OTPORNOST MATERIJALA 1

1. kolokvij, 15. studenoga 2021.

Prezime i ime:

Grupa B

1.

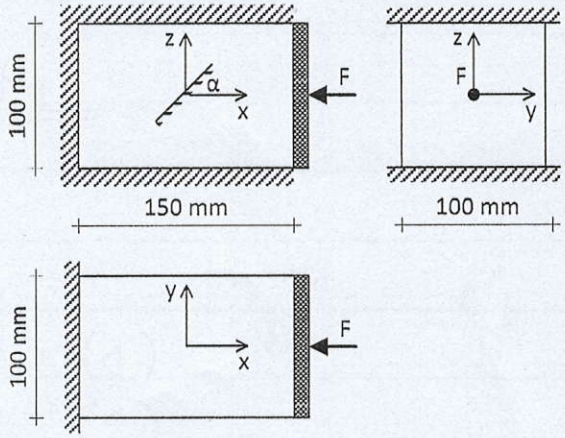
Čelična prizma opterećena je silom F prema slici.

Odredite:

a) stanje naprezanja i deformacija u smjerovima x, y i z,
b) apsolutnu promjenu volumena prizme,
c) puno naprezanje za ravninu koja sa osi x zatvara kut od $\alpha = 45°$ (skica).

Zadano:

$F = 500$ kN, $E = 200$ GPa, $\nu = 0{,}3$

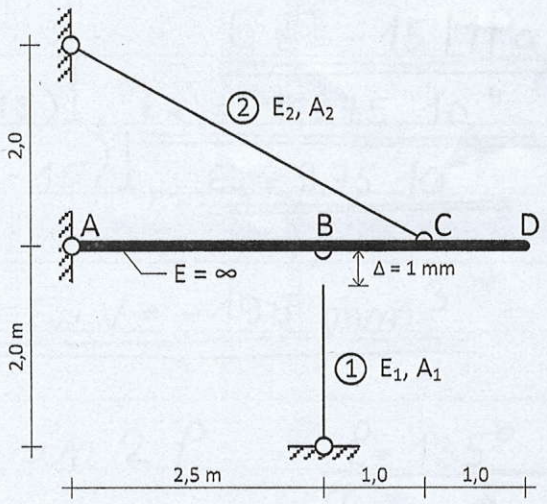


2.

Za zadani štapni sustav odredite pomak točke D i naprezanja u štapovima 1 i 2 nakon spajanja štapa 1 s gredom.

Zadano:

$E_1 = 150$ GPa
$E_2 = 210$ GPa
$A_1 = 200$ mm^2
$A_2 = 300$ mm^2

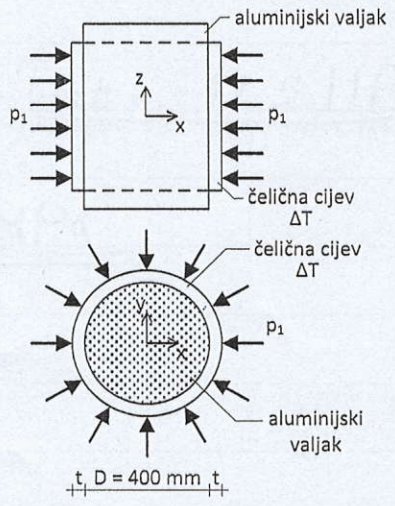


3.

Na čeličnu cijev djeluju pritisak p_1 i promjena temperature ΔT. Odredite pritisak p_1 i pritisak p između čelične cijevi i aluminijskog valjka ako je uslijed opisanih djelovanja na cijev došlo do smanjenja promjera valjka za $\Delta D = 0{,}02$ mm.

Zadano:

$E_{\text{čelik}} = 200$ GPa
$E_{\text{aluminij}} = 80$ GPa
$\nu_{\text{aluminij}} = 0{,}35$
$\alpha_{t,\text{ čelik}} = 1{,}25 \cdot 10^{-5}$ 1/K
$t = 6$ mm
$\Delta T = -30$ K



$F = 500\ kN$

$E = 200\ GPa$

$\nu = 0{,}3$

$$\sigma_x = -\frac{F}{A} = \frac{-500 \cdot 10^3}{100^2} = -50\ MPa$$

$\sigma_y = 0$, $\sigma_z \neq 0$

$$\varepsilon_x = \frac{1}{E}[\sigma_x - \nu(\sigma_y + \sigma_z)] \neq 0 \quad (1)$$

$$\varepsilon_y = \frac{1}{E}[\sigma_y - \nu(\sigma_x + \sigma_z)] \neq 0 \quad (2)$$

$$\varepsilon_z = \frac{1}{E}[\sigma_z - \nu(\sigma_x + \sigma_y)] = 0 \quad (3) \rightarrow \sigma_z = \nu\,\sigma_x$$

$\sigma_z = -15\ MPa$

$$\rightarrow iz\ (1) \Rightarrow \varepsilon_x = \frac{1}{2 \cdot 10^5}[-50 - 0{,}3 \cdot (-15)], \quad \varepsilon_x = -2{,}275 \cdot 10^{-4}$$

$$\rightarrow iz\ (2) \Rightarrow \varepsilon_y = \frac{1}{2 \cdot 10^5}[-0{,}3\,(-50 - 15)], \quad \varepsilon_y = 9{,}75 \cdot 10^{-5}$$

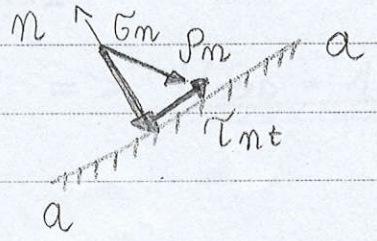
$$\varepsilon_v = \varepsilon_x + \varepsilon_y + \varepsilon_z = -1{,}3 \cdot 10^{-4}, \quad \Delta V = \varepsilon_v \cdot V = -195\ mm^3$$

$$\sigma_n = \sigma_x \cos^2\rho + \sigma_z \sin^2\rho + \tau_{xz} \sin 2\rho \qquad \rho = 135°$$

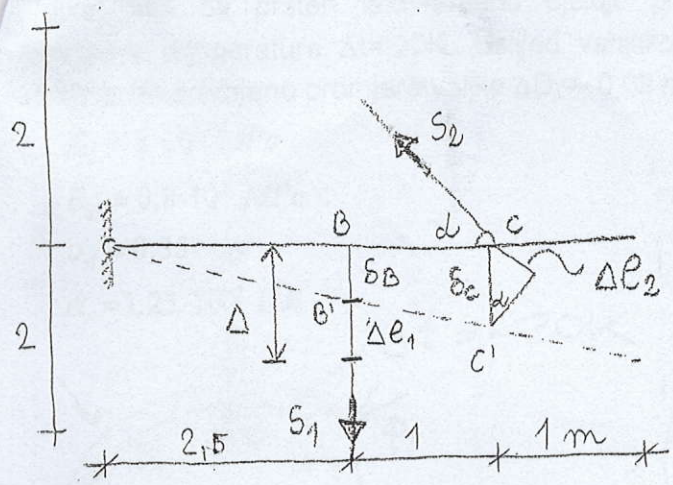
$\sigma_n = -32{,}5\ MPa$ $\qquad \tau_{xz} = 0$

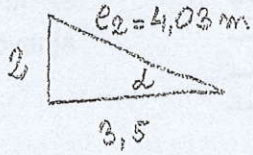
$$\tau_{nt} = \frac{\sigma_z - \sigma_x}{2} \sin 2\rho + \tau_{xz} \cos 2\rho, \quad \tau_{nt} = -17{,}5\ MPa$$

$$p_n = \sqrt{\sigma_n^2 + \tau_{nt}^2}, \quad p_n = 36{,}91\ MPa$$



2. ZADATAK





$$\operatorname{tg}\alpha = \frac{2}{3,5}$$

U.R.

$\alpha = 29,74°$

$$S_1 \cdot 2,5 = S_2 \sin\alpha \cdot 3,5$$

$$S_1 = 0,695 S_2; \quad S_2 = 1,44 S_1$$

U.D.

$$\frac{\delta_C}{3,5} = \frac{\delta_B}{2,5}$$

$$\delta_C = \frac{\Delta e_2}{\sin\alpha} = \frac{S_2 \cdot e_2}{E_2 A_2 \sin\alpha}$$

$$\delta_B = \Delta - \Delta e_1 = \Delta - \frac{S_1 \cdot e_1}{E_1 \cdot A_1}$$

$$\delta_C = \delta_B \cdot 1,4$$

$$\frac{S_2 \cdot e_2}{E_2 \cdot A_2 \cdot \sin\alpha} = \left(\Delta - \frac{S_2 \cdot 0,694 \cdot e_1}{E_1 \cdot A_1}\right) \cdot 1,4$$

$S_2 = 7,22$ kN

$S_1 = 5,01$ kN

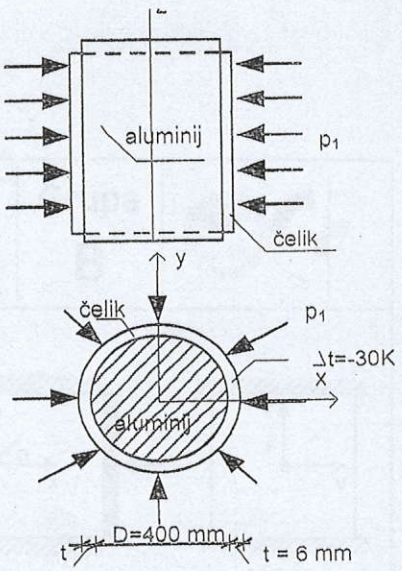
$\sigma_1 = 25,07$ MPa

$\sigma_2 = 24,08$ MPa

$$\Delta e_2 = \frac{S_2 \cdot e_2}{E_2 \cdot A_2} = 0,46 \text{ mm} \Rightarrow \delta_C = 0,93 \text{ mm}$$

$$\frac{\delta_D}{4,5} = \frac{\delta_C}{3,5} \Rightarrow \delta_D = 1,2 \text{ mm}$$

otrebno je odrediti međusobni pritisak p između prstena i ijka, ako na prsten istovremeno djeluje pritisak p_1 te promjena temperature Δt=-30K. Uslijed vanjskog djelovanja došlo je do promjene promjera valjka ΔD_1=- 0,02 mm.

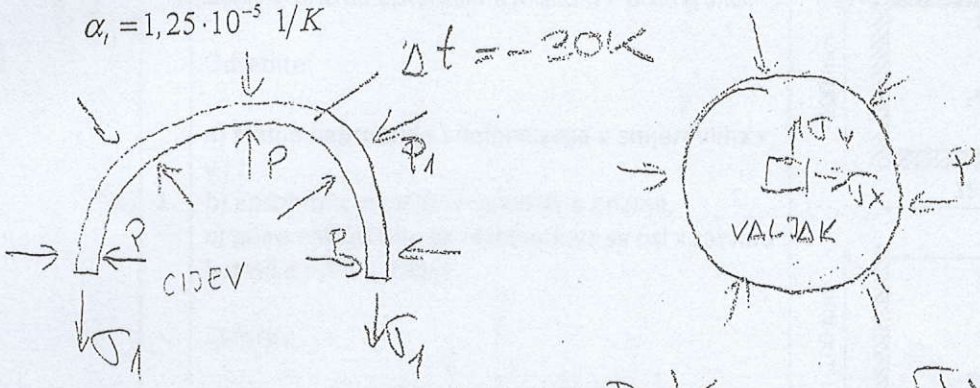


$E_č = 2 \cdot 10^5\ MPa$

$E_{al} = 0{,}8 \cdot 10^5\ MPa$

$\upsilon_{al} = 0{,}35$

$\alpha_t = 1{,}25 \cdot 10^{-5}\ 1/K$



$$\sigma_1 \cdot t \cdot b + p_1 (D+2t) b = pD \cdot b$$

$$\sigma_1 = \frac{pD - p_1(D+2t)}{2t}$$

$$\sigma_x = \sigma_y = -p$$

$$\sigma_z = 0$$

$$\varepsilon_č = \varepsilon_{al} = \frac{\Delta D}{D} = \frac{-0{,}02}{400} = -5 \cdot 10^{-5}$$

$$\varepsilon_{x\,al} = \frac{1}{E_{al}} \left(\sigma_x - \upsilon (\sigma_y + \sigma_z) \right) = -5 \cdot 10^{-5}$$

$$-p + 0p = -4 \Rightarrow \boxed{p = 6{,}15\ MPa}$$

$$-\varepsilon_{x\,č} = \frac{\sigma_x}{E_č} + \alpha_t \cdot \Delta t = -5 \cdot 10^{-5}$$

$$\frac{pD - p_1(D+2t)}{2t \cdot E_č} + \alpha_t \cdot \Delta t = -5 \cdot 10^{-5}$$

$$1{,}025 \cdot 10^{-3} - 17{,}17 \cdot 10^{-5} \cdot p_1 = -5 \cdot 10^{-5} + 37{,}5 \cdot 10^{-5}$$

$$\boxed{p_1 = 4{,}08\ MPa}$$