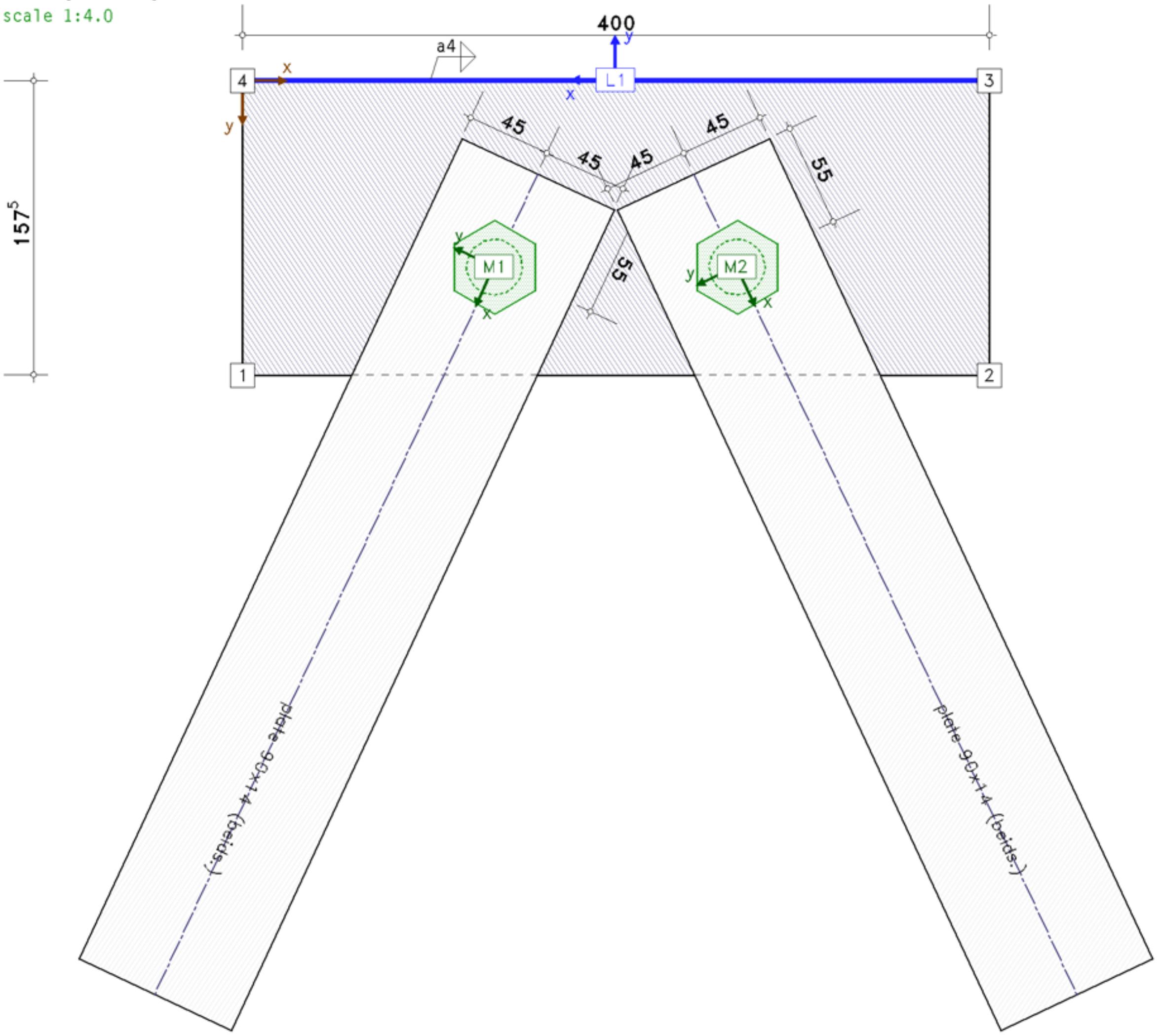
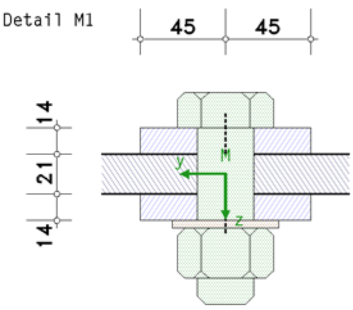
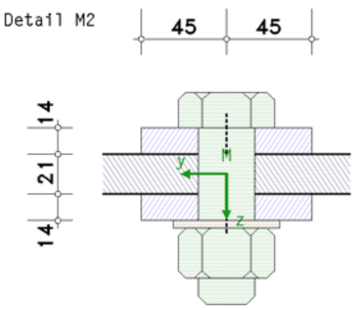
POS. 113: BSP. 3 - BRACESANSCHLUSS

gusset plate connection EC 3-1-8 (12.10), NA: Deutschland 4H-EC3FK version: 2/2019-2e

1. input report







steel grade

steel grade S235

welds

butt weld (partial penetrated), weld thickness a = 4.0 mm

bolts

strengths:

char. yield strength f_{yb} = 240.0 N/mm²

char. tensile strength f_{ub} = 420.0 N/mm²

bolt size M30, normal wrench size

shear plane passes through the unthreaded portion of the bolt

connection

gusset plate

thickness t_p = 21.0 mm, width b_p = 400.0 mm, length l_p = 157.5 mm

welds

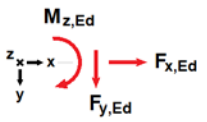
weld L1 (load out-transfer): edge of gusset plate 3-4 (double-sided welded), length l_L = 400.0 mm

bolts
group M1 (load in-transfer): load point x_M = 135.0 mm, y_M = 100.0 mm, twisting angle α_M = 115.00°
joining section (double-sided connection)
section parameters (flat steel):
height h = 90.0 mm, thickness t = 14.0 mm
distance ref. to load point b_{M1} = 45.0 mm, b_{M2} = 45.0 mm, Δb_M = 0.0 mm, Δl_M = 55.0 mm
any arrangement of bolts, coordinates of bolt axis:
x_1 = 135.0 mm, y_1 = 100.0 mm
group M2 (load in-transfer): load point x_M = 265.0 mm, y_M = 100.0 mm, twisting angle α_M = 65.00°
joining section (double-sided connection)
section parameters (flat steel):
height h = 90.0 mm, thickness t = 14.0 mm
distance ref. to load point b_{M1} = 45.0 mm, b_{M2} = 45.0 mm, Δb_M = 0.0 mm, Δl_M = 55.0 mm
any arrangement of bolts, coordinates of bolt axis:
x_1 = 265.0 mm, y_1 = 100.0 mm

calculation
calculation of internal forces and moments with FE-method
elastic verification of gusset plate
verification of welds with the directional method, weld thickness is checked
verification of bolts, check of distances
plastic verification of joining sections

internal forces and moments
internal forces and moments refering to loadpoints in node coordinate system

Lk	$F_{x,Ed}$ kN	LPkt.
1	150.00	M1
	-150.00	M2



$F_{x,Ed}$,$F_{y,Ed}$,$M_{z,Ed}$: design loads ass. to load point; LPkt.: load point M=bolt group or L=welds regarded to beam

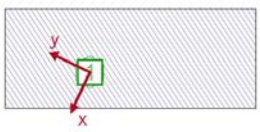
partial safety factors for material
resistance of cross-sections γ_{M0} = 1.00
resistance of bolts, welds, plates in bearing γ_{M2} = 1.25

notes
plate bending due to excentric loading is not respected.
buckling is not inspected neither at gusset plate nor at joining sections.
distances between bolts at joining section are not checked.

2. Lk 1

2.1. group of bolts M1 (load in-transfer)

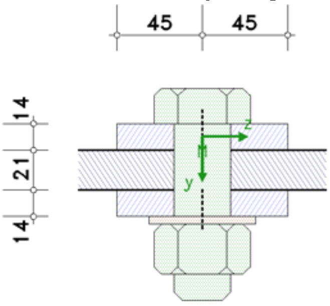
load point x_M = 135.0 mm, y_M = 100.0 mm, α_M = 115.0°
loading $F_{x,Ed}$ = 150.00 kN, $F_{y,Ed}$ = 0.00 kN, $M_{z,Ed}$ = 0.00 kNm
the group contains 1 bolts. Each bolt, forces F_x and F_y are working,
which results from the devided loading.



2.1.1. verification of bolts
bolt 1: $F_{x,1}$ = 150.00 kN $F_{y,1}$ = -0.00 kN F_1 = 150.00 kN
shear (2-shear)
shear resistance per shear plane $F_{v,Rd} = \alpha_v \cdot f_{ub} \cdot A / \gamma_{M2}$ = 142.50 kN, α_v = 0.60
shear resistance per bolt (2-shear): $\Sigma F_{v,Rd} = 2 \cdot F_{v,Rd}$ = 285.01 kN
utilisation $U_{v,1} = F_1 / \Sigma F_{v,Rd}$ = 0.526
bearing resistance gusset plate (distance min e = 57.5 mm, min p = 0.0 mm)
bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2}$ = 263.45 kN, k_1 = 2.50, α_b = 0.58
utilisation x $U_{bx,1} = F_{x,1} / F_{b,Rd}$ = 0.569
bearing resistance joining section, double-sided (distance e = 55.0 / 45.0 mm, p = 0.0 / 0.0 mm)
bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2}$ = 142.34 kN, k_1 = 2.12, α_b = 0.56
utilisation x $U_{bx,1} = F_{x,1} / (2 \cdot F_{b,Rd})$ = 0.527
total
utilisation U_1 = = 0.569 < 1 ok

utilisation of bolts: U_{sc} = 0.569 < 1 ok

2.1.2. verification of joining section



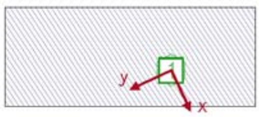
plastic verification for dieses section not möglich !!
verification not possible !!
no verification of net cross-section !!
Der verification of shear block wird bei freiem boltsbild not geführt !!

2.1.3. total

max $U_{M1} = 0.569 < 1$ ok

2.2. group of bolts M2 (load in-transfer)

load point $x_M = 265.0$ mm, $y_M = 100.0$ mm, $\alpha_M = 65.0°$
loading $F_{x,Ed} = -150.00$ kN, $F_{y,Ed} = 0.00$ kN, $M_{z,Ed} = 0.00$ kNm
the group contains 1 bolts. Each bolt, forces F_x and F_y are working, which results from the devided loading.



2.2.1. verification of bolts

bolt 1: $F_{x,1} = -150.00$ kN $F_{y,1} = 0.00$ kN $F_1 = 150.00$ kN

shear (2-shear)

shear resistance per shear plane $F_{v,Rd} = \alpha_v \cdot f_{ub} \cdot A \,/\, \gamma_{M2} = 142.50$ kN, $\alpha_v = 0.60$
shear resistance per bolt (2-shear): $\Sigma F_{v,Rd} = 2 \cdot F_{v,Rd} = 285.01$ kN
utilisation $U_{v,1} = F_1 \,/\, \Sigma F_{v,Rd} = 0.526$

bearing resistance gusset plate (distance min e = 57.5 mm, min p = 0.0 mm)

bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) \,/\, \gamma_{M2} = 263.45$ kN, $k_1 = 2.50$, $\alpha_b = 0.58$
utilisation x $U_{bx,1} = F_{x,1} \,/\, F_{b,Rd} = 0.569$

bearing resistance joining section, double-sided (distance e = 55.0 / 45.0 mm, p = 0.0 / 0.0 mm)

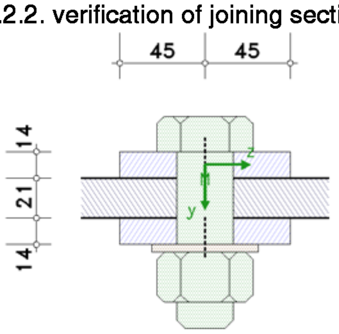
bearing resistance $F_{b,Rd} = (k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t) \,/\, \gamma_{M2} = 142.40$ kN, $k_1 = 2.12$, $\alpha_b = 0.56$
utilisation x $U_{bx,1} = F_{x,1} \,/\, (2 \cdot F_{b,Rd}) = 0.527$

total

utilisation $U_1 = \ = 0.569 < 1$ ok

utilisation of bolts: $U_{sc} = 0.569 < 1$ ok

2.2.2. verification of joining section



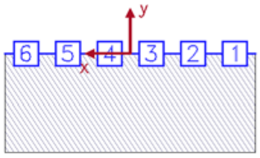
plastic verification for dieses section not möglich !!
verification not possible !!
no verification of net cross-section !!
Der verification of shear block wird bei freiem boltsbild not geführt !!

2.2.3. total

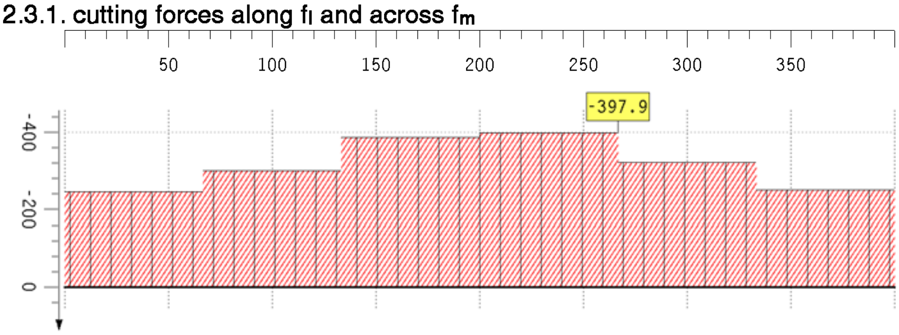
max $U_{M2} = 0.569 < 1$ ok

2.3. weld L1 (load out-transfer)

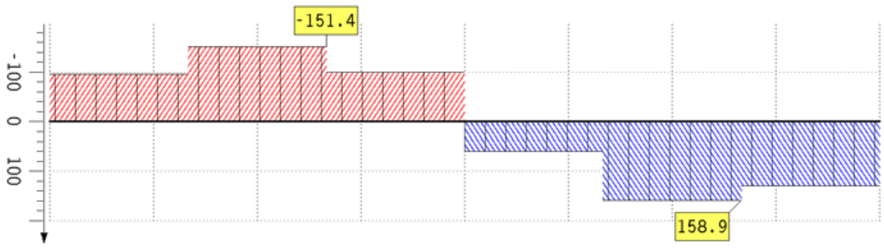
support point x_L = 200.0 mm, y_L = 0.0 mm, α_L = 180.0°, length l_L = 400.0 mm
one weld is divided into 6 sections. Each section, weld forces F_l and F_m are working,
which results from FEM-calculation: $\Sigma F_{x,i}$ = -126.79 kN, $\Sigma F_{y,i}$ = -0.00 kN, $\Sigma M_{z,i}$ = 4.93 kNm



2.3.1. cutting forces along f_l and across f_m



max f_l = -245.51 N/mm
min f_l = -397.95 N/mm
L = 400.0 mm



max f_m = 158.94 N/mm
min f_m = -151.42 N/mm
L = 400.0 mm

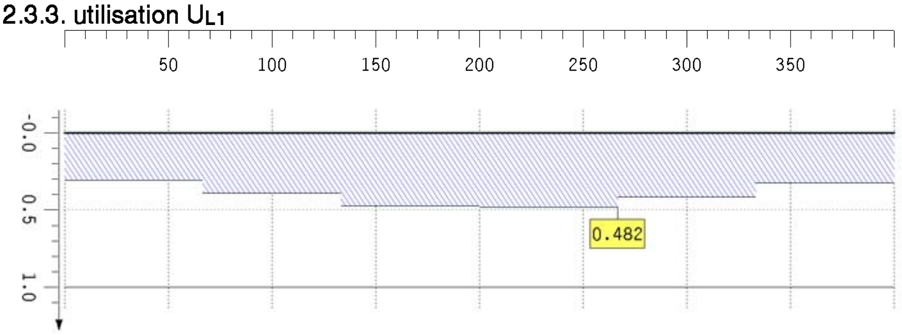
2.3.2. verification of welds

section 1: f_l = -245.5 N/mm, f_m = -96.2 N/mm ⇒ F_l = -16.37 kN, F_m = -6.41 kN, l_1 = 66.7 mm
forces on the design area of the weld: $F_{Ed}(\sigma_s)$ = -0.68 kN/cm $F_{Ed}(\tau_s)$ = -0.68 kN/cm $F_{Ed}(\tau_p)$ = -2.46 kN/cm
stresses on the design area of the weld: σ_s = 17.01 N/mm² τ_s = 17.01 N/mm² τ_p = 61.38 N/mm²
$\sigma_{1,w,Ed} = (\sigma_s^2 + 3\cdot(\tau_s^2 + \tau_p^2))^{1/2}$ = 111.62 N/mm²
resistance of a weld (req.1): $f_{1w,d} = f_u / (\beta_w \cdot \gamma_{M2})$ = 360.00 N/mm²
$\sigma_{1,w,Ed}$ = 111.62 N/mm² < $f_{1w,d}$ = 360.00 N/mm² ⇒ U = 0.310 < 1 ok
$\sigma_{2,w,Ed} = |\sigma_s|$ = 17.01 N/mm²
resistance of a weld (req.2): $f_{2w,d} = 0.9 \cdot f_u / \gamma_{M2}$ = 259.20 N/mm²
$\sigma_{2,w,Ed}$ = 17.01 N/mm² < $f_{2w,d}$ = 259.20 N/mm² ⇒ U = 0.066 < 1 ok
section 2: f_l = -300.1 N/mm, f_m = -151.4 N/mm ⇒ F_l = -20.01 kN, F_m = -10.09 kN, l_2 = 66.7 mm
forces on the design area of the weld: $F_{Ed}(\sigma_s)$ = -1.07 kN/cm $F_{Ed}(\tau_s)$ = -1.07 kN/cm $F_{Ed}(\tau_p)$ = -3.00 kN/cm
stresses on the design area of the weld: σ_s = 26.77 N/mm² τ_s = 26.77 N/mm² τ_p = 75.02 N/mm²
$\sigma_{1,w,Ed} = (\sigma_s^2 + 3\cdot(\tau_s^2 + \tau_p^2))^{1/2}$ = 140.53 N/mm²
resistance of a weld (req.1): $f_{1w,d} = f_u / (\beta_w \cdot \gamma_{M2})$ = 360.00 N/mm²
$\sigma_{1,w,Ed}$ = 140.53 N/mm² < $f_{1w,d}$ = 360.00 N/mm² ⇒ U = 0.390 < 1 ok
$\sigma_{2,w,Ed} = |\sigma_s|$ = 26.77 N/mm²
resistance of a weld (req.2): $f_{2w,d} = 0.9 \cdot f_u / \gamma_{M2}$ = 259.20 N/mm²
$\sigma_{2,w,Ed}$ = 26.77 N/mm² < $f_{2w,d}$ = 259.20 N/mm² ⇒ U = 0.103 < 1 ok
section 3: f_l = -386.3 N/mm, f_m = -100.1 N/mm ⇒ F_l = -25.75 kN, F_m = -6.67 kN, l_3 = 66.7 mm
forces on the design area of the weld: $F_{Ed}(\sigma_s)$ = -0.71 kN/cm $F_{Ed}(\tau_s)$ = -0.71 kN/cm $F_{Ed}(\tau_p)$ = -3.86 kN/cm
stresses on the design area of the weld: σ_s = 17.69 N/mm² τ_s = 17.69 N/mm² τ_p = 96.57 N/mm²
$\sigma_{1,w,Ed} = (\sigma_s^2 + 3\cdot(\tau_s^2 + \tau_p^2))^{1/2}$ = 170.97 N/mm²
resistance of a weld (req.1): $f_{1w,d} = f_u / (\beta_w \cdot \gamma_{M2})$ = 360.00 N/mm²
$\sigma_{1,w,Ed}$ = 170.97 N/mm² < $f_{1w,d}$ = 360.00 N/mm² ⇒ U = 0.475 < 1 ok
$\sigma_{2,w,Ed} = |\sigma_s|$ = 17.69 N/mm²
resistance of a weld (req.2): $f_{2w,d} = 0.9 \cdot f_u / \gamma_{M2}$ = 259.20 N/mm²
$\sigma_{2,w,Ed}$ = 17.69 N/mm² < $f_{2w,d}$ = 259.20 N/mm² ⇒ U = 0.068 < 1 ok
section 4: f_l = -397.9 N/mm, f_m = 59.1 N/mm ⇒ F_l = -26.53 kN, F_m = 3.94 kN, l_4 = 66.7 mm
forces on the design area of the weld: $F_{Ed}(\sigma_s)$ = 0.42 kN/cm $F_{Ed}(\tau_s)$ = 0.42 kN/cm $F_{Ed}(\tau_p)$ = -3.98 kN/cm
stresses on the design area of the weld: σ_s = 10.44 N/mm² τ_s = 10.44 N/mm² τ_p = 99.49 N/mm²
$\sigma_{1,w,Ed} = (\sigma_s^2 + 3\cdot(\tau_s^2 + \tau_p^2))^{1/2}$ = 173.58 N/mm²
resistance of a weld (req.1): $f_{1w,d} = f_u / (\beta_w \cdot \gamma_{M2})$ = 360.00 N/mm²
$\sigma_{1,w,Ed}$ = 173.58 N/mm² < $f_{1w,d}$ = 360.00 N/mm² ⇒ U = 0.482 < 1 ok
$\sigma_{2,w,Ed} = |\sigma_s|$ = 10.44 N/mm²
resistance of a weld (req.2): $f_{2w,d} = 0.9 \cdot f_u / \gamma_{M2}$ = 259.20 N/mm²

$\sigma_{2,w,Ed}$ = 10.44 N/mm² < $f_{2w,d}$ = 259.20 N/mm² ⇒ U = 0.040 < 1 ok
section 5: f_l = -321.9 N/mm, f_m = 158.9 N/mm ⇒ F_l = -21.46 kN, F_m = 10.60 kN, l_5 = 66.7 mm
forces on the design area of the weld: $F_{Ed}(\sigma_s)$ = 1.12 kN/cm $F_{Ed}(\tau_s)$ = 1.12 kN/cm $F_{Ed}(\tau_p)$ = -3.22 kN/cm
stresses on the design area of the weld: σ_s = 28.10 N/mm² τ_s = 28.10 N/mm² τ_p = 80.47 N/mm²
$\sigma_{1,w,Ed} = (\sigma_s^2 + 3\cdot(\tau_s^2 + \tau_p^2))^{1/2}$ = 150.27 N/mm²
resistance of a weld (req.1): $f_{1w,d} = f_u / (\beta_w \cdot \gamma_{M2})$ = 360.00 N/mm²
$\sigma_{1,w,Ed}$ = 150.27 N/mm² < $f_{1w,d}$ = 360.00 N/mm² ⇒ U = 0.417 < 1 ok
$\sigma_{2,w,Ed} = |\sigma_s|$ = 28.10 N/mm²
resistance of a weld (req.2): $f_{2w,d} = 0.9\cdot f_u / \gamma_{M2}$ = 259.20 N/mm²
$\sigma_{2,w,Ed}$ = 28.10 N/mm² < $f_{2w,d}$ = 259.20 N/mm² ⇒ U = 0.108 < 1 ok
section 6: f_l = -250.1 N/mm, f_m = 129.7 N/mm ⇒ F_l = -16.67 kN, F_m = 8.65 kN, l_6 = 66.7 mm
forces on the design area of the weld: $F_{Ed}(\sigma_s)$ = 0.92 kN/cm $F_{Ed}(\tau_s)$ = 0.92 kN/cm $F_{Ed}(\tau_p)$ = -2.50 kN/cm
stresses on the design area of the weld: σ_s = 22.93 N/mm² τ_s = 22.93 N/mm² τ_p = 62.52 N/mm²
$\sigma_{1,w,Ed} = (\sigma_s^2 + 3\cdot(\tau_s^2 + \tau_p^2))^{1/2}$ = 117.60 N/mm²
resistance of a weld (req.1): $f_{1w,d} = f_u / (\beta_w \cdot \gamma_{M2})$ = 360.00 N/mm²
$\sigma_{1,w,Ed}$ = 117.60 N/mm² < $f_{1w,d}$ = 360.00 N/mm² ⇒ U = 0.327 < 1 ok
$\sigma_{2,w,Ed} = |\sigma_s|$ = 22.93 N/mm²
resistance of a weld (req.2): $f_{2w,d} = 0.9\cdot f_u / \gamma_{M2}$ = 259.20 N/mm²
$\sigma_{2,w,Ed}$ = 22.93 N/mm² < $f_{2w,d}$ = 259.20 N/mm² ⇒ U = 0.088 < 1 ok

utilisation of welds: U_{sa} = 0.482 < 1 ok

2.3.3. utilisation U_{L1}



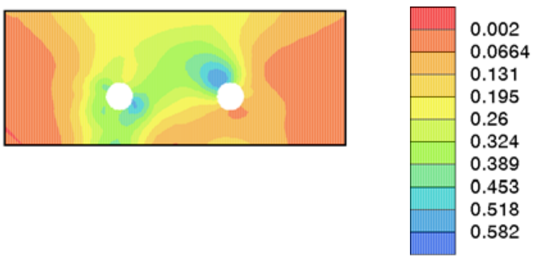
max U_{L1} = 0.482
L = 400.0 mm

2.3.4. total

max U_{L1} = 0.482 < 1 ok

2.4. gusset plate

utilisation U_p
max U_p = 0.581



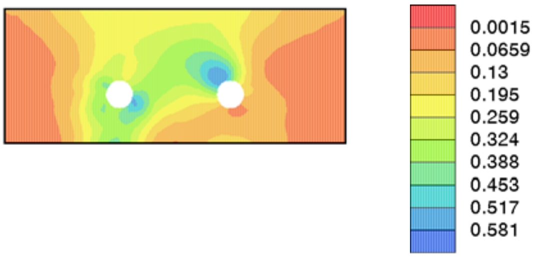
utilisation

node	x mm	y mm	σ N/mm²	τ N/mm²	σ_v N/mm²	U_p
62	150.32	106.12	125.87	0.00	0.00	0.536
184	252.50	82.29	55.16	72.18	136.64	0.581
270	245.41	82.30	26.72	74.43	131.66	0.560

x,y: node coordinates; σ,τ,σ_v: stresses; σ_v=0: σ,τ principal stresses; U_p: utilisation

3. final result

maximum utilisation of plate max U_p due to 1 Lk
max max U_p = 0.581



maximum utilisation of plate due to 1 Lk: max U_p with corresponding values

node	x	y	u_x	u_y	u	σ_x	τ	σ_v	U_p
	mm	mm	mm	mm	mm	N/mm²	N/mm²	N/mm²	
184	252.50	82.29	-0.072	-0.043	0.084	55.16	72.18	136.64	0.581

x,y: node coordinates; u_x,u_y,u: translations; n_{xx},n_{yy},n_{xy}: normal forces; σ,τ,σ_v: stresses; σ_v=0: σ,τ principal stresses
U_p: utilisation

maximum utilisation of bolts [Lk 1]	max U_{sc} = 0.569 < 1 ok
maximum utilisation of welds [Lk 1]	max U_{sa} = 0.482 < 1 ok
maximum utilisation of gusset plate [Lk 1]	max U_p = 0.581 < 1 ok

resistance not ensured !!

verification could not be executed, see Lk 1 !!

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