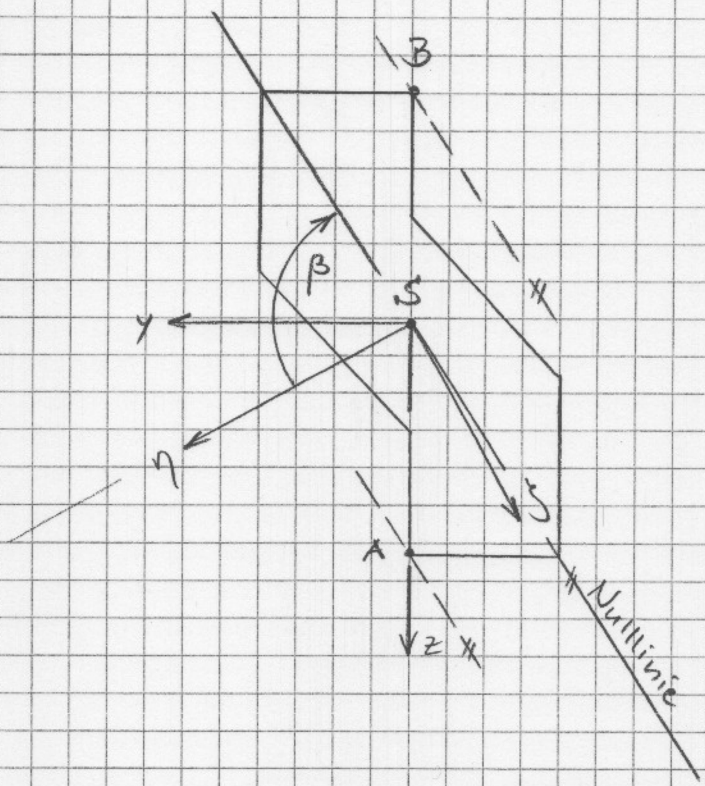
1) $\alpha = 180^\circ - 30^\circ - 29{,}5^\circ = 120{,}5^\circ$

$$\tan\beta = \frac{1818\,cm^4}{217\,cm^4} \cdot \tan 120{,}5^\circ = -14{,}22$$

$$\beta = -85{,}98^\circ$$



2) $M_{b\eta} = M_b \cdot \cos\alpha = 5\,kN \cdot m \cdot \cos 120{,}5^\circ = -2{,}54\,kN \cdot m$

$M_{b\zeta} = M_b \cdot \sin\alpha = 5\,kN \cdot m \cdot \sin 120{,}5^\circ = 4{,}31\,kN \cdot m$

$\eta_A = 7.5\,cm \cdot \sin 29{,}5^\circ = 3{,}69\,cm$

$\zeta_A = 7.5\,cm \cdot \cos 29{,}5^\circ = 6{,}53\,cm$

$\eta_B = -3{,}69\,cm$

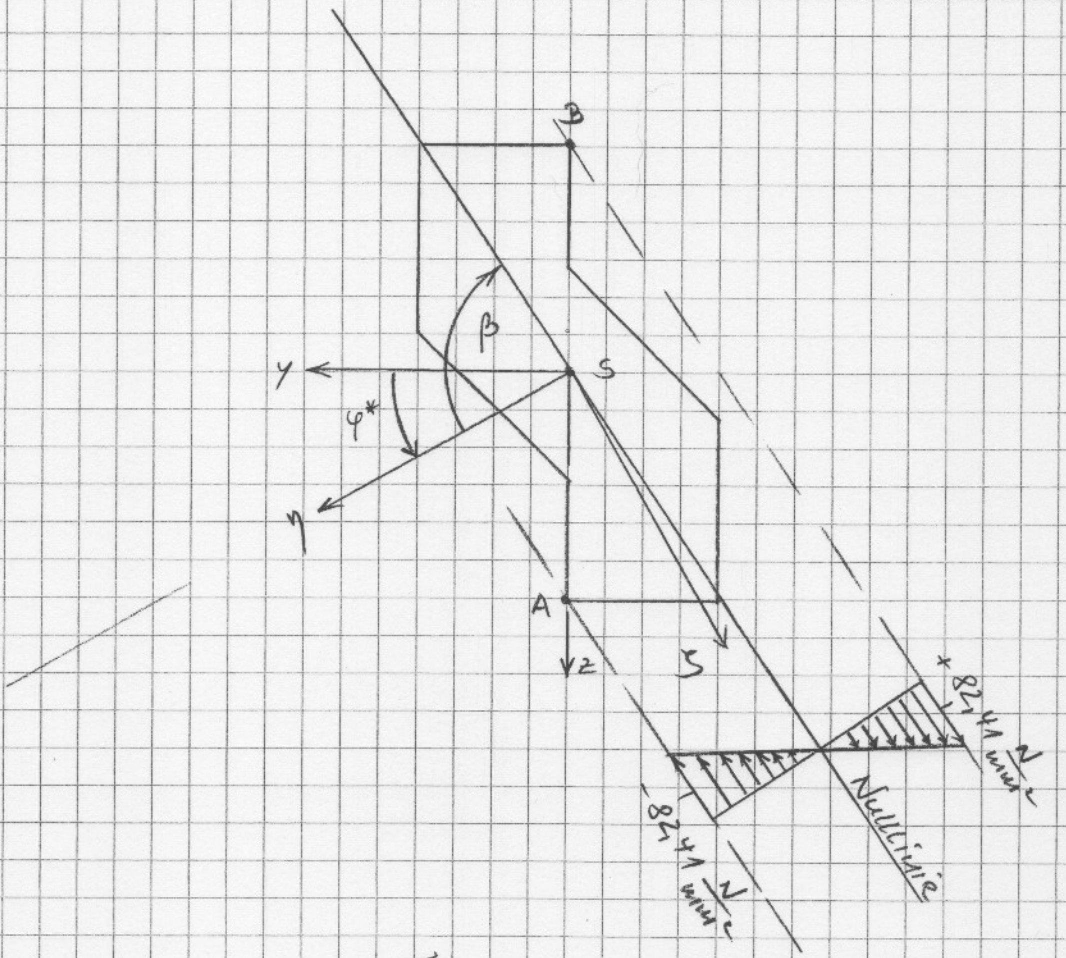
$\zeta_B = -6{,}53\,cm$

Biegespannungen

$$\sigma_b^A = \frac{-2{,}54 \cdot 100\,kN \cdot cm}{1818\,cm^4} \cdot 6{,}53\,cm - \frac{4{,}31 \cdot 100\,kN \cdot cm}{217\,cm^4} \cdot 3{,}69\,cm$$

$$\sigma_b^A = -8{,}241\,\frac{kN}{cm^2} = -82{,}41\,\frac{N}{mm^2}$$

$$\sigma_b^B = +82{,}41\,\frac{N}{mm^2}$$



3) $M_{bzul} = M_b \cdot \frac{\sigma_{bzul}}{\sigma_{bvorh}}$

$$M_{bzul} = 5\,kN \cdot m \cdot \frac{100\,\frac{N}{mm^2}}{82{,}41\,\frac{N}{mm^2}} = 6{,}07\,kN \cdot m$$

zu 1)

$S_{y1} = 0$

$S_{y2} = 8\,cm \cdot 4\,cm \cdot 3{,}41\,cm \cdot 2 = 218{,}24\,cm^3$

$S_{y3} = 218{,}24\,cm^3 + 12\,cm \cdot 2\,cm \cdot (-1{,}59\,cm) - \frac{4\,cm \cdot 2\,cm}{2} \cdot (-1{,}26\,cm)$

$S_{y3} = 185{,}12\,cm^3$

$S_{y4} = 185{,}12\,cm^3 + 12\,cm \cdot 2\,cm \cdot (-3{,}59) = 98{,}96\,cm^3$

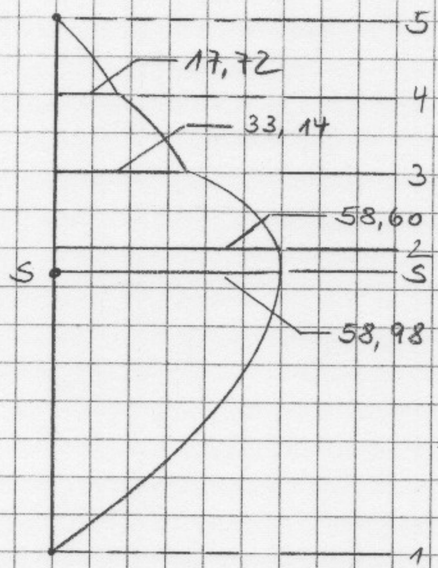
$S_{y5} = 98{,}96\,cm^3 + 6\,cm \cdot 2\,cm \cdot (-5{,}59\,cm) + 2 \cdot \frac{3\,cm \cdot 2\,cm}{2} \cdot (-5{,}26\,cm)$

$S_{y5} = 0{,}32 \approx 0$

$S_{y\,max} = 2 \cdot 4\,cm \cdot \frac{(7{,}41\,cm)^2}{2} = 219{,}63\,cm^3$

Schnitt	S_y cm^3	t cm	τ kN/cm^2	τ N/mm^2
1	0	8	0	0
2	218,24	8	5,860	58,60
3	185,12	12	3,314	33,14
4	98,96	12	1,772	17,72
5	0	6	0	0

$$\tau_{max} = \frac{400\,kN \cdot 219{,}63\,cm^3}{1862\,cm^4 \cdot 8\,cm} = 5{,}898\,\frac{kN}{cm^2} = 58{,}98\,\frac{N}{mm^2}$$



τ in $\frac{N}{mm^2}$

3A 1/2

zu 1) $a = 50\,mm$

$$F = E \cdot A \cdot \alpha_\vartheta \cdot \Delta\vartheta$$

$$F = 2{,}1 \cdot 10^5 \frac{N}{mm^2} \cdot \frac{3 \cdot \sqrt{3}}{2} \cdot (50\,mm)^2 \cdot 1{,}2 \cdot 10^{-5} K^{-1} \cdot 30\,K$$

$$F = 491036\,N$$

$$F_k = \frac{E \cdot I \cdot \pi^2}{s_k^2}$$

$$F_k = \frac{2{,}1 \cdot 10^5 \frac{N}{mm^2} \cdot \frac{5 \cdot \sqrt{3}}{16} \cdot (50\,mm)^4 \cdot \pi^2}{(0{,}7 \cdot 3000\,mm)^2}$$

$$F_k = 1589905\,N$$

$$\nu_k = \frac{1589905\,N}{491036\,N} = 3{,}24$$

Schlankheit:

$$i = \sqrt{\frac{I}{A}} = \sqrt{\frac{5 \cdot \sqrt{3} \cdot a^4 \cdot 2}{16 \cdot 3 \cdot \sqrt{3} \cdot a^2}} = \sqrt{\frac{5 \cdot a^2}{24}}$$

$$i = \sqrt{\frac{5 \cdot (50\,mm)^2}{24}} = 22{,}82\,mm$$

$$\lambda = \frac{s_k}{i} = \frac{2100\,mm}{22{,}82\,mm} = 92 > 85 = \lambda_{grenz}$$

Elastische Rechnung o.K.

zu 2)

$$\sigma_k = \frac{E \cdot \pi^2}{\lambda^2} = \nu_k \cdot E \cdot \alpha_\vartheta \cdot \Delta\vartheta$$

$$\lambda = \sqrt{\frac{\pi^2}{\nu_k \cdot \alpha_\vartheta \cdot \Delta\vartheta}} = \sqrt{\frac{\pi^2}{4 \cdot 1{,}2 \cdot 10^5 K^{-1} \cdot 30\,K}}$$

$$\lambda = 82{,}79 < 85 \Rightarrow \text{inelastische Knickung}$$

$$\sigma_K = 470 - 2{,}3 \cdot \lambda = 4 \cdot E \cdot \alpha_\vartheta \cdot \Delta\vartheta$$

$$\lambda = \frac{470 - 4 \cdot E \cdot \alpha_\vartheta \cdot \Delta\vartheta}{2{,}3}$$

$$\lambda = \frac{470\,\frac{N}{mm^2} - 4 \cdot 2{,}1 \cdot 10^5\,\frac{N}{mm^2} \cdot 1{,}2 \cdot 10^{-5}\,K^{-1} \cdot 30\,K}{2{,}3\,\frac{N}{mm^2}}$$

$$\lambda = 72{,}87$$

$$\frac{s_K}{i} = \frac{2100\,mm}{\sqrt{\frac{5 \cdot a^2}{24}}} = 72{,}87$$

$$\sqrt{\frac{5 \cdot a^2}{24}} = \frac{2100\,mm}{72{,}87}$$

$$a = \sqrt{\frac{24}{5}} \cdot \frac{2100\,mm}{72{,}87}$$

$$a = 63{,}14\,mm$$

gewählt: $a = 64\,mm$