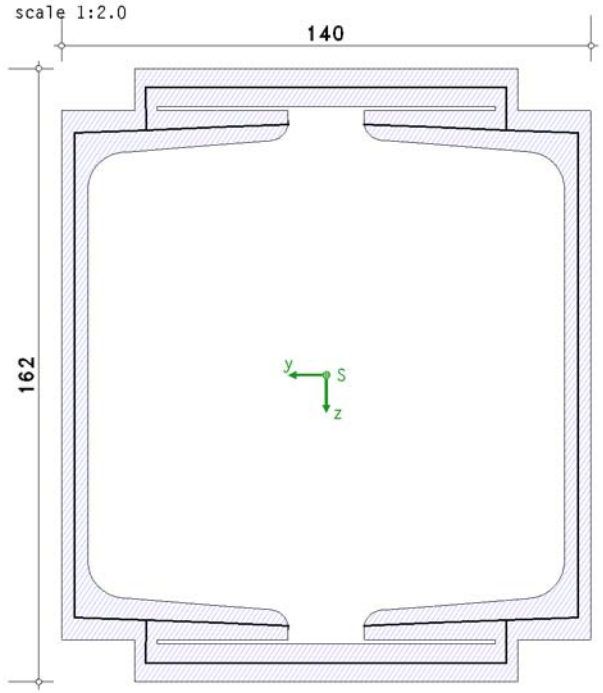
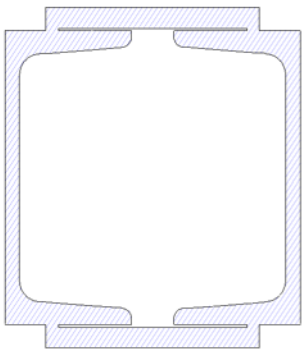
POS. 2: 2 X U 140, S355, DÜNNW.+DIV

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

1. input report



steel
steel grade S355
material safety factor
resistance of cross-sections γ_{M0} = 1.00
geometry
dimensions of cross-section: y_{min} = -80.0 mm, y_{max} = 60.0 mm, z_{min} = -11.0 mm, z_{max} = 151.0 mm
width,height of cross-section: b = 140.0 mm, h = 162.0 mm
centroid, rotation angle of main axis: e_y = -10.0 mm, e_z = 70.0 mm, α = 0.00 °



cross-sectional area	A	=	61.26 cm²
bending moment of inertia	I_η	=	2394.18 cm⁴
bending moment of inertia	I_ζ	=	1424.84 cm⁴
section modulus	$W_{\eta+}$	=	295.58 cm³
section modulus	$W_{\eta-}$	=	295.58 cm³
section modulus	$W_{\zeta+}$	=	203.56 cm³
section modulus	$W_{\zeta-}$	=	203.54 cm³
torsional moment of inertia	I_T	=	2424.61 cm⁴

resistance
elastic verification, calculation as thin-walled cross-section
plastic verification with strain iteration
valid normal, shear-, equivalent stress: $\sigma_{x,Rd}$ = 355.0 N/mm², τ_{Rd} = 205.0 N/mm², $\sigma_{v,Rd}$ = 355.0 N/mm²

notes
buckling is not investigated.

2. table of results

internal forces and moments and utilizations

Lk	$M_{y,Ed}$	$V_{z,Ed}$	$M_{z,Ed}$	$V_{y,Ed}$	$T_{t,Ed}$	$U_{\sigma el}$	$U_{c/t}$	$U_{\sigma pl}$	$U_{c/t}$	U
--	kNm	kN	kNm	kN	kNm					
1	---	---	---	---	10.00	0.222	---	0.284	---	0.284
2	50.00	30.00	30.00	60.00	10.00	0.898	0.244	0.577	0.244	0.898*
3	50.00	30.00	30.00	60.00	---	0.841	0.244	0.546	0.244	0.841
4	50.00	---	30.00	---	---	0.827	0.244	0.535	0.244	0.827

$M_{y,Ed}, V_{z,Ed}, M_{z,Ed}, V_{y,Ed}, T_{t,Ed}$: internal forces and moments by sign definition of statics; U_σ: stress utilization
$U_{c/t}$: c/t-utilization; U: total utilization
*) maximum utilization

3. final result

maximum utilization [Lk 2]:

stress	max $U_\sigma = 0.898 < 1$ ok
c/t-ratio	max $U_{c/t} = 0.244 < 1$ ok
resistance	max $U = 0.898 < 1$ 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 September 2017

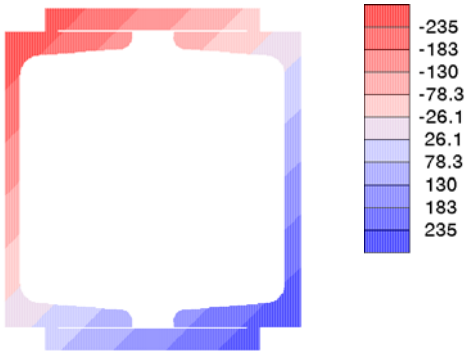
5. Lk 2 (decisive)

5.1. verification of cross-section

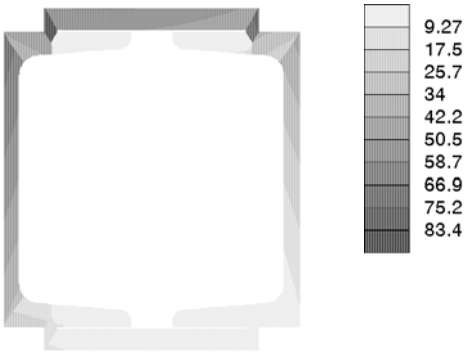
5.1.1. elastic verification

elastic verification for $M_y = 50.00$ kNm, $V_z = 30.00$ kN, $M_z = 30.00$ kNm, $V_y = 60.00$ kN
$T_t = 10.00$ kNm
verification: $\sigma_v = 318.68$ N/mm² $< \sigma_{v,Rd} = 355.00$ N/mm² $\Rightarrow U_\sigma = 0.898 < 1$ ok
c/t-ratio: outstand flange: utilization $U_{c/t} = 0.238 < 1$ ok
internal compression parts: utilization $U_{c/t} = 0.244 < 1$ ok

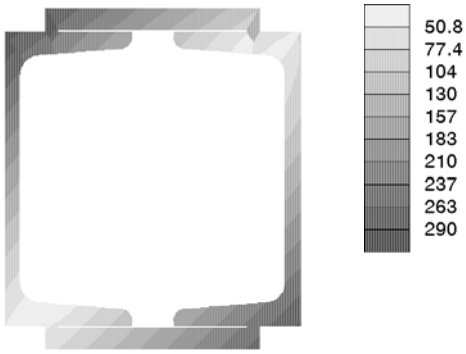
normal stresses σ_x [N/mm²]
min σ_x = -293.6, max σ_x = 293.6



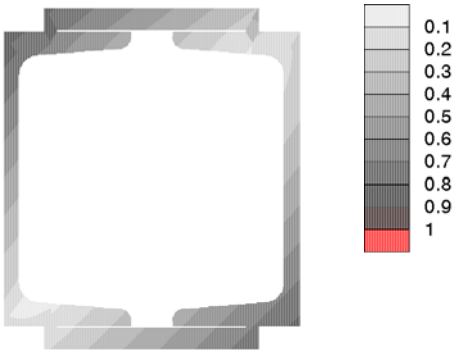
shear stresses τ [N/mm²]
max τ = 92.7



equivalent stresses σ_v [N/mm²]
max σ_v = 319.4



utilization U_σ
max U_σ = 0.900



stresses, utilizations

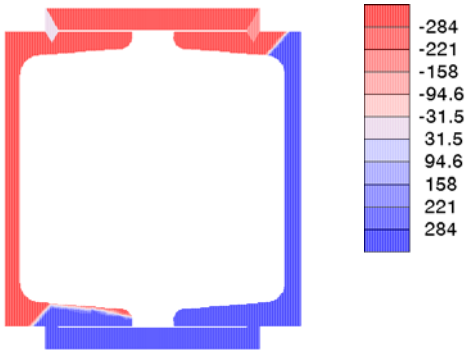
y mm	z mm	σ_x N/mm²	τ N/mm²	σ_v N/mm²	U_σ
0.0	11.0	-293.59	72.66	319.43	0.900
-140.0	151.0	293.59	7.00	293.84	0.828
-19.3	0.0	-275.83	92.67	319.13	0.899

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

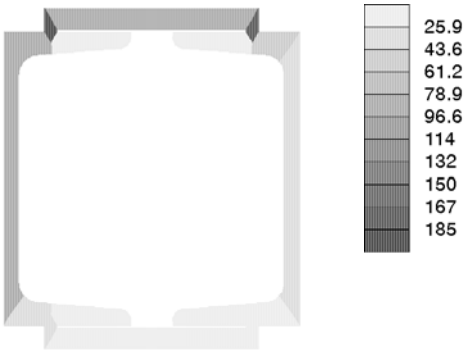
5.1.2. plastic verification

plastic verification for M_y = 50.00 kNm, V_z = 30.00 kN, M_z = 30.00 kNm, V_y = 60.00 kN
T_t = 10.00 kNm
load factor of shear stresses (plastic): $f_{\tau,pl}$ = 1.734 ⇒ $U_{\tau,pl}$ = 0.577
max. load factor of normal stresses (plastic): $f_{\sigma,pl}$ = 1.743 ⇒ $U_{\sigma,pl}$ = 0.574
total: utilization: U_{pl} = 0.577 < 1 ok
c/t-ratio: outstand flange: utilization $U_{c/t}$ = 0.238 < 1 ok
internal compression parts: utilization $U_{c/t}$ = 0.244 < 1 ok

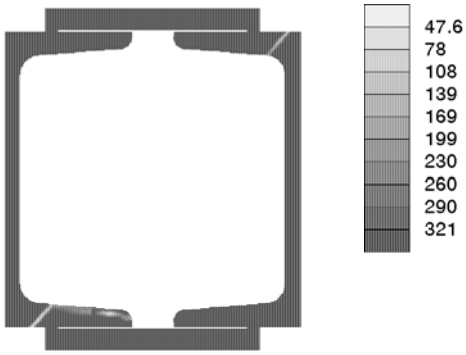
normal stresses σ_x [N/mm²]
min σ_x = -354.7, max σ_x = 354.7



shear stresses τ [N/mm²]
max τ = 204.9



equivalent stresses σ_v [N/mm²]
max σ_v = 355.0



stresses

y mm	z mm	σ_x N/mm²	τ N/mm²	σ_v N/mm²
-41.2	11.0	-354.70	6.06	354.86
0.0	11.0	-319.07	89.85	355.00
-120.7	162.0	354.70	5.97	354.86
-25.3	11.0	-5.00	204.94	355.00

y,z: node coordinates; σ_x,τ,σ_v: stresses