

M_3
 M_2
 M_1

$0 < x < L$ $L < x < 2L$ $2L < x < 3L$

$M_3 = M$ $M_3 = M + M = 2M$ $M_3 = M + M = 3M = -M$

$\tau = \frac{M_3 \cdot D}{J_{03} \cdot 2}$ $\tau = \frac{M_3 \cdot D}{J_{03} \cdot 2}$ $\tau = \frac{M}{J_{03}} \cdot \frac{D}{2}$

$\tau = \frac{32 \cdot M}{15 \pi d^3}$ $\tau_{max} = \frac{2M \cdot 32}{16 \pi d^3} \cdot \frac{2d}{2}$ $\tau = \frac{M \cdot 32}{15 \pi d^4} \cdot \frac{2d}{2}$

Dane:
 $M = 10 \text{ Nm}$
 $U_3 = 90 \text{ MPa}$
 $D = 2d$
 $G = 0,5 \text{ kN/cm}^2 = 5 \cdot 10^4 \text{ MPa}$
 $\varphi_{dep} = 0,5^\circ = 8,7 \cdot 10^{-3} \text{ rad}$

Obł: $d = ?$

$$J_{01} = \frac{\pi d^4}{32} = \frac{\pi d^4}{32} \cdot \frac{16}{16} = \frac{16\pi d^4}{32}$$

$$J_{02} = \frac{\pi d^4}{32}$$

$$J_{02} = \frac{\pi (4d)^4}{32}$$

$$J_{02} = \frac{16\pi d^4}{32}$$

to to podzielniki do x dla $0 < x < 2L$

$$d^3 \geq \frac{4M}{\pi \cdot k_s}$$

$$d \geq \left(\frac{4 \cdot 1 \cdot 10^3}{\pi \cdot 80 \cdot 10^6} \right)^{1/3}$$

$$d \geq 0,025 \text{ m}$$

$$d \geq 25 \text{ mm}$$

$$0 < x < L$$

$$\varphi_1 = \frac{M \cdot x}{G \cdot J_{01}}$$

$$\varphi_1 = \frac{M \cdot L}{15 \cdot G \cdot \pi \cdot d^4}$$

$$L < x < 2L$$

$$\varphi_2 = \frac{2M \cdot L}{G \cdot J_{02}}$$

$$\varphi_2 = \frac{2M \cdot L \cdot 32}{G \cdot \pi \cdot d^4 \cdot 16}$$

$$2L < x < 3L$$

$$\varphi_3 = \frac{M \cdot L}{G \cdot J_{02}}$$

$$\varphi_3 = \frac{32 \cdot M \cdot L}{15 \cdot G \cdot \pi \cdot d^4}$$

$$\varphi_c = \varphi_1 + \varphi_2 + \varphi_3$$

$$\varphi_0 = (2,11 + 4 - 2,11) \cdot \frac{M \cdot l}{\pi \cdot G \cdot d^4}$$

$$\varphi_1 = \frac{G \cdot M \cdot l}{\pi \cdot G \cdot d^4}$$

$$\varphi_{\max} = \varphi_1 + \varphi_2 = \frac{G \cdot M \cdot l}{\pi \cdot G \cdot d^4} \leq \varphi_{\text{dop}}$$

$$d^4 \geq \frac{G \cdot M \cdot l}{\pi \cdot G \cdot \varphi_{\text{dop}}}$$

$$d \geq \sqrt[4]{\frac{60 \cdot 10^3 \cdot 1 \cdot 10^3 \cdot 0,3}{\pi \cdot 8 \cdot 10^{10} \cdot 10^{-4} \cdot 17 \cdot 10^{-5}}}$$

$$d \geq 0,002 \text{ m}$$

$$d \geq 0,002 \text{ mm}$$

G - J₀ - silywnosci obrotowa

E - J - silywnosci giostwa