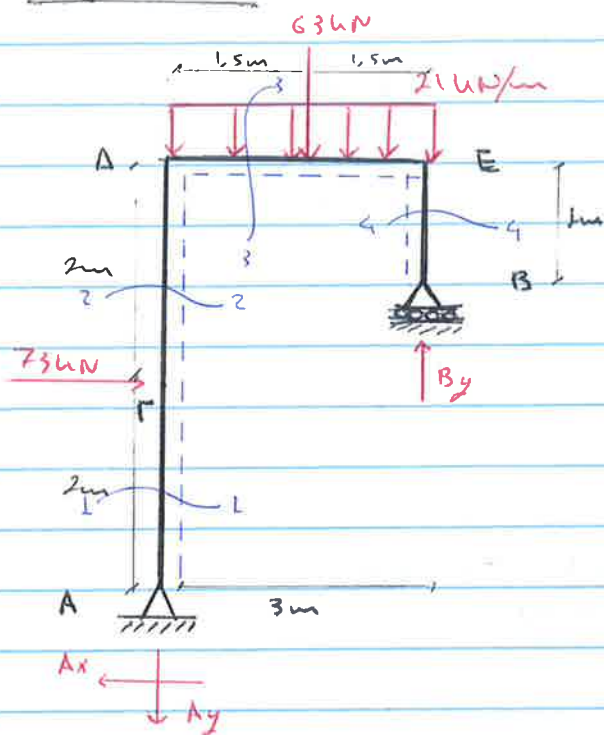


Project 70 - 2)

Thema: Apfel - 2018050055



$$G_2 = 1, G_3 = 13$$

$$R = 0,2 \text{ m}, r = 0,14 \text{ m}$$

Equilibrium

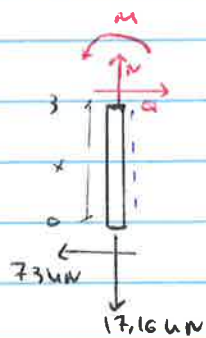
$$\sum M_A = 0 \Rightarrow 173 \cdot 2 + 63 \cdot 1,5 = B_y \cdot 3 \Rightarrow B_y = 80,16 \text{ kN} \uparrow$$

$$\sum F_y = 0 \Rightarrow A_y = 17,16 \text{ kN} \downarrow$$

$$\sum F_x = 0 \Rightarrow A_x = 73 \text{ kN} \leftarrow$$



I-L

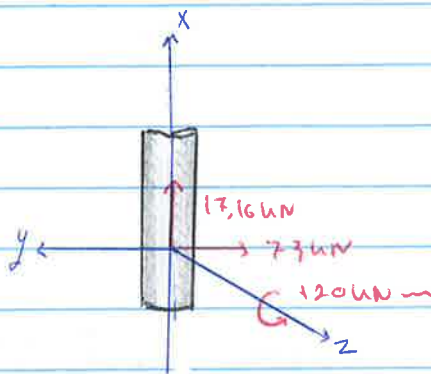


$$N = 17,16 \text{ kN}$$

$$Q = 73 \text{ kN}$$

$$M = 73 \cdot x$$

$$x = 2 \Rightarrow 146 \text{ kNm (max)}$$



$$\sigma: \begin{matrix} p & \frac{p}{A} = \frac{17,2 \cdot 10^3}{\frac{1}{2} \pi (0,2^2 - 0,14^2)} = 0,55 \text{ MPa} \\ M_z & \frac{M_z y_{\max}}{I_z} = \frac{146 \cdot 10^3 \cdot 0,2}{1,2 \cdot 10^{-3}} = 24,3 \text{ MPa} \\ M_y & = 0 \end{matrix}$$

$$\sigma_{\max} = 24,85 \approx \pm 25 \text{ MPa}$$

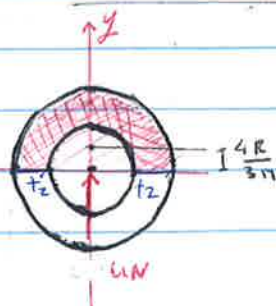
$$I_z = \frac{1}{4} \pi (0,2^4 - 0,14^4) = 1,2 \cdot 10^{-3} \text{ m}^4$$

$$\tau: \begin{matrix} T & = 0 \\ V_y & \frac{V_y Q_y}{I_z t_z} = \frac{73 \cdot 10^3 \cdot 255 \cdot 10^{-3}}{1,2 \cdot 10^{-3} \cdot 2 \cdot 0,06} = 1,3 \text{ MPa} = \tau_{\max} \\ V_z & = 0 \end{matrix}$$

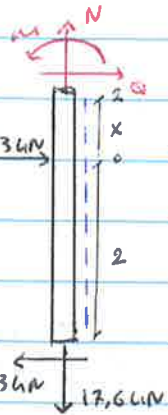
$$A^* = \frac{\pi (0,2)^2}{2} - \frac{\pi (0,14)^2}{2} = 0,03 \text{ m}^2$$

$$\bar{y}^* = \frac{4 \cdot 0,2}{3 \pi} = 0,089$$

$$\left. \begin{matrix} \sigma_y = 255 \\ \cdot 10^{-3} \text{ m}^3 \end{matrix} \right\} \begin{matrix} I_z = \frac{4R}{3\pi} \\ t_z = 0,06 \end{matrix}$$



2-2



$$N = 17,6 \text{ kN}$$

$$Q = 0$$

$$M = 73(x+2) - 73x = 146 \text{ kNm}$$

$$\sigma_{2\max} = \sigma_{1\max} = \pm 25 \text{ MPa}$$

$$\text{Para } x = 0, 2 \rightarrow \tau = 0$$

4-4



$$N = 80,16 \text{ kN}$$

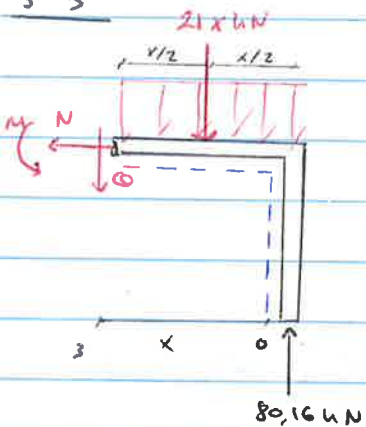
$$Q = 0$$

$$M = 0$$

$$\sigma_{4\max} = \frac{P}{A} = \frac{80,16 \cdot 10^3}{\frac{1}{2} \pi (0,2^2 - 0,14^2)} = -2,5 \text{ MPa}$$

$$\tau_4 = 0$$

3-3



$$N = 0$$

$$Q = 80,16 - 21x \xrightarrow{x=0} 80,16 \text{ kN (V}_{y\max})$$

$$M = 80,16x - \frac{21}{2}x^2 \xrightarrow{x=0} 146 \text{ kNm}$$

$$\sigma \text{ along } I_2: \sigma_{3\max} = \frac{146 \cdot 10^3 \cdot 0,2}{1,17 \cdot 10^{-3}} = \pm 24,9 \text{ MPa}$$

$$\tau \text{ along } V_{y\max}: \tau_{3\max} = \frac{80,16 \cdot 10^3 \cdot 2,55 \cdot 10^{-3}}{1,17 \cdot 10^{-3} \cdot 3 \cdot 0,06} = 1,45 \text{ MPa}$$

Área por seccionar: $\sigma_{\max} = \pm 25 \text{ MPa}$ en 1, 2, 3
 $\tau_{\max} = \pm 1,45 \text{ MPa}$ en 2 y 3

Project 70 -1.)

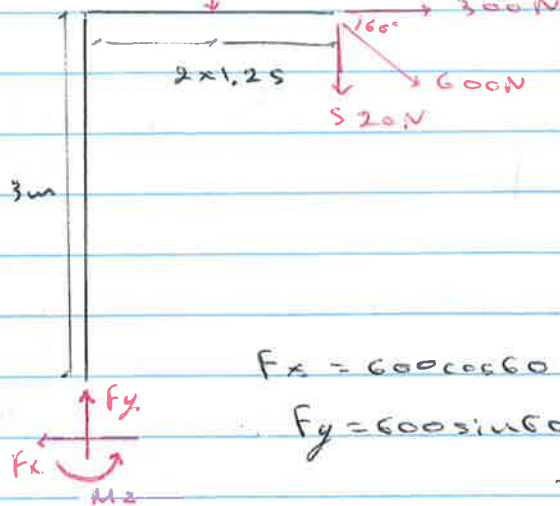
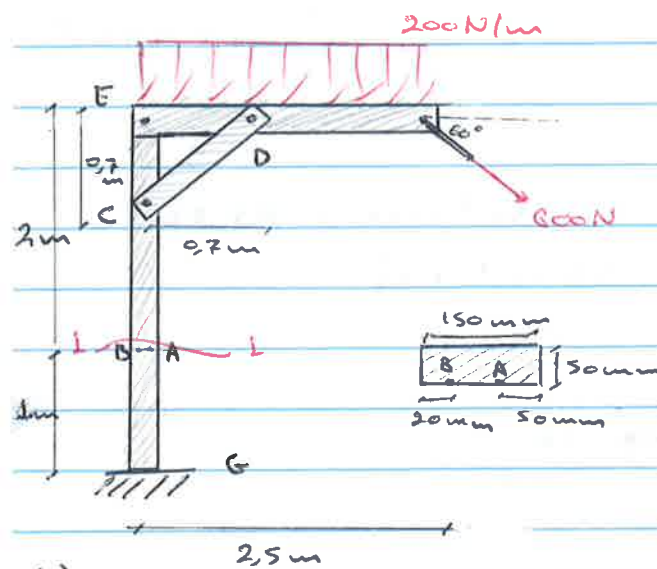
Raining, April 5
2018050055

$\epsilon_2 = 2$

$\epsilon_3 = 13$

$\sigma_{\text{cr. ed. m.}} = 81 \text{ MPa}$

$\sigma_{\text{cr. Cl.}} = 63 \text{ MPa}$



$$F_x = 600 \cos 60 = 300 \text{ N}$$

$$F_y = 600 \sin 60 + 200 \cdot 2.5 = 1020 \text{ N}$$

$$M_z = 520 \cdot 2.5 + 500 \cdot 1.25 + 300 \cdot 3$$

$$= 2825 \text{ Nm}$$

$$\frac{P}{A} = \frac{-1020}{0.15 \cdot 0.05} = -0.136 \text{ MPa (Cl. + m)}$$

$$\frac{M_y z}{I_y} = \frac{-2825 \cdot 0.025}{\frac{0.05 \cdot 0.15^3}{12}} = -4.64 \text{ MPa}$$

$$\sigma_{\text{cr. ed. m.}} = -0.136 - 4.64 = -4.64 \text{ MPa}$$

$$\sigma_{\text{cr. ed. m.}} = 4.64 \text{ MPa}$$

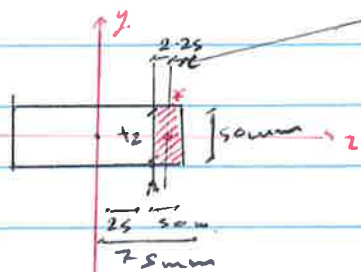
Diagramm in A

$$T_A = 0$$

$$V_A = T_A = 0$$

$$V_z = T_A = \frac{V_z @ z}{I_z + z} = \frac{300 \cdot 2.5 \cdot 10^3 \cdot 50 \cdot 10^{-3}}{(150 \cdot 10^{-3})^3 \cdot 50 \cdot 10^{-3} \cdot 50 \cdot 10^{-3}} = 53.3 \text{ MPa}$$

12



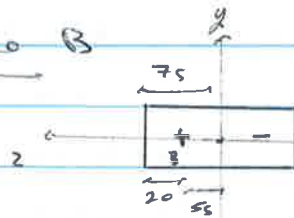
$$A^* = 50 \cdot 50 = 2.5 \cdot 10^{-3} \text{ m}^2$$

$$A_{\text{cr. ed. m.}} = 53.3 \text{ MPa}$$

$$\bar{z}^* = 50 \text{ mm}$$

$$I_z = \frac{150^3 \cdot 50}{12} = 1.4 \cdot 10^{-8}$$

Para o eixo B



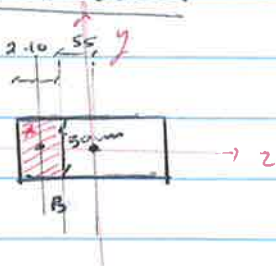
o.e. em

$$\frac{P}{A} = -0,136 \text{ MPa}$$

$$\sigma_z = \frac{M_z}{I_z} + \frac{2525 \cdot 0,055}{0,05 \cdot 0,02^3} = 9,87 \text{ MPa}$$

$$\sigma_{zB} = -0,136 + 9,87 = 9,7 \text{ MPa}$$

Diagrama

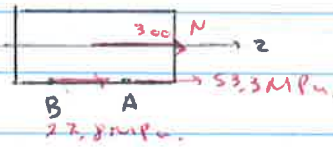


$$\tau_B = \frac{V_z \cdot z}{I_y \cdot t_y} = \frac{300 \cdot 10^{-3} \cdot 0,055}{1,4 \cdot 10^{-8} \cdot 0,05} = 27,8 \text{ MPa}$$

$$B^* = 0,02 \cdot 0,05 = 10^{-3} \text{ m}^2$$

$$\bar{z}^* = 50 + 10 = 60 \text{ mm}$$

$$t_y = 50 \text{ mm}$$



$$B) \sigma_{\text{ca. eixo}} = 81 \text{ MPa}$$

$$\sigma_{\text{ca. eixo}} = 63 \text{ MPa}$$

aviso em CD

$$\sum M_C = 0 \Rightarrow 0,7 F_{CD} \sin \phi + 300 \cdot 3 = 2825$$

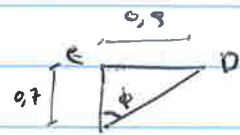
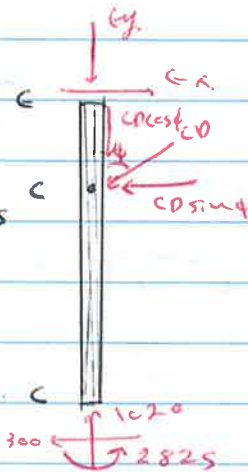
$$\Rightarrow F_{CD} = 3481 \text{ N} \approx 3,5 \text{ kN}$$



$$\sigma_{CD} = \frac{F_{CD}}{A} = \frac{3,5 \cdot 10^3}{7,5 \cdot 10^{-3}}$$

$$= 0,46 \text{ MPa} < 81 \text{ MPa} \quad \text{OK}$$

Dez polas ECG.



$$\tan \phi = \frac{0,9}{0,7}$$

$$\Rightarrow \phi = 52,1^\circ$$

$$\cos \phi = 0,61$$

$$\sin \phi = 0,79$$