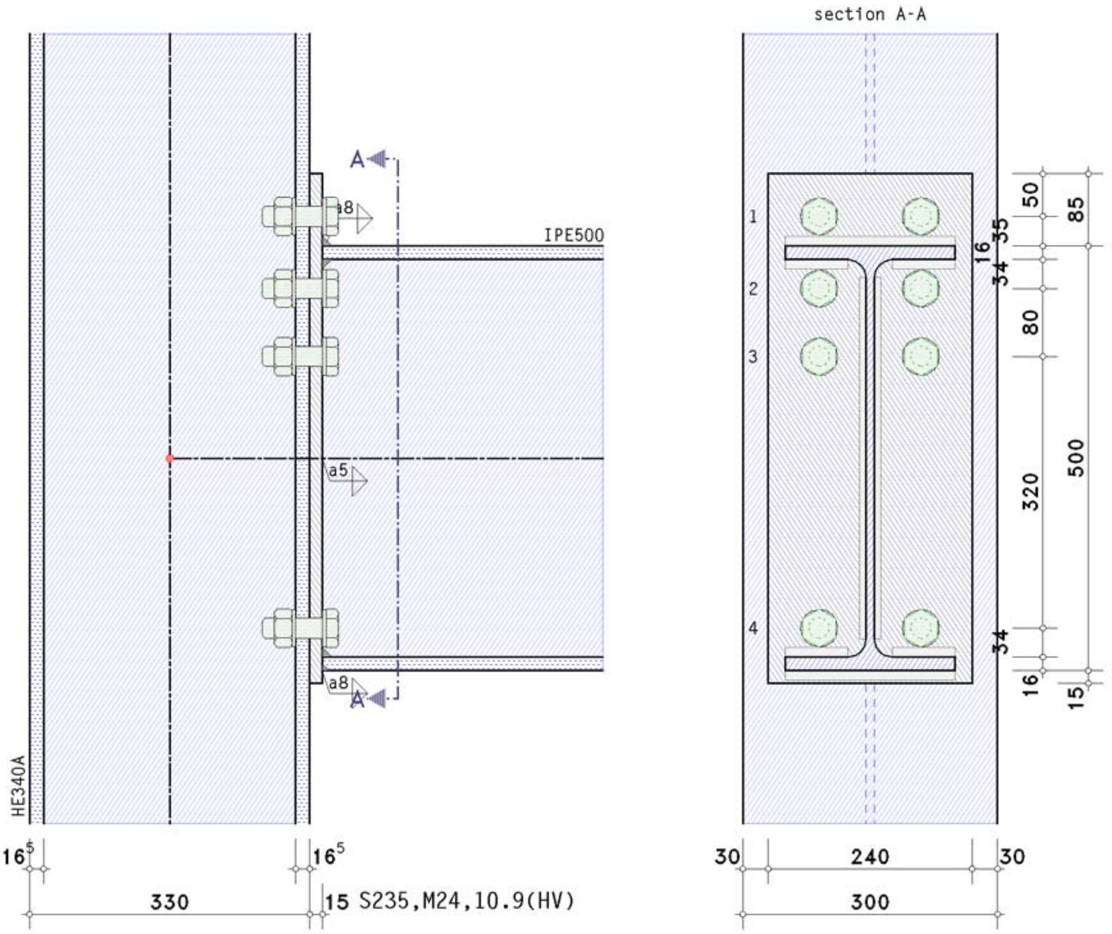
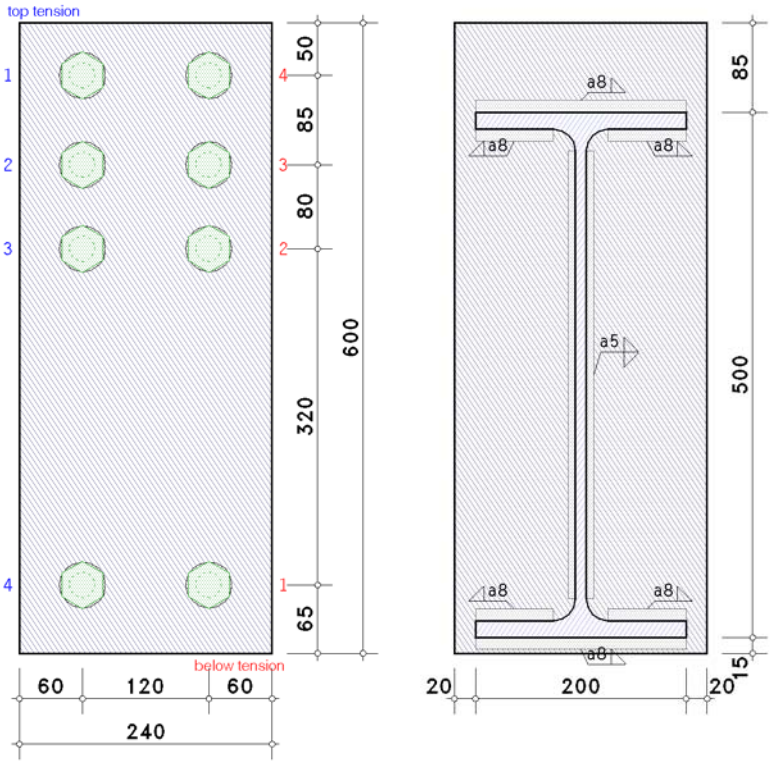
Rigid beam connection EC 3-1-8 (04.25), NA: Deutschland   4H-EC3BT version: 10/2019-2w

1. input report



details (section A - A)



steel grade

steel grade S235

column parameters

section HE340A

bolts

bolt class 10.9, bolt size M24

large wrench size (high strength bolt), preloaded (for info: preloading $F_{p,C}* = 0.7 \cdot f_{yb} \cdot A_s = 222.1$ kN)

shear plane passes through the unthreaded portion of the bolt

beam parameters

section IPE500

verification parameters

bolted end-plate connection

thickness $t_p = 15.0$ mm, width $b_p = 240.0$ mm, length $l_p = 600.0$ mm

projections $h_{p,o} = 85.0$ mm, $h_{p,u} = 15.0$ mm

bolts in connection:

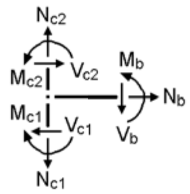
- 4 bolt-rows with 2 bolts
- all bolt-rows considered individually
- all bolt-rows for shear transfer (rows 1-4)
- bolt groups generated automatically, considering all groups reg. row 1
- centre distance of the bolts to the lateral edge of the end-plate $e_2 = 60.0$ mm
- centre distance of the first bolt-row to the upper edge of the end-plate (end row) $e_o = 50.0$ mm
- centre distance of the last bolt-row to the bottom edge of the end-plate (end row) $e_u = 65.0$ mm
- centre distance of the bolt-rows from each other $p_{1-2} = 85.0$ mm, $p_{2-3} = 80.0$ mm, $p_{3-4} = 320.0$ mm

welds at the connection point:

- beam flange top: fillet weld, weld thickness a = 8.0 mm
- beam web: fillet weld, weld thickness a = 5.0 mm
- beam flange below: fillet weld, weld thickness a = 8.0 mm

internal forces and moments in the intersection point of system axes

Lc 1: $M_{j,b,Ed} = -220.00$ kNm



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

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.

Die shear resistance of end plate is not respected.

check of data

ok

distances between bolts at end-plate

horizontal:	$e_2 = 60.0$ mm $> 1.2 \cdot d_0 = 31.2$ mm,	$e_2 = 60.0$ mm $< 4 \cdot t + 40$ mm $= 100.0$ mm
horizontal:	$p_2 = 120.0$ mm $> 2.4 \cdot d_0 = 62.4$ mm,	$p_2 = 120.0$ mm $< \min(14 \cdot t, 200$ mm$) = 200.0$ mm
top-below:	$e_1 = 50.0$ mm $> 1.2 \cdot d_0 = 31.2$ mm,	$e_1 = 50.0$ mm $< 4 \cdot t + 40$ mm $= 100.0$ mm
top-below:	$p_1 = 85.0$ mm $> 2.2 \cdot d_0 = 57.2$ mm,	$p_1 = 85.0$ mm $< \min(14 \cdot t, 200$ mm$) = 200.0$ mm
top-below:	$p_1 = 80.0$ mm $> 2.2 \cdot d_0 = 57.2$ mm,	$p_1 = 80.0$ mm $< \min(14 \cdot t, 200$ mm$) = 200.0$ mm
top-below:	$p_1 = 320.0$ mm $> 2.2 \cdot d_0 = 57.2$ mm,	$p_1 = 320.0$ mm $> \min(14 \cdot t, 200$ mm$) = 200.0$ mm !!
top-below:	$e_1 = 65.0$ mm $> 1.2 \cdot d_0 = 31.2$ mm,	$e_1 = 65.0$ mm $< 4 \cdot t + 40$ mm $= 100.0$ mm

bolt distance from column edge

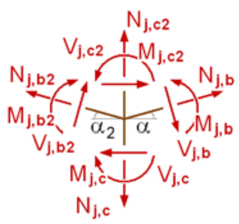
horizontal:	$e_2 = 90.0$ mm $> 1.2 \cdot d_0 = 31.2$ mm,	$e_2 = 90.0$ mm $< 4 \cdot t + 40$ mm $= 100.0$ mm

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

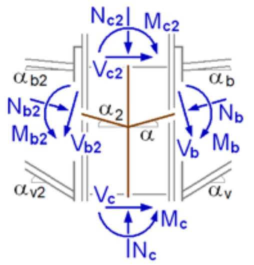
2. Lc 1

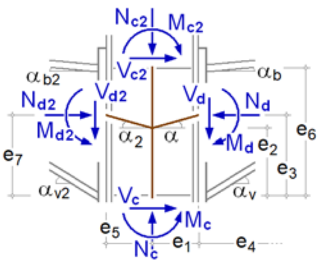
2.1. design values

internal forces at node

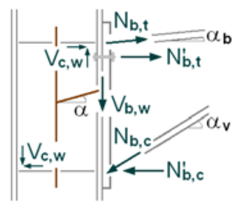


periphery connection ⊥ zur connection plane





partial internal forces and moments



slope angle: $\alpha_b = \alpha = \alpha_v = 0°$

distance: $e_1 = 165.0$ mm, $e_3 = 242.0$ mm, $e_2 = 242.0$ mm, $e_6 = 484.0$ mm

internal forces and moments perpendicular to the connection planes

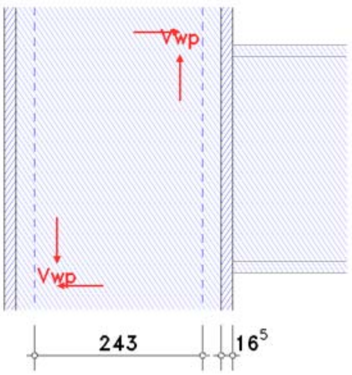
periphery beam
M_d = 220.00 kNm

partial internal forces and moments
internal forces and moments in the periphery end-plate-beam: $M'_d = M_d - V_d \cdot t_p$ = 220.00 kNm
$N_{b,t} = -N_d \cdot z_{bu}/z_b + M'_d/z_b$ = 454.55 kN, z_b = 484.0 mm, z_{bu} = 242.0 mm
$N_{b,c} = N_d \cdot z_{bo}/z_b + M'_d/z_b$ = 454.55 kN, z_b = 484.0 mm, z_{bo} = 242.0 mm

2.2. basic components

2.2.1. bc 1: Column web panel in shear

transformation parameter (EC 3-1-8, 7.2.3(4)) $\beta_j = 1.00 \leq 2$ for M_{j1} = 220.00 kNm (M_{j2} = 0)

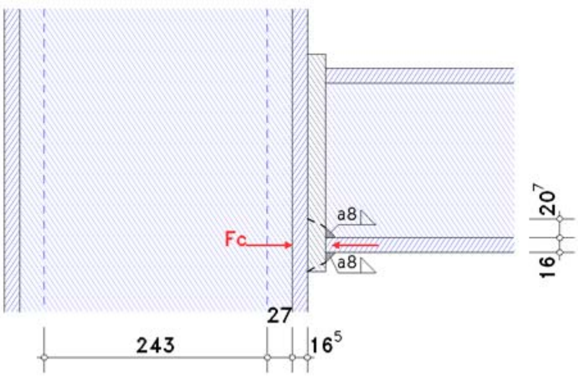


Only the essential sizes are sketched to scale.
The connection geometry is only hinted.

slenderness of column web h_{wc}/t_{wc} = 31.26 < $72 \cdot \varepsilon/\eta$ = 60.00 $\Rightarrow$ method applicable
plastic shear resistance $V_{wp,Rd} = (0.9 \cdot f_{y,w} \cdot A_{wp}) / (3^{1/2} \cdot \gamma_{M0})$ = 382.81 kN
Beitrag of column flange:
additional resistance $V_{wp,add,Rd} = 4 \cdot M_{pl,fc,Rd}/z_{wp}$ = 53.0 kN, $z_{wp} = h_r$ = 362.0 mm
plastic shear resistance plus Beitrag of column flange $V_{wp,Rd}$ = 435.8 kN

2.2.2. bc 2: column web in transverse compression

transformation parameter (EC 3-1-8, 7.2.3(4)) $\beta_j = 1.00 \leq 2$ for M_{j1} = 220.00 kNm (M_{j2} = 0)

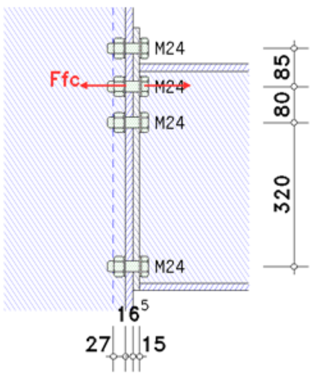


Only the essential sizes are sketched to scale.
The connection geometry is only hinted.

effective width of web in transverse compression $b_{eff,c} = t_{fb} + 2 \cdot 2^{1/2} \cdot a_p + 5 \cdot (t_{fc}+s_c) + s_p$ = 274.8 mm
reduction factor k_w = 1.0 ($\sigma_{com,Ed}$ = 0)
plate slenderness $\lambda_p = 0.932 \cdot [(b_{eff,c} \cdot d_w \cdot f_y) / (E \cdot t_w^2)]^{1/2}$ = 0.848
reduction factor for web buckling $\rho = (\lambda_p - 0.22) / \lambda_p^2$ = 0.873 for $\lambda_p > 0.673$
reduction factor for interaction with shear stress $\beta = 1 \Rightarrow \omega$ = 0.725
resistance of an unstiffened web in transverse compression:
$F_{c,w,Rd} = \omega \cdot (k_w \cdot b_{eff,c} \cdot t_w \cdot f_{y,w}) / \gamma_{M0}$ = 444.91 kN
$F_{c,w,Rd} = \omega \cdot (k_w \cdot \rho \cdot b_{eff,c} \cdot t_w \cdot f_{y,w}) / \gamma_{M1}$ = 353.20 kN (decisive)

resistance of the upper beam flange:
effective width of web in transverse compression $b_{eff,c} = t_{fb} + 2 \cdot 2^{1/2} \cdot a_p + 5 \cdot (t_{fc}+s_c) + s_p$ = 286.1 mm
reduction factor k_w = 1.0 ($\sigma_{com,Ed}$ = 0)
plate slenderness $\lambda_p = 0.932 \cdot [(b_{eff,c} \cdot d_w \cdot f_y) / (E \cdot t_w^2)]^{1/2}$ = 0.865
reduction factor for web buckling $\rho = (\lambda_p - 0.22) / \lambda_p^2$ = 0.862 for $\lambda_p > 0.673$
reduction factor for interaction with shear stress $\beta = 1 \Rightarrow \omega$ = 0.711
resistance of an unstiffened web in transverse compression:
$F_{c,w,Rd} = \omega \cdot (k_w \cdot b_{eff,c} \cdot t_w \cdot f_{y,w}) / \gamma_{M0}$ = 454.27 kN
$F_{c,w,Rd} = \omega \cdot (k_w \cdot \rho \cdot b_{eff,c} \cdot t_w \cdot f_{y,w}) / \gamma_{M1}$ = 355.90 kN (decisive)

2.2.3. bc 4: column flange in bending



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

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

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

row 1

effective length of the T-stub flange (column flange):

in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 211.4$ mm, $l_{eff,cp} = 211.4$ mm

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 247.1$ mm

tension resistance of the T-stub flange:

in mode 1: $M_{pl,1,Rd} = (0.25 \cdot \Sigma l_{eff,1} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 3.38$ kNm

in mode 2: $M_{pl,2,Rd} = (0.25 \cdot \Sigma l_{eff,2} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 3.95$ kNm

$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 253.80$ kN, $k_2 = 0.90$

in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 507.60$ kN

mode 1: complete yielding of the T-stub flange

$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 401.99$ kN

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

$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 386.40$ kN

mode 3: bolt failure

$F_{T,3,Rd} = \Sigma F_{t,Rd} = 507.60$ kN

tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 386.40$ kN

row 2

effective length of the T-stub flange (column flange):

in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 211.4$ mm, $l_{eff,cp} = 211.4$ mm

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 247.1$ mm

tension resistance of the T-stub flange:

in mode 1: $M_{pl,1,Rd} = (0.25 \cdot \Sigma l_{eff,1} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 3.38$ kNm

in mode 2: $M_{pl,2,Rd} = (0.25 \cdot \Sigma l_{eff,2} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 3.95$ kNm

$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 253.80$ kN, $k_2 = 0.90$

in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 507.60$ kN

mode 1: complete yielding of the T-stub flange

$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 401.99$ kN

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

$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 386.40$ kN

mode 3: bolt failure

$F_{T,3,Rd} = \Sigma F_{t,Rd} = 507.60$ kN

tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 386.40$ kN

row 3

effective length of the T-stub flange (column flange):

in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 211.4$ mm, $l_{eff,cp} = 211.4$ mm

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 247.1$ mm

tension resistance of the T-stub flange:

in mode 1: $M_{pl,1,Rd} = (0.25 \cdot \Sigma l_{eff,1} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 3.38$ kNm

in mode 2: $M_{pl,2,Rd} = (0.25 \cdot \Sigma l_{eff,2} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 3.95$ kNm

$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 253.80$ kN, $k_2 = 0.90$

in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 507.60$ kN

mode 1: complete yielding of the T-stub flange

$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 401.99$ kN

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

$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 386.40$ kN

mode 3: bolt failure

$F_{T,3,Rd} = \Sigma F_{t,Rd} = 507.60$ kN

tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 386.40$ kN

row 4

effective length of the T-stub flange (column flange):

in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 211.4$ mm, $l_{eff,cp} = 211.4$ mm

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 247.1$ mm

tension resistance of the T-stub flange:

in mode 1: $M_{pl,1,Rd} = (0.25 \cdot \Sigma l_{eff,1} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 3.38$ kNm

in mode 2: $M_{pl,2,Rd} = (0.25 \cdot \Sigma l_{eff,2} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 3.95$ kNm

$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 253.80$ kN, $k_2 = 0.90$

in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 507.60$ kN
mode 1: complete yielding of the T-stub flange
$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 401.99$ kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 386.40$ kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd} = 507.60$ kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 386.40$ kN

resistances and effective lengths of column flange in bending (per bolt-row)

$F_{t,fc,Rd,1} = 386.40$ kN, $l_{eff,1} = 211.4$ mm
$F_{t,fc,Rd,2} = 386.40$ kN, $l_{eff,2} = 211.4$ mm
$F_{t,fc,Rd,3} = 386.40$ kN, $l_{eff,3} = 211.4$ mm
$F_{t,fc,Rd,4} = 386.40$ kN, $l_{eff,4} = 211.4$ mm

equivalent T-stub flange (group of bolts 1):
here: number of bolt-rows $n_b = 2$
effective length of the T-stub flange (column flange):
in mode 1: $\Sigma l_{eff,1} = \min(\Sigma l_{eff,nc}, \Sigma l_{eff,cp}) = 332.1$ mm, $\Sigma l_{eff,cp} = 381.4$ mm
in mode 2: $\Sigma l_{eff,2} = \Sigma l_{eff,nc} = 332.1$ mm
tension resistance of the T-stub flange:
in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 5.31$ kNm
$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 253.80$ kN, $k_2 = 0.90$
in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 1015.20$ kN
mode 1: complete yielding of the T-stub flange
$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 631.42$ kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 704.32$ kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd} = 1015.20$ kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 631.42$ kN

equivalent T-stub flange (group of bolts 2):
here: number of bolt-rows $n_b = 3$
effective length of the T-stub flange (column flange):
in mode 1: $\Sigma l_{eff,1} = \min(\Sigma l_{eff,nc}, \Sigma l_{eff,cp}) = 412.1$ mm, $\Sigma l_{eff,cp} = 541.4$ mm
in mode 2: $\Sigma l_{eff,2} = \Sigma l_{eff,nc} = 412.1$ mm
tension resistance of the T-stub flange:
in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 6.59$ kNm
$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 253.80$ kN, $k_2 = 0.90$
in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 1522.80$ kN
mode 1: complete yielding of the T-stub flange
$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 783.53$ kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 1020.12$ kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd} = 1522.80$ kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 783.53$ kN

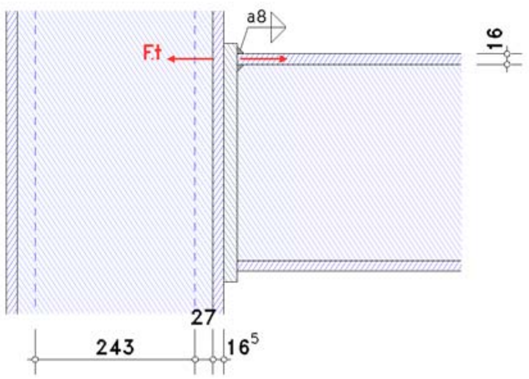
equivalent T-stub flange (group of bolts 3):
here: number of bolt-rows $n_b = 4$
distance between bolt-rows too big ($p_{3-2} = 80.0$ mm, $p_{3-4} = 320.0$ mm) $\Rightarrow$ group closed

resistances and effective lengths of column flange in bending (per bolt group):

$F_{ep,Rd,1-2} = 631.42$ kN, $\Sigma l_{eff} = 332.1$ mm, 2 rows
$F_{ep,Rd,1-3} = 783.53$ kN, $\Sigma l_{eff} = 412.1$ mm, 3 rows

2.2.4. bc 3: column web in transverse tension

transformation parameter (EC 3-1-8, 7.2.3(4)) $\beta_j = 1.00 \leq 2$ for $M_{j1} = 220.00$ kNm ($M_{j2} = 0$)



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

each individual bolt-row:
row 1
reduction factor for interaction with shear stress $\beta = 1 \Rightarrow \omega = 0.807$
resistance eines unstiffeneden column webs with transverse tension

$F_{t,wc,Rd} = \omega \cdot (b_{eff,t,wc} \cdot t_{wc} \cdot f_{y,wc}) / \gamma_{M0} = 381.15$ kN, $b_{eff,t,wc} = 211.4$ mm

row 2

reduction factor for interaction with shear stress $\beta = 1 \Rightarrow \omega = 0.807$

resistance eines unstiffeneden column webs with transverse tension

$F_{t,wc,Rd} = \omega \cdot (b_{eff,t,wc} \cdot t_{wc} \cdot f_{y,wc}) / \gamma_{M0} = 381.15$ kN, $b_{eff,t,wc} = 211.4$ mm

row 3

reduction factor for interaction with shear stress $\beta = 1 \Rightarrow \omega = 0.807$

resistance eines unstiffeneden column webs with transverse tension

$F_{t,wc,Rd} = \omega \cdot (b_{eff,t,wc} \cdot t_{wc} \cdot f_{y,wc}) / \gamma_{M0} = 381.15$ kN, $b_{eff,t,wc} = 211.4$ mm

row 4

reduction factor for interaction with shear stress $\beta = 1 \Rightarrow \omega = 0.807$

resistance eines unstiffeneden column webs with transverse tension

$F_{t,wc,Rd} = \omega \cdot (b_{eff,t,wc} \cdot t_{wc} \cdot f_{y,wc}) / \gamma_{M0} = 381.15$ kN, $b_{eff,t,wc} = 211.4$ mm

resistance of a column web with transverse tension (per bolt-row)

$F_{t,wc,Rd,1} = 381.15$ kN, $b_{eff,t,wc} = 211.4$ mm (s. bc 4)

$F_{t,wc,Rd,2} = 381.15$ kN, $b_{eff,t,wc} = 211.4$ mm (s. bc 4)

$F_{t,wc,Rd,3} = 381.15$ kN, $b_{eff,t,wc} = 211.4$ mm (s. bc 4)

$F_{t,wc,Rd,4} = 381.15$ kN, $b_{eff,t,wc} = 211.4$ mm (s. bc 4)

group of bolt-rows, group 1:

reduction factor for interaction with shear stress $\beta = 1 \Rightarrow \omega = 0.657$

resistance eines unstiffeneden column webs with transverse tension

$F_{t,wc,Rd} = \omega \cdot (b_{eff,t,wc} \cdot t_{wc} \cdot f_{y,wc}) / \gamma_{M0} = 487.12$ kN, $b_{eff,t,wc} = 332.1$ mm

group of bolt-rows, group 2:

reduction factor for interaction with shear stress $\beta = 1 \Rightarrow \omega = 0.575$

resistance eines unstiffeneden column webs with transverse tension

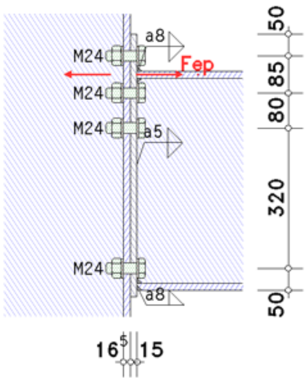
$F_{t,wc,Rd} = \omega \cdot (b_{eff,t,wc} \cdot t_{wc} \cdot f_{y,wc}) / \gamma_{M0} = 528.77$ kN, $b_{eff,t,wc} = 412.1$ mm

resistances of a column web with transverse tension (per bolt group):

$F_{t,wc,Rd,1\text{-}2} = 487.12$ kN, $\Sigma b_{eff,t,wc} = 332.1$ mm (s. bc 4), 2 rows

$F_{t,wc,Rd,1\text{-}3} = 528.77$ kN, $\Sigma b_{eff,t,wc} = 412.1$ mm (s. bc 4), 3 rows

2.2.5. 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: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 120.0$ mm, $l_{eff,cp} = 163.0$ mm

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 120.0$ mm

tension resistance of the T-stub flange:

in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 1.59$ kNm

$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 253.80$ kN, $k_2 = 0.90$

in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 507.60$ kN

mode 1: complete yielding of the T-stub flange

$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 244.52$ kN

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

$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 336.34$ kN

mode 3: bolt failure

$F_{T,3,Rd} = \Sigma F_{t,Rd} = 507.60$ kN

tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 244.52$ kN

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

$F_{t,ep,Rd,1} = 244.52$ kN, $l_{eff,1} = 120.0$ 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: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 309.4$ mm, $l_{eff,cp} = 309.4$ mm

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 354.6$ mm

tension resistance of the T-stub flange:

in mode 1: $M_{pl,1,Rd} = (0.25 \cdot \Sigma l_{eff,1} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 4.09$ kNm

in mode 2: $M_{pl,2,Rd} = (0.25 \cdot \Sigma l_{eff,2} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 4.69$ kNm
$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 253.80$ kN, $k_2 = 0.90$
in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 507.60$ kN
mode 1: complete yielding of the T-stub flange
$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 332.22$ kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 364.61$ kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd} = 507.60$ kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 332.22$ kN

row 3
effective length of the T-stub flange (end-plate):
in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 272.0$ mm, $l_{eff,cp} = 309.4$ mm
in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 272.0$ mm
tension resistance of the T-stub flange:
in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 3.60$ kNm
$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 253.80$ kN, $k_2 = 0.90$
in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 507.60$ kN
mode 1: complete yielding of the T-stub flange
$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 292.03$ kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 344.61$ kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd} = 507.60$ kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 292.03$ kN

row 4
effective length of the T-stub flange (end-plate):
in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 309.4$ mm, $l_{eff,cp} = 309.4$ mm
in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 354.6$ mm
tension resistance of the T-stub flange:
in mode 1: $M_{pl,1,Rd} = (0.25 \cdot \Sigma l_{eff,1} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 4.09$ kNm
in mode 2: $M_{pl,2,Rd} = (0.25 \cdot \Sigma l_{eff,2} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 4.69$ kNm
$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 253.80$ kN, $k_2 = 0.90$
in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 507.60$ kN
mode 1: complete yielding of the T-stub flange
$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 332.22$ kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 364.61$ kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd} = 507.60$ kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 332.22$ kN

resistances and effective lengths of end-plate in bending (per bolt-row):
$F_{ep,Rd,2} = 332.22$ kN, $l_{eff,2} = 309.4$ mm
$F_{ep,Rd,3} = 292.03$ kN, $l_{eff,3} = 272.0$ mm
$F_{ep,Rd,4} = 332.22$ kN, $l_{eff,4} = 309.4$ mm

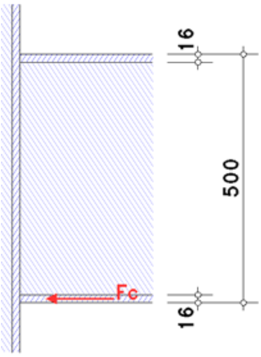
equivalent T-stub flange (group of bolts 1):
here: number of bolt-rows $n_b = 2$ (R2+R3)
effective length of the T-stub flange (end-plate):
in mode 1: $\Sigma l_{eff,1} = \min(\Sigma l_{eff,nc}, \Sigma l_{eff,cp}) = 338.6$ mm, $\Sigma l_{eff,cp} = 394.7$ mm
in mode 2: $\Sigma l_{eff,2} = \Sigma l_{eff,nc} = 338.6$ mm
tension resistance of the T-stub flange:
in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 4.48$ kNm
$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 253.80$ kN, $k_2 = 0.90$
in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 1015.20$ kN
mode 1: complete yielding of the T-stub flange
$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 363.63$ kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 639.54$ kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd} = 1015.20$ kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 363.63$ kN

equivalent T-stub flange (group of bolts 2):
here: number of bolt-rows $n_b = 3$ (R2+R3+R4)
distance between bolt-rows too big ($p_{3-2} = 80.0$ mm, $p_{3-4} = 320.0$ mm) $\Rightarrow$ group closed

resistances and effective lengths of end-plate in bending (per bolt group):
$F_{ep,Rd,2-3} = 363.63$ kN, $\Sigma l_{eff} = 338.6$ mm, 2 rows

2.2.6. bc 7: beam flange and web in compression

flange below: section class 1
web: section class 1
total: section class 1
section class of the beam: 1

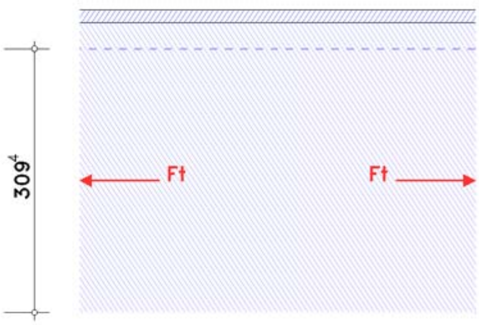


Only the essential sizes are sketched to scale.
The connection geometry is only hinted.

resistance $M_{c,Rd} = M_{pl,Rd} = (W_{pl} \cdot f_y) / \gamma_{M0} = 515.56$ kNm, $W_{pl} = 2193.86$ cm^3
resistance of flange and web in compression
$F_{c,f,Rd} = M_{c,Rd} / (h - t_f) = 1065.20$ kN

resistance of the upper beam flange:
resistance $M_{c,Rd} = M_{pl,Rd} = (W_{pl} \cdot f_y) / \gamma_{M0} = 515.56$ kNm, $W_{pl} = 2193.86$ cm^3
resistance of flange and web in compression
$F_{c,f,Rd} = M_{c,Rd} / (h - t_f) = 1065.20$ kN

2.2.7. bc 8: beam web in tension



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

each individual bolt-row:
row 2
effective width $b_{eff,t,wb} = 309.4$ mm (l_{eff} from bc 5)
resistance of a beam web in tension
$F_{t,wb,Rd} = b_{eff,t,wb} \cdot t_{wb} \cdot f_{y,wb} / \gamma_{M0} = 741.64$ kN
row 3
effective width $b_{eff,t,wb} = 272.0$ mm (l_{eff} from bc 5)
resistance of a beam web in tension
$F_{t,wb,Rd} = b_{eff,t,wb} \cdot t_{wb} \cdot f_{y,wb} / \gamma_{M0} = 651.92$ kN
row 4
effective width $b_{eff,t,wb} = 309.4$ mm (l_{eff} from bc 5)
resistance of a beam web in tension
$F_{t,wb,Rd} = b_{eff,t,wb} \cdot t_{wb} \cdot f_{y,wb} / \gamma_{M0} = 741.64$ kN

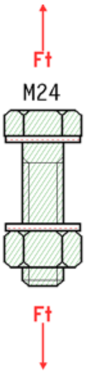
resistance of a beam web in tension (per bolt-row)
$F_{t,wb,Rd,2} = 741.64$ kN, $b_{eff,t,wb} = 309.4$ mm (s. bc 5)
$F_{t,wb,Rd,3} = 651.92$ kN, $b_{eff,t,wb} = 272.0$ mm (s. bc 5)
$F_{t,wb,Rd,4} = 741.64$ kN, $b_{eff,t,wb} = 309.4$ mm (s. bc 5)

group of bolt-rows, group 1:
effective width $b_{eff,t,wb} = 338.6$ mm (l_{eff} from bc 5)
resistance of a beam web in tension
$F_{t,wb,Rd} = b_{eff,t,wb} \cdot t_{wb} \cdot f_{y,wb} / \gamma_{M0} = 811.74$ kN

resistances of a beam web in tension (per bolt group):
$F_{t,wb,Rd,2-3} = 811.74$ kN, $\Sigma b_{eff,t,wb} = 338.6$ mm (s. bc 5), 2 rows

2.2.8. bc 10: bolts in tension

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



tension resistance of one bolt $F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 253.80$ kN, $k_2 = 0.90$
punching shear load capicity of a bolt $B_{p,Rd} = (0.6 \cdot \pi \cdot d_m \cdot t_p \cdot f_u)) / \gamma_{M2} = 350.96$ kN, $t_p = 15.0$ mm
tension-/punching shear load capicity for 2 bolts: $\Sigma F_{tp,Rd} = 2 \cdot \min(F_{t,Rd}, B_{p,Rd}) = 507.60$ kN

2.3. connection capacity

transformation parameter: $\beta_j = 1.00$

2.3.1. moment resistance

distance of tension-bolt-rows from centre of compression:
$h_1 = 527.0$ mm, $h_2 = 442.0$ mm, $h_3 = 362.0$ mm, $h_4 = 42.0$ mm

resistances acc. to EC 3-1-8, B.3.2.2(6) for bolt-rows considered individually
decisive basic components: 3, 4, 5, 8
row 1: $F_{tr,Rd} = 244.5$ kN
row 2: $F_{tr,Rd} = 332.2$ kN
row 3: $F_{tr,Rd} = 292.0$ kN
row 4: $F_{tr,Rd} = 332.2$ kN

deductions acc. to EC 3-1-8, B.3.2.2(8) for bolt-rows as part of a group (column)
decisive basic components: 3, 4
group 1
row 1: $F_{tr,Rd} = 244.5$ kN
row 2: $F_{tr,Rd} = 242.6$ kN
group 2
row 1: $F_{tr,Rd} = 244.5$ kN
row 2: $F_{tr,Rd} = 242.6$ kN
row 3: $F_{tr,Rd} = 41.6$ kN

deductions acc. to EC 3-1-8, B.3.2.2(8) for bolt-rows as part of a group (end-plate)
decisive basic components: 5, 8
group 1
row 2: $F_{tr,Rd} = 242.6$ kN
row 3: $F_{tr,Rd} = 41.6$ kN

resistance per bolt-row (tension)
row 1: $F_{tr,Rd} = 244.5$ kN
row 2: $F_{tr,Rd} = 242.6$ kN
row 3: $F_{tr,Rd} = 41.6$ kN
row 4: $F_{tr,Rd} = 332.2$ kN
$\Sigma F_{tr,Rd}^* = 861.0$ kN

deductions acc. to EC 3-1-8, B.3.2.2(7)
decisive basic components: 1, 2, 7
row 1: $F_{tr,Rd} = 244.5$ kN
row 2: $F_{tr,Rd} = 108.7$ kN
row 3: $F_{tr,Rd} = 0.0$ kN
row 4: $F_{tr,Rd} = 0.0$ kN

check acc. to EC 3-1-8, B.3.2.2(9)
decisive basic component: 10
row 1: $F_{tr,Rd} = 244.5$ kN
row 2: $F_{tr,Rd} = 108.7$ kN

resistance per bolt-row (bending)
row 1: $F_{tr,Rd} = 244.5$ kN
row 2: $F_{tr,Rd} = 108.7$ kN
row 3: $F_{tr,Rd} = 0.0$ kN
row 4: $F_{tr,Rd} = 0.0$ kN

$\Sigma F_{tr,Rd} = 353.2$ kN
potential failure by basic component 2, 3, 5

resistance of flanges (compression)
$\Sigma F_{c,Rd}^{*} = 706.4$ kN

moment resistance
$M_{j,Rd} = \Sigma(F_{tr,Rd} \cdot h_r) = 176.9$ kNm
tension resistance
$N_{j,t,Rd} = \Sigma F_{tr,Rd}^{*} = 861.0$ kN
compression resistance
$N_{j,c,Rd} = \Sigma F_{c,Rd}^{*} = 706.4$ kN

2.3.2. shear resistance

shear resistance of column web
decisive basic component: 1
$V_{wp,Rd} = 435.83$ kN

2.3.3. total

$M_{j,Rd} = 176.9$ kNm $N_{j,t,Rd} = 861.0$ kN $N_{j,c,Rd} = 706.4$ kN $V_{wp,Rd} = 435.8$ kN

2.4. verifications

2.4.1. verification of the connection capacity by means of the component method

internal moment: $M_{Ed} = M_d = 220.00$ kNm
shear force: $V_{c,w,Ed} = M_d/z - (V_{c1}-V_{c2})/2 = 487.68$ kN, $z = 451.1$ mm

$M_{Ed}/M_{j,Rd} = 1.244 > 1$ not ok !!
$V_{c,w,Ed}/V_{wp,Rd} = 1.119 > 1$ not ok !!

2.4.2. verification result

maximum utilization: max U = 1.244 > 1 not ok !!
failure at verification of bending: U = 1.244
failure at verification shear in column web: U = 1.119

3. final result

maximum utilization: max U = 1.244 > 1 not ok !!

resistance not ensured !!

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