

Cap 8

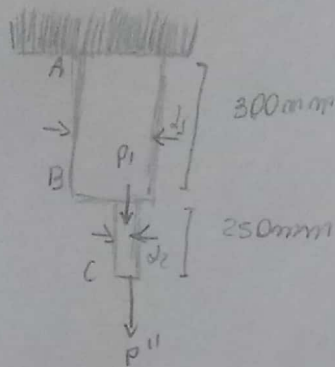
8.1

$$d_1 = 50 \text{ mm}$$

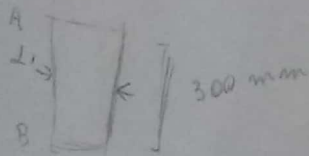
$$d_2 = 30 \text{ mm}$$

$$P' = 40 \text{ kN}$$

$$P'' = 30 \text{ kN}$$



a) barra AB



$$P = P' + P''$$

$$P = 40 \text{ kN} + 30 \text{ kN}$$

$$P = 70 \text{ kN}$$

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

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

$$A = \frac{\pi}{4} \cdot (0,05)^2$$

$$A = 1,96 \cdot 10^{-3} \text{ m}^2$$

$$\tau_{med} = \frac{P}{A}$$

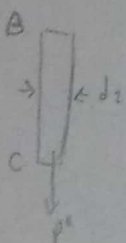
$$\tau_{med} = \frac{70 \cdot 10^3}{1,96 \cdot 10^{-3}}$$

$$= \frac{70 \cdot 10^3 \cdot 10^3}{1,96}$$

$$= 35,7 \cdot 10^6 \text{ Pa}$$

$$\tau_{med} = 35,7 \cdot 10^6 \text{ Pa}$$

b) barra BC



$$P = P''$$

$$P = 30 \text{ kN}$$

$$A = \frac{\pi}{4} \cdot (0,03)^2$$

$$A = 7,07 \cdot 10^{-4} \text{ m}^2$$

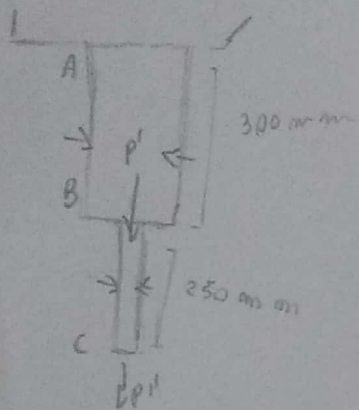
$$\tau_{med} = \frac{P}{A}$$

$$= \frac{30 \cdot 10^3}{7,07 \cdot 10^{-4}}$$

$$= \frac{30 \cdot 10^3 \cdot 10^4}{7,07}$$

$$= 4,24 \cdot 10^7 \text{ Pa}$$

8.2



$$d_1 = ?$$

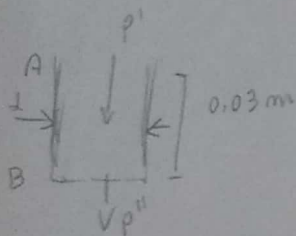
$$d_2 = ?$$

$$\tau = 140 \text{ MPa}$$

$$P' = 40 \text{ kN}$$

$$P'' = 30 \text{ kN}$$

a) em AB



$$P = P' + P''$$

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

$$P = 40 \text{ kN} + 30 \text{ kN}$$

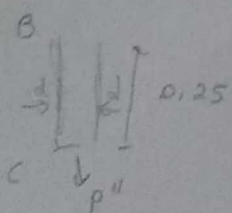
$$P = 70 \text{ kN}$$

$$\tau = \frac{P}{\frac{\pi}{4} d^2} \rightarrow d^2 = \frac{P}{\frac{\pi}{4} \cdot \tau} \rightarrow d^2 = \frac{70 \cdot 10^3}{\frac{\pi}{4} \cdot 140 \cdot 10^6} \Rightarrow d = \sqrt{\frac{70 \cdot 10^3}{\frac{\pi}{4} \cdot 140 \cdot 10^6}}$$

$$d = \sqrt{6,4 \cdot 10^{-4}}$$

$$d = 0,025 \text{ m}$$

b) em BC



$$P = P''$$

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

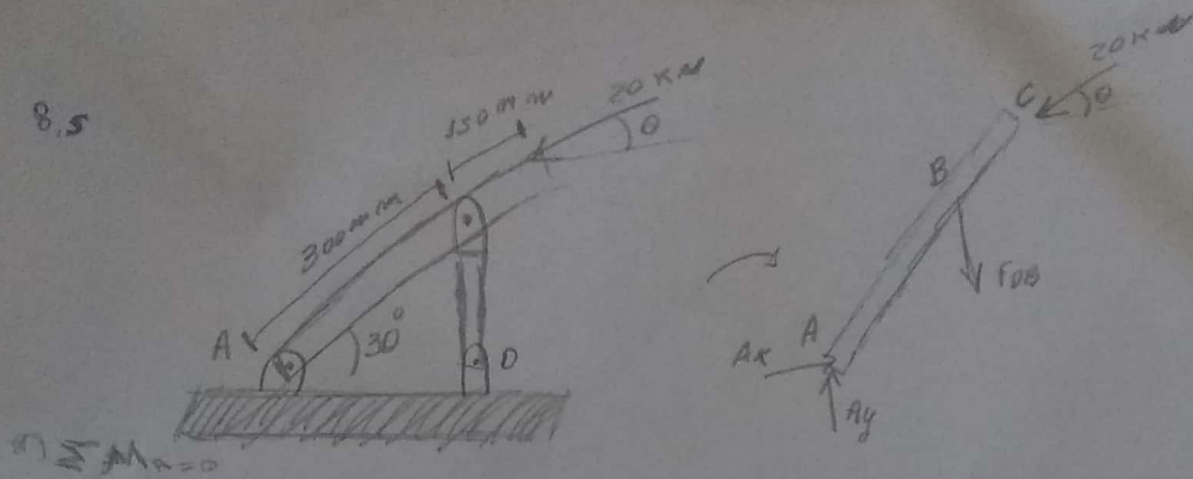
$$P = 30 \text{ kN}$$

$$\tau = \frac{P}{A} \rightarrow \tau = \frac{P}{\frac{\pi}{4} d^2} \rightarrow d^2 = \frac{P}{\frac{\pi}{4} \cdot \tau}$$

$$d = \sqrt{\frac{30 \cdot 10^3}{\frac{\pi}{4} \cdot 140 \cdot 10^6}}$$

$$d = 0,016 \text{ m}$$

8,5



$$a) \theta = 0^\circ$$

$$(0,450 \cdot \sin 30^\circ)(20 \cdot 10^3) - (0,300 \cos 30^\circ) F_{BD} = 0$$

$$F_{BD} = \frac{0,450 \cdot \sin 30^\circ \cdot 20 \cdot 10^3}{0,300 \cdot \cos 30^\circ}$$

$$F_{BD} = 17320,51 \text{ N} \quad \rightarrow \text{Tensão}$$

$$b) \theta = 90^\circ$$

$$(0,450 \cdot \cos 30^\circ)(20 \cdot 10^3) - (0,300 \cdot \cos 30^\circ) F_{BD} = 0$$

$$F_{BD} = \frac{0,450 \cdot \cos 30^\circ \cdot 20 \cdot 10^3}{0,300 \cdot \cos 30^\circ}$$

$$F_{BD} = 29910,27 \text{ N} \quad \rightarrow \text{compressão}$$

Ate0

A → Tensão corrigida

$$A = (0,030 - 0,010)(0,012)$$

$$A = 240 \cdot 10^{-6} \text{ m}^2 //$$

b → compressão

$$A = (0,030) \cdot (0,012)$$

$$A = 360 \cdot 10^{-6} \text{ m}^2 //$$

Tensão

$$a) \rightarrow \tau = \frac{F_{BD}}{A}$$

$$\tau = \frac{17320,51}{240 \cdot 10^{-6}}$$

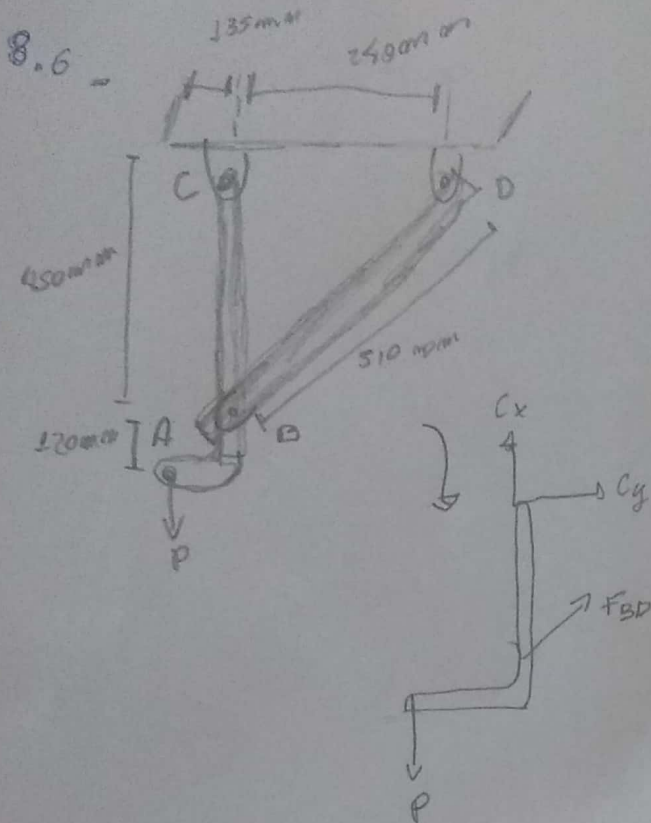
$$\tau = 7,2 \cdot 10^5 \text{ Pa}$$

$$b) \rightarrow \tau = F_{BD}$$

$$\tau = \frac{29910,27}{360 \cdot 10^{-6}}$$

$$\tau = 8,308 \cdot 10^5 \text{ Pa}$$





Dados

$$Area_{BD} = 800 \text{ mm}^2 = A_{BD}$$

$$P = ?$$

$$\tau = 50 \text{ MPa}$$

$$F_{BD} \Rightarrow \tau = \frac{F_{BD}}{A}$$

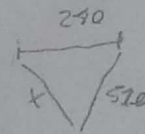
$$F_{BD} = \tau \cdot A$$

$$= 800 \cdot 10^{-6} \cdot 50 \cdot 10^6$$

$$= 4 \cdot 10^4 \text{ N}$$

$$\sum M_C = 0$$

(L.B.D.)



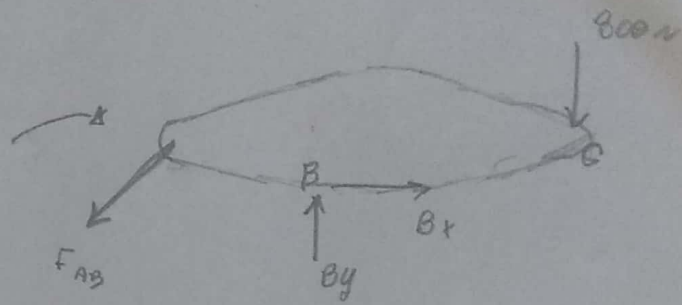
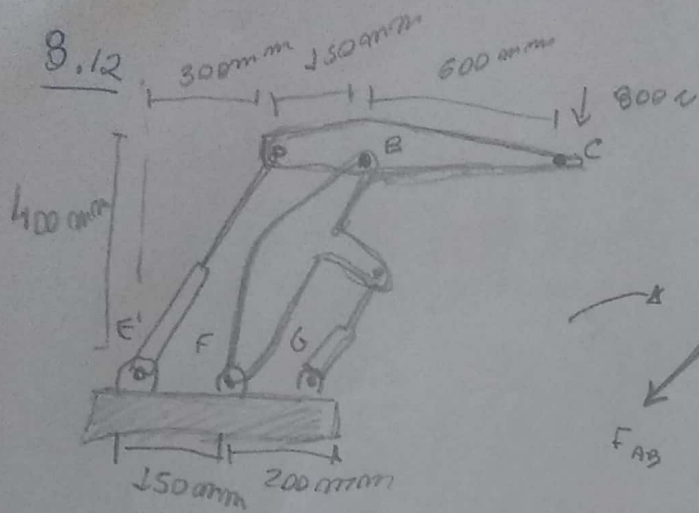
$$x = \frac{240}{510}$$

$$\sum M_C = 0$$

$$(0,450) \cdot \frac{240}{510} \cdot F_{BD} - 0,135 \cdot P = 0$$

$$P = \frac{0,450 \cdot 0,47 \cdot 40 \cdot 10^3}{0,135}$$

$$P = 62666,67 \text{ N}$$



$\sum M_B = 0$

$$(0,150) \cdot \frac{4}{5} \cdot F_{AE} - (0,600) \cdot (800) = 0$$

$$F_{AE} = \frac{0,600 \cdot 800 \cdot 5}{0,150 \cdot 4}$$

$$F_{AE} = 4000 \text{ N}$$

Dadas

$$\text{Area} = \frac{\pi}{4} \cdot d^2$$

$$= \frac{\pi}{4} \cdot (20 \cdot 10^{-3})^2$$

$$= 3,14 \cdot 10^{-4} \text{ m}^2$$

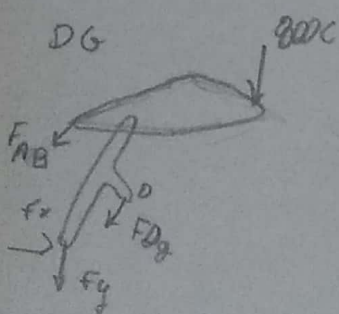
a)

$$\tau = \frac{F_{AE}}{A}$$

$$\tau = \frac{4000}{3,14 \cdot 10^{-4}}$$

$$\tau = 12,732395,45 \text{ Pa} = 12,73 \cdot 10^6 \text{ Pa}$$

b)



$$A = \frac{\pi}{4} \cdot d^2 = \frac{\pi}{4} \cdot (20 \cdot 10^{-3})^2 = 3,14 \cdot 10^{-4} \text{ m}^2$$

$\sum M_F = 0$

$$(0,150) \cdot \left(\frac{4}{5} \cdot F_{AE}\right) - (0,200) \left(\frac{4}{5} \cdot F_{FG}\right) - (1,050 - 0,350) \cdot 800 = 0$$

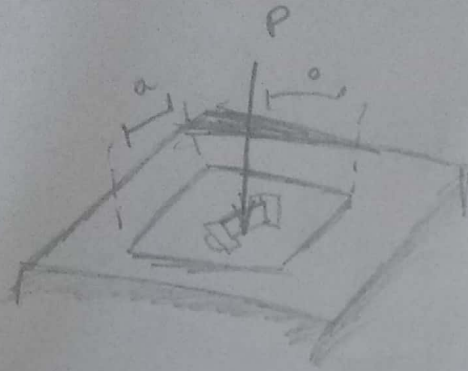
$$F_{FG} = \frac{0,150 \cdot 0,8 \cdot F_{AE} - (1,050 - 0,350) \cdot 800}{0,200 \cdot \frac{4}{5}}$$

$$\tau = \frac{F_{FG}}{A} = \frac{-1500}{3,14 \cdot 10^{-4}}$$

$$\tau = -4,77 \cdot 10^6 \text{ Pa}$$

$$F_{FG} = -1500 \text{ N}$$

8.17



$$\tau_{med} = \frac{P}{A}$$

$$P = \tau_{med} \cdot A$$

$$P = 150 \cdot 10^6 \cdot 8580 \cdot 10^{-3}$$

$$P = 1287 \cdot 10^{13} \text{ N}$$

dados

$$A = 8580 \text{ mm}^2 = 8580 \cdot 10^{-3} \text{ m}^2$$

$$\tau_{m} = 150 \text{ MPa}$$

$$\text{alongamento max} = 12,5 \text{ Pa} = \tau_b$$

$$a = ? = d$$

$$\text{area} = a \cdot a = a^2$$

$$\tau_b = \frac{P}{a^2}$$

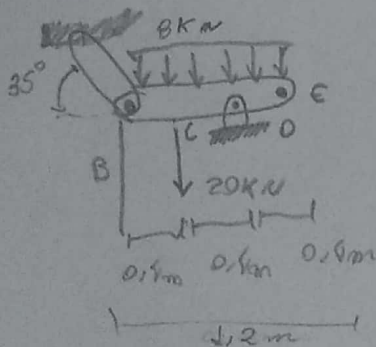
$$a^2 = \frac{P}{\tau_b}$$

$$a = \sqrt{\frac{P}{\tau_b}}$$

$$a = \sqrt{\frac{1287 \cdot 10^{13}}{12,5 \cdot 10^6}}$$

$$a = 3,08 \cdot 10^{-4} \text{ m}^2$$

8.33

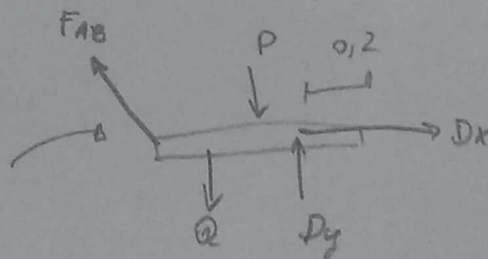


$$P = (1,2 \cdot 8 \text{ kN})$$

$$P = 9,6 \text{ kN}$$

$$\tau_{AB} = \frac{F_{AB}}{A_{AB}} \leq \frac{\tau_c}{CS}$$

$$A_{AB} = \frac{CS \cdot F_{AB}}{\tau_c} = \frac{3,50 \cdot 21,62}{450 \cdot 10^6} = 1,68 \cdot 10^{-7} \text{ m}^2$$



dados

$$= \text{Limite Tensão} = 450 \text{ MPa} = \tau_c$$

$$CS = \text{coeficiente de segurança} = 3,50$$

$$+\circlearrowleft M_D = 0$$

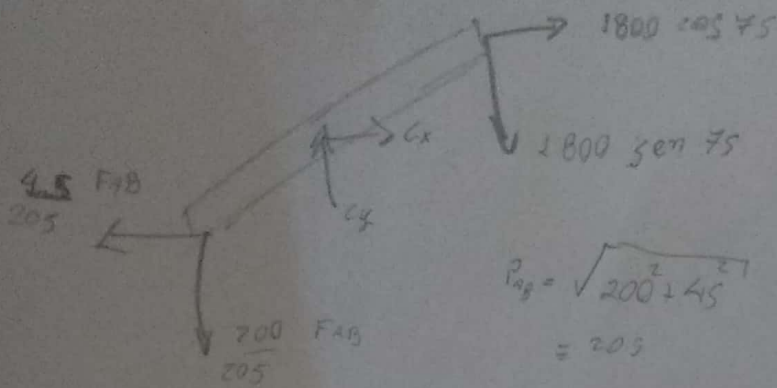
$$-(0,8)(F_{AB} \sin 35^\circ) + (0,2)(9,6) + (0,4 \cdot 20) = 0$$

$$F = \frac{0,2 \cdot 9,6 + (0,4 \cdot 20)}{0,8 \cdot \sin 35^\circ}$$

$$F_{AB} = 21,62 \text{ N}$$



B.22



$\sum M_C = 0$

$$(0,10 \cos 70) \left( \frac{700}{205} F_{AB} \right) - (0,10 \sin 20) \left( \frac{45}{205} F_{AB} \right) - (0,25 \cos 20) \cdot (1800 \sin 75) - (0,175 \sin 20) \cdot (1800 \cos 75) = 0$$

$$0,091 F_{AB} - 1,31 \cdot 10^{-4} F_{AB} - 1225,36 - 27,88 = 0$$

$$0,0908 F_{AB} = 1253,24$$

$$F_{AB} = 13802,20 \text{ N}$$

$\sum F_x = 0$

$$-\frac{45}{205} F_{AB} + C_x + 1800 \cos 75 = 0$$

$$C_x = \frac{45}{205} F_{AB} - 1800 \cos 75$$

$$C_x = 2563,07 \text{ N}$$

$$C = \sqrt{C_x^2 + C_y^2}$$

$$C = 5413,907 \text{ N}$$

$\sum F_y = 0$

$$-\frac{45}{205} F_{AB} + C_y - 1800 \sin 75 = 0$$

$$C_y = 4768,42 \text{ N}$$

a)

$$A = \frac{\pi d^2}{4} = \frac{\pi}{4} \left( \frac{0,075}{0,020} \right)^2 = 11,04 \text{ cm}^2$$

$$\tau = \frac{P}{A} = \frac{5413,907}{11,04}$$

$$\tau = 490,397 \text{ Pa}$$

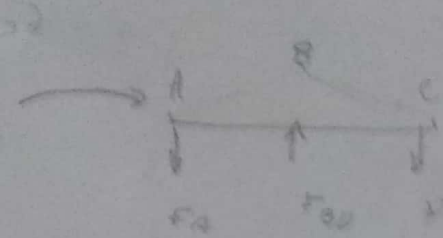
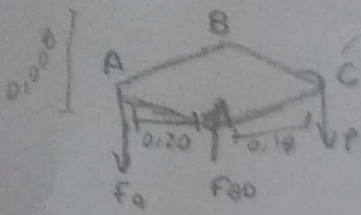
b) BCD

$$A_k \cdot L \cdot \tau = \left( \frac{0,075}{0,020} \right) \left( \frac{0,120}{0,020} \right) = 22,5 \text{ mm}$$

$$= 0,0225 \text{ m}$$

$$\tau = \frac{P}{A_k} = \frac{5413,907}{0,0225} = 24062,16 \text{ Pa}$$

8.43



$\sigma_{\text{tension}}$   
 $\sigma = \frac{F}{A}$   
 $\sigma_B = \frac{F_B}{A} = 100 \text{ MPa}$   
 $T_C = T_B = 100 \text{ MPa} = T_{\text{tension}}$   
 $T_{\text{tension}} = 100 \text{ MPa}$   
 $P = ?$   
 $F_{\text{tension}} = 100 \text{ MPa} \times A$

1)  $M_B = 0$

$+F_A \cdot d - P \cdot l = 0$

$F_A \cdot 0.20 = P \cdot 0.30$

$P = \frac{0.20 \cdot F_A}{0.30}$

$P = 1.1 F_A$

2)  $\sum M_A = 0$

$+F_B \cdot d - P \cdot l = 0$

$F_B \cdot 0.20 = P \cdot 0.30$

$P = \frac{0.20 \cdot F_B}{0.30}$

$P = 0.53 F_B$

PRIMO A

$A = \frac{\pi}{4} \cdot d^2 = \frac{\pi}{4} \cdot (0.008)^2$

$A = 5.03 \cdot 10^{-5}$

$F_A = 2 \cdot \frac{T_C \cdot A}{F.S} = 2 \cdot \frac{100 \cdot 10^6 \cdot 5.03 \cdot 10^{-5}}{3}$

$F_A = 2 \cdot \frac{100 \cdot 5.03}{3}$

$F_A = 335.33 \text{ N}$

PRIMO BD (axial tension)

$A = \frac{\pi}{4} \cdot d^2 = \frac{\pi}{4} \cdot (0.012)^2 = 113 \cdot 10^{-6}$

$F_B = 2 \cdot \frac{T_C \cdot A}{F.S} = 2 \cdot \frac{100 \cdot 10^6 \cdot (113 \cdot 10^{-6})}{3} = 2540 \text{ N}$

$P = 0.53 \cdot F_B$

$P = 0.53 \cdot 2540$

$P = 3996.2 \text{ N}$

$P = 1.1 \cdot 335.33$

$P = 368.86$

many value

PRIMO BD (compressor)

$A = (0.020) \cdot (0.008) = 160 \cdot 10^{-6}$

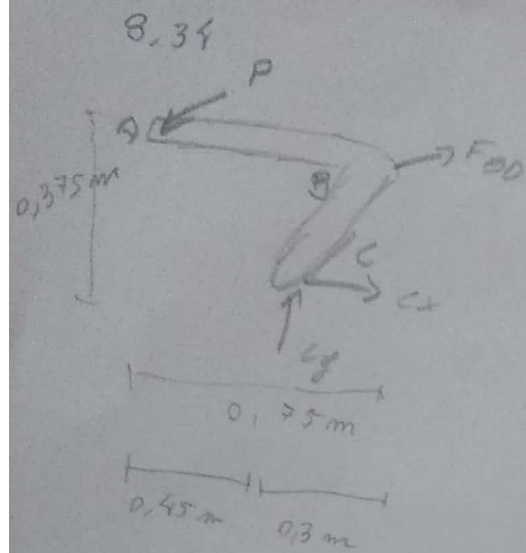
$F_B = 2 \cdot \frac{T_C \cdot A}{F.S} = 2 \cdot \frac{250 \cdot 10^6 \cdot 160 \cdot 10^{-6}}{3} = 26666.67 \text{ N}$

$P = 0.53 \cdot F_B$

$= 0.53 \cdot 26666.67$

$= 14133.33 \text{ N}$





$$\sum M_C = 0$$

$$P = 18 \text{ k}$$

$$F_C = 113 \text{ k} = \text{carga limite}$$

$$(P \cos 40^\circ)(0.75) + (P \sin 40^\circ)(0.375) - (F_{BD} \sin 30^\circ)(0.3) = 0$$

$$0.57P + 0.24P - F_{BD} \cdot 0.15 = 0$$

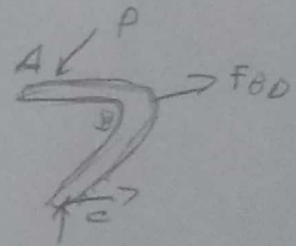
$$F_{BD} = \frac{0.81P}{0.15}$$

$$F_{BD} = 5.4 \cdot 18 \text{ kN}$$

$$F_{BD} = 97.2 \text{ kN}$$

\* fator de segurança BD

$$FS = \frac{F_C}{F_{BD}} = \frac{113 \text{ kN}}{97.2 \text{ kN}} = 1.16$$



$$0.35 - (P \cos 40^\circ)(0.75) + P \sin 40^\circ \cdot (0.375) - (F_{BD} \cos 30^\circ)(\sin 0.375) - (F_{BD} \sin 30^\circ)(0.3)$$

$$0.157P + P \cdot 0.124 - F_{BD} \cdot 5.167 \cdot 10^{-3} - F_{BD} \cdot 0.15 = 0$$

$$0.181P = 0.15562 F_{BD}$$

$$P = 0.19 F_{BD}$$

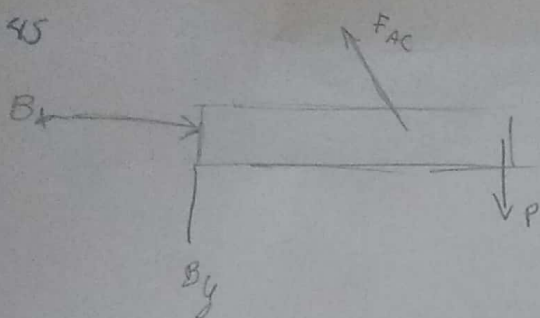
$$P = 0.19 \cdot 97.413,79$$

$$P = 18.509.62 \text{ N}$$

BD

$$F_{BD} = \frac{113 \text{ kN}}{1.16} = 97.413,79 \text{ kN}$$

8,45



$$+\uparrow M_B = 0$$

$$(0,15) + \left( \frac{0,20}{0,25} \right) \cdot F_{AC} - 0,25 P = 0$$

$$P = \frac{0,12 F_{AC}}{0,25} = 0,48 \cdot F_{AC}$$

em Y

$$\rightarrow \sum F_y = 0$$

$$B_y - \frac{0,20}{0,25} \cdot F_{AC} = 0$$

$$+\uparrow M_C = 0$$

$$- 0,15 B_y - 0,10 P = 0$$

$$B_x = \frac{0,8 F_{AC}}{0,48} = 1,67 P$$

$$B_y = \frac{0,10 P}{0,15}$$

$$B_y = 0,67 P$$

$$B_y = \frac{0,10 P}{0,15}$$

$$B = \sqrt{B_x^2 + B_y^2} \cdot P$$

$$B = \sqrt{1,67^2 + 0,67^2} \cdot P$$

$$B = 1,8 P$$

$$F_{AC} = \tau \cdot A = \frac{\tau_c}{F_s} \left( \frac{\pi}{4} \cdot d^2 \right) = \frac{173000}{3,25} \cdot \frac{\pi}{4} \cdot \left( \frac{0,075}{0,20} \right)^2 = 5879,6 \text{ N}$$

$$F_{AC} = \tau \cdot A = \frac{\tau_c}{F_s} = \frac{450000}{3,25} \cdot \left( \frac{0,025}{0,10} - \frac{0,075}{0,20} \right) = 17307,69$$

$$P = 0,48 \cdot 17307,69$$

$$P = 8307,692 \text{ N}$$

$$B = \tau A = \frac{\tau_c}{F_s} \cdot \frac{\pi}{4} d^2$$

$$\frac{173000}{3,25} \cdot \frac{\pi}{4} \cdot \left( \frac{0,127}{0,106} \right)^2 = 4082,75 \text{ N}$$

$$P = 0,016 \cdot 4082,75$$

$$P = 69397,29 \text{ N}$$