ mm}$

PASS - Recommended detailing practices are met

Check 2: Supported beam - Welds

Weld leg size $s_w = 8.0 \text{ mm}$
 Minimum weld throat thickness $0.4 \times t_{w,b} = 2.2 \text{ mm}$
 Effective weld throat thickness $a_w = 0.7 \times s_w = 5.6 \text{ mm}$
 Correlation factor $\beta_w = \text{Min}(\beta_{w,b}, \beta_{w,p}) = 0.85$
 Design shear strength $f_{w,d} = \text{Min}(f_{u,b}, f_{u,p}) / \sqrt{3} / (\beta_w \times \gamma_{M2,c}) = 253.17 \text{ N/mm}^2$
 Design resistance $F_{w,Rd} = f_{w,d} \times a_w \times h_p = 212.66 \text{ kN}$
 Design weld force $F_{w,Ed} = \sqrt{(V_{Ed1}^2 + F_{Ed1}^2)} / 2 = 27.95 \text{ kN}$
 Utilisation $F_{w,Ed} / F_{w,Rd} = 0.131$

PASS - Weld throat thickness greater than required

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Check 4: Supported beam - Web in shear

Shear area	$A_v = 0.9 \times h_p \times t_{w,b} = 729 \text{ mm}^2$
Plastic shear resistance of beam web	$V_{pl,Rd} = A_v \times (f_{y,b} / \sqrt{3}) / \gamma_{M0} = 115.74 \text{ kN}$
Design shear resistance	$V_{c,Rd} = V_{pl,Rd} = 115.74 \text{ kN}$
Utilisation	$V_{Ed1} / V_{c,Rd} = 0.432$

PASS - Web shear resistance greater than design shear

Check 5: Supported beam - Resistance at notch

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

Shear area at notch	$A_{v,DN} = 0.9 \times (h_b - d_{nt} - d_{nb}) \times t_{w,b} = 793 \text{ mm}^2$
Shear resistance at notch	$V_{pl,DN,Rd} = (A_{v,DN} \times f_{y,b}) / (\sqrt{3} \times \gamma_{M0}) = 125.93 \text{ kN}$
Moment resistance at notch	$M_{v,DN,Rd} = f_{y,b} \times t_{w,b} / (6 \times \gamma_{M0}) \times (h_b - d_{nt} - d_{nb})^2 = 6.59 \text{ kNm}$
Design moment at notch	$M_{v,Ed} = V_{Ed1} \times (t_p + l_n) = 3.75 \text{ kNm}$
Utilisation	$M_{v,Ed} / M_{v,N,Rd} = 0.569$

PASS - Notch resistance is greater than design force

Check 6: Supported beam - Local stability of notched beam

Double notch

Maximum notch depth	$h_b / 5 = 40.6 \text{ mm}$
Actual notch depth	$\text{Max}(d_{nt}, d_{nb}) = 20 \text{ mm}$
Maximum notch length ($h_b/t_{w,b} \leq 54.3$)	$h_b = 203.2 \text{ mm}$
Actual notch length	$l_n = 65 \text{ mm}$

PASS - Local stability is accounted for

Check 8: Connection - Bolt group

Bolt tensile stress area	$A_s = 157 \text{ mm}^2$
Bolt shear stress factor	$\alpha_v = 0.6$
Bolt shear resistance	$F_{v,Rd} = \alpha_v \times f_{u,bolt} \times A_s / \gamma_{M2,b} = 60.29 \text{ kN}$
For the end plate	$\alpha_{b,p} = \text{Min}(e_1 / (3 \times d_0), p_1 / (3 \times d_0) - 1/4, f_{u,bolt} / f_{u,p}, 1) = 0.74$
	$k_{1,p} = \text{Min}(2.8 \times e_2 / d_0 - 1.7, 1.4 \times p_3 / d_0 - 1.7, 2.5) = 2.5$
For the supporting member	$\alpha_{b,2} = \text{Min}(p_1 / (3 \times d_0) - 1/4, f_{u,bolt} / f_u, 1) = 1$
	$k_{1,2} = \text{Min}(1.4 \times p_3 / d_0 - 1.7, 2.5) = 2.5$
Bearing on the end plate	$F_{b,Rd,p} = k_{1,p} \times \alpha_{b,p} \times f_{u,p} \times d_b \times t_p / \gamma_{M2,b} = 97.19 \text{ kN}$
Bearing on the supporting member	$F_{b,Rd,2} = k_{1,2} \times \alpha_{b,2} \times f_u \times d_b \times t_w / \gamma_{M2,b} = 83.97 \text{ kN}$
Minimum bearing resistance	$F_{b,Rd1} = \text{Min}(F_{b,Rd,p}, F_{b,Rd,2}) = 83.97 \text{ kN}$
Resistance of the bolt group	$F_{Rd} = 0.8 \times n_b \times F_{v,Rd} = 192.92 \text{ kN}$
Utilisation	$V_{Ed1} / F_{Rd} = 0.259$

PASS - Bolt group resistance is greater than design force

Check 9: Connection - End plate in shear

Net shear area	$A_{v,net} = t_p \times (h_p - n_{1,1} \times d_0) = 1140 \text{ mm}^2$
Edge shear area	$A_{nt} = t_p \times (e_2 - d_0 / 2) = 210 \text{ mm}^2$
Shear area from end bolt	$A_{nv} = t_p \times (h_p - e_1 - (n_{1,1} - 0.5) \times d_0) = 830 \text{ mm}^2$
Gross section shear resistance	$V_{Rd,g} = (2 \times h_p \times t_p) / 1.27 \times f_{y,p} / (\sqrt{3} \times \gamma_{M0}) = 375.05 \text{ kN}$
Net section shear resistance	$V_{Rd,n} = 2 \times A_{v,net,A_c1} \times f_{u,plate,A_c1} / (\sqrt{3} \times \gamma_{M2,c}) = 490.64 \text{ kN}$
Block tearing resistance	$V_{Rd,b} = 2 \times (f_{u,p} \times A_{nt} / \gamma_{M2,c} + f_{y,p} \times A_{nv} / (\sqrt{3} \times \gamma_{M0})) = 420.11 \text{ kN}$
End plate in-plane bending resistance	$h_p < 1.36p_3$ - No additional requirements
End plate shear resistance	$V_{Rd,pl,min} = \text{Min}(V_{Rd,g}, V_{Rd,n}, V_{Rd,b}) = 375.05 \text{ kN}$

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Utilisation

$$_PlateShearUtilisationA_c1 = 0.133$$

PASS - Shear resistance of end plate greater than design force

Check 10: Supporting beam - Shear

Distance from top bolt to flange

$$e_{1,t} = 60 \text{ mm}$$

Distance from bottom bolt to flange

$$e_{1,b} = 77 \text{ mm}$$

Minimum top distance

$$e_t = \text{Min}(e_{1,t}, 5 \times d_b) = 60 \text{ mm}$$

Minimum bottom distance

$$e_b = \text{Min}(e_{1,b}, p_3 / 2, 5 \times d_b) = 45 \text{ mm}$$

Shear area of supporting member

$$A_v = t_w \times (e_t + (n_{1,1} - 1) \times p_1 + e_b) = 1120 \text{ mm}^2$$

Net shear area of supporting member

$$A_{v,net} = A_v - n_{1,1} \times d_0 \times t_w = 890 \text{ mm}^2$$

Local shear resistance

$$V_{Rd,min} = \text{Min}(A_v \times f_y / (\sqrt{3}) \times \gamma_{M0}, A_{v,net} \times f_u / (\sqrt{3}) \times \gamma_{M2,c}) = 177.82 \text{ kN}$$

Utilisation

$$V_{Ed1} / V_{Rd,min} = 0.141$$

PASS - Beam shear resistance is greater than design force

Check 11: Tying resistance - Plate and bolts

Effective end distance

$$e_{1A} = \text{Min}(e_1, 0.5 \times (p_3 - t_{w,b} - 2 \times a_w \times \sqrt{2}) + d_0/2) = 40 \text{ mm}$$

Effective bolt pitch

$$p_{1A} = \text{Min}(p_1, p_3 - t_{w,b} - 2 \times a_w \times \sqrt{2} + d_0) = 70 \text{ mm}$$

Minimum end distance

$$e_{min} = e_2 = 30 \text{ mm}$$

Bolt factor

$$k_2 = 0.9$$

Distance from weld throat to bolt

$$m_w = (p_3 - t_{w,b} - 2 \times 0.8 \times a_w \times \sqrt{2}) / 2 = 36 \text{ mm}$$

Width across bolt head points

$$d_w = 26 \text{ mm}$$

$$e_w = d_w / 4 = 6.5 \text{ mm}$$

Effective length of equivalent T-stub

$$\Sigma l_{eff} = 2 \times e_{1A} + (n_{1,1} - 1) \times p_{1A} = 150.0 \text{ mm}$$

Moment resistance of plate

$$M_{pl,1,Rd,u} = (0.25 \times \Sigma l_{eff} \times t_p^2 \times f_{u,p}) / \gamma_{M,u} = 1.4 \text{ kNm}$$

$$M_{pl,2,Rd,u} = M_{pl,1,Rd,u} = 1.4 \text{ kNm}$$

Mode 1 plate failure

$$F_{Rd,u,1} = (8 \times n_w - 2 \times e_w) \times M_{pl,1,Rd,u} / (2 \times m_w \times n_w - e_w \times (m_w + n_w)) = 183.5 \text{ kN}$$

Individual bolt resistance

$$F_{t,Rd,u} = k_2 \times f_{u,bolt} \times A_s / \gamma_{M,u} = 102.76 \text{ kN}$$

Group bolt resistance

$$\Sigma F_{t,Rd,u} = n_b \times F_{t,Rd,u} = 411.05 \text{ kN}$$

Mode 2 bolt and plate failure

$$F_{Rd,u,2} = (2 \times M_{pl,2,Rd,u} + n_w \times \Sigma F_{t,Rd,u}) / (m_w + n_w) = 229.32 \text{ kN}$$

Mode 3 bolt failure

$$F_{Rd,u,3} = \Sigma F_{t,Rd,u} = 411.05 \text{ kN}$$

Minimum resistance

$$F_{Rd,u,min} = \text{Min}(F_{Rd,u,1}, F_{Rd,u,2}, F_{Rd,u,3}) = 183.5 \text{ kN}$$

Utilisation

$$F_{Ed1} / F_{Rd,u,min} = 0.136$$

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

Check 12: Tying resistance - Supported beam web

Web resistance

$$F_{Rd,u} = (t_{w,b} \times h_p \times f_{u,b}) / \gamma_{M,u} = 301.91 \text{ kN}$$

Utilisation

$$F_{Ed1} / F_{Rd,u} = 0.083$$

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