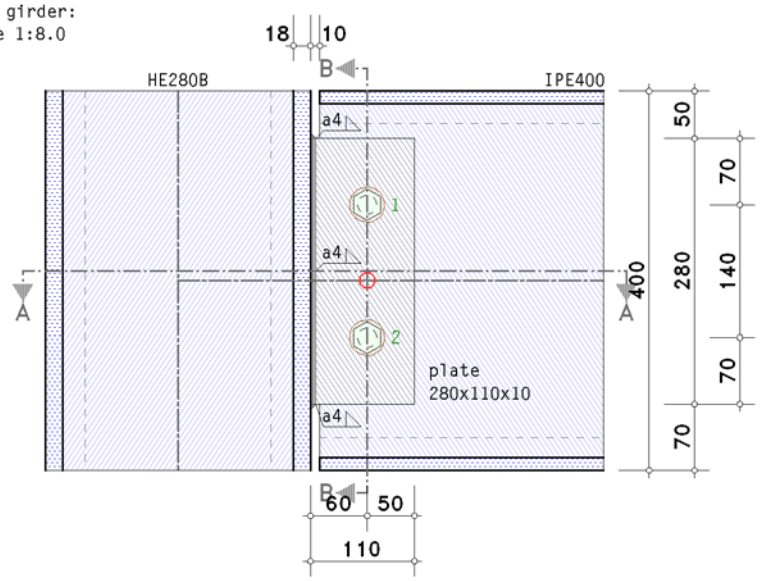
4H-EC3GT version: 6/2015-1c

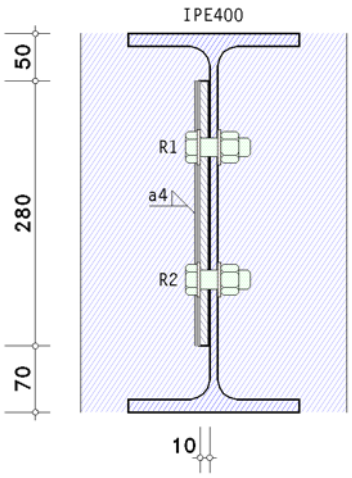
Simple Joint of Beams

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

main girder:
scale 1:8.0



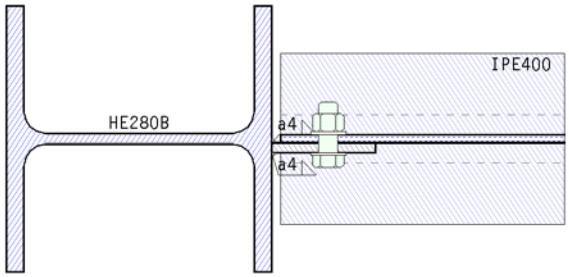
section B-B:



steel grade S 355 H
bolts M20-10.9

○ hinge

section A-A:



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

steel grade

steel grade S 355 H

bolts

bolt: bolt class 10.9, bolt size M20

shear plane passes through the unthreaded portion of the bolt

geometry

main girder

section HE280B

supported beam

section IPE400

joint configuration

fin plate: thickness t_F = 10.0 mm, length l_F = 110.0 mm, width b_F = 280.0 mm

plate lengths: h_o = 0.0 mm, $\ddot{u}_o$ = 50.0 mm (h_u = 0.0 mm, $\ddot{u}_u$ = 70.0 mm), s = 10.0 mm

distances between bolts at supported beam: $e_{z,0}$ = 70.0 mm, $p_{z,1-2}$ = 140.0 mm, $e_{x,0}$ = 50.0 mm

thickness weld: a_w = 4.0 mm

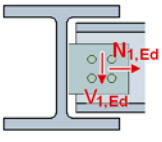
design resistance

verification of welds with the directional method

elastic cross-sectional check der supported beam

internal forces and moments

Lk 1: $V_{1,Ed}$ = 163.10 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

single shear connection with one bolt-row in direction of load transfer: washer on both sides !!

distance of bolt rows at supported beam (right)

edge dist.:	$e_2 = 50.0$ mm $> 1.2 \cdot d_0 = 26.4$ mm,	$e_2 = 50.0$ mm $< 4 \cdot t_{min} + 40$ mm $= 74.4$ mm
edge dist.:	$e_1 = 70.0$ mm $> 1.2 \cdot d_0 = 26.4$ mm,	$e_1 = 70.0$ mm $< 4 \cdot t_1 + 40$ mm $= 74.4$ mm
pitch:	$p_1 = 140.0$ mm $> 2.2 \cdot d_0 = 48.4$ mm,	$p_1 = 140.0$ mm $> \min(14 \cdot t_{min}, 200$ mm$) = 120.4$ mm !!
edge dist.:	$e_1 = 70.0$ mm $> 1.2 \cdot d_0 = 26.4$ mm,	$e_1 = 70.0$ mm $< 4 \cdot t_1 + 40$ mm $= 74.4$ mm

assumption: hinge is in centroid of bolts in the axis of supported beam

Lk 1:

design values

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

$M_{1,Ed} = V_{j1,Ed} \cdot e_1 = -32.62$ kNm, $e_1 = -200.0$ mm
$V_{1,Ed} = V_{j1,Ed} = 163.10$ kN

design resistance of the connection

calculation of the point section:
bolt 1 $T_1 = T_{z,1} = 81.55$ kN
bolt 2 $T_2 = T_{z,2} = 81.55$ kN

shear force resistance
bolts in shear:
$U_i = T_i / (1 \cdot F_{v,Rd})$, $V_{Rd,i} = V_{1,Ed} / U_i$, $V_{Rd} = \min V_{Rd,i}$
design shear resistance per shear plane: $F_{v,Rd} = \alpha_v \cdot f_{ub} \cdot A / \gamma_{M2} = 150.80$ kN, $\alpha_v = 0.60$
bolt 1: $U_1 = 0.541$ $V_{Rd,1} = 301.6$ kN
bolt 2: $U_2 = 0.541$ $V_{Rd,2} = 301.6$ kN
design shear resistance total: $V_{Rd,1} = 301.6$ kN

fin 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: $F_{b,z,1} = 204.00$ kN $U_1 = 0.400$ $V_{Rd,1} = 408.0$ kN
bolt 2: $F_{b,z,2} = 204.00$ kN $U_2 = 0.400$ $V_{Rd,2} = 408.0$ kN
design bearing resistance total: $V_{Rd,2} = 408.0$ kN

fin plate in tension and shear (shear block):
shear resistance $V_{eff,Rd} = (0.5 \cdot A_{nt} \cdot f_u) / \gamma_{M2} + (A_{nv} \cdot f_y / 3^{1/3}) / \gamma_{M0} = 352.16$ kN
shear resistance total: $V_{Rd,3} = 352.2$ kN

fin plate in bending and shear:
shear resistance $V_{Rd} = f_y / \gamma_{M0} / ((b'/W_{el})^2 + 3 \cdot (1/A + h'/W_t)^2)^{1/2} = 148.60$ kN
shear resistance total: $V_{Rd,4} = 148.6$ 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: $F_{b,z,1} = 175.44$ kN $U_1 = 0.465$ $V_{Rd,1} = 350.9$ kN
bolt 2: $F_{b,z,2} = 175.44$ kN $U_2 = 0.465$ $V_{Rd,2} = 350.9$ kN
design bearing resistance total: $V_{Rd,5} = 350.9$ kN

beam web in tension and shear (shear block):
shear resistance $V_{eff,Rd} = (0.5 \cdot A_{nt} \cdot f_u) / \gamma_{M2} + (A_{nv} \cdot f_y / 3^{1/3}) / \gamma_{M0} = 503.80$ kN
shear resistance total: $V_{Rd,6} = 503.8$ kN

shear resistance: min $V_{Rd,F} = V_{Rd,4} = 148.6$ kN

verification of the connection

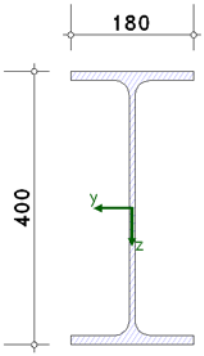
$V_{Ed} = 163.1$ kN: $V_{Ed} / \min V_{Rd} = 1.098 > 1$ not ok. !!

weld verification

$\sigma_{1,w,Ed} = 16.75$ kN/cm² $< f_{1,w,Rd} = 45.33$ kN/cm²,
$\sigma_{2,w,Ed} = 5.98$ kN/cm² $< f_{2,w,Rd} = 36.72$ kN/cm² $\Rightarrow U_w = 0.598 < 1$ ok.

cross-sectional check of supported beam

verification at $\Delta x = 15.3$ mm



elastic cross-sectional check for $M_{Ed} = -30.13$ kNm, $V_{Ed} = 163.10$ kN
elastic stresses: max $\sigma_x = 2.61$ kN/cm², min $\sigma_x = -2.61$ kN/cm², max $\tau = 5.36$ kN/cm², max $\sigma_v = 9.29$ kN/cm²
utilizations: design resistance $U_\sigma = 0.262 < 1$ ok., c/t-ratio $U_{c/t} = 0.114 < 1$ ok.

verification result

maximum utilization: max U = 1.098 > 1 not ok. !!
shear failure (right): U = 1.098

Final Result

maximum utilization: design resistance max U = 1.098 > 1 not ok. !!
c/t-ratio max U = 0.114 < 1 ok.

design resistance not ensured !!

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