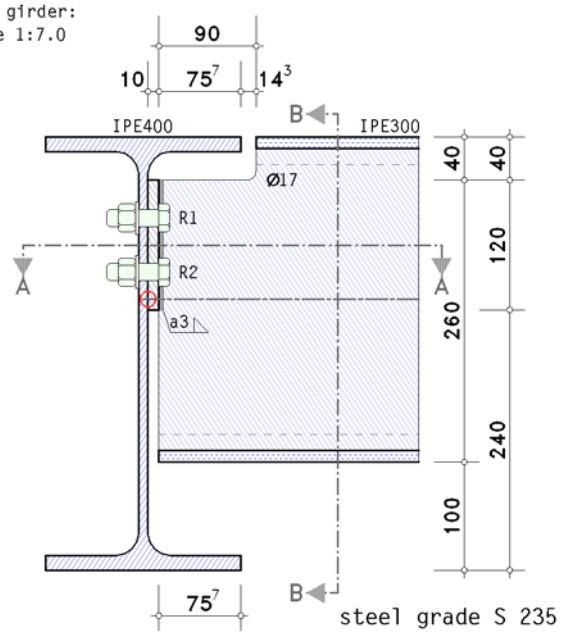
POS. 12: WAGENKNECHT 5.8.3

4H-EC3GT version: 6/2015-1c

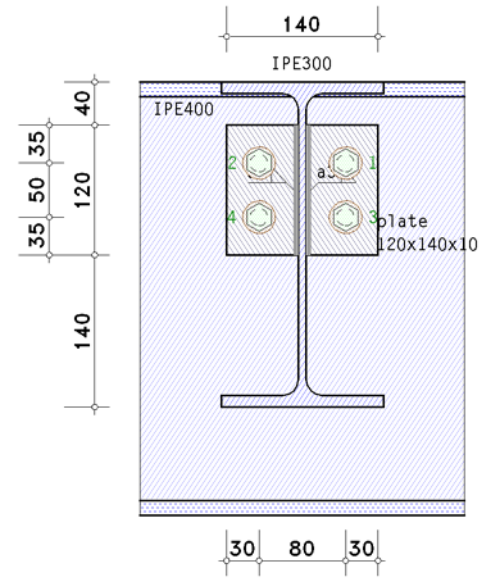
Simple Joint of Beams

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

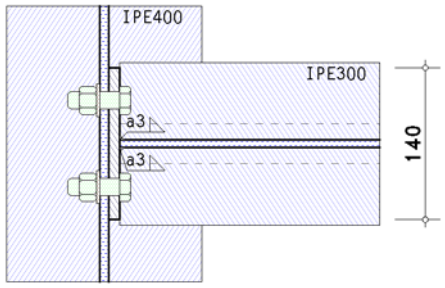
main girder:
scale 1:7.0



section B-B:



section A-A:



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

steel grade

steel grade S 235

bolts

bolt: bolt class 4.6, bolt size M16

shear plane passes through the unthreaded portion of the bolt

geometry

main girder

section IPE400

supported beam

section IPE300

joint configuration

end-plate: thickness t_p = 10.0 mm, length l_p = 120.0 mm, width b_p = 140.0 mm

plate lengths: h_o = 0.0 mm, $ü_o$ = 40.0 mm (h_u = 100.0 mm, $ü_u$ = 140.0 mm)

notch: a_o = 90.0 mm, e_o = 40.0 mm

rounded notch (root radius r_a = 8.5 mm)

distances between bolts at main girder: $e_{z,0}$ = 35.0 mm, $p_{z,1-2}$ = 50.0 mm, $e_{x,0}$ = 30.0 mm

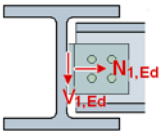
thickness weld: a_w = 3.0 mm

design resistance

verification of welds with the simplified method

elastic cross-sectional check der supported beam

internal forces and moments
Lk 1: $V_{1,Ed}$ = 75.00 kN



partial safety factors for material
resistance of cross sections γ_{M0} = 1.00
resistance of bolts, welds, plates in bearing γ_{M2} = 1.25

Simple Joint of Beams

distance of bolt rows at main girder (right)

edge dist.:	e_2 = 30.0 mm > 1.2·d_0 = 21.6 mm,	e_2 = 30.0 mm < 4·t_{min} + 40 mm = 74.4 mm
pitch:	p_2 = 80.0 mm > 2.4·d_0 = 43.2 mm,	p_2 = 80.0 mm < min(14·t_{min}, 200 mm) = 120.4 mm
edge dist.:	e_1 = 35.0 mm > 1.2·d_0 = 21.6 mm,	e_1 = 35.0 mm < 4·t_1 + 40 mm = 74.4 mm
pitch:	p_1 = 50.0 mm > 2.2·d_0 = 39.6 mm,	p_1 = 50.0 mm < min(14·t_{min}, 200 mm) = 120.4 mm
edge dist.:	e_1 = 35.0 mm > 1.2·d_0 = 21.6 mm,	e_1 = 35.0 mm < 4·t_1 + 40 mm = 74.4 mm

assumption: hinge is in the periphery to main girder web

Lk 1:

design values

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

$M_{1,Ed}$ = $V_{j1,Ed}$·e_1 = -0.32 kNm, e_1 = -4.3 mm
$V_{1,Ed}$ = $V_{j1,Ed}$ = 75.00 kN

design resistance of the connection

calculation of the point section:
bolt 1 T_1 = $T_{z,1}$ = 18.75 kN
bolt 2 T_2 = $T_{z,2}$ = 18.75 kN
bolt 3 T_3 = $T_{z,3}$ = 18.75 kN
bolt 4 T_4 = $T_{z,4}$ = 18.75 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: $F_{v,Rd}$ = α_v·f_{ub}·A / γ_{M2} = 38.60 kN, α_v = 0.60

bolt 1:	U_1 = 0.486	$V_{Rd,1}$ = 154.4 kN
bolt 2:	U_2 = 0.486	$V_{Rd,2}$ = 154.4 kN
bolt 3:	U_3 = 0.486	$V_{Rd,3}$ = 154.4 kN
bolt 4:	U_4 = 0.486	$V_{Rd,4}$ = 154.4 kN

design shear resistance total: $V_{Rd,1}$ = 154.4 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:	$F_{b,z,1}$ = 74.67 kN	U_1 = 0.251	$V_{Rd,1}$ = 298.7 kN
bolt 2:	$F_{b,z,2}$ = 74.67 kN	U_2 = 0.251	$V_{Rd,2}$ = 298.7 kN
bolt 3:	$F_{b,z,3}$ = 74.67 kN	U_3 = 0.251	$V_{Rd,3}$ = 298.7 kN
bolt 4:	$F_{b,z,4}$ = 74.67 kN	U_4 = 0.251	$V_{Rd,4}$ = 298.7 kN

design bearing resistance total: $V_{Rd,2}$ = 298.7 kN

beam web 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:	$F_{b,z,1}$ = 66.97 kN	U_1 = 0.280	$V_{Rd,1}$ = 267.9 kN
bolt 2:	$F_{b,z,2}$ = 66.97 kN	U_2 = 0.280	$V_{Rd,2}$ = 267.9 kN
bolt 3:	$F_{b,z,3}$ = 66.97 kN	U_3 = 0.280	$V_{Rd,3}$ = 267.9 kN
bolt 4:	$F_{b,z,4}$ = 66.97 kN	U_4 = 0.280	$V_{Rd,4}$ = 267.9 kN

design bearing resistance total: $V_{Rd,3}$ = 267.9 kN

end-plate in tension and shear (shear block):
shear resistance $V_{eff,Rd}$ = (A_{nt}·f_u) / γ_{M2} + (A_{nv}·f_y/$3^{1/3}$) / γ_{M0} = 257.25 kN
shear resistance total: $V_{Rd,4}$ = 257.3 kN

end-plate in bending and shear:
shear resistance V_{Rd} = f_y/γ_{M0} / ((b'/W_{el})^2 + 3·(1/A)^2)$^{1/2}$ = 88.86 kN
shear resistance total: $V_{Rd,5}$ = 2·88.86 = 177.7 kN

beam web with shear (next to the weld):

shear resistance $V_{Rd} = (A_v \cdot f_y) / (3^{1/2} \cdot \gamma_{M0}) = 115.60$ kN
shear resistance total: $V_{Rd,6} = 115.6$ kN

shear resistance: min $V_{Rd,p} = V_{Rd,6} = 115.6$ kN

verification of the connection

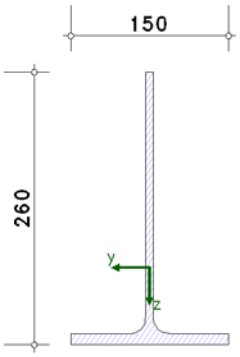
$V_{Ed} = 75.0$ kN: V_{Ed} / min $V_{Rd} = 0.649 < 1$ **ok.**

weld verification

$F_{w,Ed} = 3.49$ kN/cm $< F_{w,Rd} = 6.24$ kN/cm $\Rightarrow U_w = 0.560 < 1$ **ok.**

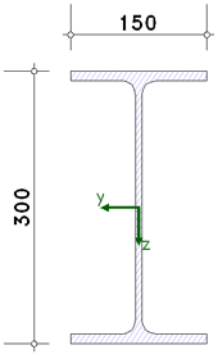
cross-sectional check of supported beam

verification at $\Delta x = 95.8$ mm with notch



elastic cross-sectional check for $M_{Ed} = 6.86$ kNm, $V_{Ed} = 75.00$ kN
elastic stresses: max $\sigma_x = 2.16$ kN/cm², min $\sigma_x = -5.47$ kN/cm², max $\tau = 5.57$ kN/cm², max $\sigma_v = 9.64$ kN/cm²
utilizations: design resistance $U_\sigma = 0.410 < 1$ **ok.**

verification at $\Delta x = 104.3$ mm



elastic cross-sectional check for $M_{Ed} = 7.50$ kNm, $V_{Ed} = 75.00$ kN
elastic stresses: max $\sigma_x = 1.35$ kN/cm², min $\sigma_x = -1.35$ kN/cm², max $\tau = 3.97$ kN/cm², max $\sigma_v = 6.88$ kN/cm²
utilizations: design resistance $U_\sigma = 0.293 < 1$ **ok.**, c/t-ratio $U_{c/t} = 0.090 < 1$ **ok.**

verification result

maximum utilization: max U = 0.649 < 1 **ok.**

Final Result

maximum utilization: design resistance max U = 0.649 < 1 **ok.**
c/t-ratio max U = 0.090 < 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