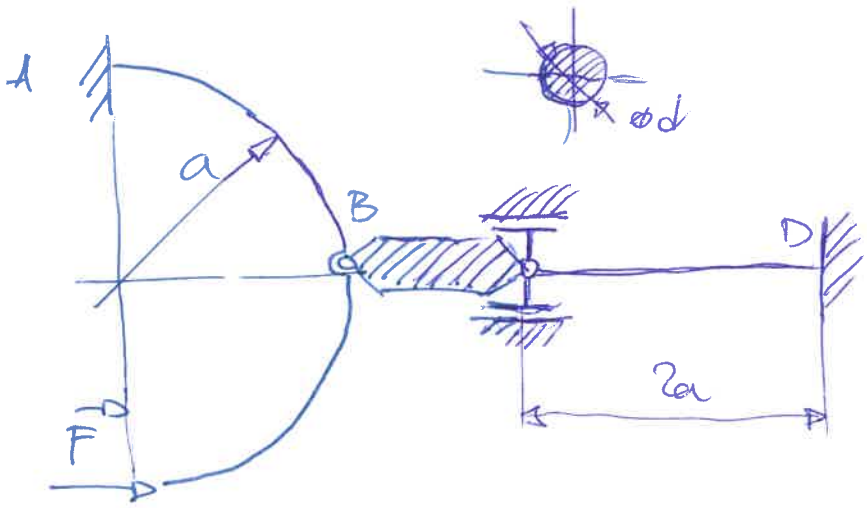
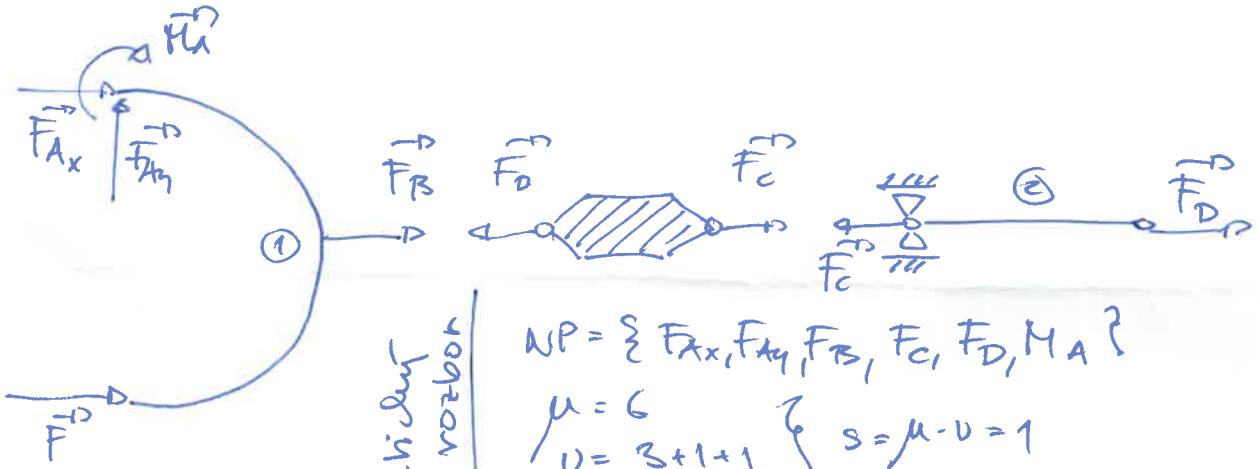
Př: U soustavy prutů určete bezpečnost vzhledem k MS pružnosti



1. Úplné uvolnění



2. Statický rozbor

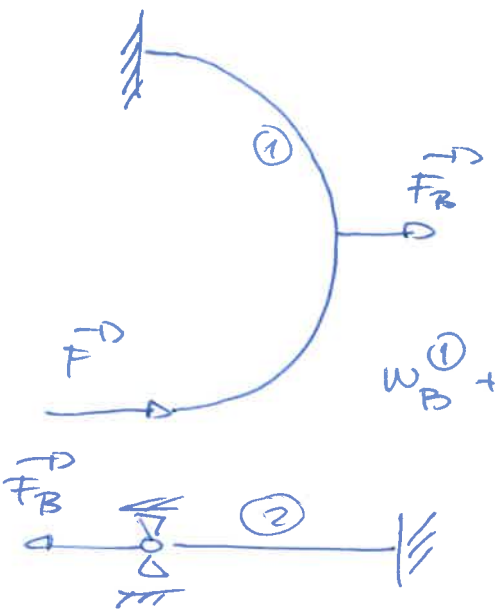
$NP = \{F_{Ax}, F_{Ay}, F_B, F_C, F_D, M_A\}$

$\mu = 6$

$v = 3+1+1$

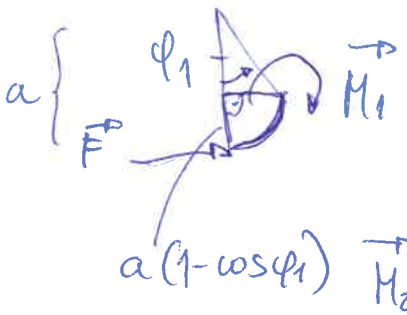
$s = \mu - v = 1$

3. Částečné uvolnění



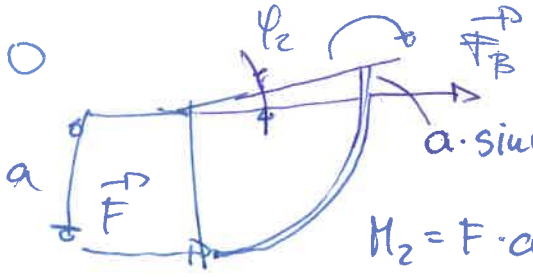
$w_B^{(1)} + w_B^{(2)} = 0$

4. MVÚ



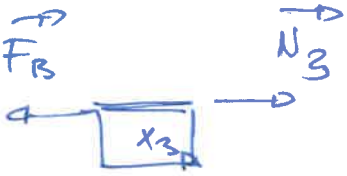
$\varphi_1 \in (0, \frac{\pi}{2})$

$M_1 = F \cdot a(1-\cos\varphi_1)$



$\varphi_2 \in (0, \frac{\pi}{2})$

$M_2 = F \cdot a(1+\sin\varphi_2) + F_B a \sin\varphi_2$



$x_3 \in (0, 2a)$

$N_3 = F_B$

5. Odstranění stat.

$$w_B^{(1)} + u_B^{(2)} = 0$$

$$\underbrace{\frac{1}{EJ}\int_0^{\frac{\pi}{2}} M_1 \frac{\partial M_1}{\partial F_B}\, a\, d\varphi_1 + \frac{1}{EJ}\int_0^{\frac{\pi}{2}} M_2 \frac{\partial M_2}{\partial F_B}\, a\, d\varphi_2}_{w_B^{(1)}} + \underbrace{\frac{N_3\, 2a}{ES}\frac{\partial N_3}{\partial F_B}}_{u_B^{(2)}} = 0$$

$$\frac{1}{EJ}\int_0^{\frac{\pi}{2}} \left[F a(1+\sin\varphi_2) + a F_B \sin\varphi_2\right] a\cdot\sin\varphi_2\, a\, d\varphi_2 + \frac{F_B 2a}{ES} = 0$$

$$\frac{1}{J}\int_0^{\frac{\pi}{2}} \left[F a^3(\sin\varphi_2 + \sin^2\varphi_2) + F_B a^3 \sin^2\varphi_2\right] d\varphi_2 + \frac{F_B \cdot 2a}{ES} = 0$$

$$\frac{1}{J} F a^3 \left[-\cos\varphi_2 + \frac{\varphi_2}{2} - \frac{\sin 2\varphi_2}{4}\right]_0^{\frac{\pi}{2}} + \frac{1}{J} F_B a^3 \left[\frac{\varphi_2}{2} - \frac{\sin 2\varphi_2}{4}\right]_0^{\frac{\pi}{2}} + \frac{F_B 2a}{S} = 0$$

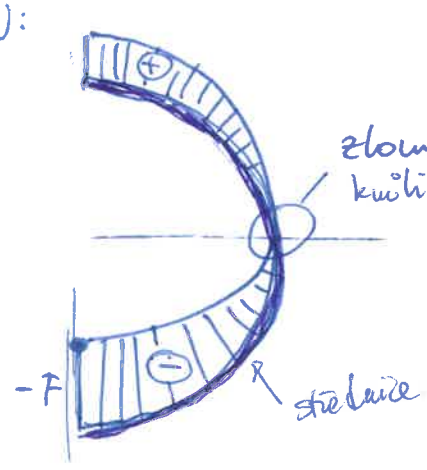
$$\frac{1}{J} F a^3 \left[1 + \frac{\pi}{4}\right] + \frac{1}{J} F_B a^3 \left[\frac{\pi}{4}\right] + \frac{F_B 2a}{S} = 0$$

$$F_B \left(\frac{\pi}{4J} a^2 + \frac{2}{S}\right) = -\frac{Fa^2}{J}\frac{4+\pi}{4}$$

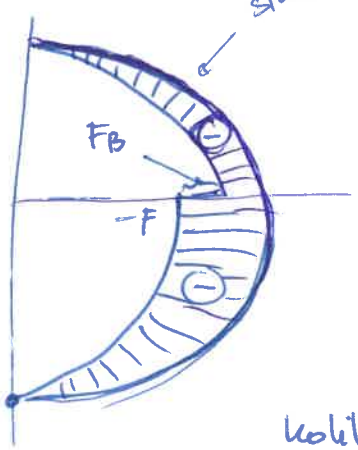
$$F_B = -\frac{4JSFa^2(4+\pi)}{4J(\pi a^2 S - 8J)} = -\frac{SFa^2(4+\pi)}{\pi a^2 S - 8J}$$

6. Řešení

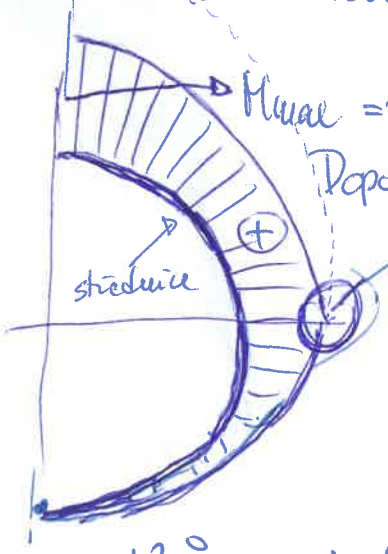
(1) N:



T:



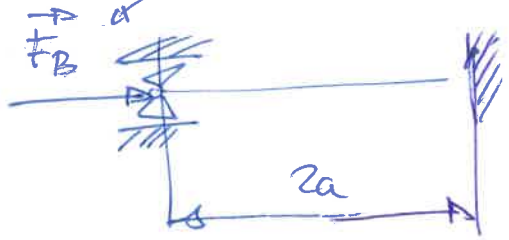
M:



Kolik je rozdílů mezi N a M?

jeden: M je "posunuté" N do kladných hodnot

(2) podle 5. má opačný smysl než v č. modelem



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

$$\lambda = \frac{L}{i} = \frac{2a}{\frac{d}{4}} = \frac{8a}{d}$$

$$\lambda_k = \sqrt{\frac{\alpha^2 \sigma_k}{E}} = \sqrt{\frac{2\pi^2 \sigma_k}{E}}$$

$$\lambda > \lambda_k \Rightarrow F_{kr} = \frac{\alpha^2 EJ}{L^2} = \frac{2\pi^2 E \frac{\pi d^4}{64}}{4a^2} = \frac{\pi^3 E d^4}{128 a^2}$$

$$k = \frac{F_{kr}}{F_B} = \dots$$

$$\lambda < \lambda_k \Rightarrow k = \frac{\sigma_k}{\frac{F_B}{S}} = \frac{\sigma_k \cdot \frac{\pi d^2}{4}}{\dots}$$