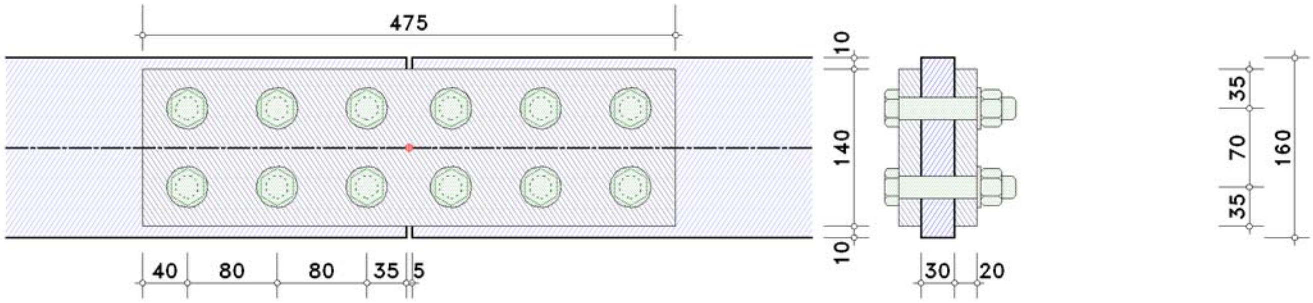
axial force connection 4H-EC3NV version: 6/2018-1n
bolted splice (indirect, double-sided splice plates) EC 3-1-8 (12.10), NA: Deutschland

1. input report



steel grade
steel grade S235
bolts
bolt class 10.9, bolt size M20, normal wrench size
beam
section parameters (flat steel):
height h = 160.0 mm, thickness t = 30.0 mm
verification parameters
bolted splice plate joint:
gap between the beams Δs = 5.0 mm
splice plates at the beam:
2 splice plates: thickness t = 20.0 mm, width b = 140.0 mm, length l = 475.0 mm
distance upper edge splice plate to the upper edge of beam (left) Δz_{Lw} = 10.0 mm (splice plates centric regarding the centroida
bolts in beam:
3 x 2 bolts
shear plane passes through the unthreaded portion of the bolt
centre distances of bolts across to tensile edge e_2 = 35.0 mm, e_{22} = 35.0 mm
centre distances of bolts to the tensional edge e_1 = 40.0 mm, e_{11} = 35.0 mm
centre distance of bolt-rows towards tension p_1 = 80.0 mm
centre distance of bolt-rows across tension p_2 = 70.0 mm
centric centre distance of bolt-rows towards tension w_1 = 75.0 mm
partial safety factors for material
resistance of cross-sections γ_{M0} = 1.00
resistance of bolts, welds, plates in bearing γ_{M2} = 1.25
internal forces and moments
Lk 1: N_{Ed} = 400.00 kN

check of data
ok
distances between bolts

vertical:	e_2 = 35.0 mm > $1.2 \cdot d_0$ = 26.4 mm,	e_2 = 35.0 mm < $4 \cdot t$ + 40 mm = 120.0 mm
vertical:	p_2 = 70.0 mm > $2.4 \cdot d_0$ = 52.8 mm,	p_2 = 70.0 mm < min($14 \cdot t$, 200 mm) = 200.0 mm
vertical:	e_2 = 35.0 mm > $1.2 \cdot d_0$ = 26.4 mm,	e_2 = 35.0 mm < $4 \cdot t$ + 40 mm = 120.0 mm
horizontal:	e_1 = 40.0 mm > $1.2 \cdot d_0$ = 26.4 mm,	e_1 = 40.0 mm < $4 \cdot t$ + 40 mm = 120.0 mm
horizontal:	p_1 = 80.0 mm > $2.2 \cdot d_0$ = 48.4 mm,	p_1 = 80.0 mm < min($14 \cdot t$, 200 mm) = 200.0 mm
horizontal:	p_1 = 75.0 mm > $2.2 \cdot d_0$ = 48.4 mm,	p_1 = 75.0 mm < min($14 \cdot t$, 200 mm) = 200.0 mm
horizontal:	e_1 = 35.0 mm > $1.2 \cdot d_0$ = 26.4 mm,	e_1 = 35.0 mm < $4 \cdot t$ + 40 mm = 120.0 mm

2. Lk 1

considering only one beam (left or right side).

beam right

2.1. elastic stresses at net section

N_{Ed} = 400.00 kN
cross-sectional properties: $A = 48.00\ cm^2$, $z_s = 80.0\ mm$, $I_y = 1024.00\ cm^4$, $y_s = 0.0\ mm$, $I_z = 36.00\ cm^4$

stresses in points of cross-section

pt. 1:	y = 0.0 mm	z = 0.0 mm	$\sigma_x = 114.94\ N/mm^2$
pt. 2:	y = 0.0 mm	z = 160.0 mm	$\sigma_x = 114.94\ N/mm^2$

2.2. beam

internal forces and moments in the beam: $N = N_w = 400.00$ kN
load parts: per splice plate $f_a = 50\%$

beam
tension (net section)
deduction of holes is respected.
maximum normal stress: $\sigma_x = 114.94\ N/mm^2$
permitted normal stress: $\sigma_{Rd} = 235.00\ N/mm^2$
verification: $\sigma_x = 114.94\ N/mm^2 < \sigma_{Rd} = 235.00\ N/mm^2 \Rightarrow U_{\sigma x} = 0.489 < 1$ ok

splice plates
tension
net cross-section $b_{net} = b - \Delta b = 96.0$ mm, $t_{net} = 20.0$ mm with $\Delta b = n_2 \cdot d_0 = 44.0$ mm, $d_0 = d + \Delta d$
resistance of plate in tension:
$N_{pl,Rd} = (A \cdot f_y) / \gamma_{M0} = 658.00$ kN
$N_{u,Rd} = (0.9 \cdot A_{net} \cdot f_u) / \gamma_{M2} = 497.66$ kN
tension resistance $N_{t,Rd} = \min(N_{pl,Rd}, N_{u,Rd}) = 497.66$ kN
verification: $F_{Ed} = 400.00\ kN < F_{t,Rd}/f_a = 995.33\ kN \Rightarrow U = 0.402 < 1$ ok

beam (model assumption: b = 140.0 mm)
tension (gross section)
resistance of plate in tension:
tension resistance $N_{t,Rd} = N_{pl,Rd} = (A \cdot f_y) / \gamma_{M0} = 987.00$ kN
verification: $F_{Ed} = 400.00\ kN < F_{t,Rd} = 987.00\ kN \Rightarrow U = 0.405 < 1$ ok

bolts
cross-section of points
internal forces and moments: N = 400.00 kN, M = 0.00 kNm, V = 0.00 kNm
coordinates of centroid $y_s' = -117.5$ mm, $z_s' = 70.0$ mm
cross-sectional area $A' = n_x \cdot n_z = 6$, polar moment of inertia $I_p' = \Sigma y_i'^2 + \Sigma z_i'^2 = 329.50\ cm^2$
member forces in centroid $V_y' = 400.0$ kN, $V_z' = -0.0$ kN, $M_x' = 0.00$ kNm
stress $T_{y,i} = V_y'/A' - M_x'/I_p' \cdot z_i'$, $T_{z,i} = V_z'/A' + M_x'/I_p' \cdot y_i'$, $T_i = (T_{y,i}^2 + T_{z,i}^2)^{1/2}$

point 1:	$y_1' = 80.0$ mm	$z_1' = -35.0$ mm	$T_1 = T_{y,1} = 66.67$ kN
point 2:	$y_2' = 80.0$ mm	$z_2' = 35.0$ mm	$T_2 = T_{y,2} = 66.67$ kN
point 3:	$y_3' = 0.0$ mm	$z_3' = -35.0$ mm	$T_3 = T_{y,3} = 66.67$ kN
point 4:	$y_4' = 0.0$ mm	$z_4' = 35.0$ mm	$T_4 = T_{y,4} = 66.67$ kN
point 5:	$y_5' = -80.0$ mm	$z_5' = -35.0$ mm	$T_5 = T_{y,5} = 66.67$ kN
point 6:	$y_6' = -80.0$ mm	$z_6' = 35.0$ mm	$T_6 = T_{y,6} = 66.67$ kN

shear
shear resistance per shear plane $F_{v,Rd} = \alpha_v \cdot f_{ub} \cdot A / \gamma_{M2} = 150.80$ kN, $\alpha_v = 0.60$
shear resistance per bolt (2-shear): $\Sigma F_{v,Rd} = 2 \cdot F_{v,Rd} = 301.59$ kN
verification: $F_{Ed} = T_1 = 66.67\ kN < F_{v,Rd} = 301.59\ kN \Rightarrow U = 0.221 < 1$ ok
bearing resistance (separated in the directions)
bolt 1:
beam
horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 415.64$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$
vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 350.18$ kN, $k_1 = 2.50$, $\alpha_b = 0.81$
splice plate
horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 174.55$ kN, $k_1 = 2.50$, $\alpha_b = 0.61$
vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 152.73$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$
minimum bearing resistance: min $F_{b,h,Rd} = 349.09$ kN, min $F_{b,v,Rd} = 305.45$ kN
verification: $F_{Ed} = |T_{y,1}| = 66.67\ kN < F_{b,Rd} = 349.09\ kN \Rightarrow U = 0.191 < 1$ ok
bolt 2:
beam
horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 415.64$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$
vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 350.18$ kN, $k_1 = 2.50$, $\alpha_b = 0.81$
splice plate
horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 174.55$ kN, $k_1 = 2.50$, $\alpha_b = 0.61$
vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 152.73$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$
minimum bearing resistance: min $F_{b,h,Rd} = 349.09$ kN, min $F_{b,v,Rd} = 305.45$ kN
verification: $F_{Ed} = |T_{y,2}| = 66.67\ kN < F_{b,Rd} = 349.09\ kN \Rightarrow U = 0.191 < 1$ ok
bolt 3:

beam
horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 415.64$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$
vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 350.18$ kN, $k_1 = 2.50$, $\alpha_b = 0.81$
splice plate
horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 277.09$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$
vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 152.73$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$
minimum bearing resistance: min $F_{b,h,Rd} = 415.64$ kN, min $F_{b,v,Rd} = 305.45$ kN
verification: $F_{Ed} = |T_{y,3}| = 66.67$ kN $<$ $F_{b,Rd} = 415.64$ kN $\Rightarrow$ U = 0.160 $<$ 1 ok
bolt 4:
beam
horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 415.64$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$
vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 350.18$ kN, $k_1 = 2.50$, $\alpha_b = 0.81$
splice plate
horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 277.09$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$
vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 152.73$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$
minimum bearing resistance: min $F_{b,h,Rd} = 415.64$ kN, min $F_{b,v,Rd} = 305.45$ kN
verification: $F_{Ed} = |T_{y,4}| = 66.67$ kN $<$ $F_{b,Rd} = 415.64$ kN $\Rightarrow$ U = 0.160 $<$ 1 ok
bolt 5:
beam
horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 229.09$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$
vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 350.18$ kN, $k_1 = 2.50$, $\alpha_b = 0.81$
splice plate
horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 277.09$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$
vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 152.73$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$
minimum bearing resistance: min $F_{b,h,Rd} = 229.09$ kN, min $F_{b,v,Rd} = 305.45$ kN
verification: $F_{Ed} = |T_{y,5}| = 66.67$ kN $<$ $F_{b,Rd} = 229.09$ kN $\Rightarrow$ U = 0.291 $<$ 1 ok
bolt 6:
beam
horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 229.09$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$
vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 350.18$ kN, $k_1 = 2.50$, $\alpha_b = 0.81$
splice plate
horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 277.09$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$
vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 152.73$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$
minimum bearing resistance: min $F_{b,h,Rd} = 229.09$ kN, min $F_{b,v,Rd} = 305.45$ kN
verification: $F_{Ed} = |T_{y,6}| = 66.67$ kN $<$ $F_{b,Rd} = 229.09$ kN $\Rightarrow$ U = 0.291 $<$ 1 ok

max. shear stress in middle of bolt pattern
plastic verification refering to the width of splice plate h = 140.0 mm
max $V_{Ed} \approx \Sigma(T_{y,i}^2+T_{z,i}^2)^{1/2}/2 = 200.00$ kN
beam: shear resistance $V_{Rd} = (A_v \cdot f_y) / (3^{1/2} \cdot \gamma_{M0}) = 569.84$ kN with $A_v = h \cdot t = 42.00$ cm², h = 140.0 mm
splice plate: shear resistance $V_{Rd} = (A_v \cdot f_y) / (3^{1/2} \cdot \gamma_{M0}) = 379.90$ kN with $A_v = h \cdot t = 28.00$ cm², h = 140.0 mm
minimum shear resistance: min V_{Rd} = min(569.84, 2·379.90) = 569.84 kN
verification: max $V_{Ed} = 200.00$ kN $<$ min $V_{Rd} = 569.84$ kN $\Rightarrow$ U = 0.351 $<$ 1 ok

2.3. verification result

maximum utilisation: max U = 0.489 $<$ 1 ok
stresses

beam left

2.4. elastic stresses at net section

$N_{Ed} = 400.00$ kN
cross-sectional properties: A = 48.00 cm², $z_s = 80.0$ mm, $I_y = 1024.00$ cm⁴, $y_s = 0.0$ mm, $I_z = 36.00$ cm⁴

stresses in points of cross-section

pt. 1:	y = 0.0 mm	z = 0.0 mm	$\sigma_x = 114.94$ N/mm²
pt. 2:	y = 0.0 mm	z = 160.0 mm	$\sigma_x = 114.94$ N/mm²

2.5. beam

internal forces and moments in the beam: $N = N_w = 400.00$ kN
load parts: per splice plate $f_a = 50\%$

beam
tension (net section)
deduction of holes is respected.
maximum normal stress: $\sigma_x = 114.94$ N/mm²
permitted normal stress: $\sigma_{Rd} = 235.00$ N/mm²
verification: $\sigma_x = 114.94$ N/mm² $<$ $\sigma_{Rd} = 235.00$ N/mm² $\Rightarrow$ $U_{\sigma x} = 0.489$ $<$ 1 ok

splice plates
tension
net cross-section $b_{net} = b - \Delta b = 96.0$ mm, $t_{net} = 20.0$ mm with $\Delta b = n_2 \cdot d_0 = 44.0$ mm, $d_0 = d + \Delta d$

resistance of plate in tension:

$N_{pl,Rd} = (A \cdot f_y) / \gamma_{M0} = 658.00$ kN

$N_{u,Rd} = (0.9 \cdot A_{net} \cdot f_u) / \gamma_{M2} = 497.66$ kN

tension resistance $N_{t,Rd} = \min(N_{pl,Rd}, N_{u,Rd}) = 497.66$ kN

verification: $F_{Ed} = 400.00$ kN $<$ $F_{t,Rd}/f_a = 995.33$ kN $\Rightarrow$ $U = 0.402 < 1$ ok

beam (model assumption: b = 140.0 mm)

tension (gross section)

resistance of plate in tension:

tension resistance $N_{t,Rd} = N_{pl,Rd} = (A \cdot f_y) / \gamma_{M0} = 987.00$ kN

verification: $F_{Ed} = 400.00$ kN $<$ $F_{t,Rd} = 987.00$ kN $\Rightarrow$ $U = 0.405 < 1$ ok

bolts

cross-section of points

internal forces and moments: N = 400.00 kN, M = 0.00 kNm, V = 0.00 kNm

coordinates of centroid $y_s' = 117.5$ mm, $z_s' = 70.0$ mm

cross-sectional area $A' = n_x \cdot n_z = 6$, polar moment of inertia $I_p' = \Sigma y_i'^2 + \Sigma z_i'^2 = 329.50$ cm²

member forces in centroid $V_y' = -400.0$ kN, $V_z' = 0.0$ kN, $M_x' = 0.00$ kNm

stress $T_{y,i} = V_y'/A' - M_x'/I_p' \cdot z_i'$, $T_{z,i} = V_z'/A' + M_x'/I_p' \cdot y_i'$, $T_i = (T_{y,i}^2 + T_{z,i}^2)^{1/2}$

point 1:	$y_1' = -80.0$ mm	$z_1' = -35.0$ mm	$T_1 = T_{y,1} = 66.67$ kN
point 2:	$y_2' = -80.0$ mm	$z_2' = 35.0$ mm	$T_2 = T_{y,2} = 66.67$ kN
point 3:	$y_3' = 0.0$ mm	$z_3' = -35.0$ mm	$T_3 = T_{y,3} = 66.67$ kN
point 4:	$y_4' = 0.0$ mm	$z_4' = 35.0$ mm	$T_4 = T_{y,4} = 66.67$ kN
point 5:	$y_5' = 80.0$ mm	$z_5' = -35.0$ mm	$T_5 = T_{y,5} = 66.67$ kN
point 6:	$y_6' = 80.0$ mm	$z_6' = 35.0$ mm	$T_6 = T_{y,6} = 66.67$ kN

shear

shear resistance per shear plane $F_{v,Rd} = \alpha_v \cdot f_{ub} \cdot A / \gamma_{M2} = 150.80$ kN, $\alpha_v = 0.60$

shear resistance per bolt (2-shear): $\Sigma F_{v,Rd} = 2 \cdot F_{v,Rd} = 301.59$ kN

verification: $F_{Ed} = T_1 = 66.67$ kN $<$ $F_{v,Rd} = 301.59$ kN $\Rightarrow$ $U = 0.221 < 1$ ok

bearing resistance (separated in the directions)

bolt 1:

beam

horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 415.64$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$

vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 350.18$ kN, $k_1 = 2.50$, $\alpha_b = 0.81$

splice plate

horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 174.55$ kN, $k_1 = 2.50$, $\alpha_b = 0.61$

vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 152.73$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$

minimum bearing resistance: $\min F_{b,h,Rd} = 349.09$ kN, $\min F_{b,v,Rd} = 305.45$ kN

verification: $F_{Ed} = |T_{y,1}| = 66.67$ kN $<$ $F_{b,Rd} = 349.09$ kN $\Rightarrow$ $U = 0.191 < 1$ ok

bolt 2:

beam

horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 415.64$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$

vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 350.18$ kN, $k_1 = 2.50$, $\alpha_b = 0.81$

splice plate

horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 174.55$ kN, $k_1 = 2.50$, $\alpha_b = 0.61$

vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 152.73$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$

minimum bearing resistance: $\min F_{b,h,Rd} = 349.09$ kN, $\min F_{b,v,Rd} = 305.45$ kN

verification: $F_{Ed} = |T_{y,2}| = 66.67$ kN $<$ $F_{b,Rd} = 349.09$ kN $\Rightarrow$ $U = 0.191 < 1$ ok

bolt 3:

beam

horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 415.64$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$

vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 350.18$ kN, $k_1 = 2.50$, $\alpha_b = 0.81$

splice plate

horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 277.09$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$

vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 152.73$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$

minimum bearing resistance: $\min F_{b,h,Rd} = 415.64$ kN, $\min F_{b,v,Rd} = 305.45$ kN

verification: $F_{Ed} = |T_{y,3}| = 66.67$ kN $<$ $F_{b,Rd} = 415.64$ kN $\Rightarrow$ $U = 0.160 < 1$ ok

bolt 4:

beam

horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 415.64$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$

vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 350.18$ kN, $k_1 = 2.50$, $\alpha_b = 0.81$

splice plate

horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 277.09$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$

vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 152.73$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$

minimum bearing resistance: $\min F_{b,h,Rd} = 415.64$ kN, $\min F_{b,v,Rd} = 305.45$ kN

verification: $F_{Ed} = |T_{y,4}| = 66.67$ kN $<$ $F_{b,Rd} = 415.64$ kN $\Rightarrow$ $U = 0.160 < 1$ ok

bolt 5:

beam

horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 229.09$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$

vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 350.18$ kN, $k_1 = 2.50$, $\alpha_b = 0.81$

splice plate

horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 277.09$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$

vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 152.73$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$
minimum bearing resistance: min $F_{b,h,Rd} = 229.09$ kN, min $F_{b,v,Rd} = 305.45$ kN
verification: $F_{Ed} = |T_{y,5}| = 66.67$ kN $<$ $F_{b,Rd} = 229.09$ kN $\Rightarrow$ $U = 0.291 < 1$ ok
bolt 6:
beam
horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 229.09$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$
vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 350.18$ kN, $k_1 = 2.50$, $\alpha_b = 0.81$
splice plate
horizontal: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 277.09$ kN, $k_1 = 2.50$, $\alpha_b = 0.96$
vertical: bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 152.73$ kN, $k_1 = 2.50$, $\alpha_b = 0.53$
minimum bearing resistance: min $F_{b,h,Rd} = 229.09$ kN, min $F_{b,v,Rd} = 305.45$ kN
verification: $F_{Ed} = |T_{y,6}| = 66.67$ kN $<$ $F_{b,Rd} = 229.09$ kN $\Rightarrow$ $U = 0.291 < 1$ ok

max. shear stress in middle of bolt pattern

plastic verification refering to the width of splice plate h = 140.0 mm

max $V_{Ed} \approx \Sigma(T_{y,i}^2+T_{z,i}^2)^{1/2}/2 = 200.00$ kN
beam: shear resistance $V_{Rd} = (A_v \cdot f_y) / (3^{1/2} \cdot \gamma_{M0}) = 569.84$ kN with $A_v = h \cdot t = 42.00$ cm², h = 140.0 mm
splice plate: shear resistance $V_{Rd} = (A_v \cdot f_y) / (3^{1/2} \cdot \gamma_{M0}) = 379.90$ kN with $A_v = h \cdot t = 28.00$ cm², h = 140.0 mm
minimum shear resistance: min V_{Rd} = min(569.84, 2·379.90) = 569.84 kN
verification: max $V_{Ed} = 200.00$ kN $<$ min $V_{Rd} = 569.84$ kN $\Rightarrow$ $U = 0.351 < 1$ ok

2.6. verification result

maximum utilisation: max $U = 0.489 < 1$ ok
stresses

3. final result

maximum utilisation: max $U = 0.489 < 1$ ok

verification succeeded

4. 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/A1, Ergänzungen zur DIN EN 1993-1-1, Ausgabe Juli 2014
DIN EN 1993-1-1/NA, Nationaler Anhang zur DIN EN 1993-1-1, Ausgabe Dezember 2018

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