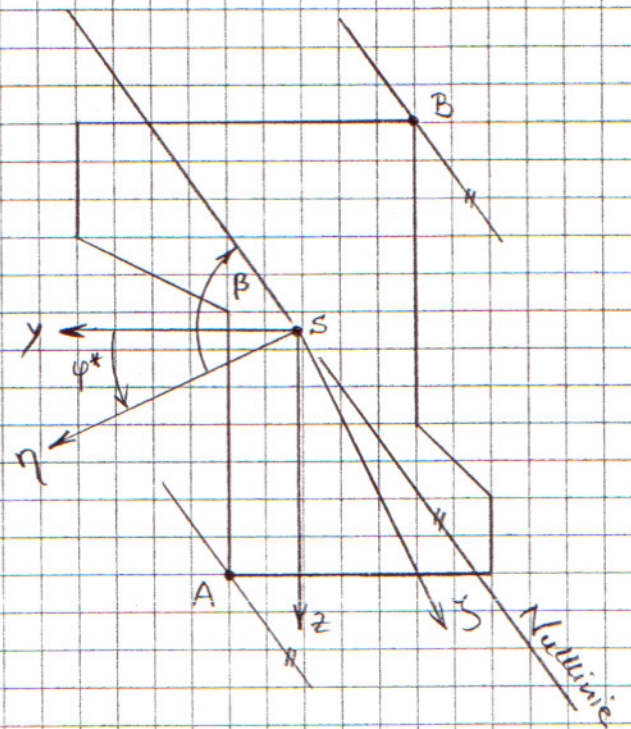
zu 1) $\alpha = 180° - 24{,}33° - 30° = 125{,}67°$ 1/1

$$\tan\beta = \frac{I_1}{I_2} \cdot \tan\alpha = \frac{1260\,cm^4}{330\,cm^4} \cdot \tan 125{,}67° = -5{,}3194$$

$$\beta = -79{,}35°$$



zu 2)

$$M_{b\eta} = M_b \cdot \cos\alpha = -0{,}5831 \cdot M_b$$

$$M_{b\zeta} = M_b \cdot \sin\alpha = 0{,}8124 \cdot M_b$$

$$y_A = 1{,}9\,cm\ ;\ z_A = 6{,}45\,cm$$

$$y_B = -3{,}1\,cm\ ;\ z_B = -5{,}55\,cm$$

$$\eta_A = 6{,}45\,cm \cdot \sin 24{,}33° + 1{,}9\,cm \cdot \cos 24{,}33° = 4{,}39\,cm$$

$$\zeta_A = 6{,}45\,cm \cdot \cos 24{,}33° - 1{,}9\,cm \cdot \sin 24{,}33° = 5{,}09\,cm$$

$$\eta_B = -5{,}55\,cm \cdot \sin 24{,}33° - 3{,}1\,cm \cdot \cos 24{,}33° = -5{,}11\,cm$$

$$\zeta_B = -5{,}55\,cm \cdot \cos 24{,}33° + 3{,}1\,cm \cdot \sin 24{,}33° = -3{,}78\,cm$$

$$\sigma_b^A = \frac{-0{,}5831 \cdot M_b}{1260 \cdot 10^4\,mm^4} \cdot (50{,}9\,mm) - \frac{0{,}8124 \cdot M_b}{330 \cdot 10^4\,mm^4} \cdot (43{,}9\,mm)$$

$$\sigma_b^A = -1{,}3163 \cdot 10^{-5}\,\frac{1}{mm^3} \cdot M_b$$

$$\sigma_b^B = \frac{-0{,}5831 \cdot M_b}{1260 \cdot 10^4\,mm^4} \cdot (-37{,}8\,mm) - \frac{0{,}8124 \cdot M_b}{330 \cdot 10^4\,mm^4} \cdot (-51{,}1\,mm)$$

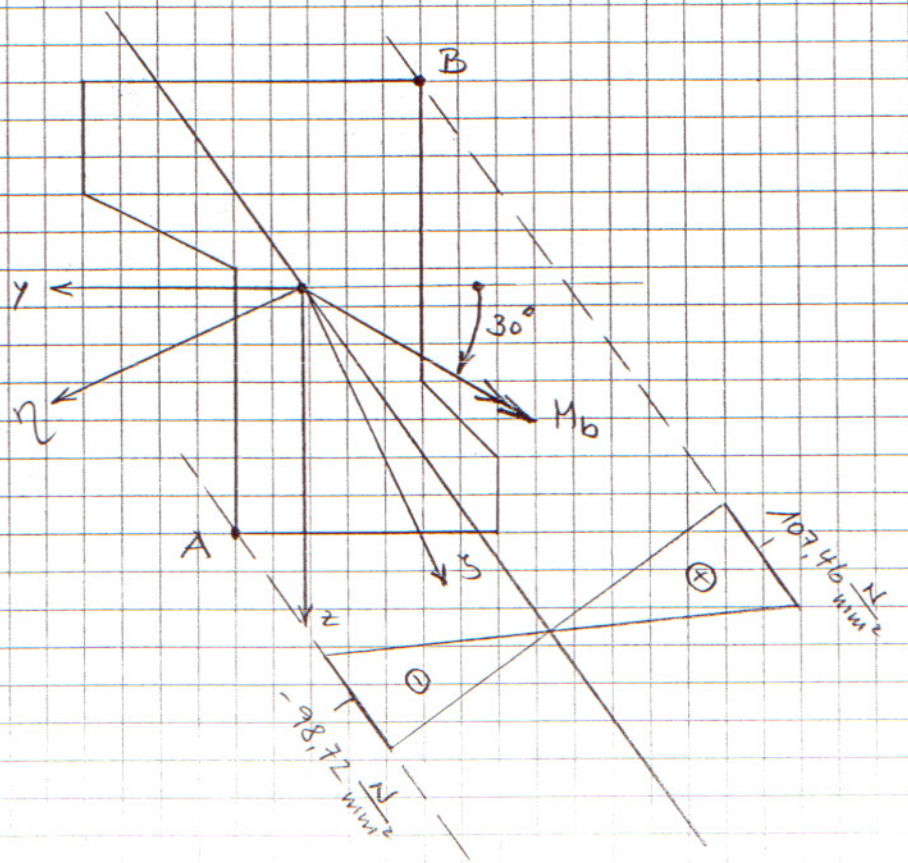
$$\sigma_b^B = 1{,}4329 \cdot 10^{-5}\,\frac{1}{mm^3} \cdot M_b$$

$$M_{bzul} = \frac{\sigma_{bzul}}{1{,}4329 \cdot 10^{-5}\,\frac{1}{mm^3}} = \frac{120\,\frac{N}{mm^2}}{1{,}4329 \cdot 10^{-5}\,\frac{1}{mm^3}}$$

$$M_{bzul} = 8374625\,N \cdot mm = 8{,}375\,kN \cdot m$$

zu 3) $\sigma_b^A = -1{,}3163 \cdot 10^{-5}\,\frac{1}{mm^3} \cdot 7{,}5 \cdot 10^6\,N \cdot mm = -98{,}72\,\frac{N}{mm^2}$

$$\sigma_b^B = \frac{7{,}5\,kN \cdot m}{8{,}375\,kN \cdot m} \cdot 120\,\frac{N}{mm^2} = 107{,}46\,\frac{N}{mm^2}$$



zu 1)

$S_{y1} = 20\,mm \cdot 5\,mm \cdot 53{,}38\,mm = 5338\,mm^3$

$S_{y2} = 5338\,mm^3$

$S_{y3} = 2 \cdot 5338\,mm^3 = 10676\,mm^3$

$S_{y4} = 10676\,mm^3 + 80\,mm \cdot 6\,mm \cdot 10{,}88\,mm = 15898{,}4\,mm^3$

$S_{y5} = 15898{,}4\,mm^4 + 60\,mm \cdot 8\,mm \cdot (-33{,}12\,mm) = 0{,}8\,mm^3 \approx 0$

$S_{y6} = 40\,mm \cdot 8\,mm \cdot 33{,}12\,mm = 10598{,}4\,mm^3$

$S_{y7} = 20\,mm \cdot 8\,mm \cdot 33{,}12\,mm = 5299{,}2\,mm^3$

Schnitt	S_y mm^3	t mm	τ N/mm^2
1	5338	5	18,90
2	5338	5	18,90
3	10676	6	31,50
4	15898,4	6	46,91
5	0	8	0
6	10598,4	8	23,46
7	5299,2	8	11,73

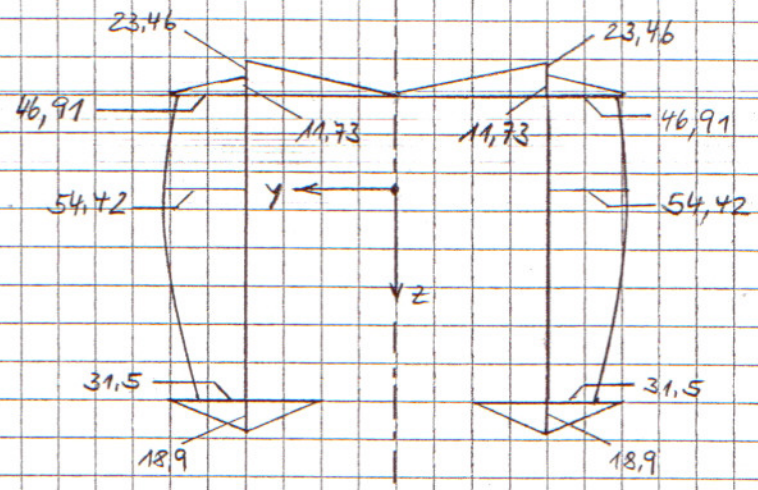
zu 2)

$S_{ymax} = 10676\,mm^3 + 6\,mm \cdot \frac{(50{,}88\,mm)^2}{2} = 18442{,}3\,mm^3$

$\tau_{max} = \frac{50000\,N \cdot 18442{,}3\,mm^3}{2824 \cdot 10^3\,mm^4 \cdot 6\,mm} = 54{,}42\ N/mm^2$

in der Faser $z = 0$

zu 3)



τ_Q N/mm²

zu 4)

$$\tau_{II} = \frac{T_{qz}}{I_y} \cdot \frac{S_{yGurt}}{2 \cdot a}$$

Steg / Untergurt

$$\tau_{II} = \frac{50000\ N}{2824 \cdot 10^3\ mm^4} \cdot \frac{10676\ mm^3}{2 \cdot 5\ mm} = 18{,}90\ \frac{N}{mm^2}$$

Steg / Obergurt

$$\tau_{II} = \frac{50000\ N}{2824 \cdot 10^3\ mm^4} \cdot \frac{15898{,}4\ mm^4}{2 \cdot 5\ mm} = 28{,}15\ \frac{N}{mm^2}$$

zu 1/ $\frac{l_2}{l_1} = \frac{1}{2}$

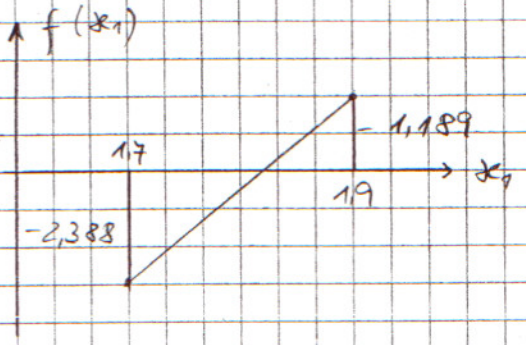
Knickbedingung

$$x_1 \cdot \tan\left(\frac{1}{2} \cdot x_1\right) + x_1 \cdot \tan(x_1) - \tan(x_1) \cdot \tan\left(\frac{1}{2} \cdot x_1\right) = 0$$

$f(x_1 = 1{,}7) = -2{,}388$

$f(x_1 = 1{,}9) = 1{,}189$

1. Iteration

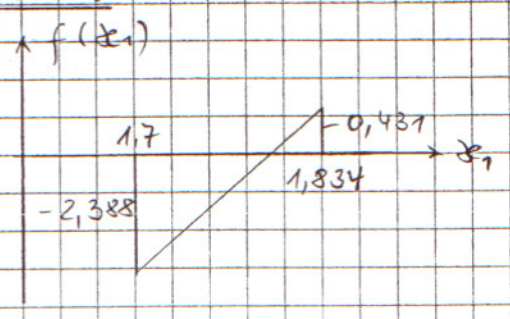


$$\frac{\Delta x_1}{2{,}388} = \frac{0{,}2}{2{,}388 + 1{,}189} \Rightarrow \Delta x_1 = 0{,}134$$

$x_{1\,Neu} = 1{,}7 + 0{,}134 = 1{,}834$

$f(x_{1\,Neu}) = 0{,}431$

2. Iteration



$$\frac{\Delta x_1}{2{,}388} = \frac{0{,}134}{2{,}388 + 0{,}431} \Rightarrow \Delta x_1 = 0{,}114$$

$x_{1\,Neu} = 1{,}814$

$f(x_{1\,Neu}) = 0{,}16$

$$\sqrt{\frac{F_k}{E \cdot I}} \cdot l_1 = \kappa_1$$

$$F_k = \frac{\kappa_1^2 \cdot E \cdot I}{l_1^2} = \frac{1{,}814^2 \cdot 2{,}1 \cdot 10^5 \frac{N}{mm^2} \cdot 111 \cdot 10^4 mm^4}{(2000\,mm)^2}$$

$$F_k = 191760\,N$$

$$F = \frac{F_k}{\nu_k} = \frac{191760\,N}{4} = 47940\,N \quad (1)$$

zu 2) $\sigma_k = \frac{F_k}{A} = \frac{191760\,N}{11{,}8 \cdot 10^2 mm^2} = 162{,}50 \frac{N}{mm^2} < 285 \frac{N}{mm^2}$ (1)

elastische Rechnung o.k.

zu 3) $F_k = 191760\,N \cdot \frac{233 \cdot 10^4 mm^4}{111 \cdot 10^4 mm^4} = 402523\,N$

$$F = \frac{402523\,N}{4} = 100631\,N \quad (1)$$

$$\sigma_k = \frac{402523\,N}{15{,}2 \cdot 10^2 mm^2} = 264{,}32 \frac{N}{mm^2} < 285 \frac{N}{mm^2}$$ (1)