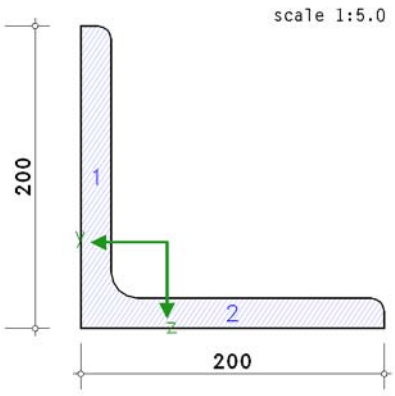
POS. 18: KINDMANN/KRÜGER 2.8.6

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

1. input report



steel
steel grade S235
material safety factor
resistance of cross-sections γ_{M0} = 1.00
geometry
section L 200 X 20
resistance
elastic verification, calculation as thin-walled cross-section
plastic verification with partial internal forces and moments
valid normal, shear-, equivalent stress: $\sigma_{x,Rd}$ = 235.0 N/mm², τ_{Rd} = 135.7 N/mm², $\sigma_{v,Rd}$ = 235.0 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: $M_{y,Ed}$ = 4375.00 kNcm, $V_{z,Ed}$ = 25.00 kN

notes
buckling is not investigated.

2. Lk 1

2.1. verification of cross-section

internal forces and moments refering to local axes of cross-section: M_y = 4375.00 kNcm, V_z = 25.00 kN
internal forces and moments refering to main axes: M_η = 3093.59 kNcm, V_ζ = 17.68 kN, M_ζ = -3093.59 kNcm, V_η = 17.68 kN
Hauptträgheitsmomente I_η = 4529.01 cm⁴, I_ζ = 1172.02 cm⁴, α = 45.00°

2.1.1. elastic verification

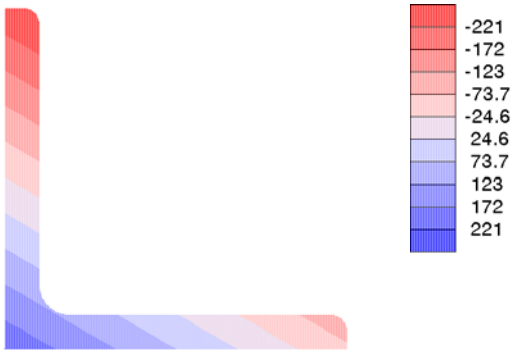
elastic verification for M_η = 43.75 kNm, V_ζ = 25.00 kN
elastic stresses: max |σ_x| = 273.37 N/mm², max τ = 8.88 N/mm², max σ_v = 273.37 N/mm²

max σ_x	bei y = 56.8 mm, z = 56.8 mm:	σ_x = 212.39 N/mm², τ = 4.93 N/mm², σ_v = 212.57 N/mm²
min σ_x	bei y = 45.8 mm, z = -143.2 mm:	σ_x = -273.37 N/mm², τ = 0.00 N/mm², σ_v = 273.37 N/mm²
max τ	bei y = 46.8 mm, z = -29.2 mm:	σ_x = -3.79 N/mm², τ = 8.88 N/mm², σ_v = 15.84 N/mm²
max σ_v	bei y = 45.8 mm, z = -143.2 mm:	σ_x = -273.37 N/mm², τ = 0.00 N/mm², σ_v = 273.37 N/mm²

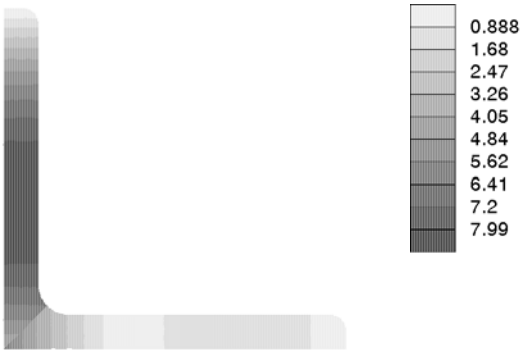
valid equivalent stress: $\sigma_{v,Rd}$ = 235.0 N/mm²
verification: σ_v = 273.37 N/mm² > $\sigma_{v,Rd}$ = 235.00 N/mm² ⇒ U_σ = 1.163 > 1 **fault !!**

c/t-ratio: outstand flange: utilization $U_{c/t}$ = 0.546 < 1 **ok**

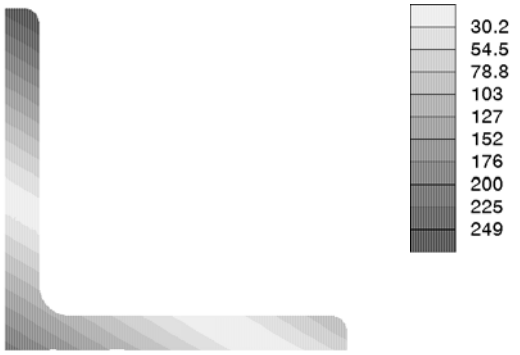
normal stresses σ_x [N/mm²]
min σ_x = -276.3, max σ_x = 212.1



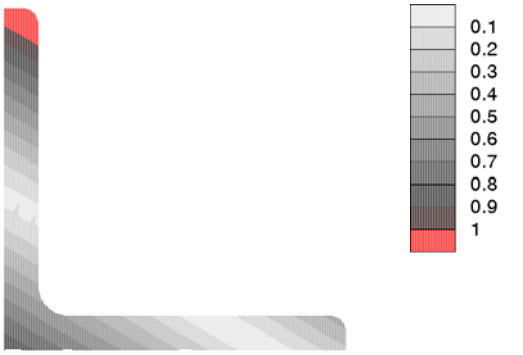
shear stresses τ [N/mm²]
max τ = 8.9



equivalent stresses σ_v [N/mm²]
max σ_v = 276.3



utilization U_σ
max U_σ = 1.176



stresses, utilizations

y	z	σ_x	τ	σ_v	U_σ
mm	mm	N/mm²	N/mm²	N/mm²	
-15.1	1.0	-276.28	0.15	276.28	1.176 > 1
0.0	200.0	212.14	3.83	212.25	0.903
-5.0	115.2	5.99	8.88	16.51	0.070

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

2.1.2. plastic verification

plastic verification for M_η = 43.75 kNm, V_ζ = 25.00 kN
valid normal/shear stress: $\sigma_{x,Rd}$ = 235.0 N/mm², τ_{Rd} = 135.7 N/mm²
bottom flange: resistance forces $N_{max,U}$ = 418.64 kN, $N_{min,U}$ = -418.64 kN
web: shear force V_S = 25.00 kN, shear stress τ_S = 6.94 N/mm² ⇒ $U_{\tau,S}$ = 0.051
resistance forces $N_{max,S}$ = 844.89 kN, $N_{min,S}$ = -844.89 kN
main bending: moment M_y = 43.75 kNm, resistance moments $M_{y,max}$ = 70.55 kNm, $M_{y,min}$ = -70.55 kNm ⇒ U_{My} = 0.620
total (possibly due to load increase): max U = 0.623 < 1 ok

c/t-ratio: outstand flange: utilization $U_{c/t}$ = 0.578 < 1 ok

3. final result

maximum utilization:	stress	max U_σ = 1.163 > 1 fault !!
	c/t-ratio	max $U_{c/t}$ = 0.578 < 1 ok
	resistance	max U = 1.163 > 1 fault !!

resistance not ensured !!