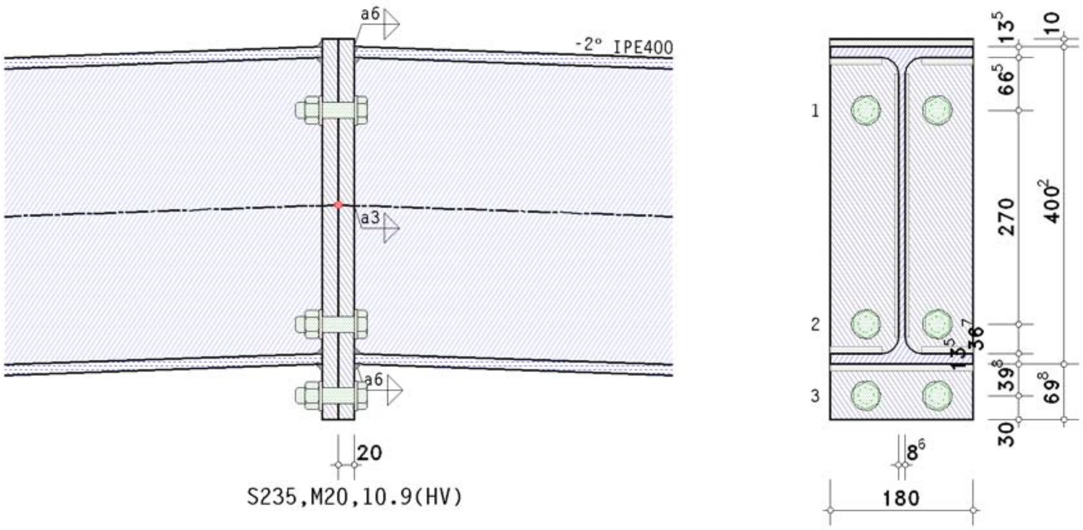
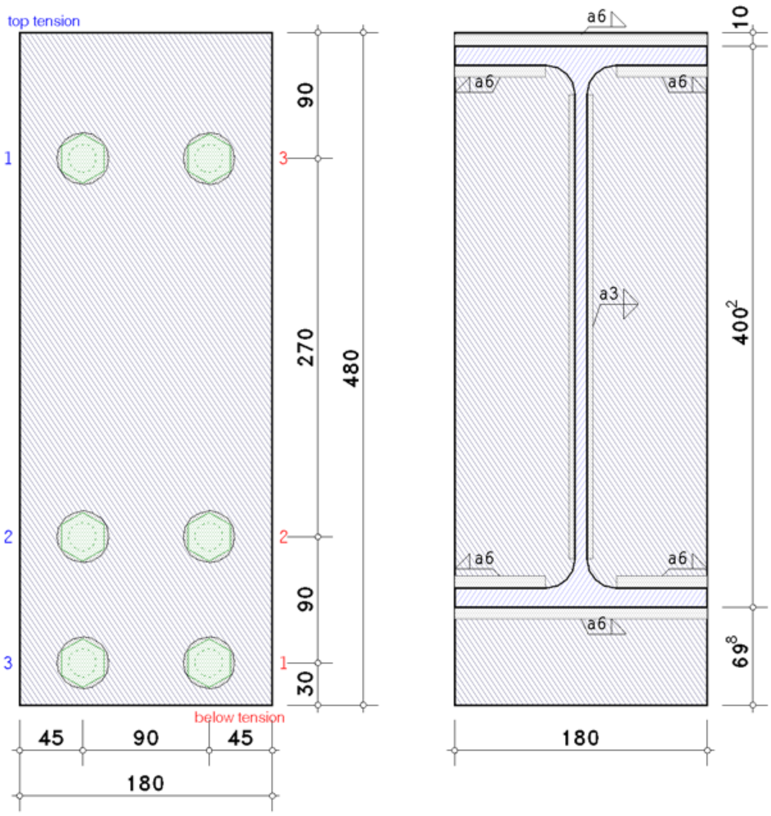
Rigid beam splice EC 3-1-8 (04.25), NA: Deutschland 4H-EC3BT version: 10/2019-2w

1. input report



details (section A - A)



steel grade

steel grade S235

bolts

bolt class 10.9, bolt size M20

large wrench size (high strength bolt), preloaded (for info: preloading $F_{p,C}^* = 0.7 \cdot f_{yb} \cdot A_s$ = 154.2 kN)

shear plane passes through the unthreaded portion of the bolt

beam parameters

section IPE400

slope angle of section about the horizontal axis α_b = -2.00°

verification parameters

bolted end-plate connection

thickness t_p = 20.0 mm, width b_p = 180.0 mm, length l_p = 480.0 mm

projections $h_{p,o}$ = 10.0 mm, $h_{p,u}$ = 69.8 mm

bolts in connection:

3 bolt-rows with 2 bolts

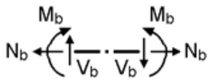
of these 1 bolt-row top in tension (row 1)

and 2 bolt-rows for shear transfer top (rows 2-3)
of these 2 bolt-rows below in tension (rows 2-3)
and 1 bolt-row for shear transfer below (row 3)
centre distance of the bolts to the lateral edge of the end-plate e_2 = 45.0 mm
centre distance of the first bolt-row to the upper edge of the end-plate (end row) e_o = 90.0 mm
centre distance of the last bolt-row to the bottom edge of the end-plate (end row) e_u = 30.0 mm
centre distance of the bolt-rows from each other p_{1-2} = 270.0 mm, p_{2-3} = 90.0 mm

welds at the connection point:
beam flange top: fillet weld, weld thickness a = 6.0 mm, angle φ = 92°
beam web: fillet weld, weld thickness a = 3.0 mm
beam flange below: fillet weld, weld thickness a = 6.0 mm, angle φ = 88°

internal forces and moments in the intersection point of system axes

Lc 1: $N_{j,b,Ed}$ = -30.10 kN $M_{j,b,Ed}$ = 184.50 kNm $V_{j,b,Ed}$ = 0.80 kN



partial safety factors for material

resistance of cross-sections γ_{M0} = 1.00
resistance of members in stability failure γ_{M1} = 1.10
resistance of bolts, welds, plates in bearing γ_{M2} = 1.25
prestressing of high strength bolts γ_{M7} = 1.10

notes

Es sind einzelne basic components due tochosen, die ggf. the resistance of the connection not gewährleisten !
connection is verified due to EC 3-1-8 regardless of preloading.
however, connections may be constructed with prestressed high strength bolts.
no verification for cross-sections.

check of data

ok

distances between bolts at end-plate

horizontal:	e_2 = 45.0 mm > 1.2·d_0 = 26.4 mm,	e_2 = 45.0 mm < 4·t + 40 mm = 120.0 mm
horizontal:	p_2 = 90.0 mm > 2.4·d_0 = 52.8 mm,	p_2 = 90.0 mm < min(14·t, 200 mm) = 200.0 mm
top-below:	e_1 = 90.0 mm > 1.2·d_0 = 26.4 mm,	e_1 = 90.0 mm < 4·t + 40 mm = 120.0 mm
top-below:	p_1 = 270.0 mm > 2.2·d_0 = 48.4 mm,	p_1 = 270.0 mm > min(14·t, 200 mm) = 200.0 mm !!
top-below:	p_1 = 90.0 mm > 2.2·d_0 = 48.4 mm,	p_1 = 90.0 mm < min(14·t, 200 mm) = 200.0 mm
top-below:	e_1 = 30.0 mm > 1.2·d_0 = 26.4 mm,	e_1 = 30.0 mm < 4·t + 40 mm = 120.0 mm

maximum values for spacings and edge distances should be in order to avoid local buckling and to prevent corrosion.

2. table of results

utilization

Lc	U
1	0.834*

U: utilization of the connection
*) maximum utilization

3. final result

maximum utilization: max U = 0.834 < 1 ok

verification succeeded

total loading capacity of the connection may not be guaranteed (s. notes) !

4. Regulations

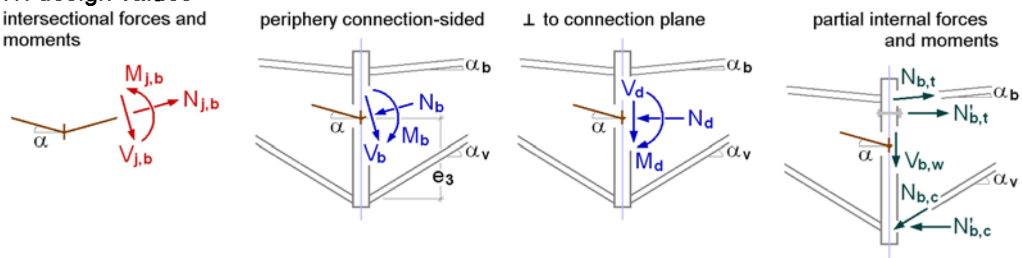
EN 1990, Eurocode 0: Grundlagen der Tragwerksplanung;
Deutsche Fassung EN 1990:2002 + A1:2005 + A1:2005/AC:2010, Ausgabe Dezember 2010
EN 1990/NA, Nationaler Anhang zur EN 1990, Ausgabe Dezember 2010

EN 1993-1-1, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau;
Deutsche Fassung EN 1993-1-1:2022, Ausgabe April 2025
EN 1993-1-1/NA, Nationaler appendix zur EN 1993-1-1, Ausgabe Oktober 2022

EN 1993-1-8, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-8: Bemessung von Anschlüssen;
Deutsche Fassung EN 1993-1-8:2024, Ausgabe April 2025
EN 1993-1-8/NA, Nationaler appendix zur EN 1993-1-8, Ausgabe November 2020

5. Lc 1 (decisive)

5.1. design values



slope angle: $\alpha_b = \alpha_v = \alpha = -2.00°$

internal forces and moments perpendicular to the connection planes

periphery beam

$N_d = 30.11$ kN, $M_d = -184.50$ kNm, $V_d = -0.25$ kN

negative internal moment M_d ⇒ mirrored model ($\alpha_b = \alpha_v = \alpha = 2.00°$)

$N_d = 30.11$ kN, $M_d = 184.50$ kNm, $V_d = 0.25$ kN

partial internal forces and moments refering to the mirrored model

internal forces and moments in the periphery end-plate-beam: $M'_d = M_d + N_d \cdot t_p \cdot \tan(\alpha) - V_d \cdot t_p = 184.52$ kNm

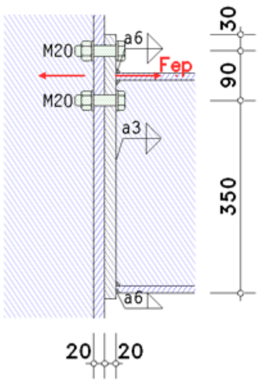
$N_{b,t} = (-N_d \cdot z_{bu}/z_b + M'_d/z_b) / \cos(\alpha_b) = 462.34$ kN, $z_b = 386.7$ mm, $z_{bu} = 193.4$ mm

$N_{b,c} = (N_d \cdot z_{bo}/z_b + M'_d/z_b) / \cos(\alpha_b) = 492.47$ kN, $z_b = 386.7$ mm, $z_{bo} = 193.4$ mm

$V_{b,t} = -N_{b,t} \cdot \sin(\alpha_b) = -16.14$ kN, $V_{b,c} = N_{b,c} \cdot \sin(\alpha_v) = 17.19$ kN, $V_{b,w} = V_d - V_{b,t} - V_{b,c} = -0.80$ kN

5.2. basic components

5.2.1. bc 5: end-plate in bending



Only the essential sizes are sketched to scale.
The connection geometry is only hinted.

extended part of end-plate

in the extended part of the end-plate only one bolt-row is considered ($n_b = 1$).

effective length of the T-stub flange (end-plate):

in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 90.0$ mm, $l_{eff,cp} = 193.6$ mm

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 90.0$ mm

tension resistance of the T-stub flange:

in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 2.11$ kNm

$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 176.26$ kN, $k_2 = 0.90$

in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 352.51$ kN

mode 1: complete yielding of the T-stub flange

$F_{T,1,Rd} = ((8 \cdot n - 2 \cdot e_w) \cdot M_{pl,1,Rd}) / (2 \cdot m \cdot n - e_w \cdot (m+n)) = 335.61$ kN

mode 2: bolt failure simultaneously with yielding of the T-stub flange

$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 235.21$ kN

mode 3: bolt failure

$F_{T,3,Rd} = \Sigma F_{t,Rd} = 352.51$ kN

tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 235.21$ kN

resistance of a fillet weld (req.1): $f_{1w,d} = f_u / (\beta_w \cdot \gamma_{M2}) = 360.0$ N/mm²

tension resistance of welds: $F_{T,w,Rd} = 2^{1/2} \cdot f_{1w,d} \cdot a \cdot l_{eff} = 274.92$ kN (≥ 235.21 kN, not decisive)

resistance and effective length of end-plate in bending (projection)

$F_{t,ep,Rd,1} = 235.21$ kN, $l_{eff,1} = 90.0$ mm

part of end-plate between beam flanges

equivalent T-stub flange (each individual bolt-row):

here: number of bolt-rows $n_b = 1$

row 2

effective length of the T-stub flange (end-plate):

in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 234.4$ mm, $l_{eff,cp} = 234.4$ mm

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 236.2$ mm

tension resistance of the T-stub flange:

in mode 1: $M_{pl,1,Rd} = (0.25 \cdot \Sigma l_{eff,1} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 5.51$ kNm

in mode 2: $M_{pl,2,Rd} = (0.25 \cdot \Sigma l_{eff,2} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 5.55$ kNm

$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 176.26$ kN, $k_2 = 0.90$
in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 352.51$ kN
mode 1: complete yielding of the T-stub flange
$F_{T,1,Rd} = ((8 \cdot n - 2 \cdot e_w) \cdot M_{pl,1,Rd}) / (2 \cdot m \cdot n - e_w \cdot (m+n)) = 724.57$ kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 327.63$ kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd} = 352.51$ kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 327.63$ kN
resistance of a fillet weld (req.1): $f_{1w,d} = f_u / (\beta_w \cdot \gamma_{M2}) = 360.0$ N/mm²
tension resistance of welds: $F_{T,w,Rd} = 2^{1/2} \cdot f_{1w,d} \cdot a \cdot l_{eff} = 358.01$ kN (≥ 327.63 kN, not decisive)

resistances and effective lengths of end-plate in bending (per bolt-row):

$F_{ep,Rd,2} = 327.63$ kN, $l_{eff,2} = 234.4$ mm

5.3. verifications

5.3.1. verification of the connection capacity with partial internal forces and moments

tension force in the bolt-rows:
$N'_{b,t} = (-N_d \cdot z_{bu} + M_d) / z = 460.27$ kN, $z = z_{eq} = 388.2$ mm, $z_{bu} = 192.7$ mm

bc 5: $F_{Rd} = \Sigma F_{t,ep,Rd,i} = 552.1$ kN, $F_{Ed} = N'_{b,t} = 460.27$ kN
$F_{Ed} = 460.3$ kN $<$ $F_{Rd} = 552.1$ kN $\Rightarrow$ $U = 0.834 < 1$ ok

utilization partial internal forces and moments $U_{bc} = 0.834 < 1$ ok

5.3.2. verification result

maximum utilization: max $U = 0.834 < 1$ ok