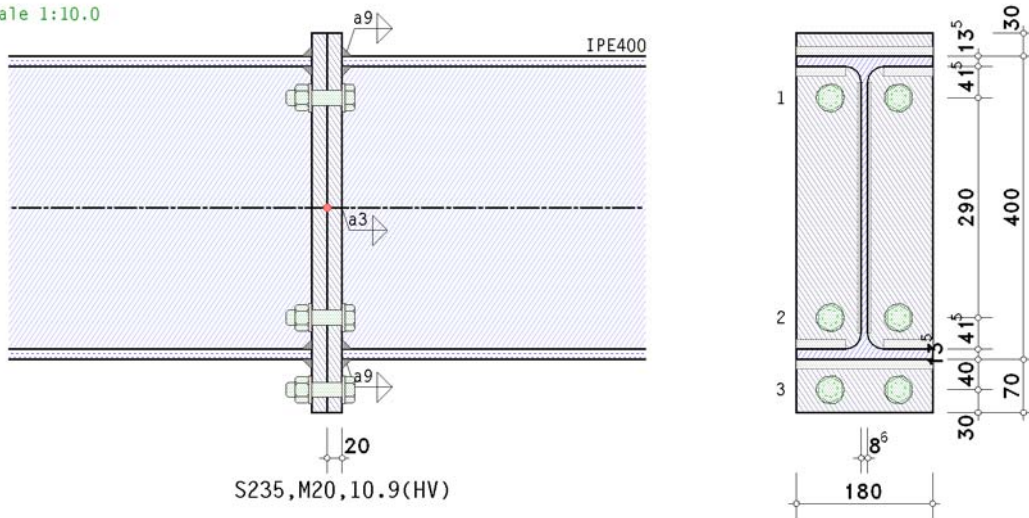
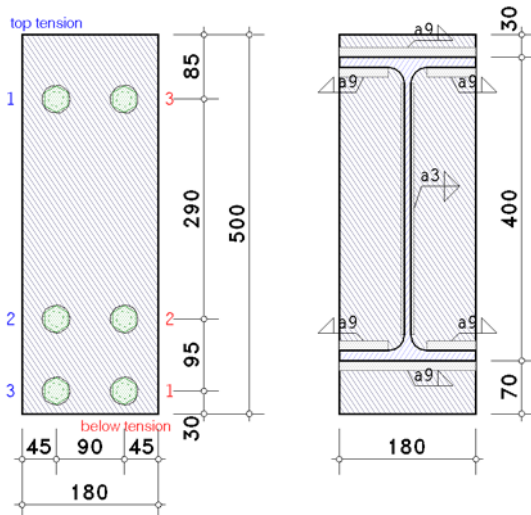


1. input report

scale 1:10.0



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

verification parameters

bolted end-plate connection

thickness $t_p = 20.0$ mm, width $b_p = 180.0$ mm, length $l_p = 500.0$ mm

projections $h_{p,o} = 30.0$ mm, $h_{p,u} = 70.0$ 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) $e_o = 85.0$ 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 $p_{1-2} = 290.0$ mm, $p_{2-3} = 95.0$ mm

welds at the connection point:

beam flange top: fillet weld, weld thickness $a = 9.0$ mm

beam web: fillet weld, weld thickness $a = 3.0$ mm

beam flange below: fillet weld, weld thickness $a = 9.0$ mm

internal forces and moments in the intersection point of system axes

Lc 1: $M_{j,b,Ed} = 185.00 \text{ kNm}$ $V_{j,b,Ed} = 100.00 \text{ kN}$

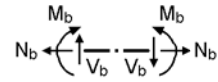
partial safety factors for material

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

resistance of members in stability failure $\gamma_{M1} = 1.10$

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

prestressing of high strength bolts $\gamma_{M7} = 1.10$



notes

Es sind einzelne basic components due to chossen, 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.

the welds are not regarded by calculation the T-stub resistance.

welds are not checked.

calculation of T-stub-resistance with the standard method.

shear block of groups of bolts is not investigated.

check of data

ok

distances between bolts at end-plate

horizontal: $e_2 = 45.0 \text{ mm} > 1.2 \cdot d_0 = 26.4 \text{ mm}$,

$e_2 = 45.0 \text{ mm} < 4 \cdot t + 40 \text{ mm} = 120.0 \text{ mm}$

horizontal: $p_2 = 90.0 \text{ mm} > 2.4 \cdot d_0 = 52.8 \text{ mm}$,

$p_2 = 90.0 \text{ mm} < \min(14 \cdot t, 200 \text{ mm}) = 200.0 \text{ mm}$

top-below: $e_1 = 85.0 \text{ mm} > 1.2 \cdot d_0 = 26.4 \text{ mm}$,

$e_1 = 85.0 \text{ mm} < 4 \cdot t + 40 \text{ mm} = 120.0 \text{ mm}$

top-below: $p_1 = 290.0 \text{ mm} > 2.2 \cdot d_0 = 48.4 \text{ mm}$,

$p_1 = 290.0 \text{ mm} > \min(14 \cdot t, 200 \text{ mm}) = 200.0 \text{ mm} \quad !!$

top-below: $p_1 = 95.0 \text{ mm} > 2.2 \cdot d_0 = 48.4 \text{ mm}$,

$p_1 = 95.0 \text{ mm} < \min(14 \cdot t, 200 \text{ mm}) = 200.0 \text{ mm}$

top-below: $e_1 = 30.0 \text{ mm} > 1.2 \cdot d_0 = 26.4 \text{ mm}$,

$e_1 = 30.0 \text{ mm} < 4 \cdot t + 40 \text{ mm} = 120.0 \text{ mm}$

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	0.850*

U: utilization of the connection

*) maximum utilization

3. final result

maximum utilization: $\max U = 0.850 < 1$ 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;

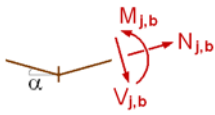
Deutsche Fassung EN 1993-1-8:2024, Ausgabe April 2025

EN 1993-1-8/NA, Nationaler appendix zur EN 1993-1-8, Ausgabe November 2020

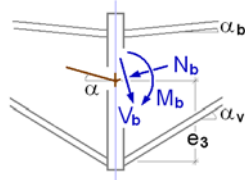
5. Lc 1 (decisive)

5.1. design values

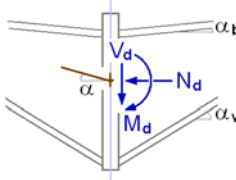
intersectional forces and moments



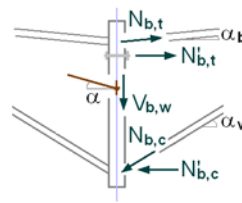
periphery connection-sided



⊥ to connection plane



partial internal forces and moments



slope angle: $\alpha_b = \alpha = \alpha_v = 0^\circ$

internal forces and moments perpendicular to the connection planes

periphery beam

$M_d = -185.00 \text{ kNm}$, $V_d = 100.00 \text{ kN}$

negative internal moment $M_d \Rightarrow$ mirrored model

$M_d = 185.00 \text{ kNm}$, $V_d = -100.00 \text{ kN}$

partial internal forces and moments referring to the mirrored model

internal forces and moments in the periphery end-plate-beam: $M'_d = M_d - V_d \cdot t_p = 187.00 \text{ kNm}$

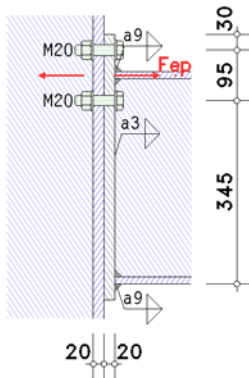
$N_{b,t} = -N_d \cdot z_{bu} / z_b + M'_d / z_b = 483.83 \text{ kN}$, $z_b = 386.5 \text{ mm}$, $z_{bu} = 193.3 \text{ mm}$

$N_{b,c} = N_d \cdot z_{bo} / z_b + M'_d / z_b = 483.83 \text{ kN}$, $z_b = 386.5 \text{ mm}$, $z_{bo} = 193.3 \text{ mm}$

$V_{b,t} = -N_{b,t} \cdot \sin(\alpha_b) = 0.00 \text{ kN}$, $V_{b,c} = N_{b,c} \cdot \sin(\alpha_v) = 0.00 \text{ kN}$, $V_{b,w} = V_d - V_{b,t} - V_{b,c} = -100.00 \text{ kN}$

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: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 90.0 \text{ mm}$, $l_{eff,cp} = 183.7 \text{ mm}$

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

tension resistance of the T-stub flange:

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

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

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

mode 1: complete yielding of the T-stub flange

$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 283.72 \text{ kN}$

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

$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 247.51 \text{ kN}$

mode 3: bolt failure

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

tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 247.51 \text{ kN}$

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

$F_{t,ep,Rd,1} = 247.51 \text{ kN}$, $l_{eff,1} = 90.0 \text{ mm}$

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: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 233.7 \text{ mm}$, $l_{eff,cp} = 234.4 \text{ mm}$

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 233.7 \text{ mm}$

tension resistance of the T-stub flange:

in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t^2 \cdot f_y) / \gamma_{M0} = 5.49 \text{ kNm}$

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

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

mode 1: complete yielding of the T-stub flange

$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 588.78 \text{ kN}$

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

$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 326.17 \text{ kN}$

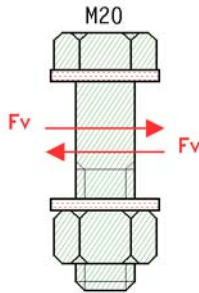
mode 3: bolt failure

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

tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 326.17 \text{ kN}$
resistances and effective lengths of end-plate in bending (per bolt-row):

$$F_{ep,Rd,2} = 326.17 \text{ kN}, \quad l_{eff,2} = 233.7 \text{ mm}$$

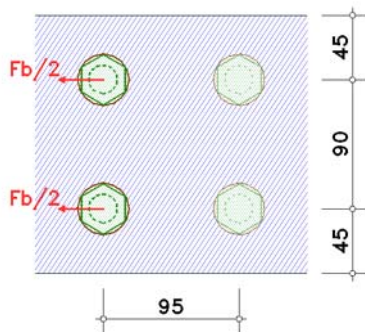
5.2.2. bc 11: bolts in shear



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

shear resistance $F_{v,Rd} = \alpha_v \cdot f_{ub} \cdot A / \gamma_{M2} = 150.80 \text{ kN}$, $\alpha_v = 0.60$
 shear resistance of 2 bolts (1-shear): $\Sigma F_{v,Rd} = 2 \cdot F_{v,Rd} = 301.59 \text{ kN}$

5.2.3. bc 12: plate with bearing resistance



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

row 3

bolt 1: bearing resistance $F_{b,Rd} = (k_m \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 345.60 \text{ kN}$, $k_m = 1.00$, $\alpha_b = 3.00$
 bolt 2: bearing resistance $F_{b,Rd} = (k_m \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 345.60 \text{ kN}$, $k_m = 1.00$, $\alpha_b = 3.00$
 bearing resistance of 1x2 bolts: $\Sigma F_{b,Rd} = 691.20 \text{ kN}$

5.3. verifications

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

tension force in the bolt-rows:

$$N'_{b,t} = (-N_d \cdot z_{bu} + M_d) / z = 479.59 \text{ kN}, \quad z = z_{eq} = 385.8 \text{ mm}, \quad z_{bu} = 193.3 \text{ mm}$$

bc 5: $F_{Rd} = \Sigma F_{t,ep,Rd,i} = 564.0 \text{ kN}$, $F_{Ed} = N'_{b,t} = 479.59 \text{ kN}$

$$F_{Ed} = 479.6 \text{ kN} < F_{Rd} = 564.0 \text{ kN} \Rightarrow U = 0.850 < 1 \text{ ok}$$

bc 11: $F_{Rd} = F_{v,Rd} = 301.6 \text{ kN}$ (without shear in tension), $F_{Ed} = |V_d| = 100.00 \text{ kN}$

$$F_{Ed} = 100.0 \text{ kN} < F_{Rd} = 301.6 \text{ kN} \Rightarrow U = 0.332 < 1 \text{ ok}$$

bc 12: $F_{Rd} = F_{b,Rd} = 691.2 \text{ kN}$, $F_{Ed} = |V_d| = 100.00 \text{ kN}$

$$F_{Ed} = 100.0 \text{ kN} < F_{Rd} = 691.2 \text{ kN} \Rightarrow U = 0.145 < 1 \text{ ok}$$

utilization partial internal forces and moments $U_{bc} = 0.850 < 1 \text{ ok}$

5.3.2. verification result

maximum utilization: $\max U = 0.850 < 1 \text{ ok}$