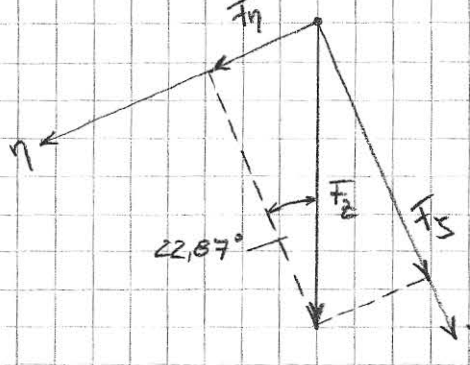
zu 1)



$$F_\eta = 8000\,N \cdot \sin 22{,}87° = 3109\,N$$

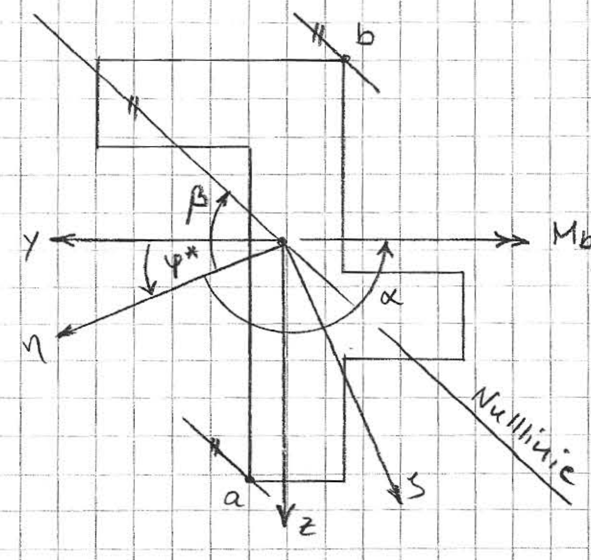
$$F_\zeta = 8000\,N \cdot \cos 22{,}87° = 7371\,N$$

$$f_\eta = \frac{3109\,N \cdot (2000\,mm)^3}{8 \cdot 2{,}1 \cdot 10^5 \frac{N}{mm^2} \cdot 235 \cdot 10^4\,mm^4} = 6{,}30\,mm$$

$$f_\zeta = \frac{7371\,N \cdot (2000\,mm)^3}{8 \cdot 2{,}1 \cdot 10^5 \frac{N}{mm^2} \cdot 1285 \cdot 10^4\,mm^4} = 2{,}73\,mm$$

$$f_{ges} = \sqrt{(6{,}30\,mm)^2 + (2{,}73\,mm)^2} = 6{,}87\,mm$$

zu 2)



$$\alpha = 180° - \varphi^* = 180° - 22{,}87° = 157{,}13°$$

$$\tan\beta = \frac{1285\,cm^4}{235\,cm^4} \cdot \tan 157{,}13° = -2{,}3064$$

$$\beta = -66{,}56°$$

zu 3) Punkt a: $y_a = 1{,}24\,cm$; $z_a = 7{,}93\,cm$

$$\eta_a = 7{,}93\,cm \cdot \sin(22{,}87°) + 1{,}24\,cm \cdot \cos(22{,}87°) = 4{,}22\,cm$$

$$\zeta_a = 7{,}93\,cm \cdot \cos(22{,}87°) - 1{,}24\,cm \cdot \sin(22{,}87°) = 6{,}82\,cm$$

Punkt b: $y_b = -1{,}76\,cm$; $z_b = -6{,}07\,cm$

$$\eta_b = -6{,}07\,cm \cdot \sin(22{,}87°) - 1{,}76\,cm \cdot \cos(22{,}87°) = -3{,}98\,cm$$

$$\zeta_b = -6{,}07\,cm \cdot \cos(22{,}87°) + 1{,}76\,cm \cdot \sin(22{,}87°) = -4{,}91\,cm$$

$$\sigma_b^a = \frac{8 \cdot 100\,kN \cdot cm \cdot \cos 157{,}13°}{1285\,cm^4} \cdot 6{,}82\,cm$$

$$- \frac{8 \cdot 100\,kN \cdot cm \cdot \sin 157{,}13°}{235\,cm^4} \cdot 4{,}22\,cm$$

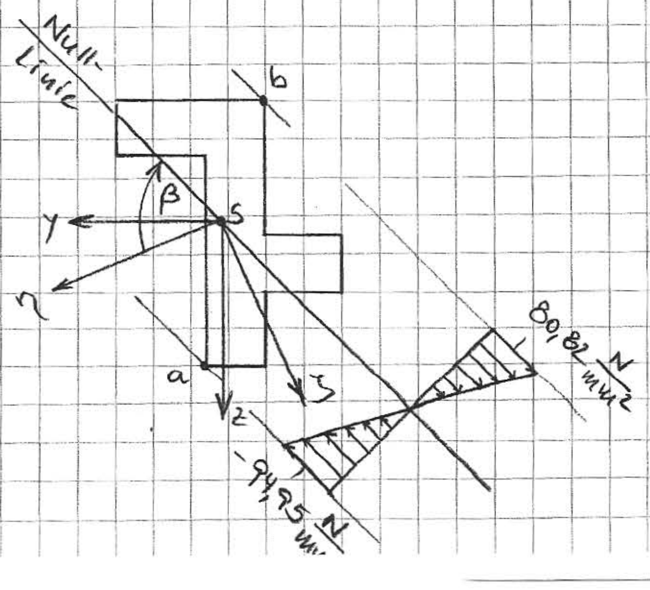
$$\sigma_b^a = -9{,}495\,\frac{kN}{cm^2} = -94{,}95\,\frac{N}{mm^2}$$

$$\sigma_b^b = \frac{8 \cdot 100\,kN \cdot cm \cdot \cos 157{,}13°}{1285\,cm^4} \cdot (-4{,}91\,cm)$$

$$- \frac{8 \cdot 100\,kN \cdot cm \cdot \sin 157{,}13°}{235\,cm^4} \cdot (-3{,}98\,cm)$$

$$\sigma_b^b = 8{,}082\,\frac{kN}{cm^2} = 80{,}82\,\frac{N}{mm^2}$$

zu 4)



zu 1)

a) $S_{y1} = S_{y2} = 3mm \cdot 38mm \cdot 51{,}36mm = 5855\,mm^3$

$S_{y3} = S_{y4} = 5855\,mm^3 + 4mm \cdot 96mm \cdot 3{,}36mm = 7145\,mm^3$

$S_{y5} = 7145\,mm^3 + 5mm \cdot 32mm \cdot (-44{,}64m) = 2\,mm^3 \sim 0$

$$\tau_1 = \frac{25000\,N \cdot 5855\,mm^3}{184{,}16 \cdot 10^4\,mm^4 \cdot 3\,mm} = 26{,}49\,\frac{N}{mm^2}$$

$$\tau_2 = 26{,}49\,\frac{N}{mm^2} \cdot \frac{3\,mm}{4\,mm} = 19{,}87\,\frac{N}{mm^2}$$

$$\tau_3 = \frac{25000\,N \cdot 7145\,mm^3}{184{,}16 \cdot 10^4\,mm^4 \cdot 4\,mm} = 24{,}25\,\frac{N}{mm^2}$$

$$\tau_4 = 24{,}25\,\frac{N}{mm^2} \cdot \frac{4\,mm}{5\,mm} = 19{,}40\,\frac{N}{mm^2}$$

$\tau_5 = 0$

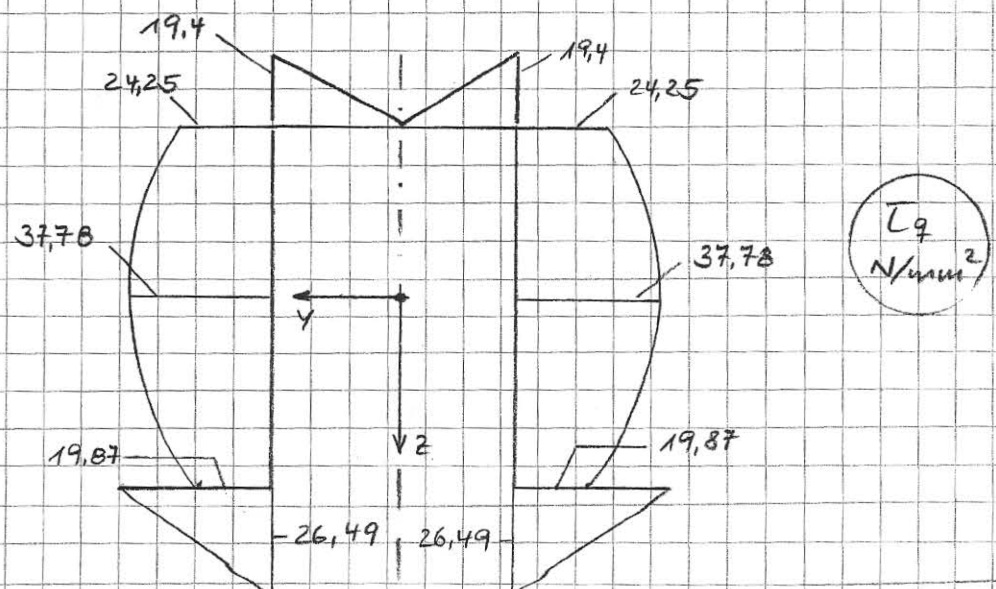
b) $S_{ymax} = 5855\,mm^3 + 4mm \cdot 51{,}36mm \cdot 25{,}68mm$

$S_{ymax} = 11131\,mm^3$

$$\tau_{qmax} = \frac{25000\,N \cdot 11131\,mm^3}{184{,}16 \cdot 10^4\,mm^4 \cdot 4\,mm} = 37{,}78\,\frac{N}{mm^2}$$

in der Faser $z = 0$

c)



zu 2)

$$I_T = 2 \cdot \frac{1}{3} \cdot \left[40mm \cdot (3mm)^3 + 92mm \cdot (4mm)^3 + 34mm \cdot (5mm)^3 \right]$$

$$I_T = 7479 mm^4$$

$$\tau_{T max} = \frac{30000 N \cdot mm}{7479 mm^4} \cdot 5mm = 20,06 \frac{N}{mm^2}$$

Tritt im Obergurt auf.

zu 3) Schubspannung τ_T im Steg:

$$\tau_T = \frac{30000 N \cdot mm}{7479 mm^4} \cdot 4mm = 16,05 \frac{N}{mm^2}$$

$$\tau_{ges} = \tau_{q max} + \tau_T = 37,78 \frac{N}{mm^2} + 16,05 \frac{N}{mm^2}$$

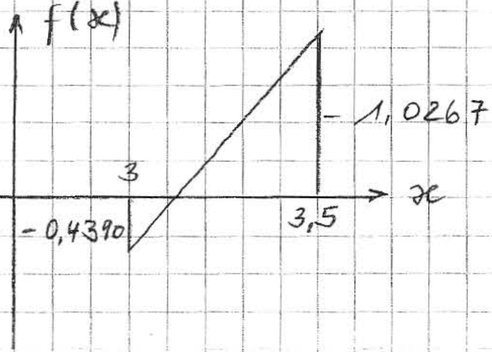
$$\tau_{ges} = 53,83 \frac{N}{mm^2} \quad (\text{in der Faser } z = 0)$$

zu 1)

$f(3{,}0) = -0{,}4390$

$f(3{,}5) = 1{,}0267$

1. Iteration



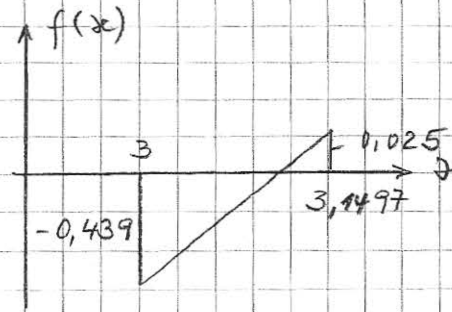
$$\frac{\Delta \varkappa}{0{,}4390} = \frac{0{,}5}{0{,}4390 + 1{,}0267}$$

$\Delta \varkappa = 0{,}1497$

$\varkappa_{Neu} = 3{,}1497$

$f(\varkappa_{Neu}) = 0{,}025$

2. Iteration



$$\frac{\Delta \varkappa}{0{,}4390} = \frac{0{,}1497}{0{,}4390 + 0{,}025}$$

$\Delta \varkappa = 0{,}1416$

$\varkappa_{Neu} = 3{,}1416 = \pi$

$f(\varkappa_{Neu}) = 0$

$$\sqrt{\frac{F_K}{E \cdot I}} \cdot l = \varkappa = \pi$$

$$F_K = \frac{E \cdot I \cdot \pi^2}{l^2}$$

$$F_K = \frac{2{,}1 \cdot 10^5 \frac{N}{mm^2} \cdot 45{,}9 \cdot 10^4 mm^4 \cdot \pi^2}{(2000 mm)^2}$$

$$F_K = 237832 N$$

$$F_{zul} = \frac{F_K}{\nu_K} = \frac{237832 N}{4} = 59458 N$$

zu 2) $$\sigma_K = \frac{F_K}{A} = \frac{237832 N}{8{,}82 \cdot 10^2 mm^2}$$

$$\sigma_K = 269{,}65 \frac{N}{mm^2} < 285 \frac{N}{mm^2} = \sigma_{dP}$$

$\Rightarrow$ elastische Rechnung o.k. ∇