general wooden joint nach EC 3 - NA-Deutschland

1. input data

1.1. general statements

service class 1, origin of the coordinate system at the intersection of the beams

1.2. node plate

external perforated plate Simpson NP20/160/400, thickness t=2.0 mm, steel plate S250GD
dimensions: b = 400.0 mm, h=160.0 mm, steel plate external, on both sides
The weakening of the cross-section due to the holes is taken into account by increasing the rated stresses
increase factor due to the imperfections = 1.3333
The steel plate must be structurally secured against buckling
fastener with a diameter < 8.0mm are discretised as a point and not as a hole
The missing areas are taken into account by reducing the cross-section thickness.
coordinates of the steel plate

Nr	x_k mm	y_k mm	Nr	x_k mm	y_k mm
1	-200.0	-80.0	4	200.0	-80.0
2	-200.0	80.0	5	-200.0	-80.0
3	200.0	80.0			

1.3. connected beams

Nr.	bar	material	b mm	t mm	α °
1	strap both sides w. kink	solconiftimbr C24	200	120	0

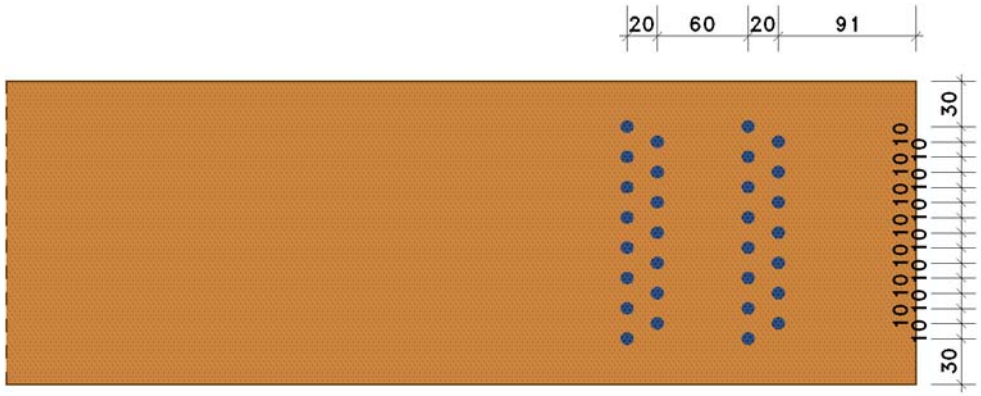
1.4. fastener

1.4.1. strap left

Simpson CSA, 5.0 x 50.0 mm, double-sided, d_k = 8.3 mm, l_{ef} = 44.0 mm, not predrilled
load-bearing capacity is reduced acc. to DIN EN 1995-1-1, 8.3.1.1(8)
$F_{v,Rk}$ increased acc. to DIN EN 1995-1-1, 8.2.3(4)
$F_{v,Rd}$ is calculated with the exact verification acc. to DIN EN 1995-1-1, 8.2.3, ETA-04/0013
30 fastener, a_1 = 50 mm, a_2 = 25 mm on both sides
centroid of the fasteners from nodal point S at x_s = -141 mm, y_s = 0 mm
polar moment of inertia I_p = 106987 mm^4
coordinates of the fasteners (origin in the nodal point, x to the right, y to the top)

Nr	x_k mm	y_k mm	Nr	x_k mm	y_k mm	Nr	x_k mm	y_k mm	Nr	x_k mm	y_k mm
1	-190.0	-70.0	9	-170.0	-60.0	17	-110.0	-50.0	25	-90.0	-40.0
2	-190.0	-50.0	10	-170.0	-40.0	18	-110.0	-30.0	26	-90.0	-20.0
3	-190.0	-30.0	11	-170.0	-20.0	19	-110.0	-10.0	27	-90.0	0.0
4	-190.0	-10.0	12	-170.0	0.0	20	-110.0	10.0	28	-90.0	20.0
5	-190.0	10.0	13	-170.0	20.0	21	-110.0	30.0	29	-90.0	40.0
6	-190.0	30.0	14	-170.0	40.0	22	-110.0	50.0	30	-90.0	60.0
7	-190.0	50.0	15	-170.0	60.0	23	-110.0	70.0			
8	-190.0	70.0	16	-110.0	-70.0	24	-90.0	-60.0			

fastener strap left scale 1:50

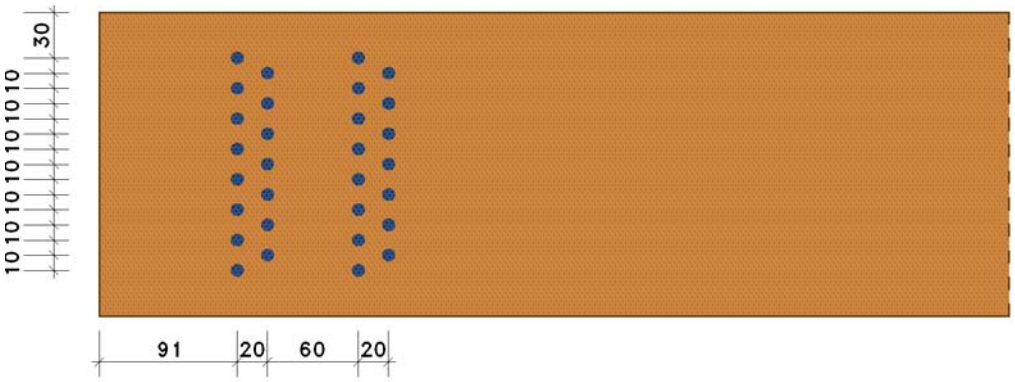


1.4.2. strap right

Simpson CSA, 5.0 x 80.0 mm, double-sided, d_k = 8.3 mm, l_{ef} = 74.0 mm, not predrilled
load-bearing capacity is reduced acc. to DIN EN 1995-1-1, 8.3.1.1(8)
$F_{v,Rk}$ increased acc. to DIN EN 1995-1-1, 8.2.3(4)
$F_{v,Rd}$ is calculated with the exact verification acc. to DIN EN 1995-1-1, 8.2.3, ETA-04/0013
30 fastener, a_1 = 50 mm, a_2 = 25 mm on both sides
centroid of the fasteners from nodal point S at x_s = 139 mm, y_s = 0 mm
polar moment of inertia I_p = 106987 mm⁴
coordinates of the fasteners (origin in the nodal point, x to the right, y to the top)

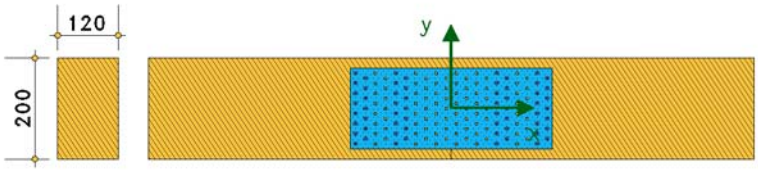
Nr	x_k mm	y_k mm	Nr	x_k mm	y_k mm	Nr	x_k mm	y_k mm	Nr	x_k mm	y_k mm
1	90.0	-70.0	9	110.0	-60.0	17	170.0	-50.0	25	190.0	-40.0
2	90.0	-50.0	10	110.0	-40.0	18	170.0	-30.0	26	190.0	-20.0
3	90.0	-30.0	11	110.0	-20.0	19	170.0	-10.0	27	190.0	0.0
4	90.0	-10.0	12	110.0	0.0	20	170.0	10.0	28	190.0	20.0
5	90.0	10.0	13	110.0	20.0	21	170.0	30.0	29	190.0	40.0
6	90.0	30.0	14	110.0	40.0	22	170.0	50.0	30	190.0	60.0
7	90.0	50.0	15	110.0	60.0	23	170.0	70.0			
8	90.0	70.0	16	170.0	-70.0	24	190.0	-60.0			

fastener strap right scale 1:50



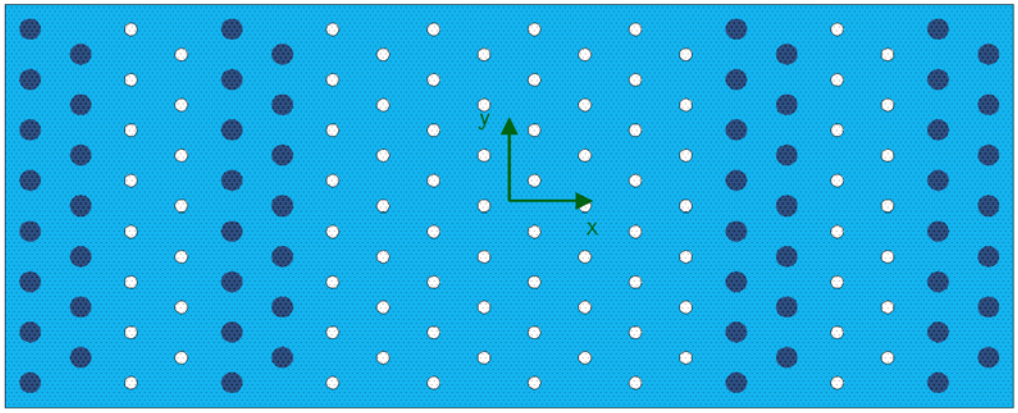
1.5. nodal point

view scale 1:150

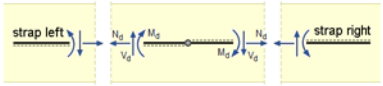


1.6. node plate

view scale 1:30



1.7. load combinations (design internal forces)



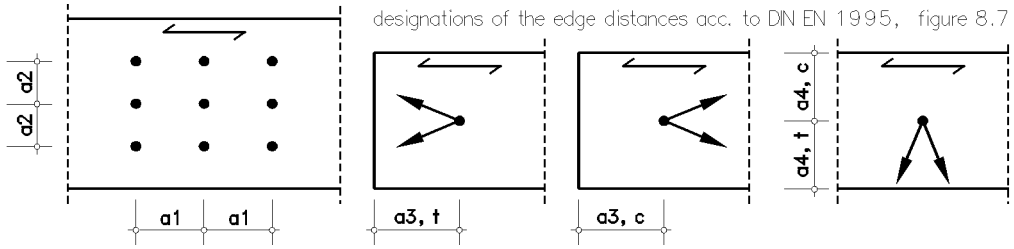
1.7.1. sum M straps, KLED: medium-term

Nr	beam	N_d kN	M_d kNm	V_d kN	k_{mod} -	γ -
1	strap left	5.0000	2.0000	5.0000	0.800	1.30
2	strap right	5.0000	-2.0000	5.0000	0.800	1.30
3	ΣH, ΣM, ΣV	-0.0000	0.0000	0.0000	---	---

2. results of all load case combinations

2.1. fastener strap left

member	a_1 mm	a_2 mm	a_{3t} mm	a_{4t} mm	a_{3c} mm	a_{4c} mm
stplt	14.4	14.4	7.2	7.2	7.2	7.2
outtimbmbr	28.0	14.0	60.0	28.0	40.0	20.0



2.1.1. sum M straps

N_d = 5.000 kN, V_d = 5.000 kN, $M_{v,d}$ = 2.000 + -0.141 x 5.000 + 0.000 x 5.000 = 1.297 KNm

Nr	F_{Mi} kN	F_{Mxi} kN	F_{Myi} kN	F_{MNi} kN	F_{MVi} kN	F_{totHi} kN	F_{totVi} kN	F_{toti} kN	α_{toti} °	$F_{v,Rd}$ kN	$U_{n,ef}$ -	$U_{F,v}$ -
1	1.0379	-0.8484	-0.5979	-0.8484	-0.5979	-0.6817	-0.4312	0.8067	-147.7	2.6369	0.26	0.31
2	0.8513	-0.6060	-0.5979	-0.6060	-0.5979	-0.4393	-0.4312	0.6156	-135.5	2.6369	0.17	0.23
3	0.6998	-0.3636	-0.5979	-0.3636	-0.5979	-0.1969	-0.4312	0.4741	-114.5	2.6369	0.07	0.18
4	0.6101	-0.1212	-0.5979	-0.1212	-0.5979	0.0455	-0.4312	0.4336	-84.0	2.6369	0.02	0.16
5	0.6101	0.1212	-0.5979	0.1212	-0.5979	0.2879	-0.4312	0.5185	-56.3	2.6369	0.11	0.20
6	0.6998	0.3636	-0.5979	0.3636	-0.5979	0.5303	-0.4312	0.6835	-39.1	2.6369	0.20	0.26
7	0.8513	0.6060	-0.5979	0.6060	-0.5979	0.7727	-0.4312	0.8849	-29.2	2.6369	0.29	0.34
8	1.0379	0.8484	-0.5979	0.8484	-0.5979	1.0151	-0.4312	1.1029	-23.0	2.6369	0.38	0.42
9	0.8094	-0.7272	-0.3555	-0.7272	-0.3555	-0.5605	-0.1889	0.5915	-161.4	2.6369	0.21	0.22
10	0.6012	-0.4848	-0.3555	-0.4848	-0.3555	-0.3181	-0.1889	0.3700	-149.3	2.6369	0.12	0.14
11	0.4303	-0.2424	-0.3555	-0.2424	-0.3555	-0.0757	-0.1889	0.2035	-111.9	2.6369	0.03	0.08
12	0.3555	0.0000	-0.3555	0.0000	-0.3555	0.1667	-0.1889	0.2519	-48.6	2.6369	0.06	0.10
13	0.4303	0.2424	-0.3555	0.2424	-0.3555	0.4091	-0.1889	0.4506	-24.8	2.6369	0.16	0.17
14	0.6012	0.4848	-0.3555	0.4848	-0.3555	0.6515	-0.1889	0.6783	-16.2	2.6369	0.25	0.26
15	0.8094	0.7272	-0.3555	0.7272	-0.3555	0.8939	-0.1889	0.9136	-11.9	2.6369	0.34	0.35
16	0.9262	-0.8484	0.3717	-0.8484	0.3717	-0.6817	0.5383	0.8687	141.7	2.6369	0.26	0.33
17	0.7109	-0.6060	0.3717	-0.6060	0.3717	-0.4393	0.5383	0.6949	129.2	2.6369	0.17	0.26
18	0.5199	-0.3636	0.3717	-0.3636	0.3717	-0.1969	0.5383	0.5732	110.1	2.6369	0.07	0.22
19	0.3909	-0.1212	0.3717	-0.1212	0.3717	0.0455	0.5383	0.5403	85.2	2.6369	0.02	0.20
20	0.3909	0.1212	0.3717	0.1212	0.3717	0.2879	0.5383	0.6105	61.9	2.6369	0.11	0.23
21	0.5199	0.3636	0.3717	0.3636	0.3717	0.5303	0.5383	0.7556	45.4	2.6369	0.20	0.29
22	0.7109	0.6060	0.3717	0.6060	0.3717	0.7727	0.5383	0.9417	34.9	2.6369	0.29	0.36
23	0.9262	0.8484	0.3717	0.8484	0.3717	1.0151	0.5383	1.1490	27.9	2.6369	0.38	0.44
24	0.9518	-0.7272	0.6141	-0.7272	0.6141	-0.5605	0.7807	0.9611	125.7	2.6369	0.21	0.36
25	0.7824	-0.4848	0.6141	-0.4848	0.6141	-0.3181	0.7807	0.8431	112.2	2.6369	0.12	0.32
26	0.6602	-0.2424	0.6141	-0.2424	0.6141	-0.0757	0.7807	0.7844	95.5	2.6369	0.03	0.30
27	0.6141	0.0000	0.6141	-0.0000	0.6141	0.1667	0.7807	0.7983	77.9	2.6369	0.06	0.30
28	0.6602	0.2424	0.6141	0.2424	0.6141	0.4091	0.7807	0.8814	62.3	2.6369	0.16	0.33
29	0.7824	0.4848	0.6141	0.4848	0.6141	0.6515	0.7807	1.0168	50.2	2.6369	0.25	0.39
30	0.9518	0.7272	0.6141	0.7272	0.6141	0.8939	0.7807	1.1868	41.1	2.6369	0.34	0.45

maximum utilization of fasteners U_{max} = 0.45 ≤ 1 => **verification fulfilled**

2.1.2. verification block shear failure acc. to DIN EN 1995-1-1, annex A, strap left

$L_{net,t}$ = 140 mm, t_1 = 45 mm ⇒ $A_{net,t}$ = 6300 mm², $M_{y,k}$ = 5000.0 Nmm, $f_{h,k}$ = 17.71 N/mm²
$L_{net,v}$ = 182 mm, t_{ef} = 45 mm ⇒ $A_{net,v}$ = 8190 mm² (Versagensmechanismus c,f,j/l,k,m)
$L_{net,v}$ = 182 mm ⇒ $A_{net,v}$ = 8190 mm² ⇒ $F_{bs,Rk}$ = 137.03 kN

load	N_d kN	$F_{bs,Rd}$ kN	U_{bs} -
1	2.500	84.323	0.03

maximum utilization block shear failure U_{max} = 0.03 ≤ 1 => **verification fulfilled**

2.2. fastener strap right

member	a_1 mm	a_2 mm	a_{3t} mm	a_{4t} mm	a_{3c} mm	a_{4c} mm
stplt	14.4	14.4	7.2	7.2	7.2	7.2
outtimbmbr	28.0	14.0	60.0	28.0	40.0	20.0

2.2.1. sum M straps

N_d = 5.000 kN, V_d = 5.000 kN, $M_{v,d}$ = -2.000 + -0.139 x 5.000 + -0.000 x 5.000 = -2.697 KNm

Nr	F_{Mi} kN	F_{Mxi} kN	F_{Myi} kN	F_{MNi} kN	F_{MVi} kN	F_{totHi} kN	F_{totVi} kN	F_{toti} kN	α_{toti} °	$F_{v,Rd}$ kN	$U_{n,ef}$ -	$U_{F,v}$ -
1	-2.1585	1.7644	1.2435	-1.7644	-1.2435	-1.5977	-1.0768	1.9267	-146.0	2.6369	0.61	0.73
2	-1.7705	1.2603	1.2435	-1.2603	-1.2435	-1.0936	-1.0768	1.5348	-135.4	2.6369	0.41	0.58
3	-1.4553	0.7562	1.2435	-0.7562	-1.2435	-0.5895	-1.0768	1.2276	-118.7	2.6369	0.22	0.47
4	-1.2688	0.2521	1.2435	-0.2521	-1.2435	-0.0854	-1.0768	1.0802	-94.5	2.6369	0.03	0.41
5	-1.2688	-0.2521	1.2435	0.2521	-1.2435	0.4187	-1.0768	1.1554	-68.8	2.6369	0.16	0.44
6	-1.4553	-0.7562	1.2435	0.7562	-1.2435	0.9228	-1.0768	1.4181	-49.4	2.6369	0.35	0.54
7	-1.7705	-1.2603	1.2435	1.2603	-1.2435	1.4269	-1.0768	1.7877	-37.0	2.6369	0.54	0.68
8	-2.1585	-1.7644	1.2435	1.7644	-1.2435	1.9311	-1.0768	2.2110	-29.1	2.6369	0.73	0.84
9	-1.6834	1.5123	0.7394	-1.5123	-0.7394	-1.3457	-0.5727	1.4625	-156.9	2.6369	0.51	0.55
10	-1.2503	1.0082	0.7394	-1.0082	-0.7394	-0.8416	-0.5727	1.0179	-145.8	2.6369	0.32	0.39
11	-0.8949	0.5041	0.7394	-0.5041	-0.7394	-0.3374	-0.5727	0.6647	-120.5	2.6369	0.13	0.25
12	-0.7394	-0.0000	0.7394	0.0000	-0.7394	0.1667	-0.5727	0.5965	-73.8	2.6369	0.06	0.23
13	-0.8949	-0.5041	0.7394	0.5041	-0.7394	0.6708	-0.5727	0.8820	-40.5	2.6369	0.25	0.33
14	-1.2503	-1.0082	0.7394	1.0082	-0.7394	1.1749	-0.5727	1.3070	-26.0	2.6369	0.45	0.50
15	-1.6834	-1.5123	0.7394	1.5123	-0.7394	1.6790	-0.5727	1.7740	-18.8	2.6369	0.64	0.67
16	-1.9263	1.7644	-0.7730	-1.7644	0.7730	-1.5977	0.9396	1.8536	149.5	2.6369	0.61	0.70
17	-1.4784	1.2603	-0.7730	-1.2603	0.7730	-1.0936	0.9396	1.4418	139.3	2.6369	0.41	0.55
18	-1.0813	0.7562	-0.7730	-0.7562	0.7730	-0.5895	0.9396	1.1092	122.1	2.6369	0.22	0.42
19	-0.8130	0.2521	-0.7730	-0.2521	0.7730	-0.0854	0.9396	0.9435	95.2	2.6369	0.03	0.36
20	-0.8130	-0.2521	-0.7730	0.2521	0.7730	0.4187	0.9396	1.0287	66.0	2.6369	0.16	0.39
21	-1.0813	-0.7562	-0.7730	0.7562	0.7730	0.9228	0.9396	1.3170	45.5	2.6369	0.35	0.50
22	-1.4784	-1.2603	-0.7730	1.2603	0.7730	1.4269	0.9396	1.7085	33.4	2.6369	0.54	0.65
23	-1.9263	-1.7644	-0.7730	1.7644	0.7730	1.9311	0.9396	2.1475	25.9	2.6369	0.73	0.81
24	-1.9794	1.5123	-1.2771	-1.5123	1.2771	-1.3457	1.4438	1.9736	133.0	2.6369	0.51	0.75
25	-1.6271	1.0082	-1.2771	-1.0082	1.2771	-0.8416	1.4438	1.6711	120.2	2.6369	0.32	0.63
26	-1.3730	0.5041	-1.2771	-0.5041	1.2771	-0.3374	1.4438	1.4827	103.2	2.6369	0.13	0.56
27	-1.2771	-0.0000	-1.2771	-0.0000	1.2771	0.1667	1.4438	1.4533	83.4	2.6369	0.06	0.55
28	-1.3730	-0.5041	-1.2771	0.5041	1.2771	0.6708	1.4438	1.5920	65.1	2.6369	0.25	0.60
29	-1.6271	-1.0082	-1.2771	1.0082	1.2771	1.1749	1.4438	1.8614	50.9	2.6369	0.45	0.71
30	-1.9794	-1.5123	-1.2771	1.5123	1.2771	1.6790	1.4438	2.2144	40.7	2.6369	0.64	0.84

maximum utilization of fasteners U_{max} = 0.84 ≤ 1 => **verification fulfilled**

2.2.2. verification block shear failure acc. to DIN EN 1995-1-1, annex A, strap right

$L_{net,t}$ = 140 mm, t_1 = 60 mm ⇒ $A_{net,t}$ = 8400 mm², $M_{y,k}$ = 5000.0 Nmm, $f_{h,k}$ = 17.71 N/mm²
$L_{net,v}$ = 182 mm, t_{ef} = 60 mm ⇒ $A_{net,v}$ = 10920 mm² (Versagensmechanismus c,f,j/l,k,m)
$L_{net,v}$ = 182 mm ⇒ $A_{net,v}$ = 10920 mm² ⇒ $F_{bs,Rk}$ = 182.70 kN

load	N_d kN	$F_{bs,Rd}$ kN	U_{bs} -
1	2.500	112.431	0.02

maximum utilization block shear failure U_{max} = 0.02 ≤ 1 => **verification fulfilled**

2.3. results beams

2.3.1. strap left with A_n = 24000 mm², W_n = 800000 mm³, I_n = 80000000 mm⁴, k_h = 1.000

load	$f_{m,d}$ N/mm²	$f_{t,d}$ N/mm²	$f_{c,d}$ N/mm²	$f_{v,d}$ N/mm²	N_d kN	M_d kNm	$\sigma_{0,d}$ N/mm²	$\sigma_{mo,d}$ N/mm²	$\sigma_{mu,d}$ N/mm²	V_d kN	τ_d N/mm²	U_σ -	U_τ -
1	14.77	8.92	12.92	2.46	5.000	1.297	0.21	1.62	1.62	9.772	1.22	0.13	0.50

beam maximum utilization U_{max} = 0.50 ≤ 1 => **verification fulfilled**

2.3.2. strap right with A_n = 24000 mm², W_n = 800000 mm³, I_n = 80000000 mm⁴, k_h = 1.000

load	$f_{m,d}$ N/mm²	$f_{t,d}$ N/mm²	$f_{c,d}$ N/mm²	$f_{v,d}$ N/mm²	N_d kN	M_d kNm	$\sigma_{0,d}$ N/mm²	$\sigma_{mo,d}$ N/mm²	$\sigma_{mu,d}$ N/mm²	V_d kN	τ_d N/mm²	U_σ -	U_τ -
1	14.77	8.92	12.92	2.46	5.000	-2.697	0.21	-3.37	-3.37	17.623	2.20	0.20	0.89

beam maximum utilization U_{max} = 0.89 ≤ 1 => **verification fulfilled**

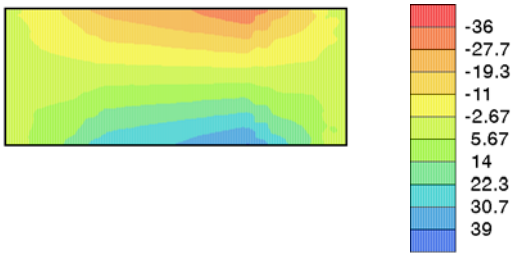
2.4. results node plate

with $\sigma_{v,R,k}$ = 250.00 N/mm², $\tau_{R,k}$ = 144.34 N/mm², $\gamma_{S/V}$ = 1.00, γ_A = 1.00

2.4.1. sum M straps

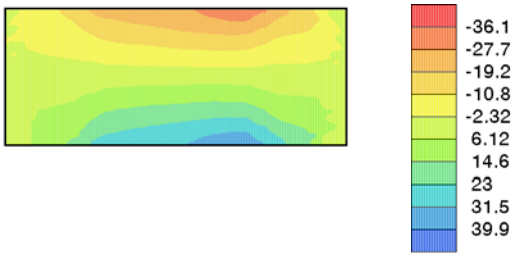
main normal stresses σ_1 [N/mm²]

min σ_1 = -35.95 N/mm², max σ_1 = 39.18 N/mm²



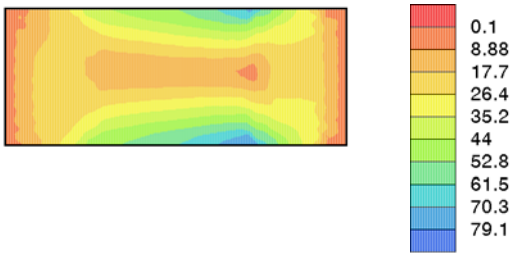
main shear stresses τ_1 [N/mm²]

min τ_1 = -36.06 N/mm², max τ_1 = 39.44 N/mm²



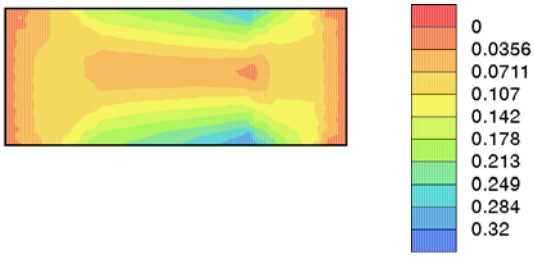
equivalent stresses σ_v [N/mm²]

min σ_v = 0.07 N/mm², max σ_v = 78.75 N/mm²



utilization of the node plate U_p

min U_p = 0.000, max U_p = 0.315



utilization of the node plate

Kno	x mm	y mm	σ_1 N/mm²	τ_1 N/mm²	σ_v N/mm²	U_p
147	85.6	-80.0	-35.95	-36.06	72.08	0.288
229	85.8	80.0	39.18	39.44	78.75	0.315

x,y: node coordinates; σ,τ: stresses; U_p: total utilization of the node plate

maximum utilization of the node plate U_{max} = 0.31 ≤ 1 => **verification fulfilled**

2.5. bearing forces strap left

p_1 = 50 mm, e_1 = 10 mm, e_2 = 10 mm, p_2 = 25.00 mm, α_b = 1.00, k_1 = 2.50 => $F_{b,Rk}$ = 20.63 kN
e_1 = 10 mm, e_2 = 10 mm, p_2 = 25 mm, α_b = 0.56, k_1 = 2.50 => $F_{b,Rk,Rand}$ = 11.46 kN

2.5.1. sum M straps

Nr	F_{toti} kN	$F_{v,Rd}$ kN	U -	Nr	F_{toti} kN	$F_{v,Rd}$ kN	U -	Nr	F_{toti} kN	$F_{v,Rd}$ kN	U -
1	0.40	9.17	0.04	11	0.10	16.50	0.01	21	0.38	16.50	0.02
2	0.31	9.17	0.03	12	0.13	16.50	0.01	22	0.47	16.50	0.03
3	0.24	9.17	0.03	13	0.23	16.50	0.01	23	0.57	9.17	0.06
4	0.22	9.17	0.02	14	0.34	16.50	0.02	24	0.48	9.17	0.05
5	0.26	9.17	0.03	15	0.46	16.50	0.03	25	0.42	16.50	0.03
6	0.34	9.17	0.04	16	0.43	9.17	0.05	26	0.39	16.50	0.02
7	0.44	9.17	0.05	17	0.35	16.50	0.02	27	0.40	16.50	0.02
8	0.55	9.17	0.06	18	0.29	16.50	0.02	28	0.44	16.50	0.03
9	0.30	9.17	0.03	19	0.27	16.50	0.02	29	0.51	16.50	0.03
10	0.18	16.50	0.01	20	0.31	16.50	0.02	30	0.59	16.50	0.04

maximum utilization of the bearing forces U_{max} = 0.06 ≤ 1 => **verification fulfilled**

2.6. bearing forces strap right

p_1 = 50 mm, e_1 = 10 mm, e_2 = 10 mm, p_2 = 25.00 mm, α_b = 1.00, k_1 = 2.50 => $F_{b,Rk}$ = 20.63 kN
e_1 = 10 mm, e_2 = 10 mm, p_2 = 25 mm, α_b = 0.56, k_1 = 2.50 => $F_{b,Rk,Rand}$ = 11.46 kN

2.6.1. sum M straps

Nr	F_{toti} kN	$F_{v,Rd}$ kN	U -	Nr	F_{toti} kN	$F_{v,Rd}$ kN	U -	Nr	F_{toti} kN	$F_{v,Rd}$ kN	U -
1	0.96	9.17	0.11	11	0.33	16.50	0.02	21	0.66	16.50	0.04
2	0.77	16.50	0.05	12	0.30	16.50	0.02	22	0.85	16.50	0.05
3	0.61	16.50	0.04	13	0.44	16.50	0.03	23	1.07	9.17	0.12
4	0.54	16.50	0.03	14	0.65	16.50	0.04	24	0.99	9.17	0.11
5	0.58	16.50	0.04	15	0.89	16.50	0.05	25	0.84	16.50	0.05
6	0.71	16.50	0.04	16	0.93	9.17	0.10	26	0.74	16.50	0.04
7	0.89	16.50	0.05	17	0.72	16.50	0.04	27	0.73	16.50	0.04
8	1.11	9.17	0.12	18	0.55	16.50	0.03	28	0.80	16.50	0.05
9	0.73	9.17	0.08	19	0.47	16.50	0.03	29	0.93	16.50	0.06
10	0.51	16.50	0.03	20	0.51	16.50	0.03	30	1.11	16.50	0.07

maximum utilization of the bearing forces $U_{max} = 0.12 \leq 1$ => **verification fulfilled**

3. summary

total utilization of all verifications $u_{max,Ges} = 0.895 \leq 1 \Rightarrow$ ok.