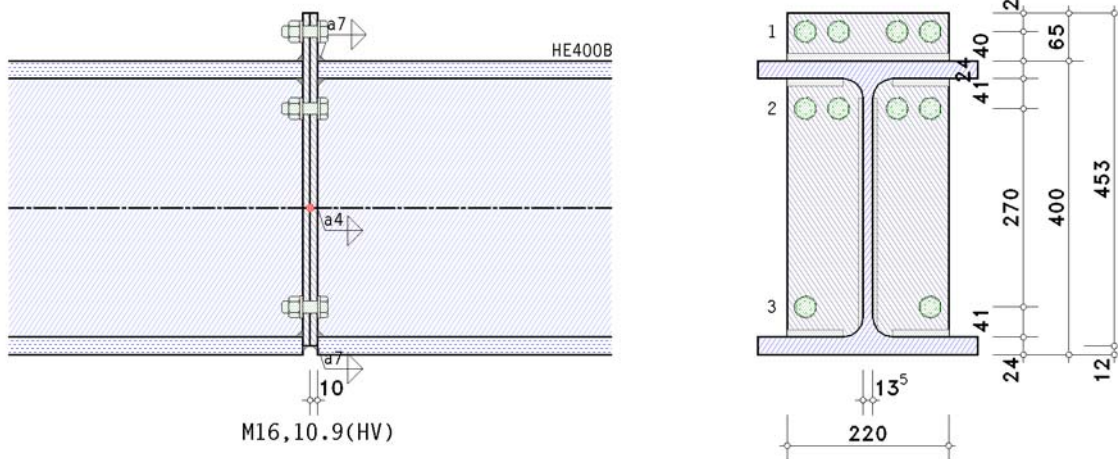
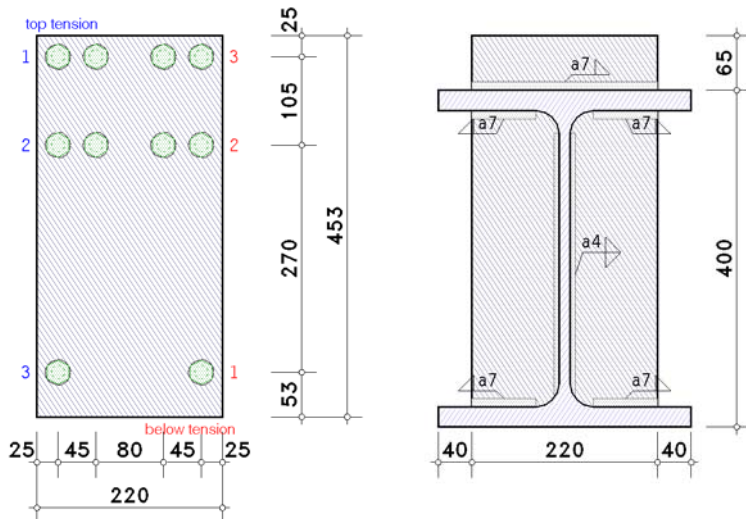


1. input report



details (section A - A)



bolts

bolt class 10.9, bolt size M16

large wrench size (high strength bolt), preloaded (for info: preloading $F_{p,c^*} = 0.7 \cdot f_{yb} \cdot A_s = 98.7$ kN)

shear plane passes through the unthreaded portion of the bolt

beam parameters

section HE400B, steel grade S235

verification parameters

bolted end-plate connection

thickness $t_p = 10.0$ mm, width $b_p = 220.0$ mm, length $l_p = 453.0$ mm

steel parameters:

char. yield strength $f_{yp} = 297.0$ N/mm²

char. tensile strength $f_{up} = 360.0$ N/mm²

correlation value of fillet weld $\beta_{wp} = 0.80$

elastic modulus $E_p = 210000.0$ N/mm²

projections $h_{p,o} = 65.0$ mm, $h_{p,u} = -12.0$ mm

bolts in connection:

3 bolt-rows with 4 bolts (maximum):

row 1: 4 bolts, row 2: 4 bolts, row 3: 2 outer bolts

all bolt-rows considered individually

all bolt-rows for shear transfer (rows 1-3)

calculation method (4 bolts per row) acc. to the final report of AIF-project 15059

centre distance between outer and inner bolt $w_2 = 45.0$ mm

centre distance of the bolts to the lateral edge of the end-plate $e_2 = 25.0$ mm

centre distance of the first bolt-row to the upper edge of the end-plate (end row) $e_o = 25.0$ mm

centre distance of the last bolt-row to the bottom edge of the end-plate (end row) $e_u = 53.0$ mm

centre distance of the bolt-rows from each other $p_{1-2} = 105.0$ mm, $p_{2-3} = 270.0$ mm

welds at the connection point:

beam flange top: fillet weld, weld thickness a = 7.0 mm
 beam web: fillet weld, weld thickness a = 4.0 mm
 beam flange below: fillet weld, weld thickness a = 7.0 mm

partial safety factors for material

safety factors independent of the specifications of the Eurocode
 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 $\gamma_{M2} = 1.00$
 prestressing of high strength bolts $\gamma_{M7} = 1.10$

notes

Es sind einzelne basic components due to choson, 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.

check of data

ok

distances between bolts at end-plate

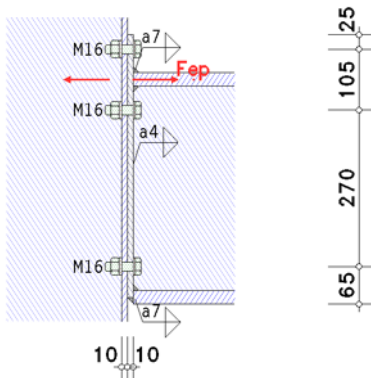
horizontal: $e_2 = 25.0 \text{ mm} > 1.2 \cdot d_0 = 21.6 \text{ mm}$,	$e_2 = 25.0 \text{ mm} < 4 \cdot t + 40 \text{ mm} = 80.0 \text{ mm}$
horizontal: $p_2 = 45.0 \text{ mm} > 2.4 \cdot d_0 = 43.2 \text{ mm}$,	$p_2 = 45.0 \text{ mm} < \min(14 \cdot t, 200 \text{ mm}) = 140.0 \text{ mm}$
horizontal: $p_2 = 80.0 \text{ mm} > 2.4 \cdot d_0 = 43.2 \text{ mm}$,	$p_2 = 80.0 \text{ mm} < \min(14 \cdot t, 200 \text{ mm}) = 140.0 \text{ mm}$
top-below: $e_1 = 25.0 \text{ mm} > 1.2 \cdot d_0 = 21.6 \text{ mm}$,	$e_1 = 25.0 \text{ mm} < 4 \cdot t + 40 \text{ mm} = 80.0 \text{ mm}$
top-below: $p_1 = 105.0 \text{ mm} > 2.2 \cdot d_0 = 39.6 \text{ mm}$,	$p_1 = 105.0 \text{ mm} < \min(14 \cdot t, 200 \text{ mm}) = 140.0 \text{ mm}$
top-below: $p_1 = 270.0 \text{ mm} > 2.2 \cdot d_0 = 39.6 \text{ mm}$,	$p_1 = 270.0 \text{ mm} < \min(14 \cdot t, 200 \text{ mm}) = 140.0 \text{ mm} \quad !!$
top-below: $e_1 = 53.0 \text{ mm} > 1.2 \cdot d_0 = 21.6 \text{ mm}$,	$e_1 = 53.0 \text{ mm} < 4 \cdot t + 40 \text{ mm} = 80.0 \text{ mm}$

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

2. Lc 1

2.1. basic components

2.1.1. bc 5: end-plate in bending



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

connections with 4 bolts per bolt-row are not treated in EC 3-1-8.
 verification follows the final report of AIF-project 15059.

extended part of end-plate

in projecting part of end plate only one bolt-row ($n_b = 1$) is considered (4 bolts per row).

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

in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 110.0 \text{ mm}$, $l_{eff,cp} = 240.8 \text{ mm}$

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 110.0 \text{ mm}$

tension resistance of the T-stub flange:

in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t^2 \cdot f_y) / \gamma_{M0} = 0.82 \text{ kNm}$

$F_{t,Rk} = k_2 \cdot f_{ub} \cdot A_s = 141.03 \text{ kN}$, $k_2 = 0.90$

in mode 3: $\Sigma F_{t,Rd} = 4 \cdot n_b \cdot F_{t,Rd} = 564.12 \text{ kN}$

mode 1: complete yielding of the T-stub flange

$F_{T,1,Rd} = ((8 \cdot n - 2 \cdot e_w) \cdot M_{pl,1,Rd}) / (2 \cdot m \cdot n \cdot e_w \cdot (m+n)) = 127.96 \text{ kN}$

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

$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 275.69 \text{ kN}$

mode 3: bolt failure

$F_{T,3,Rd} = \Sigma F_{t,Rd} = 564.12 \text{ kN}$

tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 127.96 \text{ kN}$

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

$F_{t,ep,Rd,1} = 127.96 \text{ kN}$, $l_{eff,1} = 110.0 \text{ mm}$

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 (4 bolts per row)

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



in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 221.3 \text{ mm}$, $l_{eff,cp} = 361.0 \text{ mm}$

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 221.3 \text{ mm}$

tension resistance of the T-stub flange:

in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 1.64 \text{ kNm}$

$F_{t,Rk} = k_2 \cdot f_{ub} \cdot A_s = 141.03 \text{ kN}$, $k_2 = 0.90$

in mode 3: $\Sigma F_{t,Rd} = 4 \cdot n_b \cdot F_{t,Rd} = 564.12 \text{ kN}$

mode 1: complete yielding of the T-stub flange

$F_{T,1,Rd} = ((8 \cdot n \cdot 2 \cdot e_w) \cdot M_{pl,1,Rd}) / (2 \cdot m \cdot n \cdot e_w \cdot (m+n)) = 282.43 \text{ kN}$

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

$F_{T,2,p,Rd} = (2 \cdot M_{pl,2,Rd} + 0.5 \cdot \Sigma F_{t,Rd} \cdot (n_1^2 + 2 \cdot n_2^2 + 2 \cdot n_1 \cdot n_2) / (n_1 + n_2)) / (m + n_1 + n_2) = 258.79 \text{ kN}$

$F_{T,2,np,Rd} = (2 \cdot M_{pl,1,Rd} + 0.5 \cdot \Sigma F_{t,Rd} \cdot n_1) / (m + n_1) = 216.74 \text{ kN}$

$F_{T,2,Rd} = \min(F_{T,2,p,Rd}, F_{T,2,np,Rd}) = 216.74 \text{ kN}$

mode 3: bolt failure

$F_{T,3,Rd} = 0.9 \cdot \Sigma F_{t,Rd} = 507.71 \text{ kN}$

tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 216.74 \text{ kN}$

row 3 (2 bolts per row)

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

in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 366.1 \text{ mm}$, $l_{eff,cp} = 463.2 \text{ mm}$

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 366.1 \text{ mm}$

tension resistance of the T-stub flange:

in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 2.72 \text{ kNm}$

$F_{t,Rk} = k_2 \cdot f_{ub} \cdot A_s = 141.03 \text{ kN}$, $k_2 = 0.90$

in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 282.06 \text{ kN}$

mode 1: complete yielding of the T-stub flange

$F_{T,1,Rd} = ((8 \cdot n \cdot 2 \cdot e_w) \cdot M_{pl,1,Rd}) / (2 \cdot m \cdot n \cdot e_w \cdot (m+n)) = 170.73 \text{ kN}$

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

$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 126.50 \text{ kN}$

mode 3: bolt failure

$F_{T,3,Rd} = \Sigma F_{t,Rd} = 282.06 \text{ kN}$

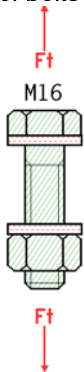
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 126.50 \text{ kN}$

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

$F_{ep,Rd,2} = 216.74 \text{ kN}$, $l_{eff,2} = 221.3 \text{ mm}$

$F_{ep,Rd,3} = 126.50 \text{ kN}$, $l_{eff,3} = 366.1 \text{ mm}$

2.1.2. bc 10: bolts in tension



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

tension resistance of one bolt $F_{t,Rk} = k_2 \cdot f_{ub} \cdot A_s = 141.03 \text{ kN}$, $k_2 = 0.90$

punching shear load capacity of a bolt $B_{p,Rd} = (0.6 \cdot \pi \cdot d_m \cdot t_p \cdot f_u) / \gamma_{M2} = 191.90 \text{ kN}$, $t_p = 10.0 \text{ mm}$

tension-/punching shear load capacity for 4 bolts: $\Sigma F_{tp,Rd} = 4 \cdot \min(F_{t,Rd}, B_{p,Rd}) = 564.12 \text{ kN}$

row (shear): $\Sigma F_{tp,Rd,1} = 564.1 \text{ kN}$, $\Sigma F_{tp,Rd,2} = 564.1 \text{ kN}$, $\Sigma F_{tp,Rd,3} = 282.1 \text{ kN}$

row (bending): $\Sigma F_{tp,Rd,1} = 564.1 \text{ kN}$, $\Sigma F_{tp,Rd,2} = 564.1 \text{ kN}$, $\Sigma F_{tp,Rd,3} = 282.1 \text{ kN}$

2.2. connection capacity

2.2.1. moment resistance

distance of tension-bolt-rows from centre of compression: $h_1 = 422.0 \text{ mm}$, $h_2 = 317.0 \text{ mm}$, $h_3 = 47.0 \text{ mm}$

resistances acc. to EC 3-1-8, B.3.2.2(6) for bolt-rows considered individually

row 1: $F_{tr,Rd} = 128.0 \text{ kN}$

row 2: $F_{tr,Rd} = 216.7 \text{ kN}$

row 3: $F_{tr,Rd} = 126.5 \text{ kN}$

resistance per bolt-row (tension)

row 1: $F_{tr,Rd} = 128.0 \text{ kN}$

row 2: $F_{tr,Rd} = 216.7 \text{ kN}$

row 3: $F_{tr,Rd} = 126.5 \text{ kN}$

$\Sigma F_{tr,Rd}^* = 471.2 \text{ kN}$

check acc. to EC 3-1-8, B.3.2.2(9)

row 1: $F_{tr,Rd} = 128.0 \text{ kN}$

row 2: $F_{tr,Rd} = 216.7 \text{ kN}$

resistance per bolt-row (bending)

row 1: $F_{tr,Rd} = 128.0 \text{ kN}$

row 2: $F_{tr,Rd} = 216.7 \text{ kN}$

row 3: $F_{tr,Rd} = 126.5 \text{ kN}$

$\Sigma F_{tr,Rd} = 471.2 \text{ kN}$

potential failure by basic component 5

resistance of flanges (compression)

$\Sigma F_{c,Rd}^* = 0.0 \text{ kN}$

moment resistance

$M_{j,Rd} = \Sigma(F_{tr,Rd} \cdot h_r) = 128.7 \text{ kNm}$

tension resistance

$N_{j,t,Rd} = \Sigma F_{tr,Rd}^* = 471.2 \text{ kN}$

2.3. rotational stiffness

stiffness coefficients

equivalent stiffness coefficient for 3 tension-bolt-rows:

1: $k_5 = 3.00 \text{ mm} \Rightarrow k_{eff,1} = 1 / \Sigma(1/k_{i,1}) = 1.499 \text{ mm}$

2: $k_5 = 8.40 \text{ mm} \Rightarrow k_{eff,2} = 1 / \Sigma(1/k_{i,2}) = 4.202 \text{ mm}$

3: $k_5 = 0.82 \text{ mm} \Rightarrow k_{eff,3} = 1 / \Sigma(1/k_{i,3}) = 0.411 \text{ mm}$

equivalent internal lever arm $z_{eq} = \Sigma(k_{eff,r} \cdot h_r^2) / \Sigma(k_{eff,r} \cdot h_r) = 347.86 \text{ mm}$

äquivalenter stiffness coefficient $k_{eq} = \Sigma(k_{eff,r} \cdot h_r) / z_{eq} = 5.703 \text{ mm}^{-1}$

rotational stiffness

initial rotational stiffness: $S_{j,ini} = (E \cdot z^2) / \Sigma(1/k_i) = 144928.7 \text{ kNm/rad}$, $z = z_{eq} = 347.9 \text{ mm}$, $\Sigma(1/k_i) = 0.175 \text{ mm}^{-1}$

3. 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

Schlussbericht: Entwicklung eines Bemessungsmodells for boltede, momententragfähige

cap platenverbindungen with 4 bolts in of one bolt-row auf Grundlage

der prEN 1993-1-8:2003, Forschungsprojekt, AIF-Nr. 15059