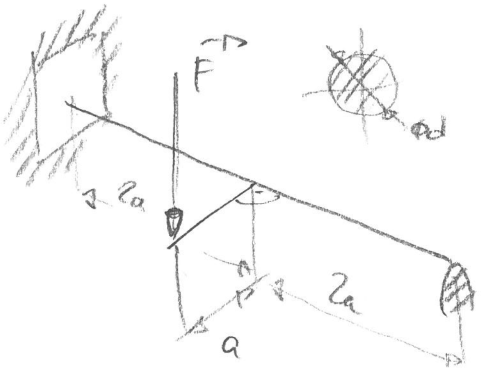
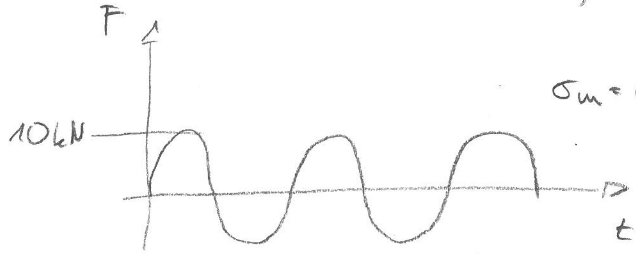
1. U hřídele podle obr. stanovte bezpečnost k MS únavy:
(kombinované namáhání – pouze souosé a střídavé)

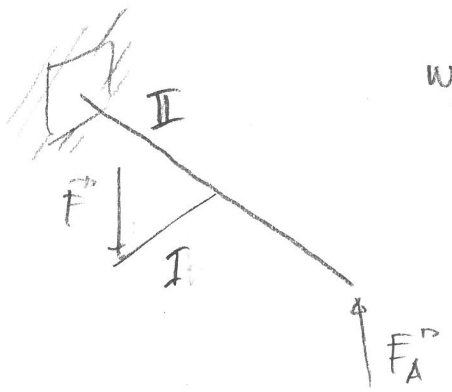




$\sigma_m = 0$!!

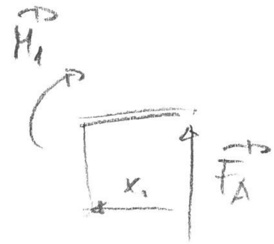
$\sigma_{ar} = 560$ MPa
$d = 65$ mm
$a = 500$ mm

Částečné uvolnění:

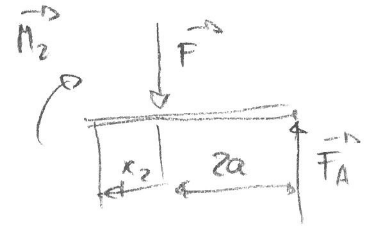


$w_A = 0$

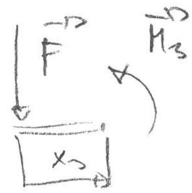
VVÚ:



$x_1 \in (0, 2a)$
$M_1 = F_A \cdot x_1$



$x_2 \in (0, 2a)$
$M_2 = F_A(x_2 + 2a) - F x_2$



$x_3 \in (0, a)$
$M_3 = -F \cdot x_3$

Odstranění stat. neurčitosti

$$w = \frac{\partial W}{\partial F_A}$$

$$0 = \int_0^{2a} \frac{M_1}{EJ}\frac{\partial M_1}{\partial F_A}dx_1 + \int_0^{2a} \frac{M_2}{EJ}\frac{\partial M_2}{\partial F_A}dx_2 + \int_0^{a} \frac{M_3}{EJ}\frac{\partial M_3}{\partial F_A}dx_3$$

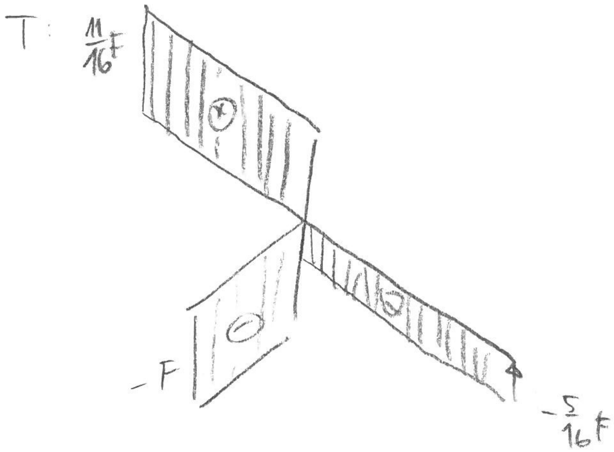
$$0 = \int_0^{2a} F_A x_1 \cdot x_1\, dx_1 + \int_0^{2a} \left[F_A(x_2+2a) - F\cdot x_2\right](x_2+2a)\,dx_2 + \int_0^{2a}(-F x_3)\cdot 0\, dx_3$$

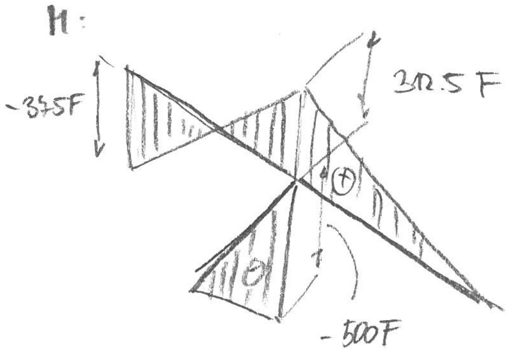
$$0 = F_A \frac{(2a)^3}{3} + F_A\left[\frac{(2a)^3}{3} + 4a\frac{(2a)^2}{2} + 4a^2\cdot 2a\right] - F\cdot\left[\frac{(2a)^3}{3} + 2a\frac{(2a)^2}{2}\right]$$

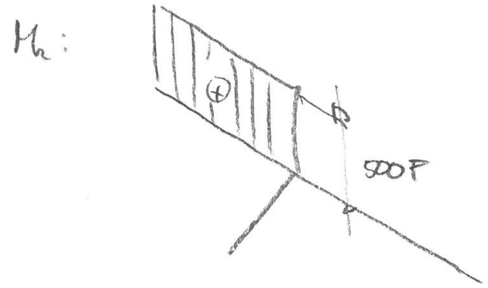
$$0 = F_A\left(\frac{8}{3} + \frac{8}{3} + 8 + 8\right) - F\left(\frac{8}{3} + 4\right)$$

$$F_A = F\,\frac{\frac{20}{\cancel{3}}}{\frac{16+48}{\cancel{3}}} = F\,\frac{20}{64} = F\,\frac{10}{32} = F\,\frac{5}{16}$$

Řešení





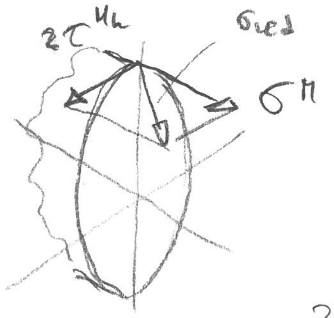


I: $\sigma_a = \frac{M_{max}}{W_o} = \frac{500 \cdot 10\,000}{\frac{\pi \cdot 65^3}{32}} = 185\,\mathrm{MPa}$

$\sigma_m = 0$

$\frac{\sigma_a}{\sigma_{ar}} = \frac{1}{k} \Rightarrow k = \frac{\sigma_{ar}}{\sigma_a} = \frac{560}{185} = 3$

II:



$\sigma_{red} = \sqrt{\left(\frac{375 \cdot 10\,000}{\frac{\pi \cdot 65^3}{32}}\right)^2 + 4\left(\frac{500 \cdot 10000}{\frac{\pi \cdot 65^3}{16}}\right)^2} = \sqrt{19346 + 4 \cdot 8598}$

$= 232\,\mathrm{MPa}$

Za předpokladu, že $\sigma_{ar} = 4 \cdot \tau_{ar}$ a $\sigma_m = 0$ platí:

$\frac{\sigma_{red}}{\sigma_{ar}} = \frac{1}{k} \Rightarrow k = \frac{\sigma_{ar}}{\sigma_{red}} = \frac{560}{232} = 2.4$ nebo také pro $k_\sigma = \frac{\sigma}{\sigma_{ar}}$ a $k_\tau = \frac{\tau}{\tau_{ar}}$

platí:

$\frac{\sqrt{\sigma^2 + 4\tau^2}}{\sigma_{ar}} = \frac{1}{k} \Rightarrow \sqrt{\frac{\sigma^2}{\sigma_{ar}^2} + 4\frac{\tau^2}{\sigma_{ar}^2}} = \frac{1}{k} \Rightarrow \sqrt{\left(\frac{\sigma}{\sigma_{ar}}\right)^2 + \left(\frac{\tau}{\tau_{ar}}\right)^2} = \frac{1}{k}$

$\Rightarrow \sqrt{\frac{1}{k_\sigma^2} + \frac{1}{k_\tau^2}} = \frac{1}{k} \Rightarrow k = \frac{k_\sigma \cdot k_\tau}{\sqrt{k_\sigma^2 + k_\tau^2}} = \underline{\underline{2.4}}$