Dimenzionisati stap kružnog poprečnog presjeka ($R = ?$) koji je opterećen aksijalnom silom zatezanja prema slici. $\sigma_{dop} = 16 kN/cm^2$. Odrediti:

a) dijagram normalnih napona u proizvoljnom poprečnom presjeku štapa

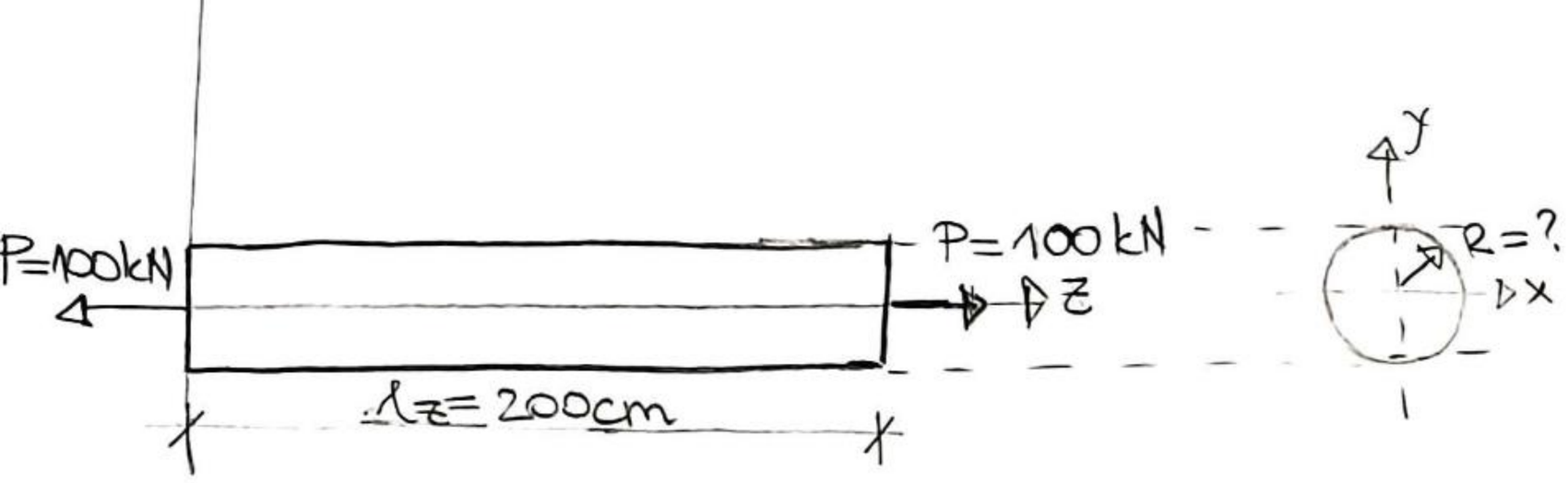
b) izduženje štapa ($\Delta l = ?$)

c) tenzor napona i deformacije za proizvoljnu tačku štapa

$\sigma_{dop} = 16 kN/cm^2$

$E = 150 GPa$

$\nu = 0,2$



a) $\sigma_z = \frac{N}{A} \leq \sigma_{dop}$

$\sigma = \frac{N}{A}$

$A_{pot} \geq \frac{N}{\sigma_{dop}} = \frac{100 kN}{16 \frac{kN}{cm^2}} = 6.25 cm^2$

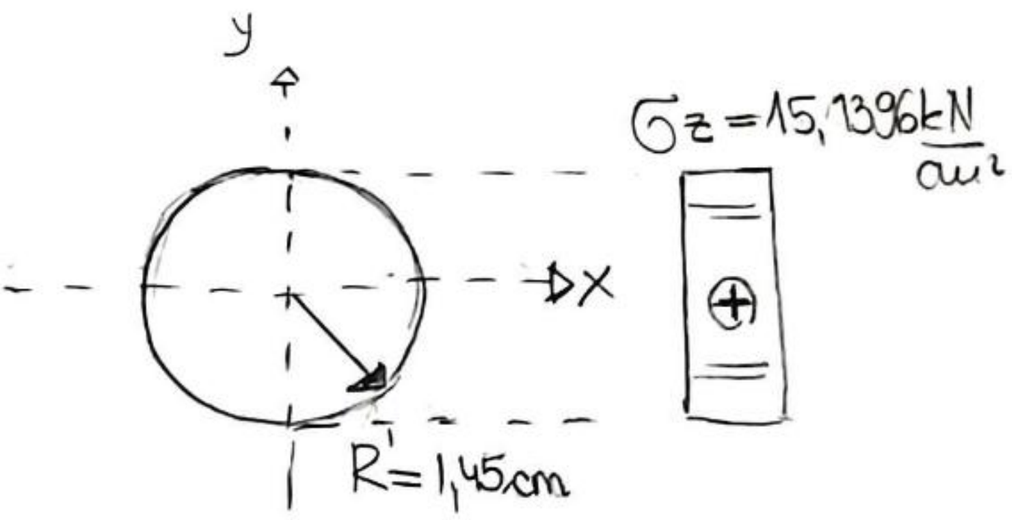
$A = R^2 \pi = 1,45^2 \cdot \pi = 6,6052 cm^2$

$A_{pot} = R^2 \pi, \quad R^2 \geq \frac{A_{pot}}{\pi}, \quad R \geq \sqrt{\frac{A_{pot}}{\pi}} \geq 1.41 cm$

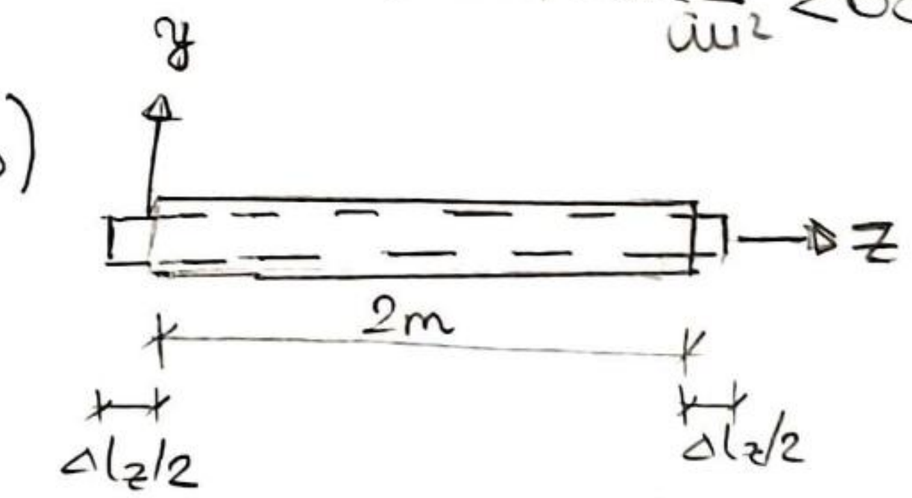
$\sigma = \frac{100 kN}{6.6052} = 15,1396 \frac{kN}{cm^2}$

$\boxed{R = 1,45 cm}$

$\sigma = 15,1396 \frac{kN}{cm^2} < \sigma_{dop}$



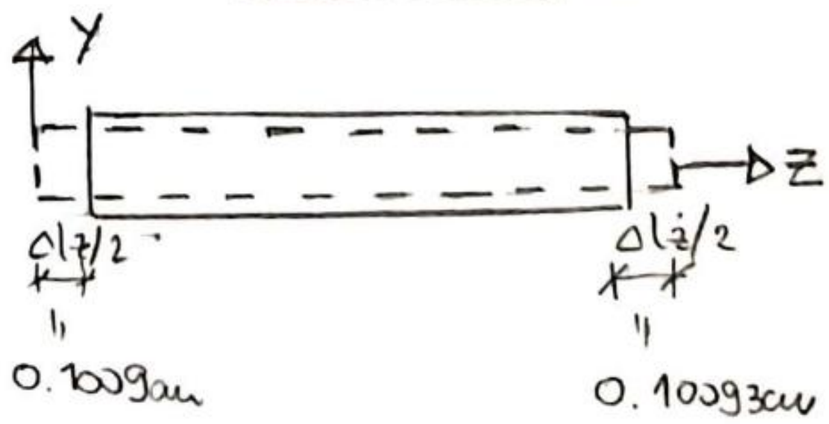
b)



$\varepsilon_z = \frac{\sigma_z}{E} = \frac{N}{EA} = \frac{\Delta l_z}{l_z}$

$\boxed{\Delta l_z = \frac{N \cdot l_z}{EA}} = \frac{100 kN \cdot 200 cm}{150 \cdot 10^2 \cdot 6.6052 cm^2}$

$\boxed{\Delta l_z} = \boxed{0..20186 cm}$



c) $\sigma = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & \sigma_z \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 15,1396 \end{bmatrix} (kN/cm^2)$ - tenzor naprona

$\varepsilon_x = \varepsilon_y = \frac{\nu}{E} \cdot \sigma_z = -\frac{0,2}{150 \cdot 10^2} \cdot 15,1396 = -2,0186 \cdot 10^{-4}$

$\varepsilon_z = \frac{\sigma_z}{E} = \frac{15,1396}{150 \cdot 10^2} = 1,0093 \cdot 10^{-3}$

$D = \begin{bmatrix} \varepsilon_x & 0 & 0 \\ 0 & \varepsilon_y & 0 \\ 0 & 0 & \varepsilon_z \end{bmatrix} = \begin{bmatrix} -0,20186 & 0 & 0 \\ 0 & -0,2018 & 0 \\ 0 & 0 & 1,0093 \end{bmatrix} 10^{-3}$ - tenzor deformacije

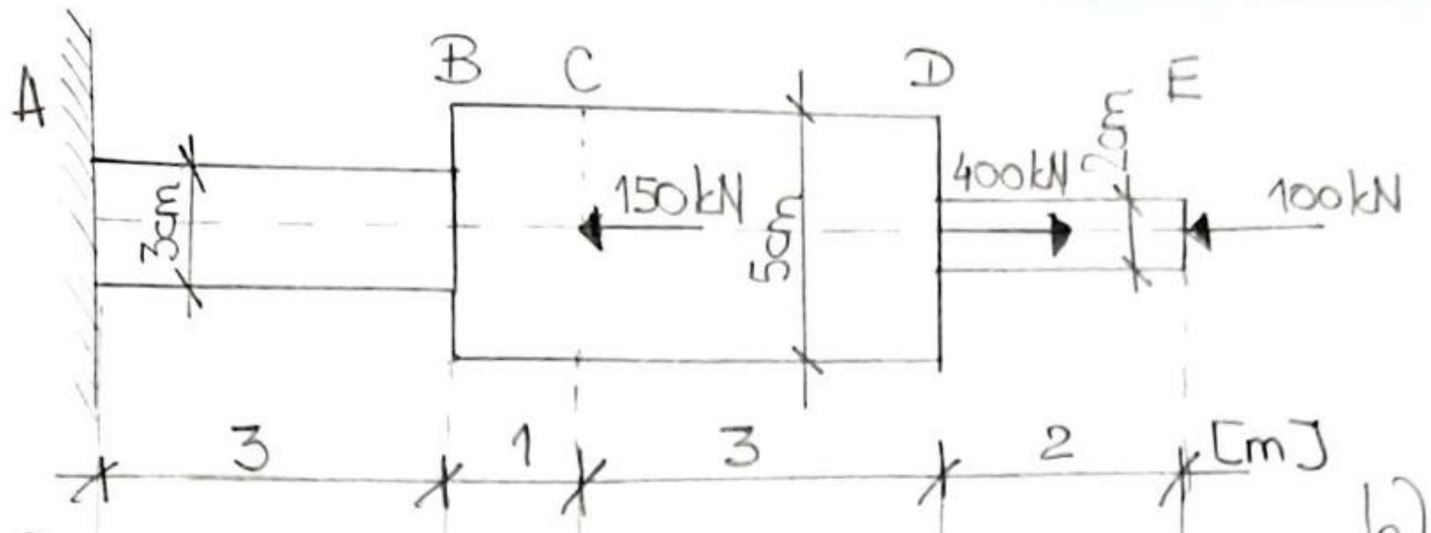
2. Štap skokovitog kvadratnog poprečnog presjeka ($E = 210 GPa$, $\alpha t = 1 \cdot 10^{-5} \cdot \frac{1}{C}$), opterećen je kao na slici. Odrediti:

a) dijagram normalnih sila (N) duž nosača

b) dijagram normalnih napona duž nosača i nacrtati dijagram normalnog napona u presjecima E i A

c) dijagram poduznih pomjeranja (naznačiti pomjeranja u točkama A, B, C, D, E)

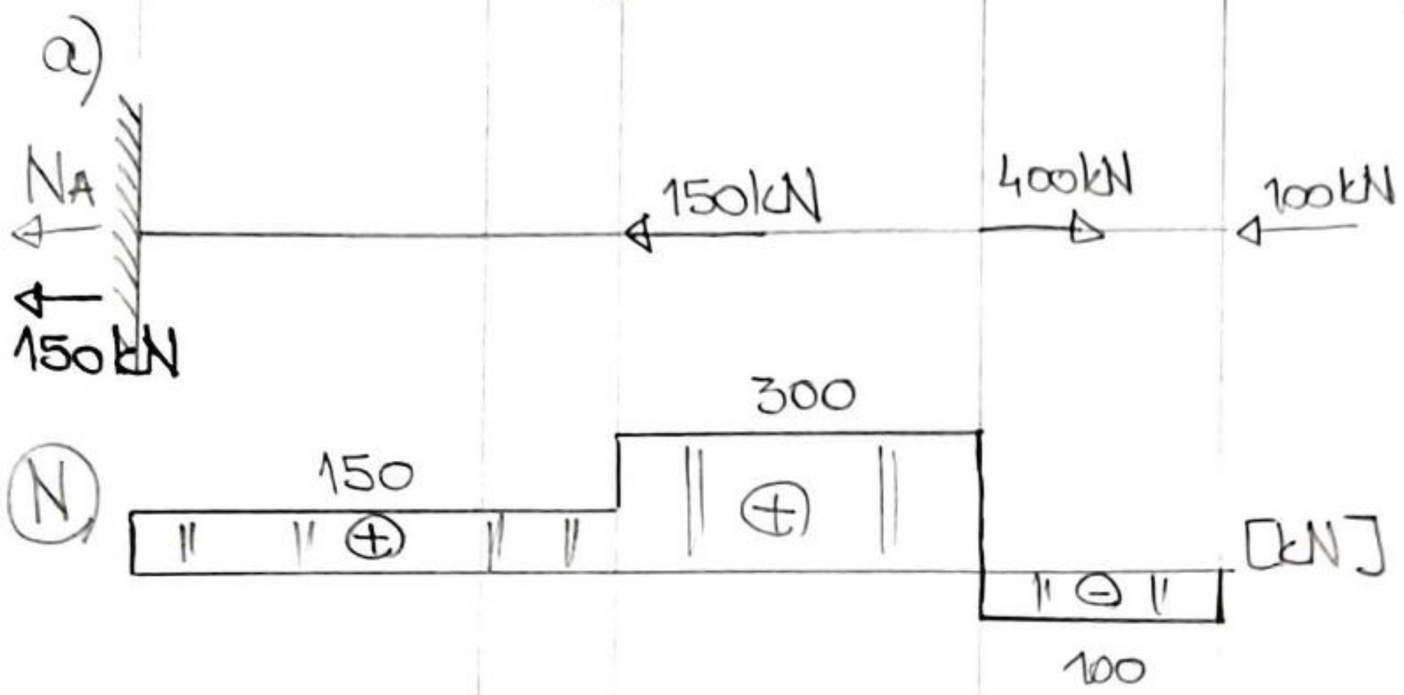
d) dijagram poduznih pomjeranja iz slučaja c) pod uslovom da se štap zagrije za 30°C.



a) Uslov ravnoteže:

$\Sigma N = 0,\ N_A + 150 + 100 - 400 = 0$

$N_A = 150\,kN$



b) dio A-B:

$\sigma_z = \frac{N}{A} = \frac{150}{9} = 16,6\,kN/cm^2$ (zatezanje)

$A_{AB} = 3^2 = 9cm^2$

dio B-C:

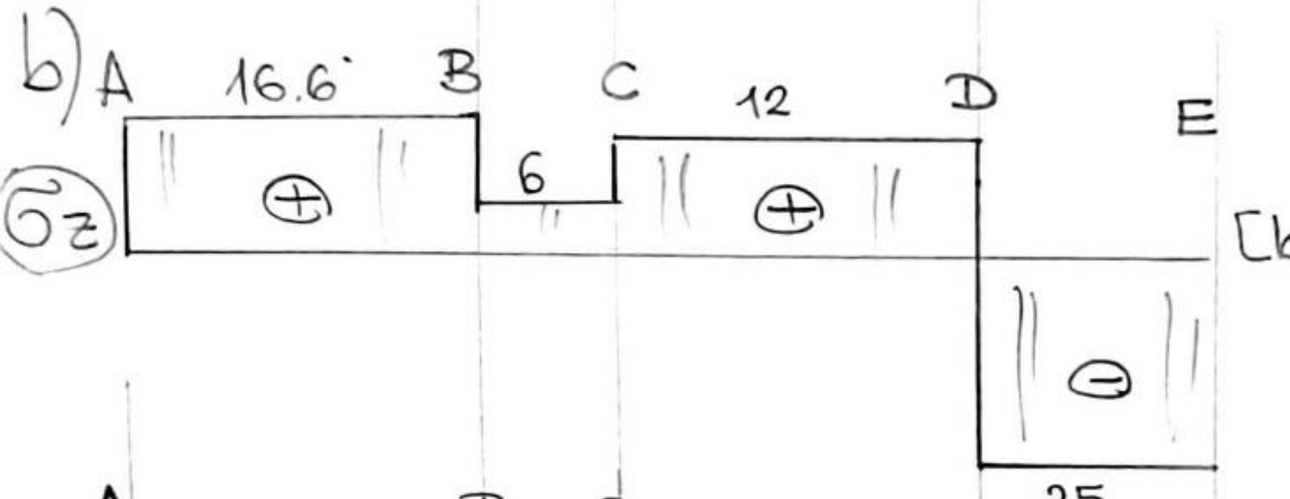
$\sigma_z = \frac{150}{25} = 6\,kN/cm^2$ (zatezanje)

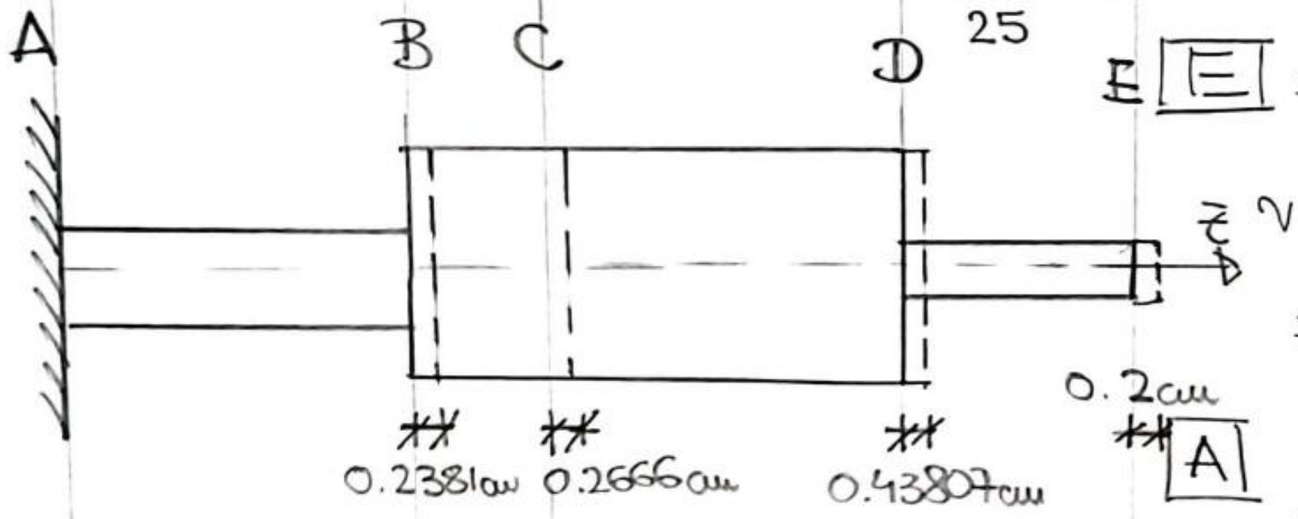
$A_{BC} = A_{CD} = 5 \cdot 5 = 25cm^2$

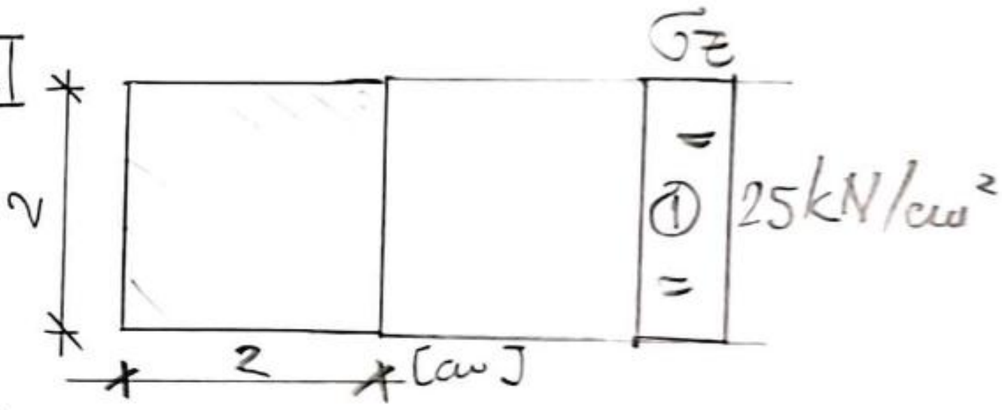
dio C-D: $\sigma_z = \frac{300}{25} = 12\,kN/cm^2$ (zatezanje)

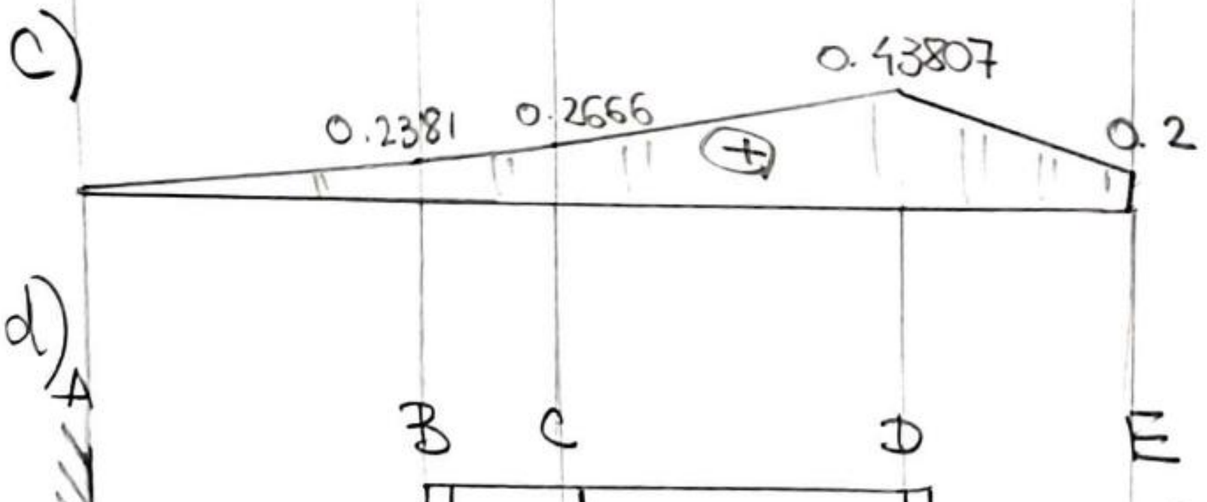
dio D-E: $\sigma_z = -\frac{100}{4} = -25\,kN/cm^2$ (pritisak)

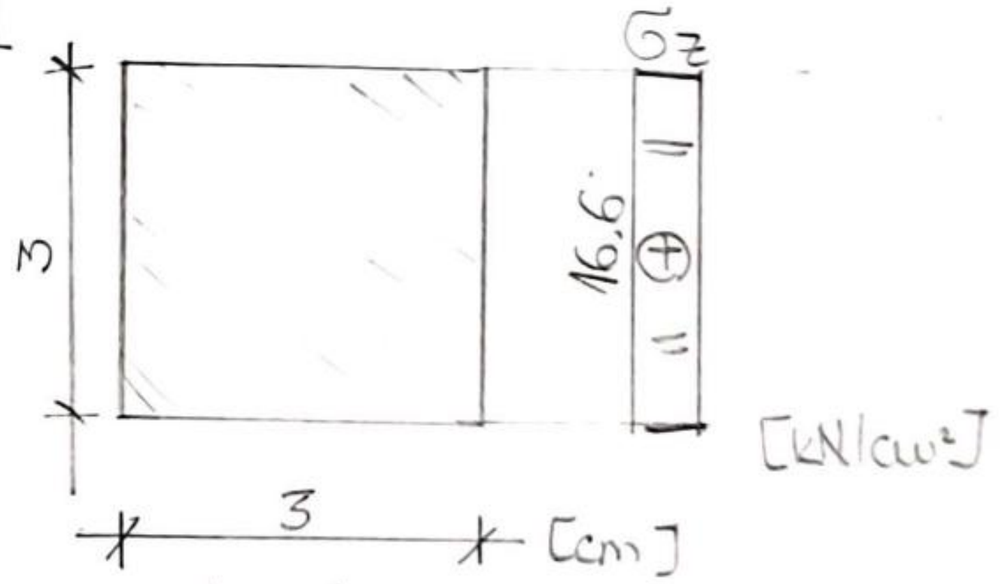
$A_{DE} = 2 \cdot 2 = 4cm^2$

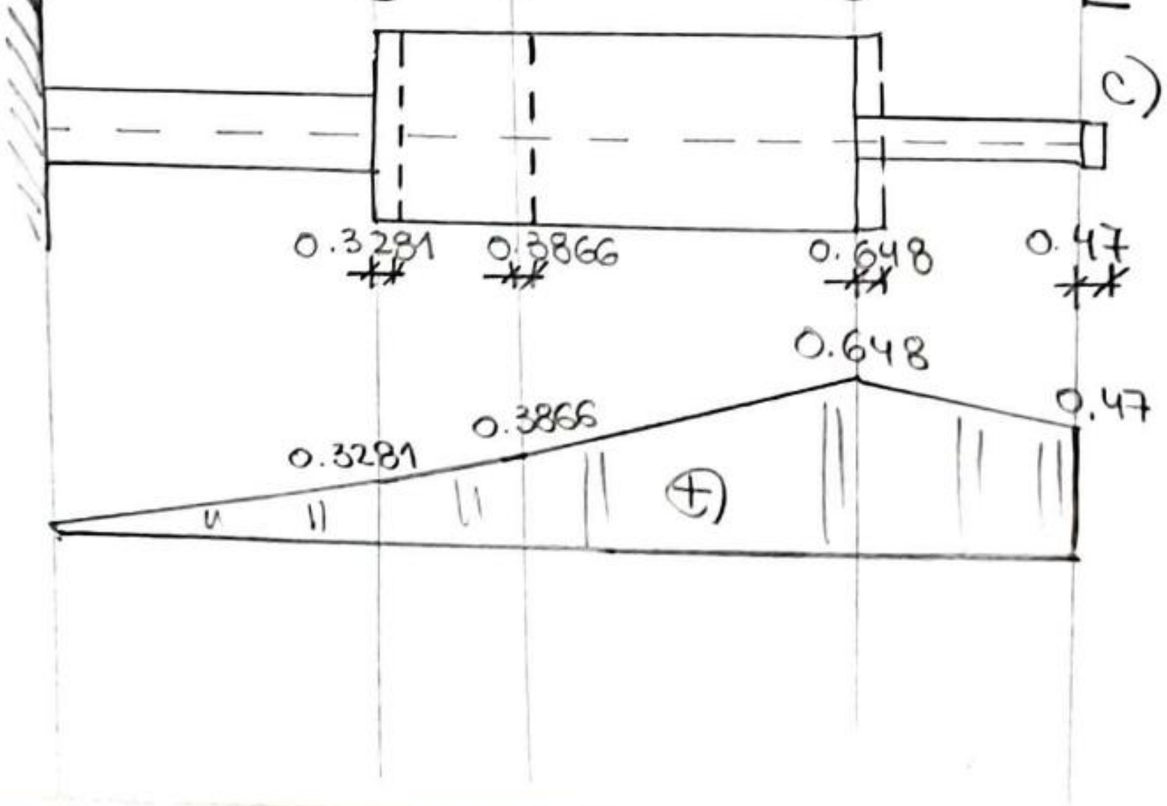












c) $\Delta l_{AB} = \frac{N_{AB} \cdot l_{AB}}{E \cdot A_{AB}} = \frac{150 \cdot 300\,cm}{210 \cdot 10^3 \cdot 9} = 0,2381cm$

$\Delta l_{BC} = \frac{N_{BC} \cdot l_{BC}}{E A_{BC}} = \frac{150 \cdot 100}{210 \cdot 10^2 \cdot 25} = 0,02857cm$

$\Delta l_{CD} = \frac{N_{CD} \cdot l_{CD}}{E \cdot A_{CD}} = \frac{300 \cdot 300}{210 \cdot 10^3 \cdot 25} = 0,1714cm$

$\Delta l_{DE} = \frac{N_{DE} \cdot l_{CD}}{E \cdot A_{DE}} = \frac{-100 \cdot 200}{210 \cdot 10^3 \cdot 4} = -0,2381cm$

$\Delta l_A = 0$

$\Delta l_B = \Delta l_{AB} = 0,2381 cm$

$\Delta l_C = \Delta l_{AB} + \Delta l_{BC} = 0,2381 + 0,02857 = 0,2666 cm$

$\Delta l_D = \Delta l_{AB} + \Delta l_{BC} + \Delta l_{CD} = 0,2381 + 0,02857 + 0,1714 = 0,43807 cm$

$\Delta l_E = \Delta l_{AB} + \Delta l_{BC} + \Delta l_{CD} + \Delta l_{DE} = 0,2381 + 0,02857 + 0,1714 - 0,2381 = 0,2 cm$

d) $\Delta l_B = 0,2381 + \alpha_t \cdot \Delta t \cdot l_B = 0,2381 + 10^{-5} \cdot 30 \cdot 300 = 0,3181 cm$

$\Delta l_C = 0,2666 + 10^{-5} \cdot 30 \cdot 400 = 0,3866 cm$

$\Delta l_D = 0,43807 + 10^{-5} \cdot 30 \cdot 700 = 0,64807 cm$

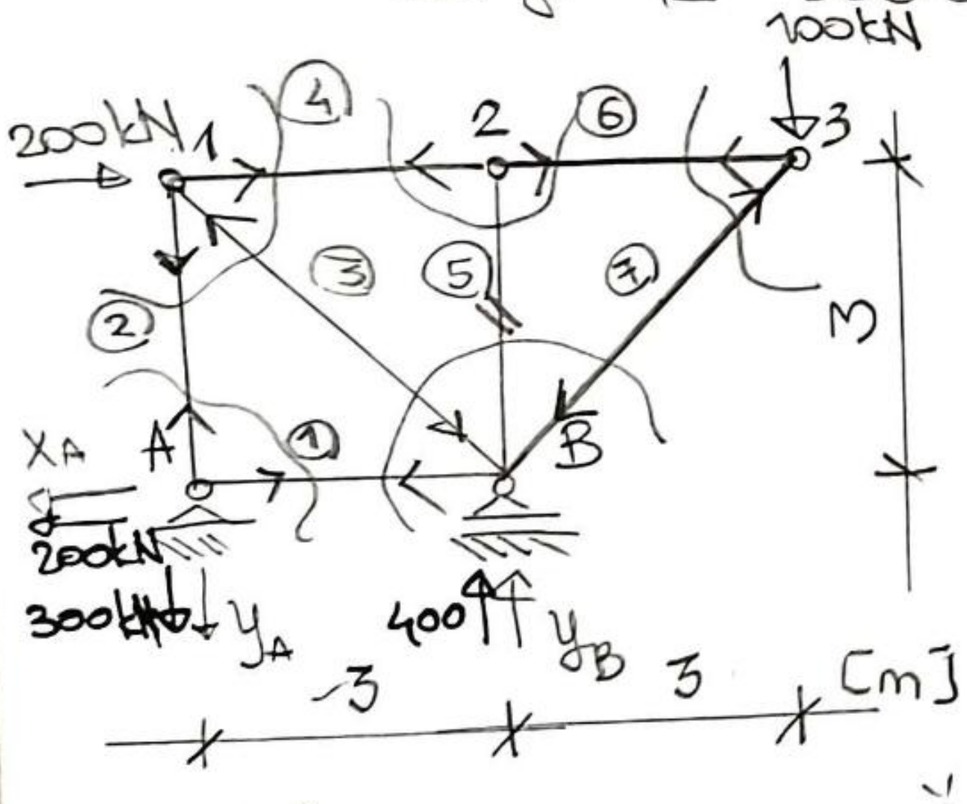
$\Delta l_E = 0,2 + 10^{-5} \cdot 30 \cdot 900 = 0,47 cm$

3. Za rešetkasti nosač odrediti:

a) Vrijednosti aksijalnih sila metodom isijecanja čvorova

b) Dimenzionisati nosač, ako je $\sigma_{dop} = 10 kN/cm^2$

c) Izračunati maksimalno izduženje i maksimalno skraćenje štapova ako je $E = 200 GPa$.



a) Uslovi ravnoteže:

$\sum x = 0$ (→) $\quad \sum M_B = 0$ (↺)

$X_A - 200 = 0$ $\quad 200 \cdot 3 + 100 \cdot 3 - y_A \cdot 3 = 0$ (2)

$X_A = 200 kN$ $\quad y_A = 300 kN$

$\sum y = 0$, $-300 + y_B - 100 = 0$, $y_B = 400 kN$

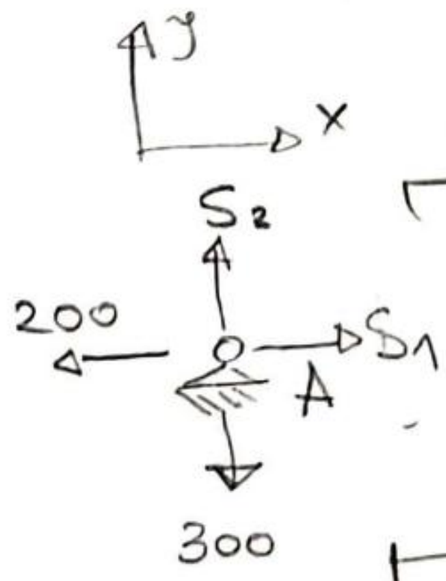
Kontrola:

$\sum M_A = 0$ (↺)

$400 \cdot 3 - 100 \cdot 6 - 200 \cdot 3 = 0$

$0 = 0$ (T)

Čvor A:



$\sum x = 0$

$S_1 - 200 = 0$

$S_1 = 200 kN$ |

(zat.)

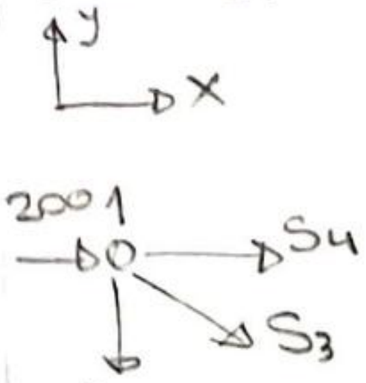
$\sum y = 0$

$S_2 - 300 = 0$

$S_2 = 300 kN$ |

(zatezanje)

Čvor 1:



$\sum y = 0$

$-300 - S_3 \frac{\sqrt{2}}{2} = 0$

$S_3 = -424,264 kN$

(pritisak)

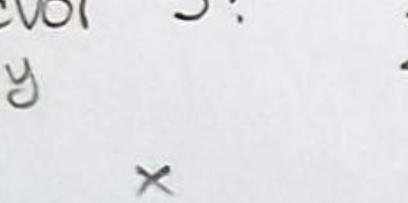
$\sum X = 0$

$200 + S_4 + S_3 \frac{\sqrt{2}}{2} = 0$

$S_4 = -200 - S_3 \cdot \frac{\sqrt{2}}{2}$

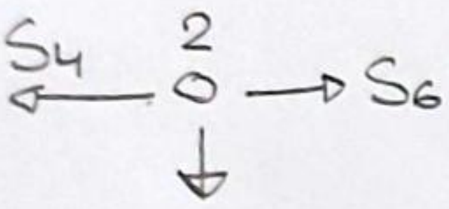
$S_4 = 100kN$
(zatezanje)

čvor 2:



$\sum X = 0$

$-S_4 + S_6 = 0$



$S_6 = S_4 = +100kN$
(zatezanje)

$\sum y = 0$

$S_5 = 0$

čvor 3:

$\sum X = 0$

$-S_6 - S_7 \frac{\sqrt{2}}{2} = 0$

$S_7 = -S_6 \cdot \frac{2}{\sqrt{2}}$

$S_7 = -141,42kN$
(pritisak)

b) $\sigma_{dop} = 10kN/cm^2$

$\sigma_z = \frac{|N|}{A} \leq \sigma dop \Rightarrow A_{pot} \geq \frac{|N|}{\sigma dop}$

$A_{pot} \geq \frac{|-424,264|}{10} = 42,426 cm^2$, usvaja se $\boxed{A = 42,5cm^2}$

c) maks. izduženje:

$S_2 = 300kN$ (max. sila zatezanja)

$\Delta l_2 = \frac{S_2 \cdot l_2}{E \cdot A_2} = \frac{300 \cdot 300}{200 \cdot 10^2 \cdot 42,5} = 0,10588cm$

maks. skraćenje:

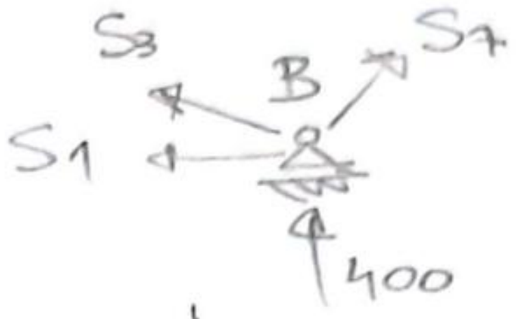
$S_3 = -424,264kN$ (max sila pritiska)

$\Delta l_3 = \frac{-424,264 \cdot 4,242 \cdot 10^2}{200 \cdot 10^2 \cdot 42,5} = -0,21173cm$

$l_3 = 3\sqrt{2} = 4,242m$

provjera:

čvor B:



$\sum X = 0$

$-S_3 \frac{\sqrt{2}}{2} + S_7 \frac{\sqrt{2}}{2} - S_1 = 0$

$300 - 700 - 200 = 0 \; (+) \; W$

$\sum y = 0$

$400 + S_3 \frac{\sqrt{2}}{2} + S_7 \frac{\sqrt{2}}{2} = 0$

$400 - 300 - 100 = 0 \; (+) \; W$