

FORMULARIO

$$\epsilon = \frac{\delta}{L}$$

$$\delta = \frac{P}{A}$$

$$\delta = \int_0^L \frac{P}{AE} dx$$

$$\epsilon_r = \alpha (\Delta T)$$

$$\sigma = \epsilon \cdot E$$

$$\int p dF = \int p \tau dA = T$$

$$\gamma = \frac{\rho \theta}{L} \Rightarrow \frac{P}{C} = \gamma_{max}$$

$$\gamma_{max} = \frac{C \theta}{L}$$

$$\tau = \frac{P}{C} \gamma_{max} \Rightarrow$$

$$\tau_{max} > \tau_c$$

$$\tau = \alpha (AT) L$$

$$\theta = \frac{TL}{JG}$$

$$\tau_{max} = \frac{16T}{\pi d^3}$$

$$\tau_{xy} = G \gamma_{xy}$$

$$\sum M_0 = 0$$

$$A = \frac{\pi d^2}{4}$$

$$\frac{E}{2G} = 1 + \nu$$

$$\tau_{adm} = \frac{F_{vc}}{A}$$

DIONATAS SANTOS BRITO

① - ESPESSURA BC?

DIÂMETRO A :

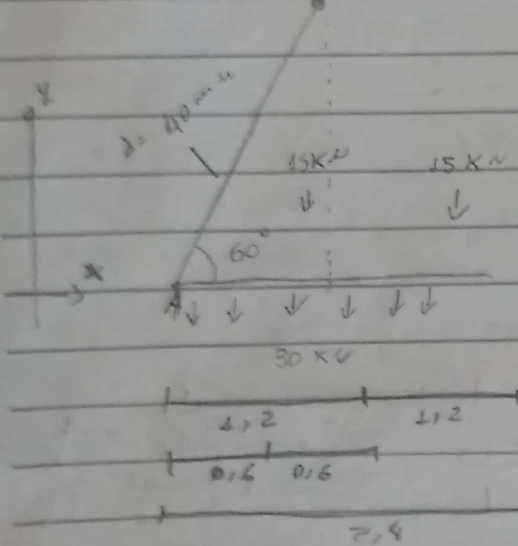
DIÂMETRO B :

$$\sigma = 200 \text{ MPa}$$

$$\tau_{adm} = 70 \text{ MPa}$$

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• PINO A



$$\sum M_a = 0$$

$$30 \text{ kN} \cdot 2.4 \cdot 1.2 - F_{BC} \cdot \sin 60 \cdot 2.4 = 0$$

$$30000 \cdot 1.2 = F_{BC} \sin 60$$

$$F_{BC} = \frac{30000 \cdot 1.2}{\sin 60}$$

$$F_{BC} = 41569.22 \text{ N}$$

$$\sum F_x = 0$$

$$F_{BC} \cdot \cos 60 - A_x = 0$$

$$= 41569.22 \cdot \cos 60 = A_x$$

$$A_x = 20784.61 \text{ N}$$

CISALHAMENTO
DUPLO

$$F = \sqrt{A_x^2 + A_y^2}$$

$$F_A = \sqrt{(36000)^2 + (20784.61)^2}$$

$$F_A = 41569.22 \text{ N}$$

$$V_A = V_B = F \cdot 2$$

$$\text{CISALHAMENTO SIMPLES} = V_B = \frac{F_{BC}}{2} = \frac{41569.22}{2}$$

$$V_B = 20784.61 = A_x$$

• PINO A

$$\tau_{adm} = \frac{F_{BC}}{A} \quad A = \frac{\pi d^2}{4}$$

$$d_A = \sqrt{\frac{4 \cdot F_{BC}}{\pi \cdot \tau_{adm}}}$$

$$d_A = \sqrt{\frac{4 \cdot 41569.22}{\pi \cdot 70 \cdot 10^6}}$$

$$d_A = 0.027 \text{ m}$$

• PINO B

$$\tau_{adm} = \frac{F_{BC}}{2A} \quad A = \frac{\pi d^2}{4}$$

$$d_B = \sqrt{\frac{2 \cdot F_{BC}}{\pi \cdot \tau_{adm}}}$$

$$d_B = \sqrt{\frac{2 \cdot 41569.22}{\pi \cdot 70 \cdot 10^6}}$$

$$d_B = 0.019 \text{ m}$$

D	S	T	Q	Q	S	S
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ESPESSURA

$$P_{max} = 200 \text{ MP}$$

PAG 2

$$F_{bc} = 41569,22 \text{ N}$$

$$P_{max} = \frac{F_{bc}}{A_{bc}}$$

$$A_{bc} = (0,04 - 2B) \cdot l = (0,04 - 0,039) l = (0,021) l$$

$$200 \cdot 10^6 = \frac{41569,22}{0,021 l}$$

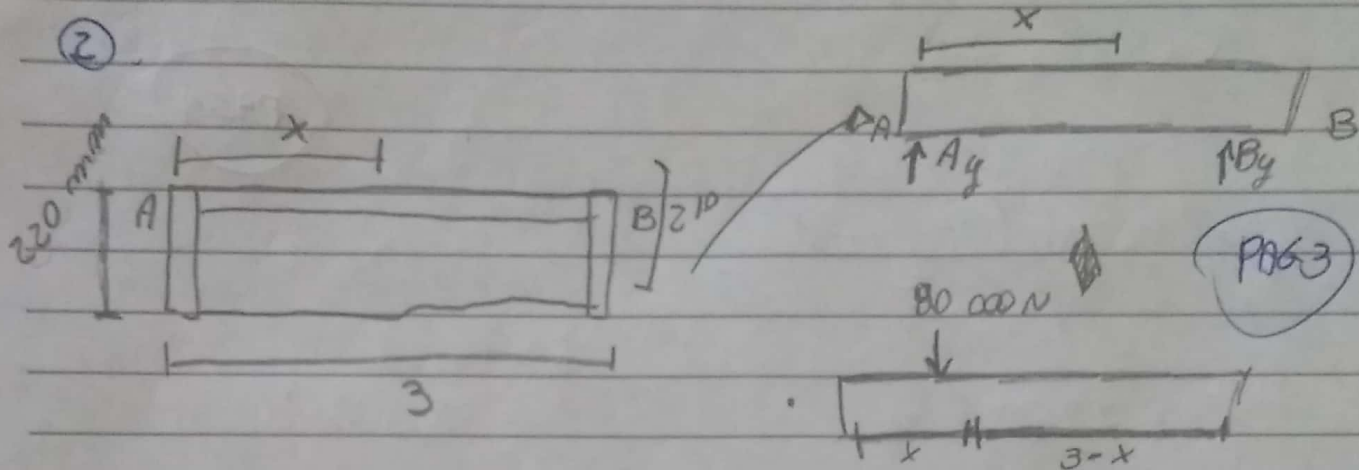
$$l = 9,89 \cdot 10^{-3}$$

$$l = \frac{41569,22}{200 \cdot 10^6 \cdot 0,021}$$

$$\# (0,04 - 2B) \cdot l$$

→ espessura do parafuso

$$(DIÂMETRO DA BARRA - DIÂMETRO DO PARAFUSO)$$



$$\sum M_A = 0$$

$$\sum M_B = 0$$

$$3F_B - 80 \cdot x = 0$$

$$F_B = \frac{80x}{3}$$

$$B_y = F_B$$

$$-3F_A + 80(3-x) = 0$$

$$-3F_A + 240 - 80x = 0$$

$$3F_A = 240 - 80x$$

$$F_A = \frac{(240 - 80x)}{3}$$

$$A_y = F_A$$

$$\delta = E \cdot \epsilon \quad \epsilon = \frac{\delta}{L} \quad \delta = \frac{P}{A}$$

$$\frac{P}{A} = E \cdot \frac{\delta}{L}$$

$$\text{na Horizontal } \delta_A = \delta_B$$

$$\delta = \frac{PL}{AE}$$

$$\left(\frac{PL}{AE} \right)_A = \left(\frac{PL}{AE} \right)_B$$

$$\frac{220(240 - 80x)}{3} = \frac{80x \cdot 220}{3}$$

$$32800 - 17600x = 16800x$$

$$32800 = 34400x$$

$$x = \frac{32800}{34400}$$

$$x = 1,53 \text{ m}$$

com $x = 1,53 \text{ m}$

P964

80 kN ↓

$$F_A = \frac{80.000 (3 - 1,53)}{3}$$

$$F_A = 39200 \text{ N}$$

$$E = 73,16$$

$$= 73,1 \cdot 10^9$$

$$\sigma_A = \frac{F_A}{A} \quad A = \frac{\pi d^2}{4}$$

$$\sigma_A = \frac{39200 \cdot 4}{\pi (0,03)^2} = 55456655,73 \approx 55,4 \cdot 10^6 \text{ Pa}$$

$$\epsilon = \frac{\sigma_A}{E} \rightarrow - \left(\frac{55456655,73}{73,1 \cdot 10^9} \right) = -7,58 \cdot 10^{-4}$$

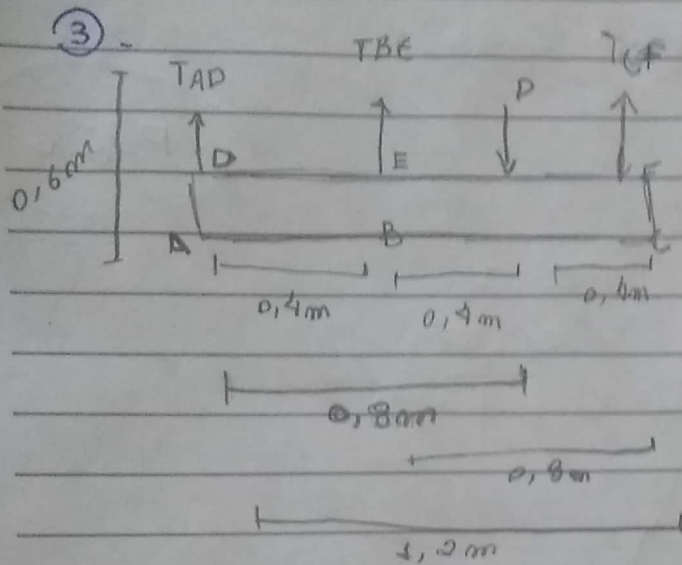
$$\epsilon_T = \nu \cdot \epsilon \quad \epsilon_T = -0,35 (-7,58 \cdot 10^{-4}) \quad \epsilon_T = 2,65 \cdot 10^{-4}$$

$$d' = d_A + d \cdot \epsilon_T \rightarrow d' = 30 + 30 (2,65 \cdot 10^{-4})$$

$$d' = 30,0079 \text{ mm}$$

Horizontal = Deflection = Neg

D	S	Y	Q	Q	S	S
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$$P = 230 \text{ kN}$$

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$$\sum M_A = 0$$

$$\sum F_y = 0$$

$$T_{CF} \cdot 1,2 - 0,8P + 0,4 T_{BE} = 0$$

$$T_{AD} + T_{BE} - P + T_{CF} = 0$$

$$T_{AD} + T_{BE} + T_{CF} = 230 \text{ kN}$$

$$1,2 T_{CF} + 0,4 T_{BE} = + 0,8 \cdot 230 \text{ kN}$$

$$1,2 T_{CF} + 0,4 T_{BE} = 184 \text{ kN}$$

$$\delta_{BE} = \delta_{AD} + \left(\frac{\delta_{CF} - \delta_{AD}}{1,2} \right) 0,4$$

$$T_{BE} = \frac{2}{3} \left(\frac{T_{AD} L}{AE} \right) + \frac{1}{3} \left(\frac{T_{CF} L}{AE} \right)$$

$$T_{BE} = \frac{2}{3} T_{AD} + \frac{1}{3} T_{CF}$$

... continuando (utilizando algebra linear)

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$$L_2 - \left(\frac{2}{3}\right) L_1 \rightarrow L_2$$

$$\begin{pmatrix} 2/3 & -1 & 1/3 & 0 \\ 0 & 5/2 & 1/2 & 230000 \\ 0 & 0 & 28/25 & 147200 \end{pmatrix} \begin{matrix} = 0 \\ = 230000 \\ = 184000 \end{matrix}$$

$$= \begin{pmatrix} 2/3 & -1 & 1/3 & 0 \\ 0 & 5/2 & 1/2 & 230000 \\ 0 & 2/5 & 6/5 & 184000 \end{pmatrix} \left(\begin{matrix} -4 \\ 25 \end{matrix} \right) L_1 - \left[\frac{4}{25} \right] L_2 \rightarrow L_3$$

$$= \begin{pmatrix} 2/3 & -1 & 1/3 & 0 \\ 0 & 5/2 & 1/2 & 230000 \\ 0 & 0 & 28/25 & 147200 \end{pmatrix} \begin{matrix} \textcircled{1} \\ \textcircled{2} \\ \textcircled{3} \end{matrix}$$

③

$$\frac{28}{25} TCF = 147200$$

$$TCF = \frac{147200 \cdot 25}{28} = \frac{920000}{7} = 131428,57 N$$

$$\textcircled{2} - \frac{5}{2} TBE + \frac{1}{2} TCF = 230000$$

$$\frac{5}{2} TBE = \left(230000 - \frac{1}{2} \cdot \frac{920000}{7} \right) \cdot \frac{2}{5}$$

$$TBE = \frac{1150000}{7} \cdot \frac{2}{5} \quad \text{B} TBE = 65714,28 N$$

$$TBE = \frac{460000}{7}$$

continua

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$$\frac{2}{3} TAD = TBE - \frac{1}{3} TCF \rightarrow \frac{46000}{7} - \frac{1}{3} \left(\frac{92000}{7} \right) = \frac{2}{3} TAD$$

$$TAD = \frac{3}{2} \cdot \left[\frac{46000}{21} \right]$$

$$TAD = \frac{230000}{7} = 32857,14 \text{ N}$$

$$A = \frac{\pi d^2}{4}$$

$$\begin{cases} TAD = FAD \\ TBE = FBE \\ TCF = FCF \end{cases}$$

$$\sigma_{CF} = \frac{F_{CF}}{A_{CF}} = \frac{131428,57 \cdot 4}{\pi (0,025)^2} = 267,74 \cdot 10^6 \text{ Pa} =$$

$$\sigma_{BE} = \frac{F_{BE}}{A_{BE}} = \frac{65714,29 \cdot 4}{\pi (0,025)^2} = 133,87 \cdot 10^6 \text{ Pa}$$

$$\sigma_{AD} = \frac{F_{AD}}{A_{AD}} = \frac{32857,14 \cdot 4}{\pi (0,025)^2} = 66,94 \cdot 10^6 \text{ Pa}$$

comparando com o σ dado no enunciado ($= 250 \text{ MPa}$)
a análise elástica para FCF, pois $\sigma = 267,74 \text{ MPa}$
superior ao enunciado

para ser válida devemos calcular novamente utilizando a data de enunciado

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$$F_{cf} = \sigma_e \cdot A \rightarrow \frac{\pi d^2}{4}$$

$$F_{cf} = \frac{230\,000\,000}{4} \cdot \left[\pi \cdot (0,025)^2 \right] = 122\,718,46\,N$$

como F_{AD} e F_{BE} foram encontrados usando o valor anterior de F_{cf} , devemos calcular novamente:

$F_{BE}?$

$$0,4 \cdot F_{BE} = -1,2 F_{cf} + 184\,000$$

$$F_{BE} = \frac{-1,2 \cdot 122\,718,46 + 184\,000}{0,4}$$

$$F_{BE} = +918\,44,61\,N$$

$F_{AD} = ?$

$$F_{AD} + F_{BE} + F_{cf} = 230\,000$$

$$F_{AD} = -F_{BE} - F_{cf} + 230\,000$$

$$F_{AD} = -91844,61 - 122\,718,46 + 230\,000$$

$$F_{AD} = +15\,436,93\,N$$

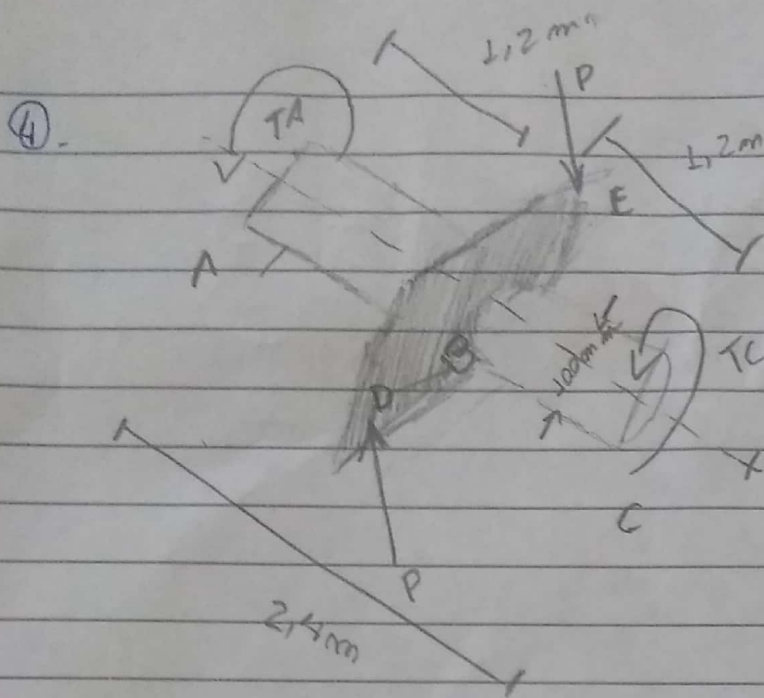
... continuando

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$$\sigma_{BE} = \frac{F_{BE}}{A_{BE}} \Rightarrow \frac{91844,61 \cdot 4}{\pi (0,025)^2} = 187,10 \cdot 10^6 \text{ Pa}$$

$$\sigma_{AD} = \frac{F_{AD}}{A_{AD}} \Rightarrow \frac{15436,96 \cdot 4}{\pi (0,025)^2} = 31,45 \cdot 10^6 \text{ Pa}$$

$$\left. \begin{array}{l} 250 \text{ MPa} = \sigma_{CF} \\ 187 \text{ MPa} = \sigma_{BE} \\ 31,45 \text{ MPa} = \sigma_{AD} \end{array} \right\} \checkmark$$



DADOS

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$$G_a = 75 \text{ GPa}$$

$$G_{ol} = 26 \text{ GPa}$$

$$P =$$

$$\sum M_x = 0$$

$$\phi_{B/A} = \phi_{B/C}$$

$$T_A + T_C - 1,6P = 0$$

$$T_C = 1,6P - T_A$$

$$\frac{T_A L_{AB}}{J G_{ol}} = \frac{T_C L_{BC}}{J G_{ol}}$$

$$\frac{T_A L_A}{26 \cdot 10^9} = \frac{T_C L_C}{75 \cdot 10^9}$$

• Resolviendo

$$T_A = 0,34 T_C$$

$$T_A = T_C \cdot \frac{26}{75}$$

$$T_A = 0,34 (1,6P - T_A)$$

$$T_A = 0,34 T_C$$

$$T_A + 0,34 T_A = 0,544P$$

$$T_A = \frac{0,544P}{1,34}$$

$$T_A = 0,4P$$

$$T_C = 1,6P - T_A$$

$$T_C = 1,6P - 0,4P$$

$$T_C = 1,2P$$

Alumínio

$$\tau_{\text{alum}} = 90 \cdot 10^6 \text{ Pa}$$

$$\gamma_{\text{max}} = \frac{T_{AC}}{J}$$

$$90 \cdot 10^6 = \frac{0,4P(0,05)}{\frac{\pi}{2} \cdot (6,25 \cdot 10^{-6})} = 44\,178,65 = P$$

$$P = \frac{883,57}{0,05 \cdot 0,4}$$

DESCARTADO

Aço

$$120 \cdot 10^6 = \frac{1,2P(0,05)}{\frac{\pi}{2} \cdot (6,25 \cdot 10^{-6})} = 19\,634,95 = P$$

$$P = \frac{11\,78,09}{1,2 \cdot (0,05)}$$

CONTROLADO

$$\therefore P = 19\,634,95 \approx 19,63 \text{ K}$$