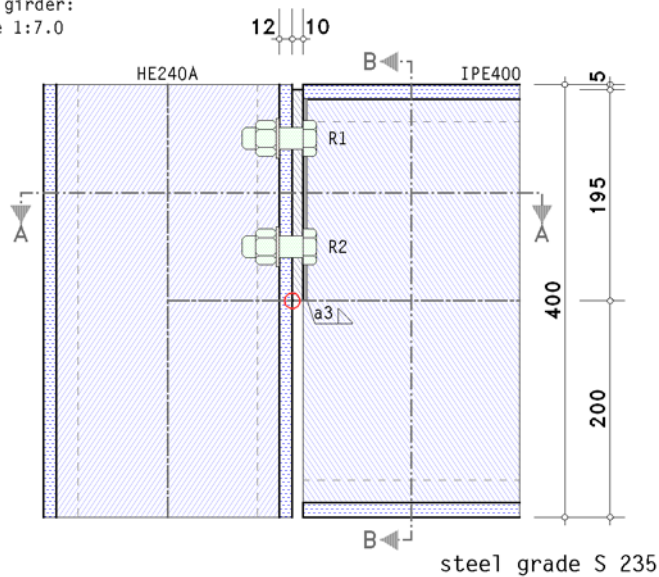


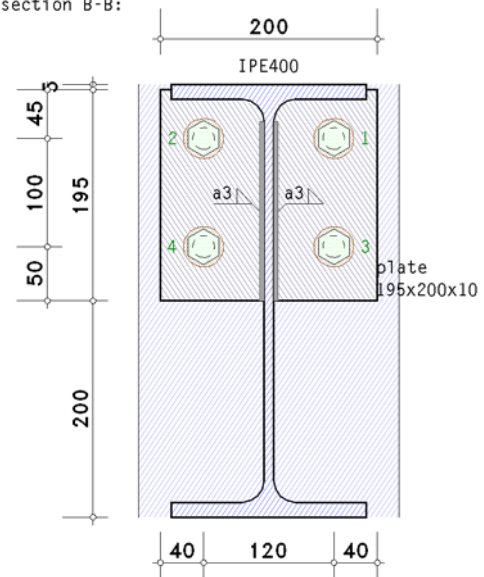
Simple Joint of Beams

EC 3-1-8 (12.10), NA: Deutschland

main girder:
scale 1:7.0

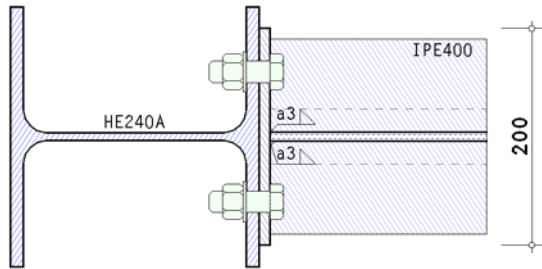


section B-B:



○ hinge

section A-A:



beam connection with end-plate, connected to the flange of the main girder

steel grade

steel grade S 235

bolts

bolt: bolt class 4.6,

dimensions:

shaft diameter $d = 20.0$ mm, clearance $\Delta d = 1.0$ mm $\Rightarrow$ hole diameter $d_0 = 21.0$ mm

gross cross-section area $A = 3.142$ cm²

tensile stress area $A_s = 2.450$ cm²

diameter of the bolt head (across flats dimension) $d_s = 30.0$ mm

diameter of the bolt head (across points dimension) $d_e = 32.95$ mm

thickness of the bolt head $t_k = 12.5$ mm

thickness of nut $t_m = 19.0$ mm

diameter of the plate under the bolt or the nut $d_p = 37.0$ mm

thickness of the plate under the bolt or the nut $t_p = 3.0$ mm

shear plane passes through the unthreaded portion of the bolt

geometry

main girder

section HE240A

supported beam

section IPE400

joint configuration

end-plate: thickness $t_p = 10.0$ mm, length $l_p = 195.0$ mm, width $b_p = 200.0$ mm

plate lengths: $h_o = 0.0$ mm, $\ddot{u}_o = 5.0$ mm ($h_u = 0.0$ mm, $\ddot{u}_u = 200.0$ mm)

distances between bolts at main girder: $e_{z,0} = 45.0$ mm, $p_{z,1-2} = 100.0$ mm, $e_{x,0} = 40.0$ mm

thickness weld: $a_w = 3.0$ mm

design resistance

verification of welds with the directional method

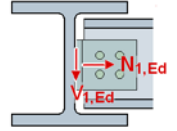
internal forces and moments

Lk 1: $V_{1,Ed} = 200.00 \text{ kN}$

partial safety factors for material

resistance of cross sections $\gamma_{M0} = 1.00$

resistance of bolts, welds, plates in bearing $\gamma_{M2} = 1.25$



Simple Joint of Beams

distance of bolt rows at main girder (right)

edge dist.:	$e_2 = 40.0 \text{ mm} > 1.2 \cdot d_0 = 25.2 \text{ mm}$,	$e_2 = 40.0 \text{ mm} < 4 \cdot t_{\min} + 40 \text{ mm} = 80.0 \text{ mm}$
pitch:	$p_2 = 120.0 \text{ mm} > 2.4 \cdot d_0 = 50.4 \text{ mm}$,	$p_2 = 120.0 \text{ mm} < \min(14 \cdot t_{\min}, 200 \text{ mm}) = 140.0 \text{ mm}$
edge dist.:	$e_1 = 45.0 \text{ mm} > 1.2 \cdot d_0 = 25.2 \text{ mm}$,	$e_1 = 45.0 \text{ mm} < 4 \cdot t_1 + 40 \text{ mm} = 88.0 \text{ mm}$
pitch:	$p_1 = 100.0 \text{ mm} > 2.2 \cdot d_0 = 46.2 \text{ mm}$,	$p_1 = 100.0 \text{ mm} < \min(14 \cdot t_{\min}, 200 \text{ mm}) = 140.0 \text{ mm}$
edge dist.:	$e_1 = 50.0 \text{ mm} > 1.2 \cdot d_0 = 25.2 \text{ mm}$,	$e_1 = 50.0 \text{ mm} < 4 \cdot t_1 + 40 \text{ mm} = 88.0 \text{ mm}$

assumption: hinge is in the periphery to the flange of the main girder

Lk 1:

design values

transformation of member forces to the reference point (intersection point of beam axis')

$M_{1,Ed} = V_{j1,Ed} \cdot e_1 = -23.00 \text{ kNm}$, $e_1 = -115.0 \text{ mm}$

$V_{1,Ed} = V_{j1,Ed} = 200.00 \text{ kN}$

design resistance of the connection

calculation of the point section:

bolt 1 $T_1 = T_{z,1} = 50.00 \text{ kN}$

bolt 2 $T_2 = T_{z,2} = 50.00 \text{ kN}$

bolt 3 $T_3 = T_{z,3} = 50.00 \text{ kN}$

bolt 4 $T_4 = T_{z,4} = 50.00 \text{ kN}$

shear force resistance

bolts in shear:

$U_i = T_i / F_{v,Rd}$, $V_{Rd,i} = V_{1,Ed} / U_i$, $V_{Rd} = \min V_{Rd,i}$

design shear resistance per shear plane: $F_{v,Rd} = \alpha_v \cdot f_{ub} \cdot A / \gamma_{M2} = 60.32 \text{ kN}$, $\alpha_v = 0.60$

bolt 1: $U_1 = 0.829$ $V_{Rd,1} = 241.3 \text{ kN}$

bolt 2: $U_2 = 0.829$ $V_{Rd,2} = 241.3 \text{ kN}$

bolt 3: $U_3 = 0.829$ $V_{Rd,3} = 241.3 \text{ kN}$

bolt 4: $U_4 = 0.829$ $V_{Rd,4} = 241.3 \text{ kN}$

design shear resistance total: $V_{Rd,1} = 241.3 \text{ kN}$

end-plate with bearing resistance:

$U_{z,i} = T_{z,i} / F_{b,z,Rd}$, $U_{y,i} = T_{y,i} / F_{b,y,Rd}$, $U_i = \max(U_{z,i}, U_{y,i})$, $V_{Rd,i} = V_{1,Ed} / U_i$, $V_{Rd} = \min V_{Rd,i}$

bolt 1: $F_{b,z,1} = 102.86 \text{ kN}$ $U_1 = 0.486$ $V_{Rd,1} = 411.4 \text{ kN}$

bolt 2: $F_{b,z,2} = 102.86 \text{ kN}$ $U_2 = 0.486$ $V_{Rd,2} = 411.4 \text{ kN}$

bolt 3: $F_{b,z,3} = 114.29 \text{ kN}$ $U_3 = 0.438$ $V_{Rd,3} = 457.1 \text{ kN}$

bolt 4: $F_{b,z,4} = 114.29 \text{ kN}$ $U_4 = 0.438$ $V_{Rd,4} = 457.1 \text{ kN}$

design bearing resistance total: $V_{Rd,2} = 411.4 \text{ kN}$

beam flange with bearing resistance:

$U_{z,i} = T_{z,i} / F_{b,z,Rd}$, $U_{y,i} = T_{y,i} / F_{b,y,Rd}$, $U_i = \max(U_{z,i}, U_{y,i})$, $V_{Rd,i} = V_{1,Ed} / U_i$, $V_{Rd} = \min V_{Rd,i}$

bolt 1: $F_{b,z,1} = 172.80 \text{ kN}$ $U_1 = 0.289$ $V_{Rd,1} = 691.2 \text{ kN}$

bolt 2: $F_{b,z,2} = 172.80 \text{ kN}$ $U_2 = 0.289$ $V_{Rd,2} = 691.2 \text{ kN}$

bolt 3: $F_{b,z,3} = 172.80 \text{ kN}$ $U_3 = 0.289$ $V_{Rd,3} = 691.2 \text{ kN}$

bolt 4: $F_{b,z,4} = 172.80 \text{ kN}$ $U_4 = 0.289$ $V_{Rd,4} = 691.2 \text{ kN}$

design bearing resistance total: $V_{Rd,3} = 691.2 \text{ kN}$

end-plate in tension and shear (shear block):

shear resistance $V_{eff,Rd} = (A_{nt} \cdot f_u) / \gamma_{M2} + (A_{nv} \cdot f_y / 3^{1/3}) / \gamma_{M0} = 439.11 \text{ kN}$

shear resistance total: $V_{Rd,4} = 439.1 \text{ kN}$

end-plate in bending and shear:

shear resistance $V_{Rd} = f_y / \gamma_{M0} / ((b' / W_{el})^2 + 3 \cdot (1/A)^2)^{1/2} = 147.23 \text{ kN}$

shear resistance total: $V_{Rd,5} = 2 \cdot 147.23 = 294.5 \text{ kN}$

beam web with shear (next to the weld):
shear resistance $V_{Rd} = (A_v \cdot f_y) / (3^{1/2} \cdot \gamma_{M0}) = 217.61 \text{ kN}$
shear resistance total: $V_{Rd,6} = 217.6 \text{ kN}$

shear resistance: $\min V_{Rd,p} = V_{Rd,6} = 217.6 \text{ kN}$

verification of the connection

$V_{Ed} = 200.0 \text{ kN}$: $V_{Ed} / \min V_{Rd} = 0.919 < 1$ **ok.**

weld verification

$\sigma_{1,w,Ed} = 32.01 \text{ kN/cm}^2 < f_{1,w,Rd} = 36.00 \text{ kN/cm}^2$,
 $\sigma_{2,w,Ed} = 4.07 \text{ kN/cm}^2 < f_{2,w,Rd} = 25.92 \text{ kN/cm}^2 \Rightarrow U_w = 0.889 < 1$ **ok.**

verification result

maximum utilization: $\max U = 0.919 < 1$ **ok.**

Final Result

maximum utilization: design resistance $\max U = 0.919 < 1$ **ok.**

verification succeeded

Regulations

DIN EN 1990, Eurocode 0: Grundlagen der Tragwerksplanung;
Deutsche Fassung EN 1990:2002 + A1:2005 + A1:2005/AC:2010, Ausgabe Dezember 2010
DIN EN 1990/NA, Nationaler Anhang zur DIN EN 1990, Ausgabe Dezember 2010

DIN EN 1993-1-1, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau;
Deutsche Fassung EN 1993-1-1:2005 + AC:2009, Ausgabe Dezember 2010
DIN EN 1993-1-1/NA, Nationaler Anhang zur DIN EN 1993-1-1, Ausgabe Dezember 2010

DIN EN 1993-1-8, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-8: Bemessung von Anschlüssen;
Deutsche Fassung EN 1993-1-8:2005 + AC:2009, Ausgabe Dezember 2010
DIN EN 1993-1-8/NA, Nationaler Anhang zur DIN EN 1993-1-8, Ausgabe Dezember 2010

ECCS Document No. 126: European Recommendations for the Design of Simple Joints in Steel Structures.
ECCS TC10 - Structural Connections, 2009. J.P. Jaspart, J.F. Demonceau, S. Renkin, M.L. Guillaume