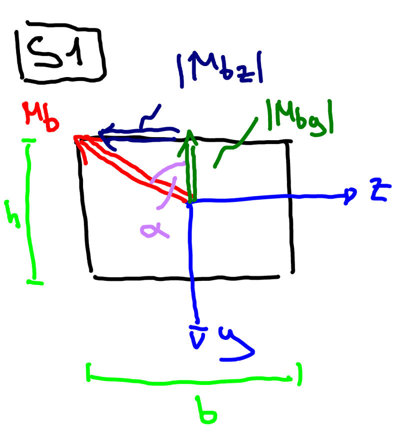
S1



1.) Projektion von M_b auf die Hauptachsen

$M_{b,y} = \cos(\alpha) M_b \ (-1)$
$M_{b,z} = \sin(\alpha) M_b \ (-1)$

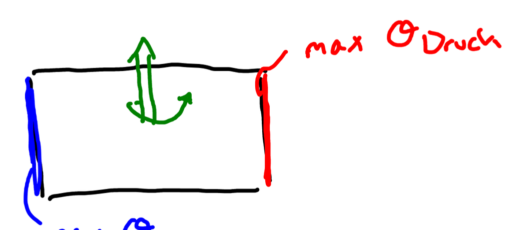
2.) Formeln für allgemeine Biegung

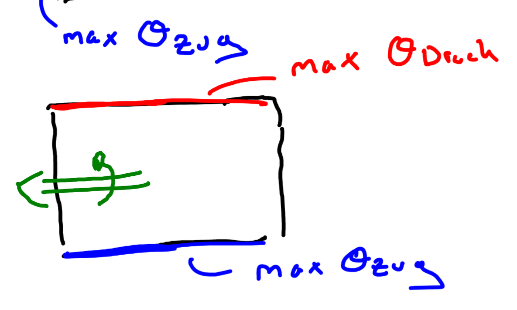
$$\sigma_x(x,y,z) = \cancel{\frac{N(x)}{A(x)}}^{0} - \frac{M_z(\cancel{x})}{I_z(\cancel{x})} \cdot y + \frac{M_y(\cancel{x})}{I_y(\cancel{x})} z$$

$$\sigma_x(y,z) = -\frac{M_{b,z}}{I_z} \cdot y + \frac{M_{b,y}}{I_y} \cdot z$$

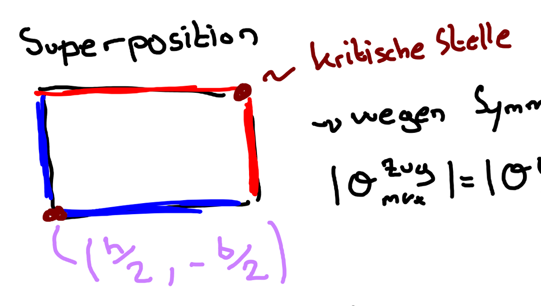
$I_z = \frac{bh^3}{12}$ $\quad I_y = \frac{b^3 h}{12}$

→ Maximum finden:





Super-position



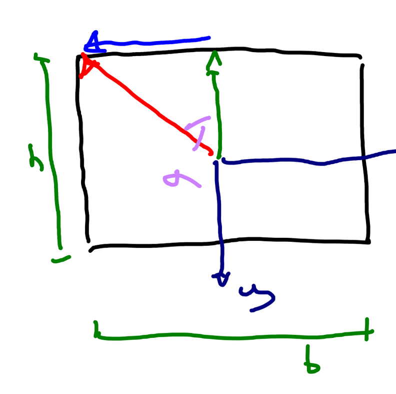
→ wegen Symmetrie: $|\sigma^{Zug}_{max}| = |\sigma^{Druck}_{max}|$

→ $\sigma_x(y = h/2, z = -b/2) =$

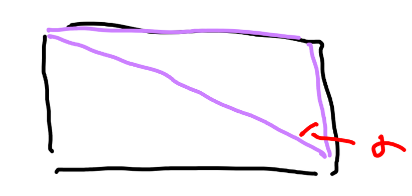
$$\frac{\sin(\alpha) M_b \cdot \cancel{12}^{6} \cancel{h}}{b h^{\cancel{3}2} \cancel{2}} + \frac{\cos(\alpha) M_b \cdot \cancel{12}^{6}}{b^{\cancel{3}2} h}\left(+\cancel{\frac{b}{2}}\right)$$

$$\boxed{= \frac{6 M_b}{bh}\left(\frac{\sin(\alpha)}{h^2} + \frac{\cos(\alpha)}{b^2}\right)}$$

→ $\cos(\alpha)$ & $\sin(\alpha)$ als Funktion von b & h



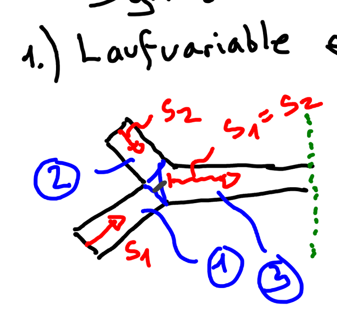
$\cos(\alpha) = \frac{h}{\sqrt{h^2+b^2}}$



$\sin(\alpha) = \frac{b}{\sqrt{h^2+b^2}}$

S2

→ dünnwandig
→ Symmetrie
1.) Laufvariable s einführen



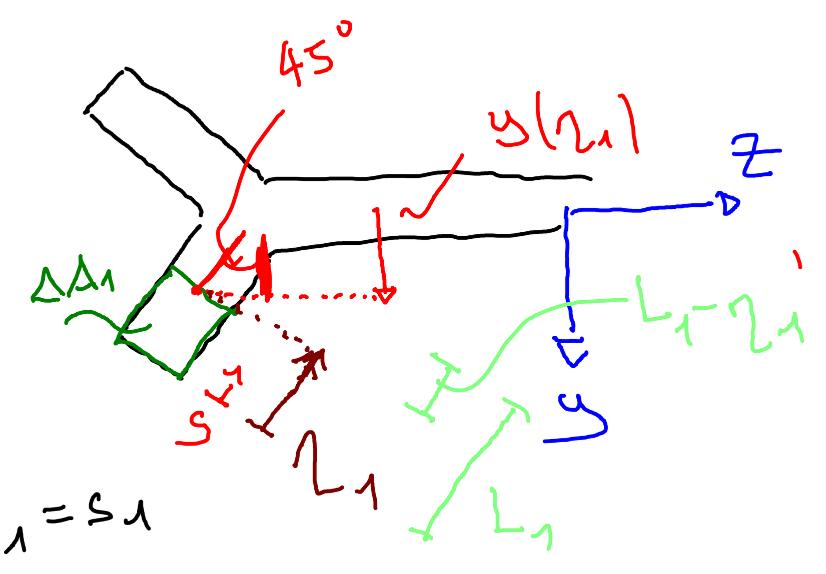
2.) Schubfluss im Abschnitt 1:

$q := \frac{Q_y}{I_z}$

$$\mathcal{T}_{xs_1}(x, s_1) = -\frac{Q_y(\cancel{x})}{I_z(\cancel{x})} \cdot \frac{H_z(s_1)}{\cancel{e(s_1)}}_{e}$$

$$H_z(s_1) = \int_0^{s} y(\eta) e(\eta)\, d\eta$$

$$= \int_0^{s_1} (L_1 - \eta_1)\cos(\alpha) e \, d\eta_1$$



$$= \frac{\sqrt{2}}{2} e \left[L_1 \eta_1 - \frac{\eta_1^2}{2}\right]_{\eta_1 = 0}^{\eta_1 = s_1}$$

$$= \frac{\sqrt{2}}{2} e \left[L_1 s_1 - \frac{s_1^2}{2}\right]$$

$$\mathcal{T}_{xs_1}(s_1) = -q \frac{\sqrt{2}}{2} \cancel{\frac{e}{e}} \left(L_1 s_1 - \frac{s_1^2}{2}\right)$$

3.) Schubfluss im Abschnitt 2:

$$\mathcal{T}_{xs_2}(s_2) = -\mathcal{T}_{xs_1}$$

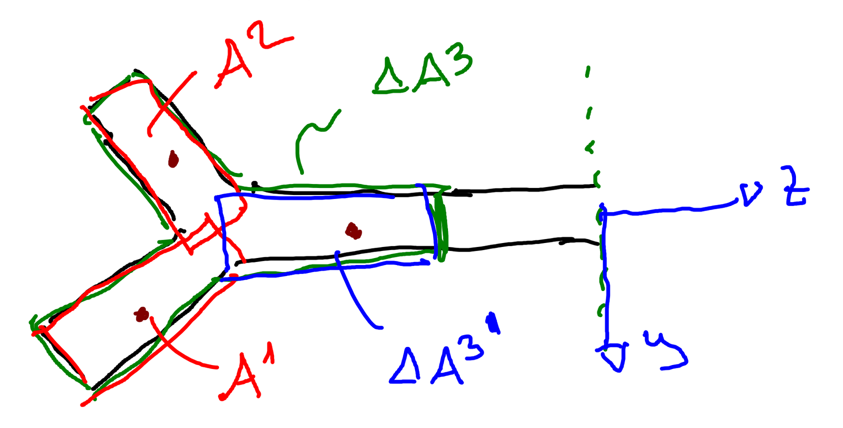
$$H_z(s_2) = \int_0^{s_2} y(\eta_2) e(\eta_2)\, d\eta_2$$

$$= -\cos(\alpha) e \left[L_1 \eta_2 - \frac{\eta_2^2}{2}\right]_{\eta_2 = 0}^{\eta_2 = s_2}$$

$$= -\frac{\sqrt{2}}{2} e \left[L_1 s_2 - \frac{s_2^2}{2}\right]$$

$$\rightarrow \mathcal{T}_{xs_2}(s_2) = q \frac{\sqrt{2}}{2} \left(L_1 s_2 - \frac{s_2^2}{2}\right)$$

4.) Schubspannungen im Abschnitt 3:



$$H_z^3 = H_z^1 + H_z^2 + H_z^{3'} =$$

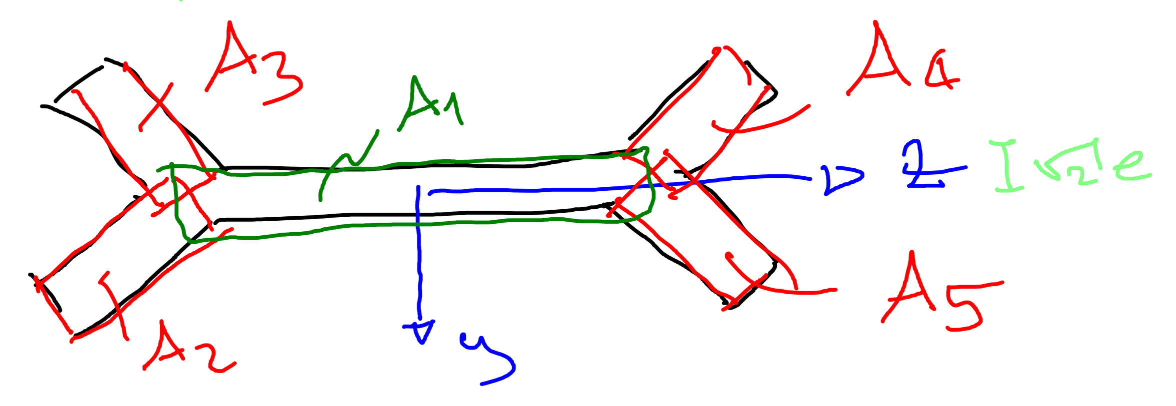
$$y_{s,1} \cdot A^1 + y_{s,2} \cdot A^2 + \cancel{y_{s,3'}}^{0} \cdot \Delta A^{3'}$$

$$= A^1 (\cancel{y_{s,1} + y_{s,2}}^{0}) = 0$$

$$y_{s,1} = -y_{s,2}$$

→ $\mathcal{T}_{xs_3} =$

6.) Extra: I_z berechnen

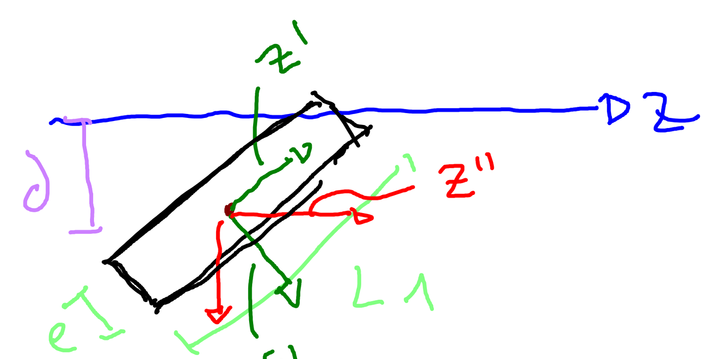


$I_z^2 = I_z^3 = I_z^4 = I_z^5$ each

$I_z^{total} = 4 \cdot I_z^2 \cdot \cancel{I_z^1}^{0}$

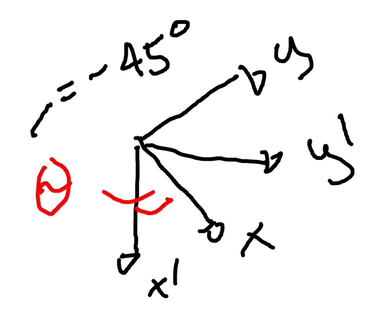
$$I_z^1 = \frac{L_2 \cdot (\sqrt{2} e)^3}{12} = \frac{L_2 \sqrt{2} \cdot 2 \cancel{e^3}^{\approx 0}}{12} \approx 0$$

$I_{z'} = \frac{e^3 L_1}{12} \approx 0$



$I_{y'} = \frac{e L_1^3}{12}$

$C_{y'z'} = 0$



$$I_{z''} = I_{y'} \sin^2(\theta) + \cancel{I_{z'}}^{0} \cos^2(\theta) - \cancel{C_{yz}}^{0} \sin\theta \cos\theta$$

$$I_{z''} = \frac{e L_1^3}{12}\left(\frac{\sqrt{2}}{2}\right)^2 = \frac{e L_1^3}{24}$$

$$I_z = I_{z''} + A \cdot d^2 = \frac{e L_1^3}{24} + e L_1 \left(\frac{L_1}{2} \frac{\sqrt{2}}{2}\right)^2$$

$$= e L_1^3 \left(\frac{1}{24} + \frac{1}{8}\right) = \frac{e L_1^3}{6}$$

$$I_z^{tot} = 4 I_z^2 = \frac{e L_1^3 \cdot 4}{6} = \boxed{\frac{2}{3} e L_1^3}$$

$$I_{y''} = I_{y'} \cos^2(\theta) + I_{z'} \sin^2(\theta) + 2 C_{yz} \sin\theta \cos\theta$$

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