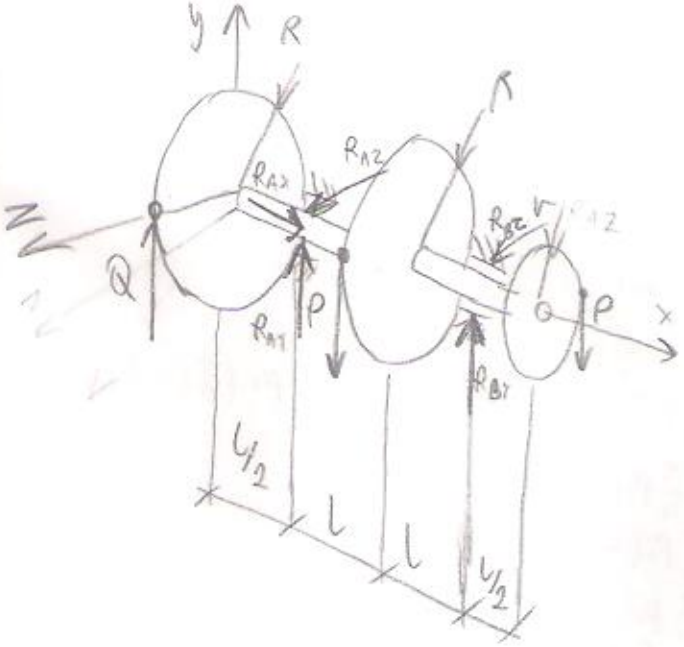
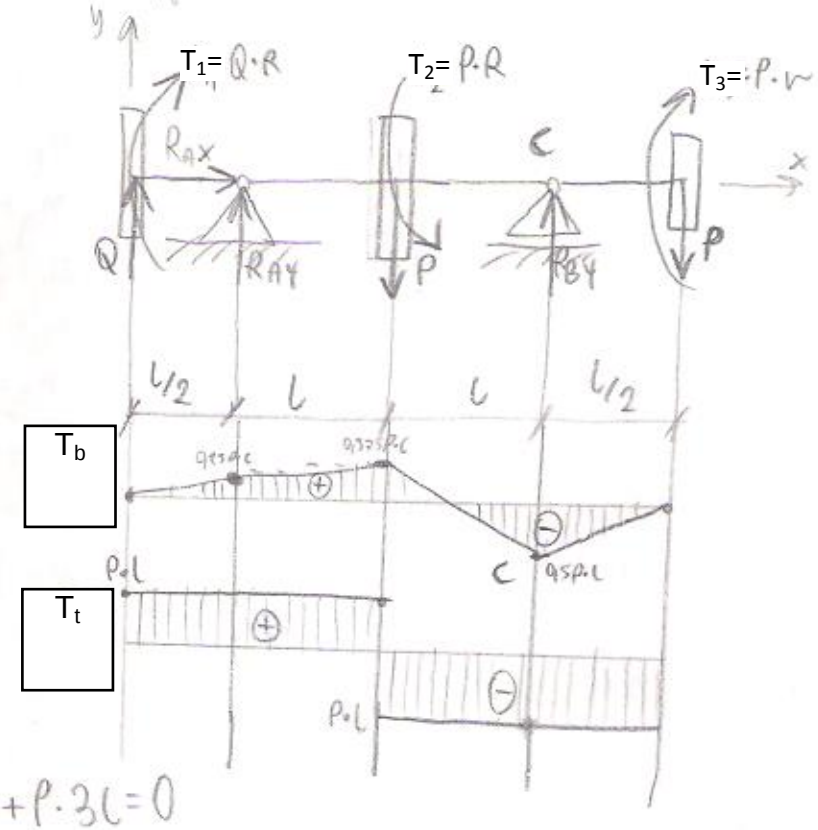


Known:
P=2[kN] - force
l=0,2[m] - length
r=l - radius
R=2r - radius
k_r=140[MPa] - maximum stress

Find:
d=?
d - shaft diameter



$\Sigma F_{ix}=0 \quad R_{AX}=0$

$\Sigma F_{iy}=0 \quad Q+R_{AY}-P+R_{BY}-P=0$

$\Sigma F_{iz}=0 \quad R_{A2}+R_{B2}=0$

$\Sigma T_{ix}=0 \quad Q\cdot R-P\cdot R+P\cdot r=0$

$\Sigma T_{iy}=0 \quad R_{A2}\cdot \frac{l}{2}+R_{B2}\cdot 2\frac{1}{2}l=0$

$\Sigma T_{iz}=0 \quad -R_{AY}\cdot \frac{l}{2}+P\cdot 1\frac{1}{2}l+R_{BY}\cdot 2\frac{1}{2}l+P\cdot 3l=0$

$Q\cdot 2l-P\cdot 2l+P\cdot l=0 \;/:l$

$2Q-2P+P=0$

$2Q=2P-P$

$2Q=P \;/:2$

$\underline{Q=\frac{1}{2}P}$

$\frac{1}{2}R_{A2}\cdot l+2\frac{1}{2}R_{B2}\cdot l=0 \;/:l$

$\frac{1}{2}R_{A2}+2\frac{1}{2}R_{B2}=0$

$R_{A2}+R_{B2}=0$

$\Rightarrow R_{A2}=0, \; R_{B2}=0$

$-\frac{1}{2}R_{AY}\cdot l+1\frac{1}{2}P\cdot l-2\frac{1}{2}R_{BY}\cdot l+3P\cdot l=0 \;/:l$

$-\frac{1}{2}R_{AY}+1\frac{1}{2}P-2\frac{1}{2}R_{BY}+3P=0$

$\frac{1}{2}R_{AY}=4\frac{1}{2}P-2\frac{1}{2}R_{BY} \;/\cdot 2$

$R_{AY}=9P-5R_{BY}$

$R_{AY}=\frac{72}{8}P-\frac{75}{8}P$

$R_{AY}=-\frac{3}{8}P$

$Q+(9P-5R_{BY})-P+R_{BY}-P=0$

$\frac{1}{2}P+9P-5R_{BY}-P+R_{BY}-P=0$

$4R_{BY}=\frac{1}{2}P+9P-2P$

$4R_{BY}=7\frac{1}{2}P$

$4R_{BY}=\frac{15}{2}\cdot P \;/:4$

$R_{BY}=\frac{15}{2}\cdot\frac{1}{4}\cdot P$

$\underline{R_{BY}=\frac{15}{8}P}$

$0 < x < \frac{1}{2}l$

$T_b = Q \cdot x$

for $x = 0$

$T_b = 0$

for $x = \frac{1}{2}l$

$T_b = \frac{1}{2}Q \cdot l$

$T_b = \frac{1}{4}P \cdot l$

$T_t = M_1$

$T_t = Q \cdot R$

$T_t = 2Q \cdot l$

$T_t = 2\left(\frac{1}{2}P\right) \cdot l$

$T_t = P \cdot l$

$\frac{1}{2}l < x < \frac{3}{2}l$

$T_b = Q \cdot x + R_{AY} \cdot \left(x - \frac{1}{2}\right)$

for $x = \frac{1}{2}l$

$T_b = \frac{1}{2}P \cdot \frac{1}{2}l$

$T_b = \frac{1}{4}P \cdot l$

$T_b = x = \frac{3}{2}l$

$T_b = \frac{1}{2}P \cdot \frac{3}{2}l + \left(-\frac{3}{8}P\right) \cdot l$

$T_b = \frac{3}{4}P \cdot l - \frac{3}{8}P \cdot l$

$T_b = \frac{3}{8}P \cdot l$

for $x = \frac{1}{2}l$ } $x = \frac{3}{2}l$ } $T_t = T_1$

$T_t = P \cdot l$

$\frac{3}{2}l < x < \frac{5}{2}l$

$T_b = Q \cdot x + R_{AY} \cdot \left(x - \frac{1}{2}\right) - P \cdot \left(x - \frac{3}{2}l\right)$

for $x = \frac{3}{2}l$

$T_b = \frac{1}{2} \cdot P \cdot \frac{3}{2}l + \left(-\frac{3}{8}P\right) \cdot l - 0$

$T_b = \frac{3}{4}P \cdot l - \frac{3}{8}P \cdot l$

$T_b = \frac{3}{8}P \cdot l$

for $x = \frac{5}{2}l$

$T_b = \frac{1}{2}P \cdot \frac{5}{2}l + \left(-\frac{3}{8}P\right) \cdot \left(\frac{5}{2}l - \frac{1}{2}l\right) - P \cdot \left(\frac{5}{2}l - \frac{3}{2}l\right)$

$T_b = \frac{5}{4}P \cdot l - \frac{3}{8}P \cdot 2l - P \cdot l$

$T_b = \frac{5}{4}P \cdot l - \frac{3}{4}P \cdot l - P \cdot l$

$T_b = \frac{1}{2}P \cdot l - P \cdot l$

$T_b = -\frac{1}{2}P \cdot l$

for $x = 3l$ } $x = \frac{5}{2}l$ } $T_t = T_1 - T_2$

$T_t = Q \cdot R - P \cdot R$

$T_t = \frac{1}{2}P \cdot 2l - P \cdot 2l$

$T_t = P \cdot l - 2P \cdot l$

$T_t = -P \cdot l$

$\frac{5}{2}l < x < 3l$

$T_b = Q \cdot x + R_{AY} \cdot \left(x - \frac{1}{2}\right) - P \cdot \left(x - \frac{3}{2}l\right) + R_{BY} \cdot \left(x - \frac{5}{2}l\right)$

for $x = \frac{5}{2}l$

$T_b = \frac{1}{2}P \cdot \frac{5}{2}l + \left(-\frac{3}{8}P\right) \cdot \left(\frac{5}{2}l - \frac{1}{2}l\right) - P \cdot \left(\frac{5}{2}l - \frac{3}{2}l\right) + 0$

$T_b = \frac{5}{4}P \cdot l + \left(-\frac{3}{8}P\right) \cdot 2l - P \cdot l$

$T_b = \frac{5}{4}P \cdot l - \frac{3}{4}P \cdot l - P \cdot l$

$T_b = -\frac{1}{2}P \cdot l$

for $x = 3l$

$T_b = \frac{1}{2}P \cdot 3l + \left(-\frac{3}{8}P\right) \cdot \left(3l - \frac{1}{2}l\right) - P \cdot \left(3l - \frac{3}{2}l\right) + \frac{15}{8}P \cdot \left(3l - \frac{5}{2}l\right)$

$T_b = \frac{3}{2}P \cdot l + \left(-\frac{3}{8}P\right) \cdot 2\frac{1}{2}l - P \cdot \frac{3}{2}l + \frac{15}{8}P \cdot \frac{1}{2}l$

$T_b = \frac{6}{4}P \cdot l - \frac{3}{8}P \cdot \frac{5}{2}l - \frac{3}{2}P \cdot l + \frac{15}{16}P \cdot l$

$T_b = \frac{24}{16}P \cdot l - \frac{15}{16}P \cdot l - \frac{24}{16}P \cdot l + \frac{15}{16}P \cdot l$

$T_b = 0$

for $x = \frac{5}{2}l$ } $x = 3l$ } $T_t = T_1 - T_2$

$T_t = Q \cdot R - P \cdot R$

$T_t = \frac{1}{2}P \cdot 2l - 2P \cdot l$

$T_t = -P \cdot l$

for circle sections

$$\sigma_{r\_v} = \frac{T_{r\_v}}{W} \leq k_r$$

$$T_{r\_v} = \sqrt{T_b^2 + 0{,}75 \cdot T_t^2}$$

$W = \frac{J_{xc}}{y_{max}}$

$T_{r\_v}{}^c = \sqrt{(0{,}5P \cdot l)^2 + 0{,}75(P \cdot l)^2}$

$T_{r\_v}{}^c = P \cdot l\sqrt{0{,}25 + 0{,}75}$

$T_{r\_v}{}^c = P \cdot l \cdot \sqrt{1}$

$T_{r\_v}{}^c = P \cdot l$

$W = \frac{\pi d^4}{64} \cdot \frac{2}{d}$

$W = \frac{\pi d^3}{32}$

$\sigma_{r\_v} = \frac{32 \cdot P \cdot l}{\pi d^3} \leq k_r$

$d^3 \geq \frac{32 P \cdot l}{\pi \cdot k_r}$

$d \geq \left(\frac{32 \cdot P \cdot l}{\pi \cdot k_r}\right)^{1/3}$

$d \geq \left(\frac{32 \cdot 2 \cdot 10^3 \cdot 0{,}2}{\pi \cdot 140 \cdot 10^6}\right)^{1/3}$

$d \geq 31\ mm$