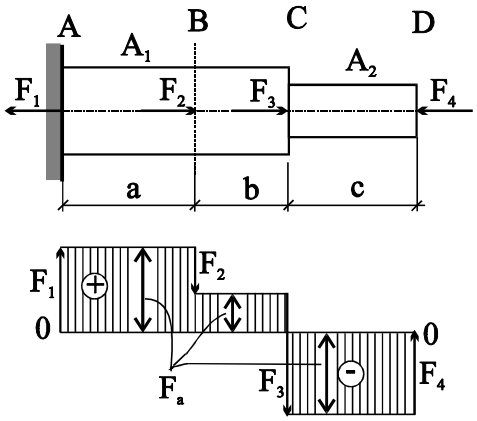
AKSIJALNO OPTEREĆENI NOSAČI

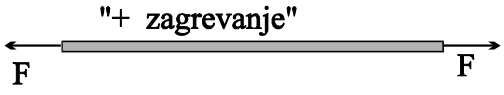
$\sigma = \frac{F_a}{A}, \quad \Delta l = \frac{F_a l}{AE}, \quad \Delta l_t = l\alpha\Delta t,$ dimenzionisanje $|\sigma|_{max} \le \sigma_d$



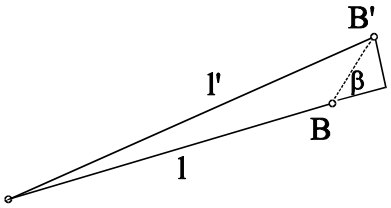
$\Delta l_{A-D} = \Delta l_{A-B} + \Delta l_{B-C} + \Delta l_{C-D}$

$\Delta l_{A-B} = \frac{F_1 a}{A_1 E}, \quad \Delta l_{B-C} = \frac{(F_1 - F_2)b}{A_1 E}, \quad \Delta l_{C-D} = -\frac{F_4 c}{A_2 E}$

$\sigma_{A-B} = \frac{F_1}{A_1}, \quad \sigma_{B-C} = \frac{(F_1 - F_2)}{A_1}, \quad \sigma_{C-D} = -\frac{F_4}{A_2}$



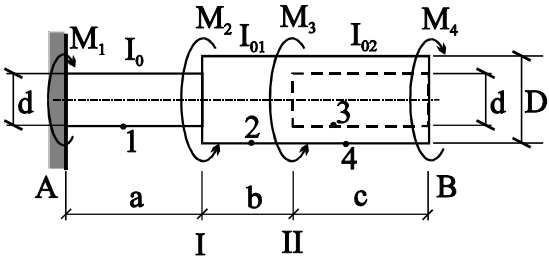
$\Delta l = \frac{Fl}{AE} + l\alpha\Delta t$



l'-dužina elastičnog štrapa nakon deformacije
l-dužina elastičnog štrapa pre deformacije
$\Delta l \approx \overline{BB'}\cos\beta$

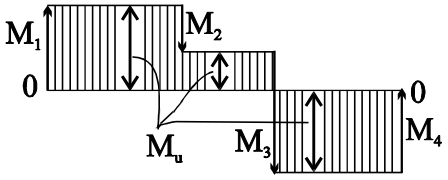
UVIJANJE

$\tau = \frac{M_u}{I_0}\rho, \quad \rho_{max} = \text{poluprečnik}, \qquad \theta = \frac{M_u l}{GI_0}$ dimenzionisanje $\tau_{max} \le \tau_d$



$\tau_1 = \frac{M_1}{I_0}\frac{d}{2}, \quad \tau_2 = \frac{(M_1 - M_2)}{I_{01}}\frac{D}{2}, \quad \tau_4 = \frac{M_4}{I_{02}}\frac{D}{2}$

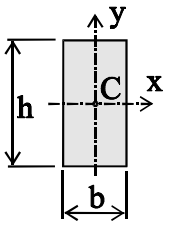
$I_0 = \frac{d^4\pi}{32}, \quad I_{02} = \frac{\pi}{32}(D^4 - d^4)$



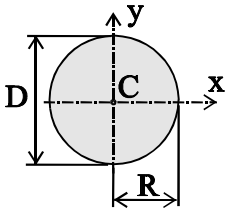
$\theta_{A-B} = \theta_{A-I} + \theta_{I-II} + \theta_{II-B}$

$\theta_{A-I} = \frac{M_1 a}{GI_0}, \quad \theta_{I-II} = \frac{(M_1 - M_2)b}{GI_{01}}, \quad \theta_{II-B} = -\frac{M_4 c}{GI_{02}}$

MOMENTI INERCIJE ELEMENTARNIH POVRŠINA

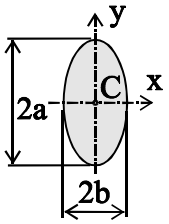


$$I_x = \frac{bh^3}{12},\ I_y = \frac{hb^3}{12}$$



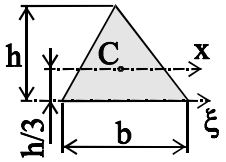
$$I_0 = \frac{D^4\pi}{32} = \frac{R^4\pi}{2}$$

$$I_x = I_y = \frac{D^4\pi}{64} = \frac{R^4\pi}{4}$$



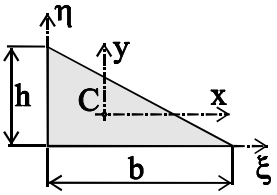
$$A = \pi ab$$

$$I_x = \frac{\pi a^3 b}{4},\ I_y = \frac{\pi b^3 a}{4}$$



$$I_\xi = \frac{bh^3}{12},\ I_x = \frac{bh^3}{36}$$

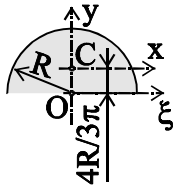
$$\eta_C = \frac{h}{3}$$



$$I_\xi = \frac{bh^3}{12} \quad I_\eta = \frac{hb^3}{12}$$

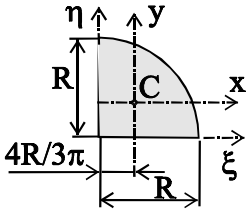
$$I_{\xi\eta} = \frac{b^2h^2}{24} \quad I_x = \frac{bh^3}{36}$$

$$I_y = \frac{hb^3}{36} \quad I_{xy} = -\frac{b^2h^2}{72}$$



$$I_\xi = \frac{D^4\pi}{128} = \frac{R^4\pi}{8}$$

$$I_x = \left(\frac{\pi}{8} - \frac{8}{9\pi}\right)R^4$$

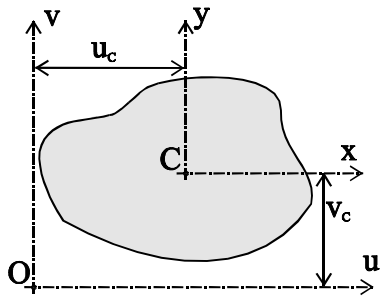


$$I_x = I_y = \left(\frac{\pi}{16} - \frac{4}{9\pi}\right)R^4$$

$$I_{xy} = \left(\frac{1}{8} - \frac{4}{9\pi}\right)R^4$$

$$I_\xi = I_\eta = \frac{\pi R^4}{16},\ I_{\xi\eta} = \frac{R^4}{8}$$

VEZA IZMEĐU MOMENATA INERCIJE ZA PARALELNE OSE – ŠTAJNEROVI OBRASCI

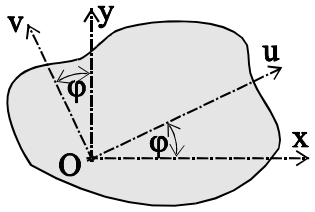


$$I_U = I_x + v_c^2 A$$

$$I_v = I_y + u_c^2 A$$

$$I_{uv} = I_{xy} + u_c v_c A$$

MOMENATI INERCIJE ZA ZAKRENUT KOORDINATNI SISTEM



$$I_u = I_x \cos^2\varphi + I_y \sin^2\varphi - I_{xy}\sin 2\varphi$$

$$I_{uv} = \frac{I_x - I_y}{2}\sin 2\varphi + I_{xy}\cos 2\varphi$$

GLAVNE OSE – GLAVNI MOMENTI INERCIJE

u i v postaju glavne ose 1 i 2 (odnosno 2 i 1) za $\varphi = \alpha$

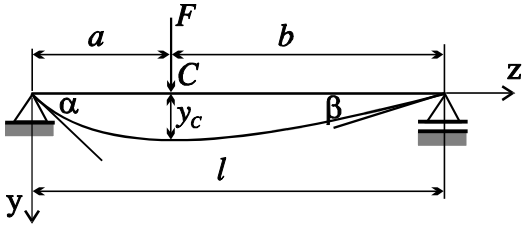
$$\operatorname{tg} 2\alpha = -\frac{2I_{xy}}{I_x - I_y}$$

$$I_{1,2} = \frac{I_x + I_y}{2} \pm \frac{1}{2}\sqrt{(I_x - I_y)^2 + 4I_{xy}^2}$$

$$\left.\frac{d^2 I_u}{d\varphi^2}\right|_{\varphi=\alpha} = 2(I_y - I_x)\cos 2\alpha + 4I_{xy}\sin 2\alpha$$

INVARIJANTE MOMENATA INERCIJE

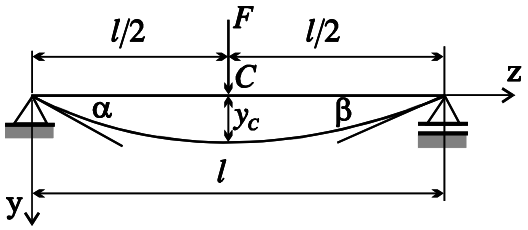
$$I_1 + I_2 = I_x + I_y \quad , \qquad I_1 I_2 = I_x I_y - I_{xy}^2$$



$$y=\frac{Fl^3}{6EI}\left\{\frac{b}{l}\frac{z}{l}\left[1-\left(\frac{b}{l}\right)^2-\left(\frac{z}{l}\right)^2\right]+\left\|\left(\frac{z-a}{l}\right)^3\right\}\right.$$

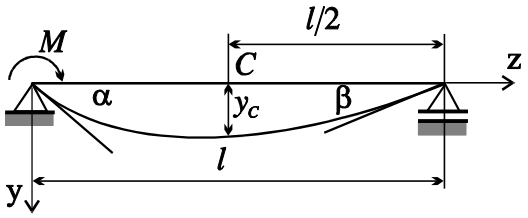
$$y(a)=y_c=\frac{Fl^3}{3EI}\left(\frac{a}{l}\right)^2\left(\frac{b}{l}\right)^2$$

$$\alpha=\frac{Fl^2}{6EI}\frac{a}{l}\frac{b}{l}\left(1+\frac{b}{l}\right)\qquad \beta=\frac{Fl^2}{6EI}\frac{a}{l}\frac{b}{l}\left(1+\frac{a}{l}\right)$$



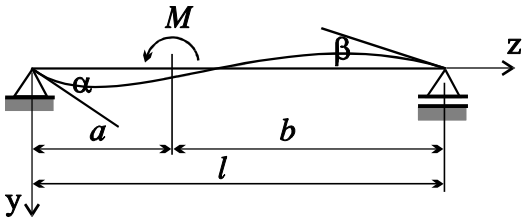
$$y=\frac{Fl^3}{12EI}\left\{\frac{z}{l}\left[\frac{3}{4}-\left(\frac{z}{l}\right)^2\right]+\left\|\frac{1}{4}\left(2\frac{z}{l}-1\right)^3\right\}\right.$$

$$y\left(\frac{l}{2}\right)=y_c=y_{\max}=\frac{Fl^3}{48EI}\qquad \alpha=\beta=\frac{Fl^2}{16EI}$$



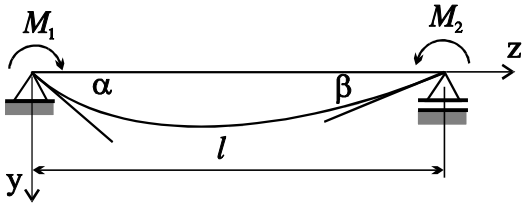
$$y=\frac{Ml^2}{6EI}\frac{z}{l}\left[2-3\left(\frac{z}{l}\right)+\left(\frac{z}{l}\right)^2\right]$$

$$y\left(\frac{l}{2}\right)=y_c=\frac{Ml^2}{16EI}\qquad \alpha=\frac{Ml}{3EI}\qquad \beta=\frac{Ml}{6EI}$$



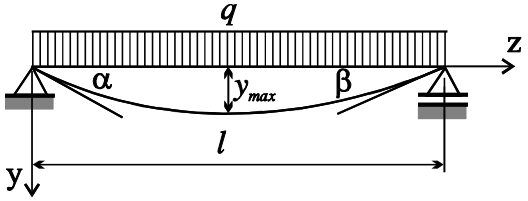
$$y=\frac{Ml^2}{6EI}\left\{\frac{z}{l}\left[1-3\left(\frac{b}{l}\right)^2-\left(\frac{z}{l}\right)^2\right]+\left\|3\left(\frac{z-a}{l}\right)^2\right\}\right.$$

$$\alpha=\frac{Ml}{6EI}\left[1-3\left(\frac{b}{l}\right)^2\right]\qquad \beta=\frac{Ml}{6EI}\left[1-3\left(\frac{a}{l}\right)^2\right]$$



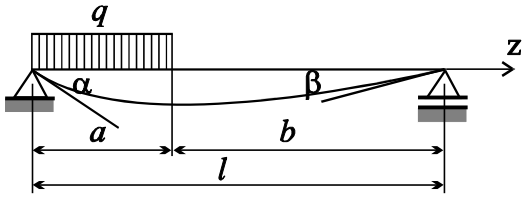
$$y=\frac{l^2}{6EI}\frac{z}{l}\left(1-\frac{z}{l}\right)\left[M_1\left(2-\frac{z}{l}\right)+M_2\left(1+\frac{z}{l}\right)\right]$$

$$\alpha=\frac{l}{6EI}\left(2M_1+M_2\right)\qquad \beta=\frac{l}{6EI}\left(M_1+2M_2\right)$$



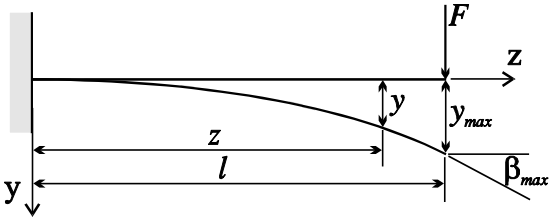
$$y=\frac{ql^4}{24EI}\left[\frac{z}{l}-2\left(\frac{z}{l}\right)^3+\left(\frac{z}{l}\right)^4\right]$$

$$y\left(\frac{l}{2}\right)=y_{\max}=\frac{5ql^4}{384EI}\qquad \alpha=\beta=\frac{ql^3}{24EI}$$



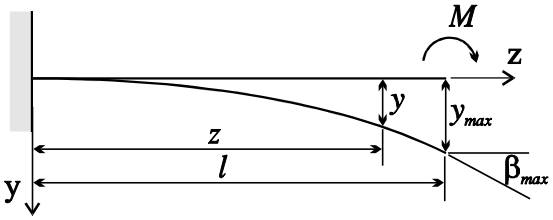
$$y=\frac{ql^4}{24EI}\left\{\frac{z}{l}\left(2-\frac{a}{l}\right)^2\left(\frac{a}{l}\right)^2-\frac{z}{l}\left[2\left(2-\frac{a}{l}\right)\frac{a}{l}\left(\frac{z}{l}\right)^2-\left(\frac{z}{l}\right)^3\right]\right\|-\left(\frac{z-a}{l}\right)^4\right\}$$

$$\alpha=\frac{ql^3}{24EI}\left(\frac{a}{l}\right)^2\left(2-\frac{a}{l}\right)^2\qquad \beta=\frac{ql^3}{24EI}\left(\frac{a}{l}\right)^2\left[2-\left(\frac{a}{l}\right)^2\right]$$



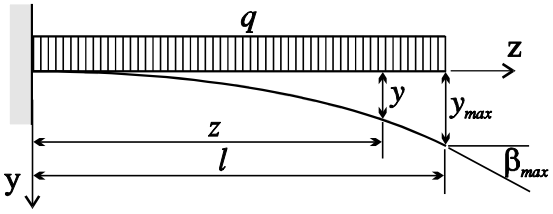
$$y = \frac{Fl^3}{6EI}\left(\frac{z}{l}\right)^2\left(3-\frac{z}{l}\right) \qquad y(l) = y_{\max} = \frac{Fl^3}{3EI}$$

$$\beta_{\max} = \frac{Fl^2}{2EI}$$



$$y = \frac{Ml^2}{2EI}\left(\frac{z}{l}\right)^2 \qquad y(l) = y_{\max} = \frac{Ml^2}{2EI}$$

$$\beta_{\max} = \frac{Ml}{EI}$$



$$y = \frac{ql^4}{24EI}\left(\frac{z}{l}\right)^2\left[6-4\left(\frac{z}{l}\right)+\left(\frac{z}{l}\right)^2\right] \qquad y(l) = y_{\max} = \frac{ql^4}{8EI}$$

$$\beta_{\max} = \frac{ql^3}{6EI}$$

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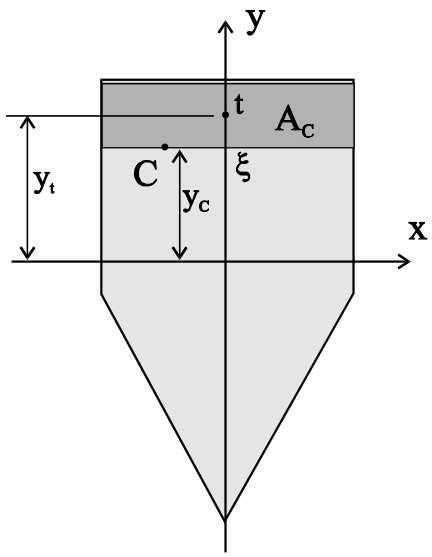
normalni i tangencijalni naponi pri savijanju



$$|\sigma_C| = \frac{|M_S|}{I_x}|y_C|, \quad |\tau_C| = \frac{|F_T|}{I_x}\frac{S_C}{\xi}, \quad S_C = S_x^{(A_C)} = A_C \bullet y_t$$

glavni naponi pri savijanju

$$\sigma_1 = \frac{\sigma}{2} + \frac{1}{2}\sqrt{\sigma^2 + 4\tau^2} \qquad \sigma_2 = \frac{\sigma}{2} - \frac{1}{2}\sqrt{\sigma^2 + 4\tau^2}$$

dimenzionisanje pri savijanju

$$|\sigma_{\max}| = \frac{|M_{S\max}|}{I_x}|y_{\max}| = \frac{|M_{S\max}|}{W_x} \le \sigma_d \qquad W_x = \frac{I_x}{|y_{\max}|}$$

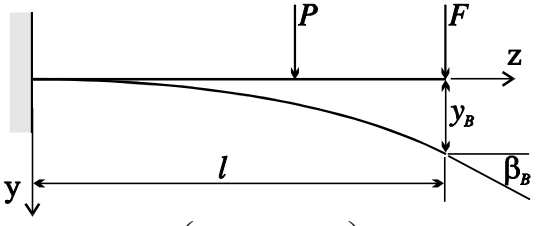
$$\Rightarrow W_x \ge \frac{|M_{S\max}|}{\sigma_d}$$

diferencijalna jednačina elastične linije $EIy'' = -M$

težište složene površine

$$u_T = \frac{\sum u_i A_i}{\sum A_i}, \quad v_T = \frac{\sum v_i A_i}{\sum A_i} \quad \text{gde je} \quad \sum A_i = A$$

statički moment složene površine za osu x $S_x = \sum y_i A_i = y_T A$



superponiranje deformacija

$y_B = y_B^{(F)} + y_B^{(P)}$ odnosno $y_B = \sum y_{Bi}$

$\beta_B = \beta_B^{(F)} + \beta_B^{(P)}$ odnosno $\beta_B = \sum \beta_{Bi}$

KLAPEJRONOVA JEDNAČINA

$$M_{k-1}l_k + 2M_k\left(l_k + l_{k+1}\frac{I_k}{I_{k+1}}\right) + M_{k+1}l_{k+1}\frac{I_k}{I_{k+1}} = -6EI_k\sum_K(\alpha_S + \beta_S)$$