

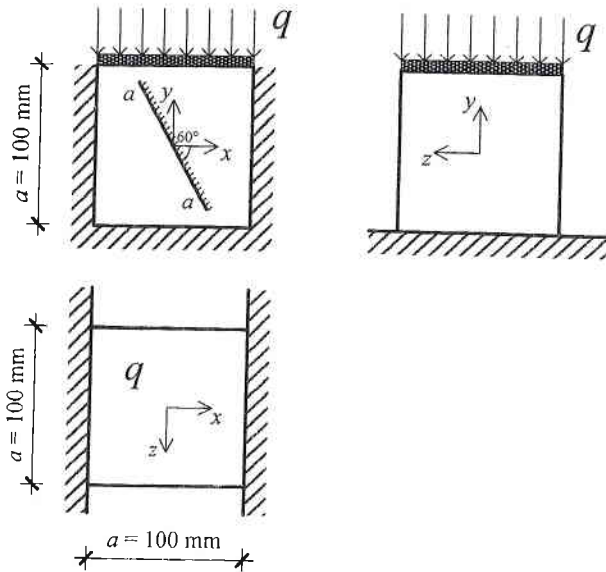
1. Čelična kocka brida  $a = 100 \text{ mm}$  opterećena je prema skici s  $q = 60 \text{ MPa}$ .

Treba odrediti:

- tenzor naprezanja i tenzor deformacija
- promjenu volumena
- vektor punog naprezanja na ravnini  $a-a$  koja s osi  $x$  zatvara kut od  $60^\circ$ .

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

$$\nu = 0,3$$



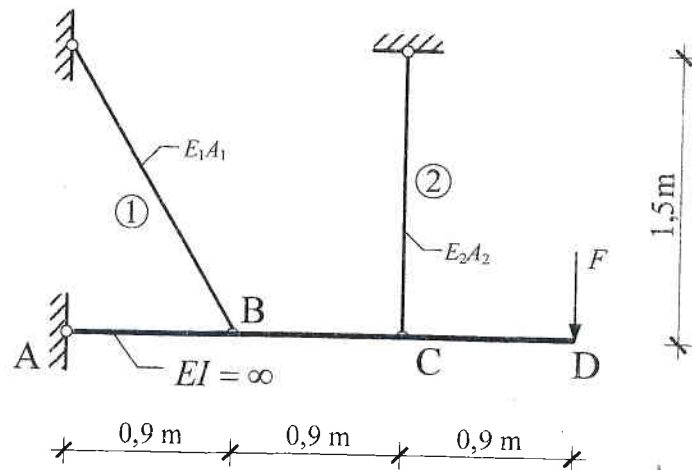
2. Treba odrediti pomak točke **D** i naprezanje u štapovima **1** i **2**, ako je zadano:

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

$$A_1 = 120 \text{ mm}^2$$

$$A_2 = 80 \text{ mm}^2$$

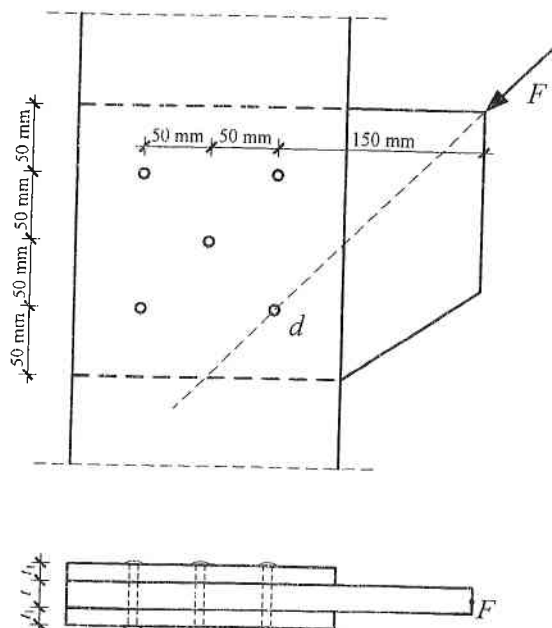
$$F = 100 \text{ kN}$$

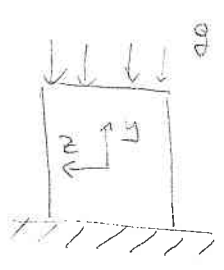
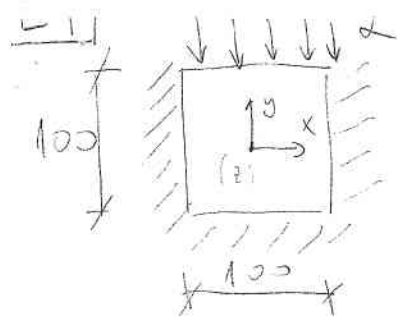


3. Tri lima ( $t_1 = 10 \text{ mm}$ ,  $t = 20 \text{ mm}$ ) spojena su međusobno s pet zakovica promjera  $d = 20 \text{ mm}$ . Treba odrediti dopuštenu silu  $F$ , ako je:

$$\tau_{dop} = 100 \text{ MPa}$$

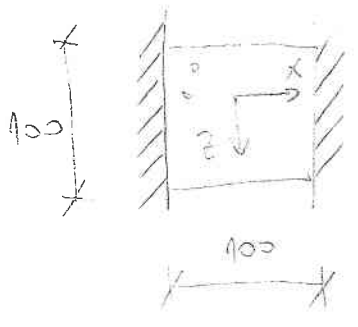
$$\sigma_{odop} = 240 \text{ MPa}$$





$\nu = 0,3$   
 $\sigma = 60 \text{ MPa}$   
 $E = 2 \cdot 10^5 \text{ MPa}$   
 $\nu = 0,3$

a)  $\epsilon_x = \frac{1}{E} [\sigma_x - \nu(\sigma_y + \sigma_z)] = 0$   
 $\epsilon_y = \frac{1}{E} [\sigma_y - \nu(\sigma_x + \sigma_z)]$   
 $\epsilon_z = \frac{1}{E} [\sigma_z - \nu(\sigma_x + \sigma_y)]$



$\sigma_y = -60 \text{ MPa (tlač)}$   
 $\sigma_z = 0$

$\sigma_x = \nu(\sigma_y + \sigma_z) = 0,3(-60) = -18 \text{ MPa}$

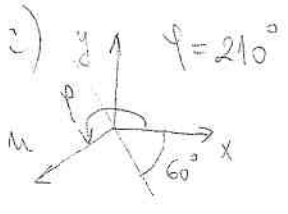
$\epsilon_x = \frac{1}{2 \cdot 10^5} [-60 - 0,3(-18)] = -2,73 \cdot 10^{-4}$

$\epsilon_z = \frac{1}{2 \cdot 10^5} [0 - 0,3(-60 - 18)] = 1,17 \cdot 10^{-4}$

$[\sigma_{ij}] = \begin{bmatrix} -18 & 0 & 0 \\ 0 & -60 & 0 \\ 0 & 0 & 0 \end{bmatrix} \text{ MPa}; [\epsilon_{ij}] = \begin{bmatrix} 0 & 0 & 0 \\ 0 & -2,73 & 0 \\ 0 & 0 & 1,17 \end{bmatrix} \cdot 10^{-4}$

2)  $\epsilon_v = \frac{\Delta V}{V} = \epsilon_x + \epsilon_y + \epsilon_z = -2,73 \cdot 10^{-4} + 1,17 \cdot 10^{-4} = -1,56 \cdot 10^{-4}$

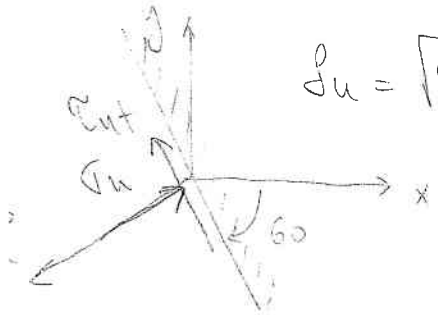
$\Delta V = V \cdot \epsilon_v = 100^3 \cdot (-1,56 \cdot 10^{-4}) = -156 \text{ mm}^3$



$\sigma_n = \sigma_x \cos^2 \phi + \sigma_y \sin^2 \phi + \tau_{xy} \sin 2\phi = -18 \cdot \cos^2 210 - 60 \cdot \sin^2 210 = -28,5 \text{ MPa}$

$\tau_{nt} = \frac{\sigma_y - \sigma_x}{2} \sin 2\phi + \tau_{xy} \cos 2\phi = \frac{-60 + 18}{2} \sin(2 \cdot 210) = -18,9 \text{ MPa}$

$\rho_n = \sqrt{\sigma_n^2 + \tau_{nt}^2} = 33,81 \text{ MPa}$



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

$A_1 = 120 \text{ mm}^2$

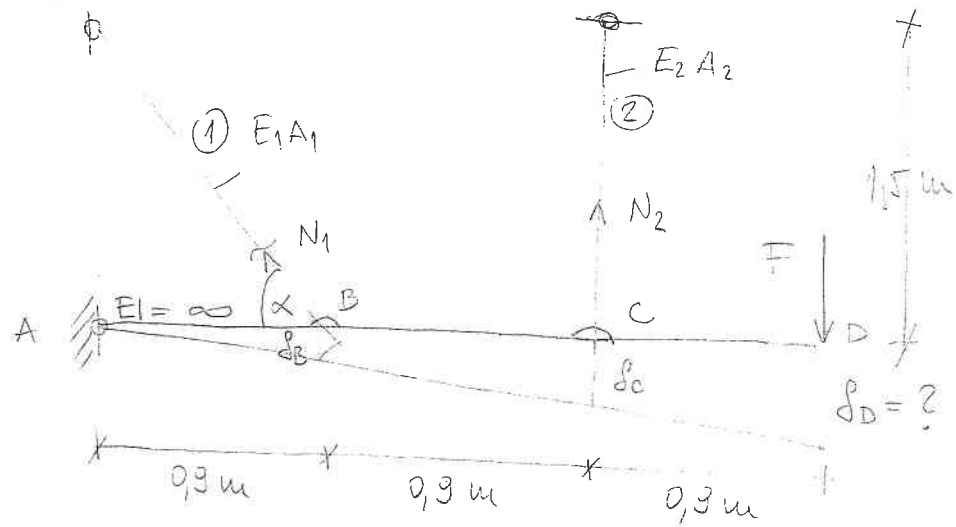
$A_2 = 80 \text{ mm}^2$

$F = 100 \text{ kN}$

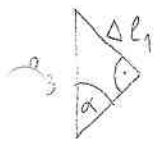
$l_1 = \sqrt{0,9^2 + 1,5^2} = 1,749 \text{ m}$

$l_2 = 1,5 \text{ m}$

$\tan \alpha = \frac{1,5}{0,9} \quad \alpha = 59,04^\circ$

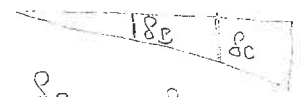


$\sum M_A = 0 \quad 0,9 N_1 \sin \alpha + 1,8 N_2 = 2,7 F$



$\sin \alpha = \frac{\Delta l_1}{\delta_B} \Rightarrow \delta_B = \frac{\Delta l_1}{\sin \alpha} = \frac{N_1 l_1}{E_1 A_1 \sin \alpha}$

$\delta_C = \Delta l_2 = \frac{N_2 l_2}{E_2 A_2}$



$\frac{\delta_B}{0,9} = \frac{\delta_C}{1,8}$

$\delta_C = 2 \delta_B$

$\frac{N_2 l_2}{E_2 A_2} = 2 \frac{N_1 l_1}{E_1 A_1 \sin \alpha} \Rightarrow N_2 = 2 N_1 \frac{l_1}{l_2} \frac{A_2}{A_1} \frac{E_2}{E_1} \frac{1}{\sin \alpha}$

$0,9 N_1 \sin \alpha + 1,8 \cdot 2 N_1 \frac{l_1}{l_2} \frac{A_2}{A_1} \frac{E_2}{E_1} \frac{1}{\sin \alpha} = 2,7 F$

$N_1 = \frac{2,7 F}{\left(0,9 \sin \alpha + 3,6 \frac{l_1}{l_2} \frac{A_2}{A_1} \frac{E_2}{E_1} \frac{1}{\sin \alpha}\right)} = \frac{2,7 \cdot 100}{\left(0,9 \sin 59,04 + 3,6 \frac{1,749}{1,5} \frac{80}{120} \frac{1}{\sin 59,04}\right)}$

$N_1 = 66,91 \text{ kN}$

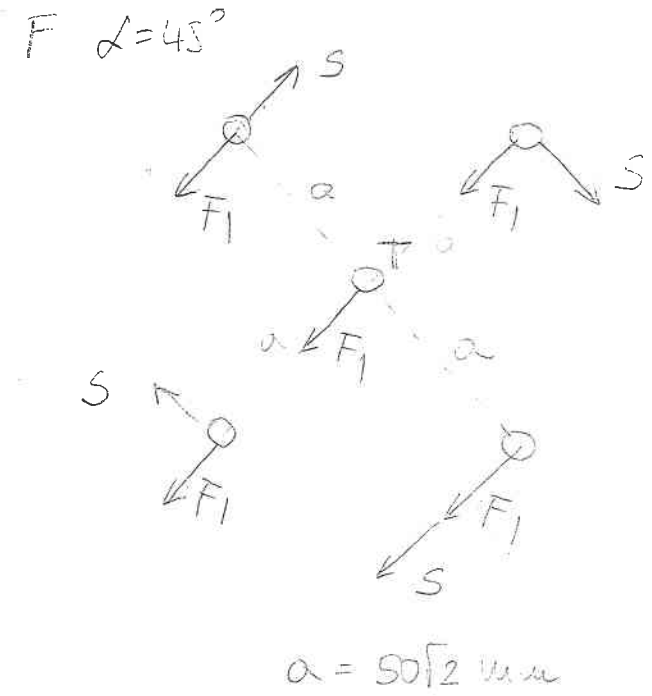
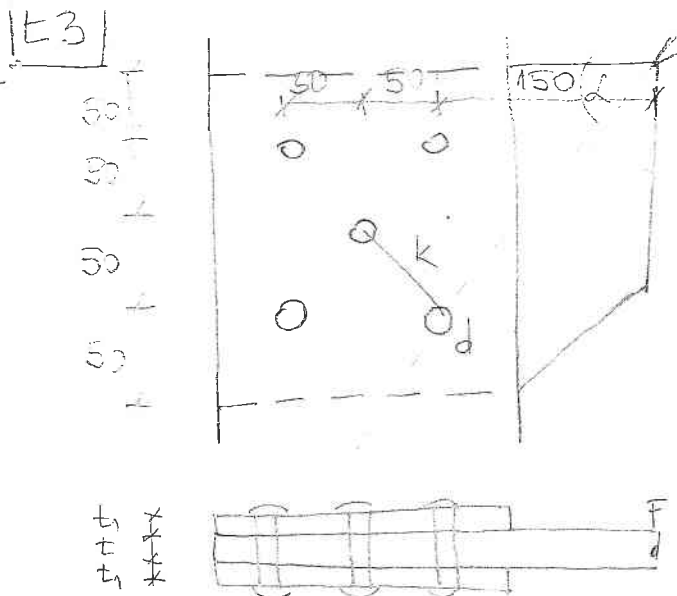
$N_2 = 121,31 \text{ kN}$

$\delta_C = \Delta l_2 = \frac{N_2 \cdot l_2}{E_2 \cdot A_2} = \frac{121310 \cdot 1500}{2 \cdot 10^5 \cdot 80} = 11,37 \text{ mm}$

$\frac{\delta_D}{2,7} = \frac{\delta_C}{1,8} \quad \delta_D = 1,5 \delta_C = 17 \text{ mm}$

$\sigma_1 = \frac{N_1}{A_1} = \frac{66,91 \cdot 10^3}{120} = 557,58 \text{ MPa}$

$\sigma_2 = \frac{N_2}{A_2} = \frac{121,31 \cdot 10^3}{80} = 1516,38 \text{ MPa}$



$$a = 50\sqrt{2} \text{ mm}$$

$$t_1 = 10 \text{ mm} \quad d = 20 \text{ mm}$$

$$t = 20 \text{ mm}$$

$$\sigma_{\text{dop}} = 100 \text{ MPa}$$

$$\sigma_{\text{odop}} = 240 \text{ MPa}$$

$$F_1 = \frac{F}{5}$$

$$M = F \cdot k = F \sqrt{2} \cdot 50 = 4 \cdot S \cdot a$$

$$\sqrt{2} \cdot 50 F = 4 \cdot S \cdot \sqrt{2} \cdot 50 \Rightarrow S = \frac{F}{4}$$

$$S_{\text{max}} = S + F_1 = \frac{F}{4} + \frac{F}{5} = 0,45 F$$

Wzrost na pobruik

$$\gamma = \frac{S_{\text{max}}}{\frac{2 \cdot d^2 \pi}{42}} \leq \sigma_{\text{dop}} \quad 0,45 F \leq 100 \frac{20^2 \pi}{2}$$

$$F \leq 139626 \text{ N}$$

Wzrost na obodui pitivoli

$$\sigma_0 = \frac{S_{\text{max}}}{t \cdot d} \leq \sigma_{\text{odop}} \quad 0,45 F \leq 240 \cdot 20 \cdot 20$$

$$F \leq 213333 \text{ N}$$

Ujnorodamo  $F \leq 139,626 \text{ kN}$