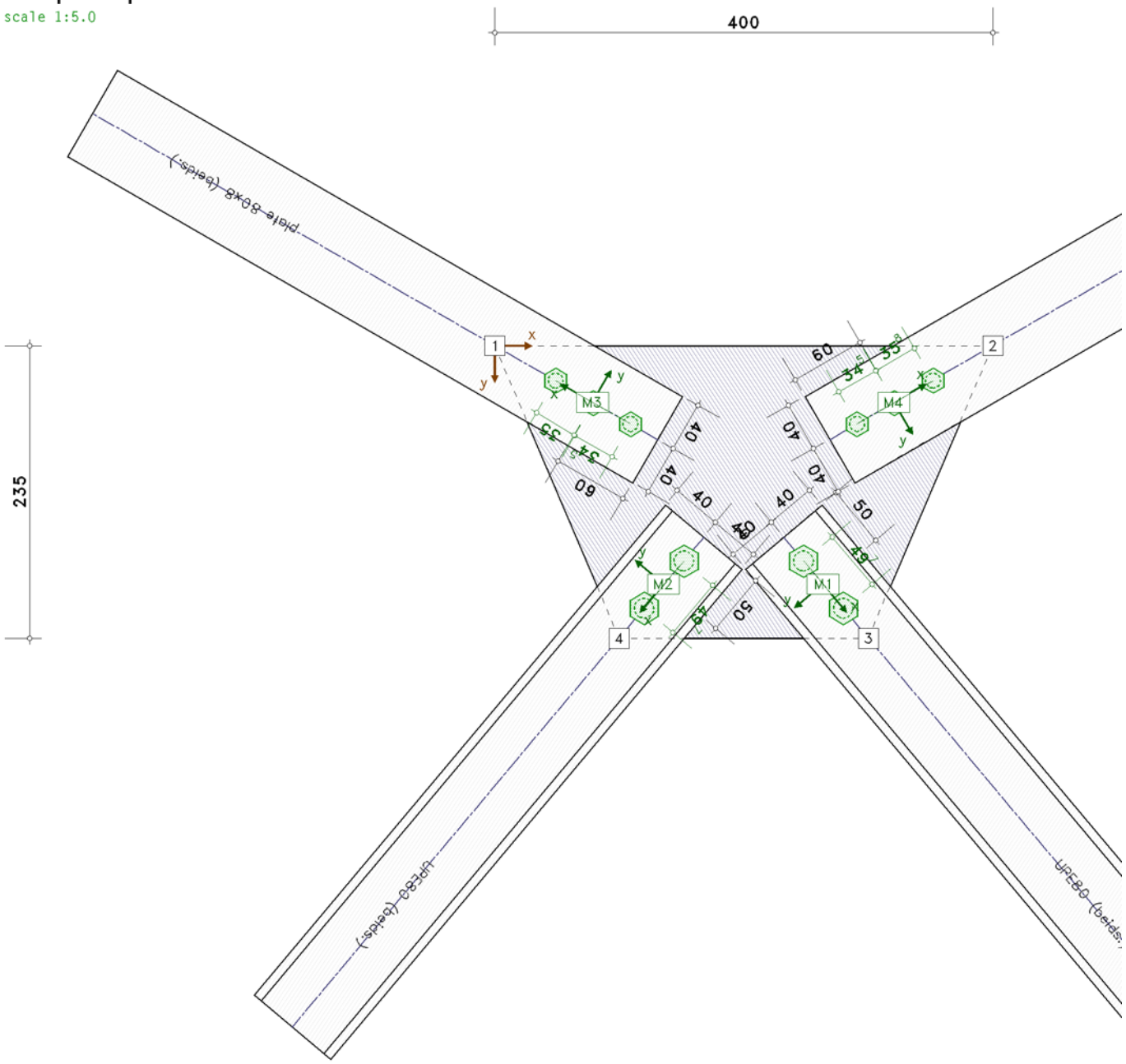
POS. 110: BSP. 2 - KREUZUNGSPUNKT

gusset plate connection EC 3-1-8 (12.10), NA: Deutschland

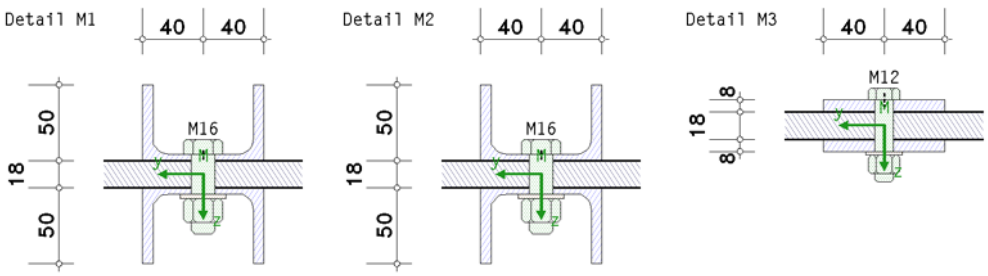
4H-EC3FK version: 2/2019-2e

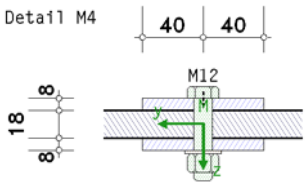
1. input report

scale 1:5.0



steel grade S235





steel grade

steel grade S235

connection

gusset plate: thickness t_p = 18.0 mm

	x_p mm	y_p mm
4	100.0	235.0
3	300.0	235.0
2	400.0	0.0
1	0.0	0.0

bolts

group M1 (load in-transfer): load point x_M = 264.3 mm, y_M = 192.1 mm, twisting angle α_M = 50.00°
2 bolts at a distance of 50.0 mm, load point centric
joining section (double-sided connection)
section UPE80
distance ref. to load point b_{M1} = 40.0 mm, b_{M2} = 40.0 mm, Δb_M = 0.0 mm, Δl_M = 50.0 mm
bolts
bolt class 8.8, bolt size M16, normal wrench size
shear plane passes through the unthreaded portion of the bolt

group M2 (load in-transfer): load point x_M = 135.7 mm, y_M = 192.1 mm, twisting angle α_M = 130.00°
2 bolts at a distance of 50.0 mm, load point centric
joining section (double-sided connection)
section UPE80
distance ref. to load point b_{M1} = 40.0 mm, b_{M2} = 40.0 mm, Δb_M = 0.0 mm, Δl_M = 50.0 mm
bolts
bolt class 8.8, bolt size M16, normal wrench size
shear plane passes through the unthreaded portion of the bolt

group M3 (load in-transfer): load point x_M = 78.8 mm, y_M = 45.5 mm, twisting angle α_M = -150.00°
3 bolts auf einer length von 70.0 mm gleichmäßig verteilt, load point centric
joining section (double-sided connection)
section parameters (flat steel):
height h = 80.0 mm, thickness t = 8.0 mm
distance ref. to load point b_{M1} = 40.0 mm, b_{M2} = 40.0 mm, Δb_M = 0.0 mm, Δl_M = 60.0 mm
bolts
bolt class 8.8, bolt size M12, normal wrench size
shear plane passes through the unthreaded portion of the bolt

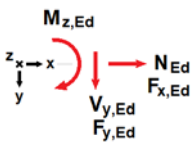
group M4 (load in-transfer): load point x_M = 321.2 mm, y_M = 45.5 mm, twisting angle α_M = -30.00°
3 bolts auf einer length von 70.0 mm gleichmäßig verteilt, load point centric
joining section (double-sided connection)
section parameters (flat steel):
height h = 80.0 mm, thickness t = 8.0 mm
distance ref. to load point b_{M1} = 40.0 mm, b_{M2} = 40.0 mm, Δb_M = 0.0 mm, Δl_M = 60.0 mm
bolts
bolt class 8.8, bolt size M12, normal wrench size
shear plane passes through the unthreaded portion of the bolt

calculation

calculation of internal forces and moments with FE-method
elastic verification of gusset plate
verification of bolts, check of distances
plastic verification of joining sections

internal forces and moments

Lk	$F_{x,Ed}$ N_{Ed} kN	LPkt.
1	65.00	M1
	65.00	M2
	99.58	M3
	99.58	M4



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

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 (group 1)
x-direction: e_1 = 25.0 mm > 1.2·d_0 = 21.6 mm, e_1 = 25.0 mm < 4·t + 40 mm = 56.0 mm
x-direction: p_1 = 50.0 mm > 2.2·d_0 = 39.6 mm, p_1 = 50.0 mm < min(14·t, 200 mm) = 56.0 mm

minimum distance of bolts on gusset plate (group 1)
bolt 1: e_1 = 62.0 mm > 1.2·d_0 = 21.6 mm, e_1 = 62.0 mm < 4·t + 40 mm = 112.0 mm
bolt 1: p_1 = 50.0 mm > 2.2·d_0 = 39.6 mm, p_1 = 50.0 mm < min(14·t, 200 mm) = 200.0 mm
bolt 2: e_1 = 23.7 mm > 1.2·d_0 = 21.6 mm, e_1 = 23.7 mm < 4·t + 40 mm = 112.0 mm
bolt 2: p_1 = 50.0 mm > 2.2·d_0 = 39.6 mm, p_1 = 50.0 mm < min(14·t, 200 mm) = 200.0 mm

distances between bolts at joining section (group 2)
x-direction: e_1 = 25.0 mm > 1.2·d_0 = 21.6 mm, e_1 = 25.0 mm < 4·t + 40 mm = 56.0 mm
x-direction: p_1 = 50.0 mm > 2.2·d_0 = 39.6 mm, p_1 = 50.0 mm < min(14·t, 200 mm) = 56.0 mm

minimum distance of bolts on gusset plate (group 2)
bolt 1: e_1 = 62.0 mm > 1.2·d_0 = 21.6 mm, e_1 = 62.0 mm < 4·t + 40 mm = 112.0 mm
bolt 1: p_1 = 50.0 mm > 2.2·d_0 = 39.6 mm, p_1 = 50.0 mm < min(14·t, 200 mm) = 200.0 mm
bolt 2: e_1 = 23.7 mm > 1.2·d_0 = 21.6 mm, e_1 = 23.7 mm < 4·t + 40 mm = 112.0 mm
bolt 2: p_1 = 50.0 mm > 2.2·d_0 = 39.6 mm, p_1 = 50.0 mm < min(14·t, 200 mm) = 200.0 mm

distances between bolts at joining section (group 3)
x-direction: e_1 = 25.0 mm > 1.2·d_0 = 15.6 mm, e_1 = 25.0 mm < 4·t + 40 mm = 72.0 mm
x-direction: p_1 = 35.0 mm > 2.2·d_0 = 28.6 mm, p_1 = 35.0 mm < min(14·t, 200 mm) = 112.0 mm
y-direction: e_1 = 25.0 mm > 1.2·d_0 = 15.6 mm, e_1 = 25.0 mm < 4·t + 40 mm = 72.0 mm

minimum distance of bolts on gusset plate (group 3)
bolt 1: e_1 = 63.0 mm > 1.2·d_0 = 15.6 mm, e_1 = 63.0 mm < 4·t + 40 mm = 112.0 mm
bolt 1: p_1 = 35.0 mm > 2.2·d_0 = 28.6 mm, p_1 = 35.0 mm < min(14·t, 200 mm) = 200.0 mm
bolt 2: e_1 = 45.5 mm > 1.2·d_0 = 15.6 mm, e_1 = 45.5 mm < 4·t + 40 mm = 112.0 mm
bolt 2: p_1 = 35.0 mm > 2.2·d_0 = 28.6 mm, p_1 = 35.0 mm < min(14·t, 200 mm) = 200.0 mm
bolt 3: e_1 = 28.0 mm > 1.2·d_0 = 15.6 mm, e_1 = 28.0 mm < 4·t + 40 mm = 112.0 mm
bolt 3: p_1 = 35.0 mm > 2.2·d_0 = 28.6 mm, p_1 = 35.0 mm < min(14·t, 200 mm) = 200.0 mm

distances between bolts at joining section (group 4)
x-direction: e_1 = 25.0 mm > 1.2·d_0 = 15.6 mm, e_1 = 25.0 mm < 4·t + 40 mm = 72.0 mm
x-direction: p_1 = 35.0 mm > 2.2·d_0 = 28.6 mm, p_1 = 35.0 mm < min(14·t, 200 mm) = 112.0 mm
y-direction: e_1 = 25.0 mm > 1.2·d_0 = 15.6 mm, e_1 = 25.0 mm < 4·t + 40 mm = 72.0 mm

minimum distance of bolts on gusset plate (group 4)
bolt 1: e_1 = 63.0 mm > 1.2·d_0 = 15.6 mm, e_1 = 63.0 mm < 4·t + 40 mm = 112.0 mm
bolt 1: p_1 = 35.0 mm > 2.2·d_0 = 28.6 mm, p_1 = 35.0 mm < min(14·t, 200 mm) = 200.0 mm
bolt 2: e_1 = 45.5 mm > 1.2·d_0 = 15.6 mm, e_1 = 45.5 mm < 4·t + 40 mm = 112.0 mm
bolt 2: p_1 = 35.0 mm > 2.2·d_0 = 28.6 mm, p_1 = 35.0 mm < min(14·t, 200 mm) = 200.0 mm
bolt 3: e_1 = 28.0 mm > 1.2·d_0 = 15.6 mm, e_1 = 28.0 mm < 4·t + 40 mm = 112.0 mm
bolt 3: p_1 = 35.0 mm > 2.2·d_0 = 28.6 mm, p_1 = 35.0 mm < min(14·t, 200 mm) = 200.0 mm

2. load distribution

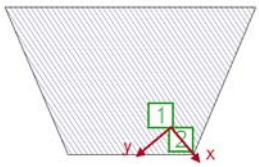
load combination 1:
bolts:

group M1				
bolt 1:	x = 248.2 mm	y = 173.0 mm	F_x = 20.89 kN	F_y = 24.90 kN
bolt 2:	x = 280.3 mm	y = 211.3 mm	F_x = 20.89 kN	F_y = 24.90 kN
group M2				
bolt 1:	x = 151.8 mm	y = 173.0 mm	F_x = -20.89 kN	F_y = 24.90 kN
bolt 2:	x = 119.7 mm	y = 211.3 mm	F_x = -20.89 kN	F_y = 24.90 kN
group M3				
bolt 1:	x = 109.1 mm	y = 63.0 mm	F_x = -28.75 kN	F_y = -16.60 kN
bolt 2:	x = 78.8 mm	y = 45.5 mm	F_x = -28.75 kN	F_y = -16.60 kN
bolt 3:	x = 48.4 mm	y = 28.0 mm	F_x = -28.75 kN	F_y = -16.60 kN
group M4				
bolt 1:	x = 290.9 mm	y = 63.0 mm	F_x = 28.75 kN	F_y = -16.60 kN
bolt 2:	x = 321.2 mm	y = 45.5 mm	F_x = 28.75 kN	F_y = -16.60 kN
bolt 3:	x = 351.6 mm	y = 28.0 mm	F_x = 28.75 kN	F_y = -16.60 kN

3. Lk 1

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

load point x_M = 264.3 mm, y_M = 192.1 mm, α_M = 50.0°
loading $F_{x,Ed}$ = 65.00 kN, $F_{y,Ed}$ = 0.00 kN, $M_{z,Ed}$ = 0.00 kNm
The group consists of 2 bolts. Each bolt, forces F_x and F_y are working,
which results from the devided loading.

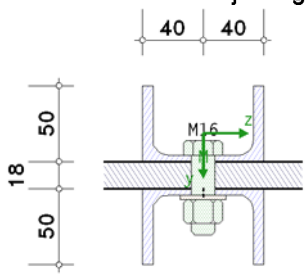


3.1.1. verification of bolts

U_v utilisation due to shear, U_b utilisation due to bearing resistance, U utilisation of bolts

bolt 1:	$F_{x,1}$ = 32.50 kN	$F_{y,1}$ = -0.00 kN	F_1 = 32.50 kN
	$U_{v,1}$ = 0.210	$U_{b,1}$ = 0.762	U_1 = = 0.762 < 1 ok
bolt 2:	$F_{x,2}$ = 32.50 kN	$F_{y,2}$ = 0.00 kN	F_2 = 32.50 kN
	$U_{v,2}$ = 0.210	$U_{b,2}$ = 0.522	U_2 = = 0.522 < 1 ok
total:	U_v = 0.210	U_b = 0.762	U_{sc} = 0.762 < 1 ok

3.1.2. verification of joining section



plastic verification for N = 32.50 kN
main bending: N = 32.50 kN, resistance forces N_{max} = 149.67 kN, N_{min} = -117.63 kN ⇒ U_N = 0.123
total (possibly due to load increase): max U = 0.144 < 1 ok

verification of net cross-section for N_{Ed} = 32.50 kN
net cross-section with 1 bolt A_{net} = 934.5 mm² ⇒ $\beta = 0.9 \cdot A_{net}$ = 841.04 mm²
resistance $N_{u,Rd} = \beta \cdot f_u / \gamma_{M2}$ = 242.22 kN
verification: $U_{net} = N_{Ed}/N_{u,Rd}$ = 0.134 < 1 ok

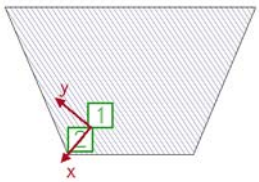
verification of shear block for N_{Ed} = 32.50 kN
shear resistance $V_{eff,Rd} = (A_{nt} \cdot f_u) / \gamma_{M2} + (A_{nv} \cdot f_y/3^{1/2}) / \gamma_{M0}$ = 52.10 kN
verification: $U_{eff} = N_{Ed}/V_{eff,Rd}$ = 0.624 < 1 ok

3.1.3. total

max U_{M1} = 0.762 < 1 ok

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

load point x_M = 135.7 mm, y_M = 192.1 mm, α_M = 130.0°
loading $F_{x,Ed}$ = 65.00 kN, $F_{y,Ed}$ = 0.00 kN, $M_{z,Ed}$ = 0.00 kNm
The group consists of 2 bolts. Each bolt, forces F_x and F_y are working,
which results from the devided loading.



3.2.1. verification of bolts

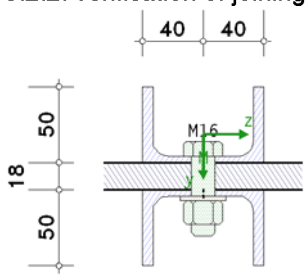
U_v utilisation due to shear, U_b utilisation due to bearing resistance, U utilisation of bolts

bolt 1: $F_{x,1} = 32.50$ kN $F_{y,1} = -0.00$ kN $F_1 = 32.50$ kN
$U_{v,1} = 0.210$ $U_{b,1} = 0.762$ $U_1 = \ = 0.762 < 1$ ok

bolt 2: $F_{x,2} = 32.50$ kN $F_{y,2} = -0.00$ kN $F_2 = 32.50$ kN
$U_{v,2} = 0.210$ $U_{b,2} = 0.522$ $U_2 = \ = 0.522 < 1$ ok

total: $U_v = 0.210$ $U_b = 0.762$ $U_{sc} = 0.762 < 1$ ok

3.2.2. verification of joining section



plastic verification for N = 32.50 kN
main bending: N = 32.50 kN, resistance forces $N_{max} = 149.67$ kN, $N_{min} = -117.63$ kN $\Rightarrow$ $U_N = 0.123$
total (possibly due to load increase): max U = 0.144 < 1 ok

verification of net cross-section for $N_{Ed} = 32.50$ kN
net cross-section with 1 bolt $A_{net} = 934.5$ mm² $\Rightarrow$ $\beta = 0.9 \cdot A_{net} = 841.04$ mm²
resistance $N_{u,Rd} = \beta \cdot f_u / \gamma_{M2} = 242.22$ kN
verification: $U_{net} = N_{Ed} / N_{u,Rd} = 0.134 < 1$ ok

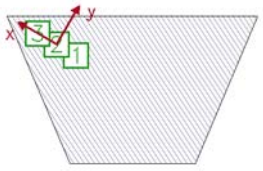
verification of shear block for $N_{Ed} = 32.50$ kN
shear resistance $V_{eff,Rd} = (A_{nt} \cdot f_u) / \gamma_{M2} + (A_{nv} \cdot f_y / 3^{1/2}) / \gamma_{M0} = 52.10$ kN
verification: $U_{eff} = N_{Ed} / V_{eff,Rd} = 0.624 < 1$ ok

3.2.3. total

max $U_{M2} = 0.762 < 1$ ok

3.3. group of bolts M3 (load in-transfer)

load point $x_M = 78.8$ mm, $y_M = 45.5$ mm, $\alpha_M = -150.0°$
loading $F_{x,Ed} = 99.58$ kN, $F_{y,Ed} = 0.00$ kN, $M_{z,Ed} = 0.00$ kNm
The group consists of 3 bolts. Each bolt, forces F_x and F_y are working,
which results from the devided loading.



3.3.1. verification of bolts

U_v utilisation due to shear, U_b utilisation due to bearing resistance, U utilisation of bolts

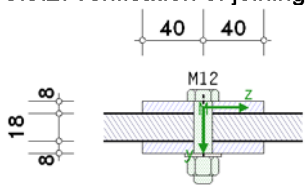
bolt 1: $F_{x,1} = 33.19$ kN $F_{y,1} = -0.00$ kN $F_1 = 33.19$ kN
$U_{v,1} = 0.382$ $U_{b,1} = 0.398$ $U_1 = \ = 0.398 < 1$ ok

bolt 2: $F_{x,2} = 33.19$ kN $F_{y,2} = -0.00$ kN $F_2 = 33.19$ kN
$U_{v,2} = 0.382$ $U_{b,2} = 0.398$ $U_2 = \ = 0.398 < 1$ ok

bolt 3: $F_{x,3} = 33.19$ kN $F_{y,3} = -0.00$ kN $F_3 = 33.19$ kN
$U_{v,3} = 0.382$ $U_{b,3} = 0.398$ $U_3 = \ = 0.398 < 1$ ok

total: $U_v = 0.382$ $U_b = 0.398$ $U_{sc} = 0.398 < 1$ ok

3.3.2. verification of joining section



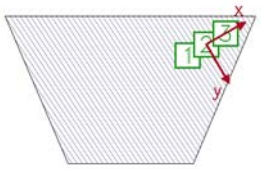
plastic verification for dieses section not möglich !!
verification not possible !!

verification of net cross-section for $N_{Ed} = 49.79$ kN
net cross-section with 1 bolt $A_{net} = 536.0$ mm² $\Rightarrow$ $\beta = 0.9 \cdot A_{net} = 482.40$ mm²
resistance $N_{u,Rd} = \beta \cdot f_u / \gamma_{M2} = 138.93$ kN
verification: $U_{net} = N_{Ed} / N_{u,Rd} = 0.358 < 1$ ok

3.3.3. total
max U_{M3} = 0.398 < 1 ok

3.4. group of bolts M4 (load in-transfer)

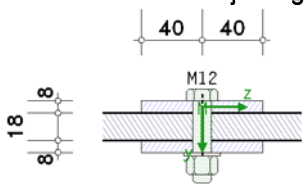
load point x_M = 321.2 mm, y_M = 45.5 mm, α_M = -30.0°
loading $F_{x,Ed}$ = 99.58 kN, $F_{y,Ed}$ = 0.00 kN, $M_{z,Ed}$ = 0.00 kNm
The group consists of 3 bolts. Each bolt, forces F_x and F_y are working, which results from the devided loading.



3.4.1. verification of bolts
U_v utilisation due to shear, U_b utilisation due to bearing resistance, U utilisation of bolts

bolt 1:	$F_{x,1}$ = 33.19 kN	$F_{y,1}$ = -0.00 kN	F_1 = 33.19 kN
	$U_{v,1}$ = 0.382	$U_{b,1}$ = 0.398	U_1 = = 0.398 < 1 ok
bolt 2:	$F_{x,2}$ = 33.19 kN	$F_{y,2}$ = -0.00 kN	F_2 = 33.19 kN
	$U_{v,2}$ = 0.382	$U_{b,2}$ = 0.398	U_2 = = 0.398 < 1 ok
bolt 3:	$F_{x,3}$ = 33.19 kN	$F_{y,3}$ = -0.00 kN	F_3 = 33.19 kN
	$U_{v,3}$ = 0.382	$U_{b,3}$ = 0.398	U_3 = = 0.398 < 1 ok
total:	U_v = 0.382	U_b = 0.398	U_{sc} = 0.398 < 1 ok

3.4.2. verification of joining section



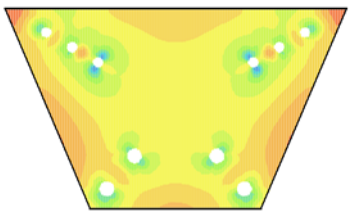
plastic verification for dieses section not möglich !!
verification not possible !!

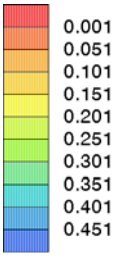
verification of net cross-section for N_{Ed} = 49.79 kN
net cross-section with 1 bolt A_{net} = 536.0 mm² ⇒ $\beta = 0.9 \cdot A_{net}$ = 482.40 mm²
resistance $N_{u,Rd} = \beta \cdot f_u / \gamma_{M2}$ = 138.93 kN
verification: $U_{net} = N_{Ed}/N_{u,Rd}$ = 0.358 < 1 ok

3.4.3. total
max U_{M4} = 0.398 < 1 ok

3.5. gusset plate

utilisation U_p
max U_p = 0.446





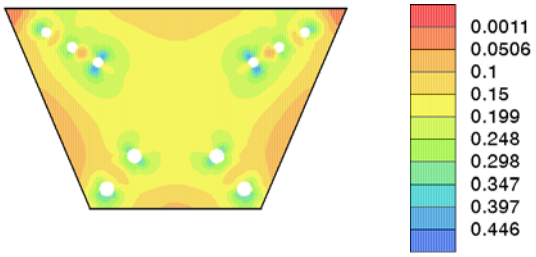
utilisation

node	x mm	y mm	n_{xx} kN/m	n_{yy} kN/m	n_{xy} kN/m	σ N/mm²	τ N/mm²	σ_v N/mm²	U_p
249	106.61	69.02	944.56	705.76	670.49	104.91	0.00	0.00	0.446
536	110.55	54.60	1367.84	-16.62	270.32	76.46	15.02	80.76	0.344
875	40.89	21.06	-234.22	-89.78	-798.15	11.37	44.34	77.64	0.330

x,y: node coordinates; n_{xx},n_{yy},n_{xy}: regarded normal stresses; σ,τ,σ_v: stresses; σ_v=0: σ,τ principal stresses; U_p: utilisation

4. final result

maximum utilisation of plate max U_p due to 1 Lk
max max U_p = 0.446



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	
249	106.61	69.02	-0.006	-0.019	0.019	104.91	0.00	0.00	0.446

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} = 0.762 < 1 ok
maximum utilisation of gusset plate [Lk 1] — max U_p = 0.446 < 1 ok

resistance not ensured !!

verification could not be executed, see Lk 1 !!

5. 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