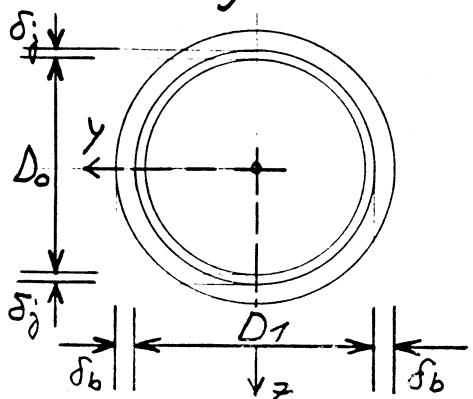


1. Podvodni cevovod je sestavljen iz jeklene notranje in varovalne bakrene zunanjé cevi, ki se med seboj tesno, vendar brez napetosti prilegata. Določi normalne napetosti v tangencialni smeri v obih cevih med obratovanjem cevovoda v globini 50 m pri notranjem pritisku $p = 0,15 \text{ kN/cm}^2$



$$D_o = 50 \text{ cm}, \quad D_1 = 52 \text{ cm}$$

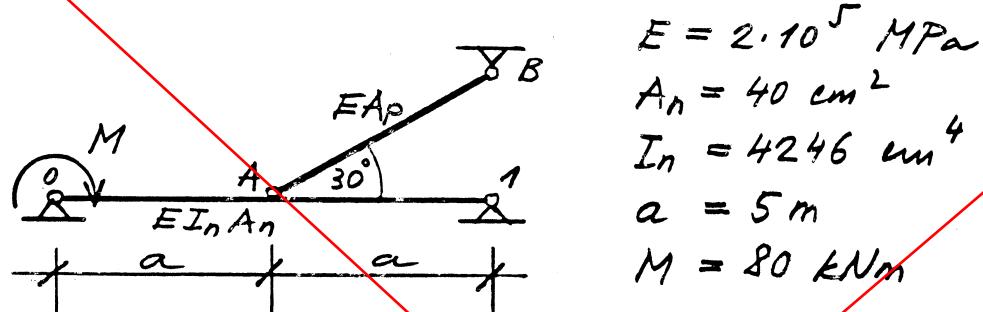
$$\delta_j = 1 \text{ cm}, \quad \delta_b = 1,5 \text{ cm}$$

$$E_j = 2 E_b$$

$$\gamma_j = 0,3 \quad \gamma_b = 0,34$$

Vzdolžne napetosti v cevih lahko zanemarim.

2. Določi potrebeni prečni presek vrvi \overline{AB} , če je dopustni navpični pomik točke A 1 cm! Določi in skiciraj notranje sile v tem primeru!



$$E = 2 \cdot 10^5 \text{ MPa}$$

$$A_n = 40 \text{ cm}^2$$

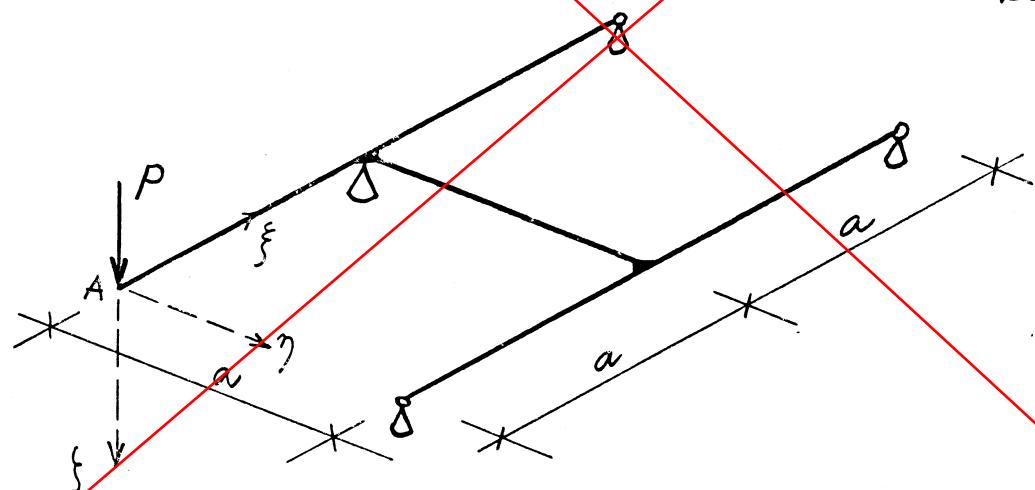
$$I_n = 4246 \text{ cm}^4$$

$$a = 5 \text{ m}$$

$$M = 80 \text{ kNm}$$

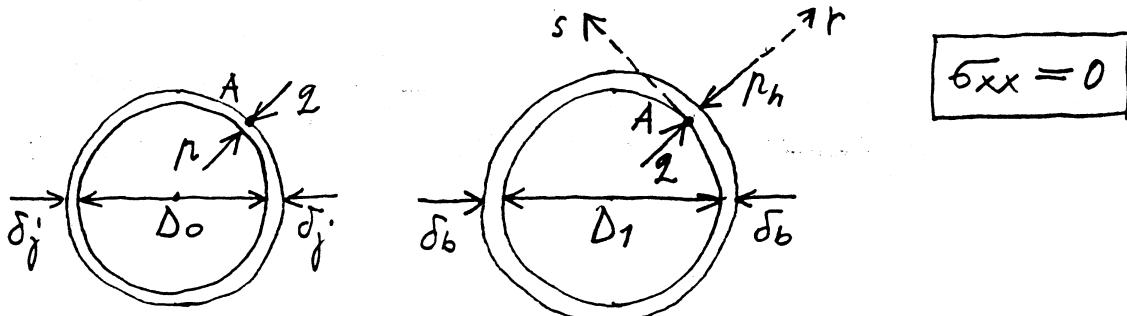
3. Določi poves točke A ter skiciraj notranje sile!

$$EI_y = GI_x$$



$$\text{Ad 1.) } \gamma = 10 \text{ kN/m}^3$$

$$p_h = \gamma \cdot h = 10 \cdot 50 = 500 \text{ kN/m}^2 = 0,05 \text{ kN/cm}^2$$



v staci A:

$$\sigma_{ss}^j = (r - q) \frac{D_o}{2\delta_j} \quad \sigma_{rr}^j = -q$$

$$\sigma_{ss}^b = (q - p_h) \frac{D_1}{2\delta_b} \quad \sigma_{rr}^b = -q$$

$$\epsilon_{ss}^j = \frac{1}{E_j} (\sigma_{ss}^j - \nu_j \sigma_{rr}^j) = \frac{1}{E_j} \left[(r - q) \frac{D_o}{2\delta_j} + \nu_j q \right]$$

$$\epsilon_{ss}^b = \frac{1}{E_b} (\sigma_{ss}^b - \nu_b \sigma_{rr}^b) = \frac{1}{E_b} \left[(q - p_h) \frac{D_1}{2\delta_b} + \nu_b q \right]$$

$$\boxed{\epsilon_{ss}^b = \epsilon_{ss}^j}$$

$$(r - q) \frac{D_o}{2\delta_j} + \nu_j q = \frac{E_j}{E_b} \left[(q - p_h) \frac{D_1}{2\delta_b} + \nu_b q \right]$$

$$q \left[\frac{D_1}{\delta_b} + \frac{D_o}{2\delta_j} + 2\nu_b - \nu_j \right] = \frac{r D_o}{2\delta_j} + \frac{p_h D_1}{\delta_b}$$

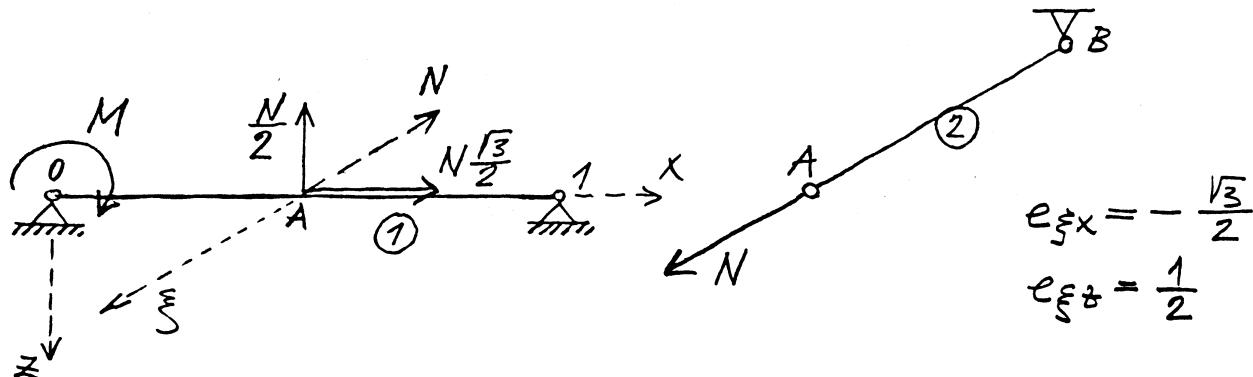
$$85,047 q = 5,483 \rightarrow$$

$$\sigma_{ss}^j = (0,15 - 0,064) \cdot \frac{50}{2 \cdot 7} \rightarrow \boxed{\sigma_{ss}^j = 0,064 \text{ kN/cm}^2}$$

$$\sigma_{ss}^b = (0,064 - 0,05) \cdot \frac{52}{2 \cdot 1,5} \rightarrow \boxed{\sigma_{ss}^b = 0,251 \text{ kN/cm}^2}$$

Ad 2.)

$$l_{AB} = \frac{2a}{\sqrt{3}}$$



$$\textcircled{1} \quad u_x^1(A) = \frac{1}{2} N \frac{\sqrt{3}}{2} \cdot \frac{a}{EA_n}$$

$$u_z^1(A) = M \frac{a^2}{4EI_y} - \frac{N}{2} \cdot \frac{a^3}{6EI_y}$$

|
②

$$u_z^2(A) = N \frac{2a}{\sqrt{3}EA_p}$$

$$u_{\xi}^2 = u_x^1 e_{\xi x} + u_z^1 e_{\xi z}$$

$$N \frac{2a}{\sqrt{3}EA_p} = N \frac{a\sqrt{3}}{4EA_n} \cdot \left(-\frac{\sqrt{3}}{2}\right) + \left(M \frac{a^2}{4EI_y} - N \frac{a^3}{12EI_y}\right) \cdot \frac{1}{2}$$

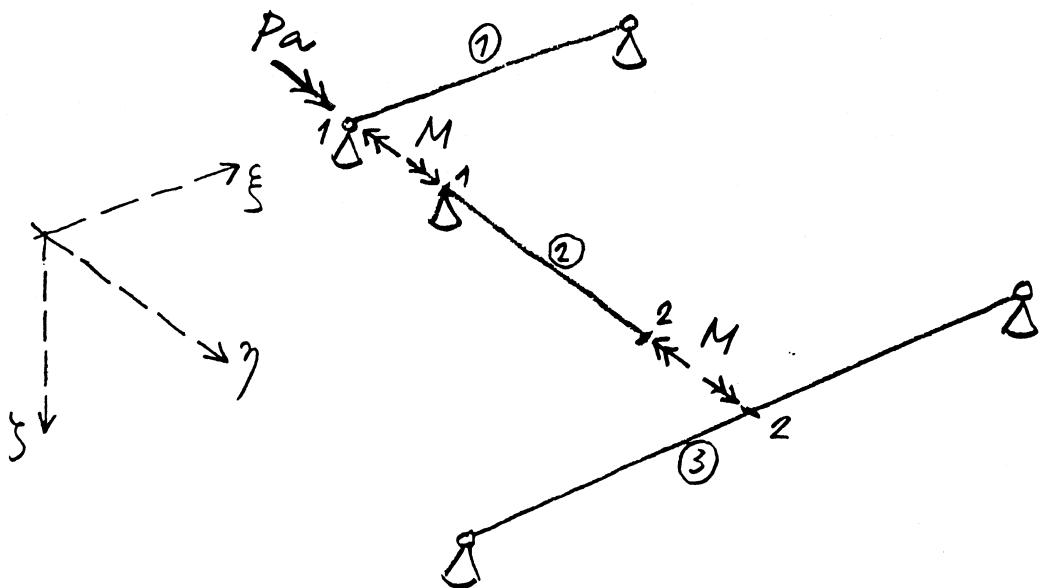
$$\boxed{N \left(\frac{2}{\sqrt{3}A_p} + \frac{3}{8A_n} + \frac{a^2}{24I_y} \right) = M \frac{a}{8I_y}}$$

$$u_z^1(A) = M \frac{a^2}{4EI_y} - N \frac{a^3}{12EI_y} = 1 \text{ cm}$$

$$N = M \frac{3}{a} - 1 \cdot \frac{12EI_y}{a^3} \rightarrow \boxed{N = 39,85 \text{ kN}}$$

$$39,85 \left(\frac{1,155}{A_p} + 0,009 + 2,453 \right) = 117,758$$

$$\boxed{A_p = 2,34 \text{ cm}^2}$$

Ad 3.)

$$\textcircled{1} \quad \omega_3^{(1)}(1) = (Pa - M) \frac{a}{3EI_y}$$

$$\textcircled{2} \quad \omega_3^{(2)}(1) = \omega_3^{(1)}(1) = (Pa - M) \frac{a}{3EI_y}$$

$$\omega_3^{(2)}(2) = \omega_3^{(1)}(1) - M \frac{a}{GJ_x} = (Pa - M) \frac{a}{3GJ_x} - M \frac{a}{GJ_x}$$

$$\omega_3^{(2)}(2) = P \frac{a^2}{3GJ_x} - M \frac{4a}{3GJ_x}$$

$$\textcircled{3} \quad \omega_3^{(3)}(2) = M \frac{a}{6EI_y} = M \frac{a}{6GJ_x}$$

$$\omega_3^{(3)}(2) = \omega_3^{(2)}(2) \rightarrow M \frac{a}{6GJ_x} = P \frac{a^2}{3GJ_x} - M \frac{4a}{3GJ_x}$$

$$M = P \cdot \frac{2a}{9}$$

$$\omega_3^{(1)}(1) = P \frac{a^2}{3EI_y} - P \frac{2a^2}{27EI_y} = P \frac{7a^2}{27EI_y}$$

$$w_A = P \frac{a^3}{3EI_y} + P \frac{7a^3}{27EI_y}$$

$$w_A = P \frac{16a^3}{27EI_y}$$