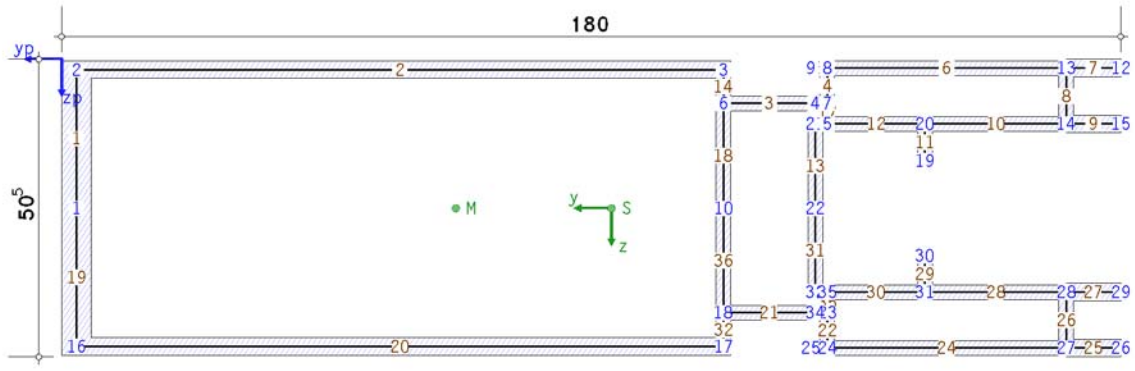
POS. 32: LAUFS/WHEELLBECK A.2

verification of cross-section EC 3-1-8 (12.10), NA: Deutschland

1. input report



aluminium

alloy 6060, T6, t ≤ 15 mm, calculation parameters:
- char. value of 0,2%-yield strength f_o = 140.0 N/mm²
- char. tensile strength f_u = 170.0 N/mm²
- elastic modulus E = 70000.0 N/mm²

material safety factor

resistance of cross-sections γ_{M0} = 1.10

geometry

dimensions of cross-section: y_{min} = 0.0 mm, y_{max} = 180.0 mm, z_{min} = -25.3 mm, z_{max} = 25.3 mm
width,height of cross-section: b = 180.0 mm, h = 50.5 mm
centroid, rotation angle of main axis: e_y = 86.5 mm, e_z = 0.0 mm, α = 0.00 °

cross-sectional area	A =	17.94 cm²	
bending moment of inertia	I_η =	69.59 cm⁴	
bending moment of inertia	I_ζ =	612.54 cm⁴	
section modulus	$W_{\eta+}$ =	27.56 cm³	
section modulus	$W_{\eta-}$ =	27.56 cm³	
section modulus	$W_{\zeta+}$ =	65.54 cm³	
section modulus	$W_{\zeta-}$ =	70.78 cm³	
torsional moment of inertia	I_T =	125.40 cm⁴	

y_p,z_p: coordinates of nodes (due to 4H-QUER)

	y_p mm	z_p mm		y_p mm	z_p mm		y_p mm	z_p mm		y_p mm	z_p mm		y_p mm	z_p mm
1	-2.5	25.3	12	-180.0	1.5	22	-128.1	25.3	23	-130.1	43.0	30	-146.8	33.3
2	-2.5	1.7	13	-170.8	1.5	4	-128.1	7.5	24	-130.1	49.0	31	-146.8	39.5
3	-112.5	1.7	14	-170.8	11.0	5	-130.1	11.0	25	-127.3	49.0	32	-128.1	39.5
6	-112.5	7.5	15	-180.0	11.0	10	-112.5	25.3	26	-180.0	49.0	34	-128.1	43.0
7	-130.1	7.5	19	-146.8	17.3	16	-2.5	48.8	27	-170.8	49.0	35	-130.1	39.5
8	-130.1	1.5	20	-146.8	11.0	17	-112.5	48.8	28	-170.8	39.5			
9	-127.3	1.5	21	-128.1	11.0	18	-112.5	43.0	29	-180.0	39.5			

p_a,p_e: points numbers at the beginning,end; d: plate thickness

	p_a	p_e	d mm		p_a	p_e	d mm		p_a	p_e	d mm		p_a	p_e	d mm
1	1	2	5.00	10	14	20	2.50	19	1	16	5.00	28	28	31	2.50
2	2	3	3.00	11	19	20	2.50	20	16	17	3.00	29	30	31	2.50
3	6	4	2.50	12	20	5	2.50	21	18	34	2.50	30	31	35	2.50
4	7	8	2.50	13	21	22	2.50	22	23	24	2.50	31	32	22	2.50
5	8	9	2.50	14	3	6	2.50	23	24	25	2.50	32	17	18	2.50
6	8	13	2.50	15	4	7	2.50	24	24	27	2.50	33	34	23	2.50
7	12	13	3.00	16	5	21	2.50	25	26	27	3.00	34	35	32	2.50
8	13	14	2.50	17	5	7	2.50	26	27	28	2.50	35	35	23	2.50
9	14	15	3.00	18	6	10	2.50	27	28	29	3.00	36	18	10	2.50

resistance

elastic verification, calculation with FE-method
valid normal, shear-, equivalent stress: $\sigma_{x,Rd}$ = 127.3 N/mm², τ_{Rd} = 73.5 N/mm², $\sigma_{v,Rd}$ = 139.4 N/mm²

internal forces and moments refering to local axes of cross-section
σ-generating forces (N, M) work at centroid, τ-generating forces (V, T_t) work at shear center
Lk 1: N_{Ed} = -4.30 kN, $M_{z,Ed}$ = 6.59 kNm, $V_{y,Ed}$ = 3.77 kN

notes
alluminium alloy cross-sections must be at least in class 3.
buckling is not investigated.

2. Lk 1

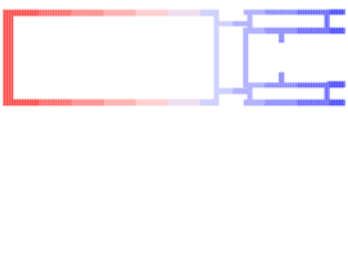
2.1. verification of cross-section

internal forces and moments: N = -4.30 kN, M_z = 6.59 kNm, V_y = 3.77 kN

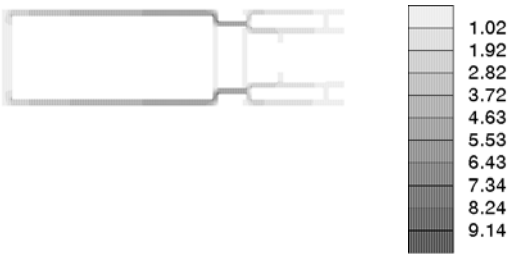
2.1.1. elastic verification

elastic verification for N = -4.30 kN, M_z = 6.59 kNm, V_y = 3.77 kN

normal stresses σ_x [N/mm²]
min σ_x = -102.9, max σ_x = 90.7

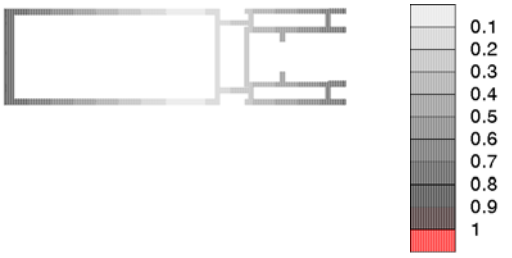


shear stresses τ [N/mm²]
max τ = 10.2



equivalent stresses σ_v [N/mm²]
max σ_v = 103.0

utilization U_σ
max U_σ = 0.809



strains, stresses, utilizations

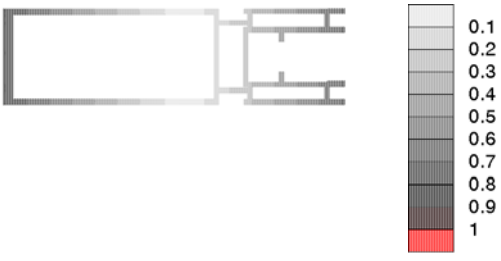
y	z	ε	σx	τ	σv	Uσ
mm	mm	‰	N/mm²	N/mm²	N/mm²	
0.0	0.2	-1.539	-102.94	0.08	102.94	0.809
0.0	25.3	-1.539	-102.94	0.00	102.94	0.809
0.0	50.3	-1.539	-102.94	0.08	102.94	0.809
-180.0	50.5	1.313	90.71	0.01	90.71	0.713
-180.0	47.5	1.313	90.71	0.01	90.71	0.713
-113.7	6.3	0.277	19.41	10.16	26.20	0.188
0.0	5.6	-1.539	-102.94	0.94	102.96	0.809

y,z: node coordinates; σ_x,τ,σ_v: stresses; U_σ: stress utilization

verifications
max $|\sigma_x|$ = 102.94 N/mm² < $\sigma_{x,Rd}$ = 127.27 N/mm² ⇒ $U_{\sigma x}$ = 0.809 < 1 ok
max τ = 10.16 N/mm² < τ_{Rd} = 73.48 N/mm² ⇒ U_τ = 0.138 < 1 ok
max σ_v = 102.96 N/mm² < $\sigma_{v,Rd}$ = 139.42 N/mm² ⇒ $U_{\sigma v}$ = 0.738 < 1 ok
total: max U_σ = 0.809 < 1 ok

3. final result

maximum stress utilization max U_σ due to 1 Lk
max max U_σ = 0.809



maximum stress utilization max U_σ due to 1 Lk

y mm	z mm	ε ‰	σ_x N/mm²	τ N/mm²	σ_v N/mm²	U_σ
-0.0	0.2	-1.539	-102.94	0.08	102.94	0.809

y,z: node coordinates; ε: cross-sectional strains; σ_x,τ,σ_v: stresses; U_σ: stress utilization

maximum utilization: resistance max U = 0.809 < 1 ok

verification succeeded