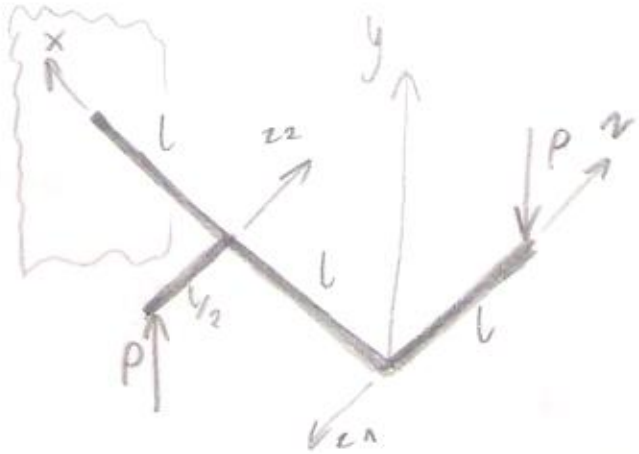


$0 < x < l$

$M_g = -P \cdot x$

dla $x = 0$

$M_g = 0$

dla $x = l$

$M_g = -P \cdot l$

$M_S = M_1$

$M_S = P \cdot l$

$l < x < 2l$

$M_g = -P \cdot x + P \cdot (x - l)$

dla $x = l$

$M_g = -P \cdot l + 0$

$M_g = -P \cdot l$

dla $x = 2l$

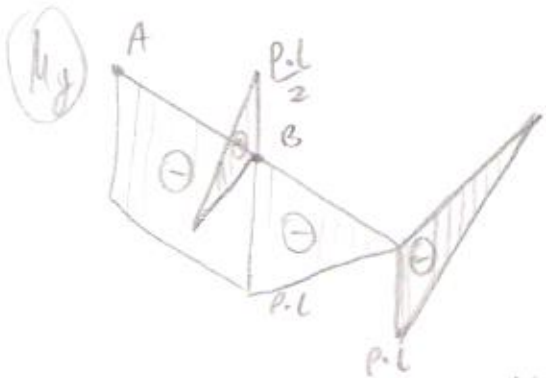
$M_g = -P \cdot 2l + P \cdot l$

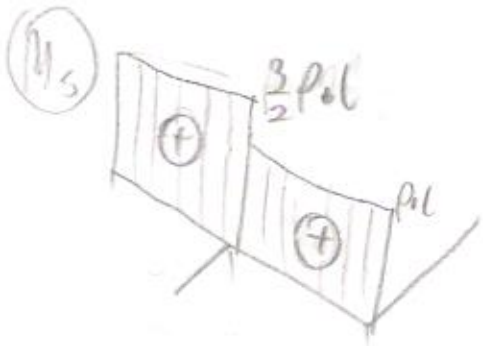
$M_g = -P \cdot l$

$M_S = M_1 + M_2$

$M_S = P \cdot l + \frac{P \cdot l}{2}$

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





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

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

dla osi z_1

$0 < z_1 < l$

$M_g = -P \cdot z_1$

dla $z_1 = 0$

$M_g = 0$

dla $z_1 = l$

$M_g = -P \cdot l$

dla osi z_2

$0 < z_2 < l/2$

$M_g = P \cdot z_2$

dla $z_2 = 0$

$M_g = 0$

dla $z_2 = l/2$

$M_g = P \cdot \frac{l}{2}$

dla kołowych przekrojów wg. Hubera

$M_{zr} = \sqrt{M_g^2 + 0{,}75 M_S^2}$

$M_{zr} = \frac{1}{2} \cdot \sqrt{M_g^2 + 0{,}75 M_S^2}$

$\sigma_{zr} = \frac{M_{zr}}{W} \leq k_w$

$\sigma_{zr} = \frac{32}{\pi d^3} \cdot \sqrt{M_g^2 + 0{,}75 \cdot M_S^2} \leq k_r$

Dane:
$P = 4\,kN$
$l = 0{,}2\,m$
$k_r = 120\,MPa$

Obliczyć:
$d = ?$

$M_{2r}^{(B)} = M_{2r}^{(A)}$

$M_{2r}^{(B)} = \sqrt{(-P \cdot l)^2 + 0{,}75\left(\frac{3}{2} P \cdot l\right)^2}$

$M_{2r}^{(B)} = P^2 \cdot l^2 + 0{,}75 \cdot \frac{9}{4} P^2 \cdot l^2$

$M_{2r}^{(B)} = P \cdot l \cdot \sqrt{1 + \frac{3}{4} \cdot \frac{9}{4}}$

$M_{2r} = P \cdot l \cdot \sqrt{\frac{16}{16} + \frac{27}{16}}$

$M_{2r} = P \cdot l \cdot \sqrt{\frac{43}{16}}$

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

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

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

$\sigma_{2r} = \frac{M_{2r}}{W} \leq k_r$

$\frac{P \cdot l \cdot \sqrt{\frac{43}{16}}}{\frac{\pi d^3}{32}} \leq k_r$

$P \cdot l \cdot \sqrt{\frac{43}{16}} \cdot \frac{32}{\pi d^3} \leq k_r$

$d^3 \cdot k_r \geq P \cdot l \cdot \sqrt{\frac{43}{16}} \cdot \frac{32}{\pi}$

$d^3 \geq \frac{32 \cdot P \cdot l \sqrt{\frac{43}{16}}}{\pi \cdot k_r}$

$d \geq \left(\frac{32 \cdot P \cdot l \sqrt{\frac{43}{16}}}{\pi \cdot k_r}\right)^{1/3}$

$d \geq \left(\frac{32 \cdot 4 \cdot 10^3 \cdot 0{,}2 \cdot \sqrt{\frac{43}{16}}}{\pi \cdot 120 \cdot 10^6}\right)^{1/3}$

$d \geq 40\,mm$