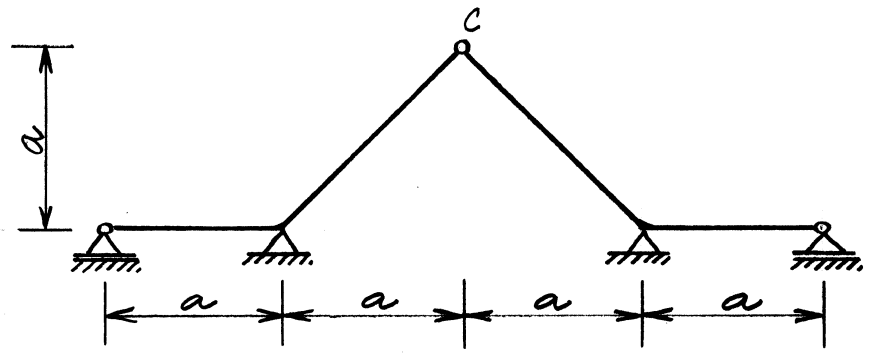
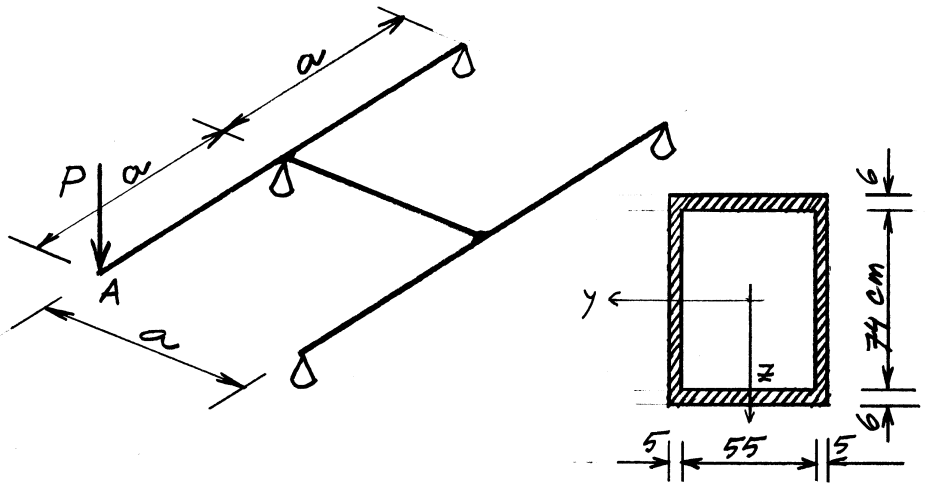
1. Ob upoštevanju vpliva osnih sil določi in skiciraj notranje sile, ki nastopijo v prikazanem nosilcu, če ga enakomerno segrejemo za 30 K! Določi tudi pomik točke C! (Nasvet: Upoštevaj simetrijo konstrukcije!)



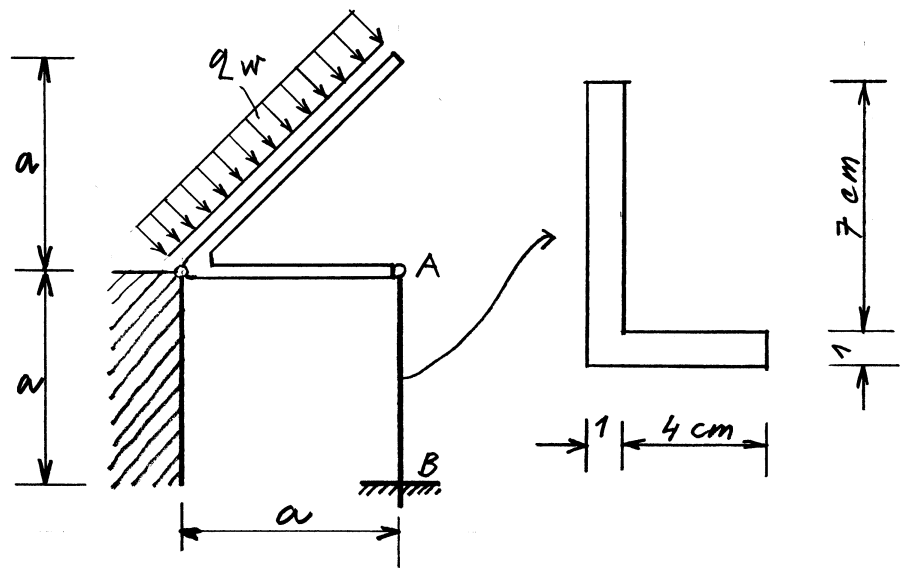
$E = 20\,000\,\mathrm{kN/cm^2}$
$A_x = 60\,\mathrm{cm^2}$
$I_y = 4000\,\mathrm{cm^4}$
$\alpha_T = 1.25 \cdot 10^{-5}/\mathrm{K}$
$\Delta T = 30\,\mathrm{K}$
$a = 4\,\mathrm{m}$

2. Branasta konstrukcija je sestavljena iz enakih elementov, katerih prečni prerez je prikazan na skici. Ob upoštevanju čiste torzije določi navpični pomik točke A!



$E = 210\,000\,\mathrm{MPa}$
$G = 100\,000\,\mathrm{MPa}$
$P = 0.1\,\mathrm{MN}$
$a = 12\,\mathrm{m}$

3. Tog strešni nosilec je obtežen z akcijo vetra q_w. Določi koeficient uklonske varnosti stebra AB!



$E = 210\,000\,\mathrm{MPa}$
$q_w = 2\,\mathrm{kN/m}$
$a = 6\,\mathrm{m}$

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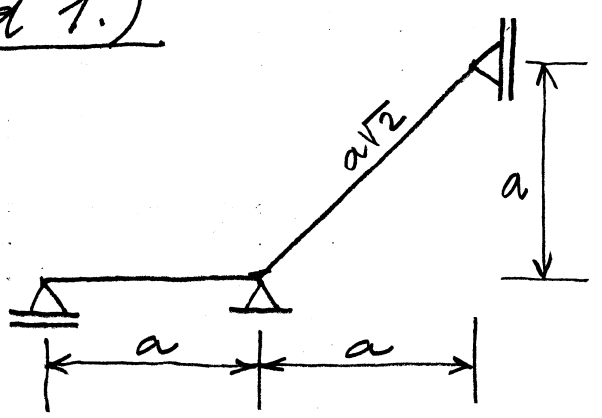
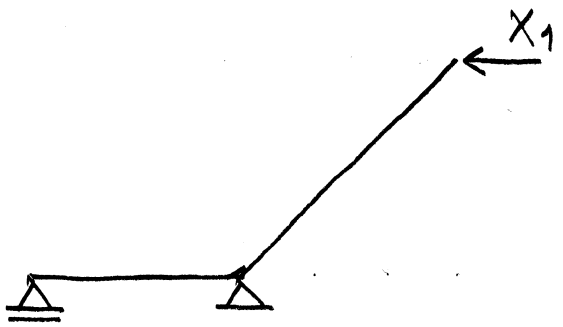
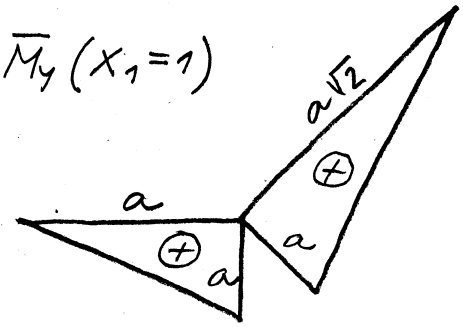
Ad 1.)

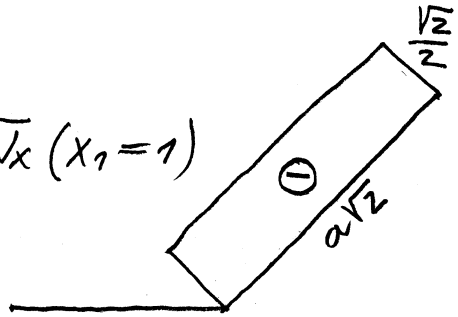




$\overline{M}_y\,(X_1=1)$



$\overline{N}_x\,(X_1=1)$



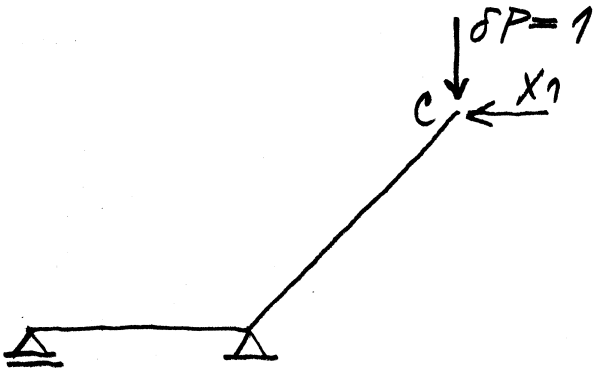
$$a_{11} = \frac{1}{EI_y}\left(\frac{a^2}{2}\cdot\frac{2a}{3} + \frac{a^2\sqrt{2}}{2}\cdot\frac{2a}{3}\right) + \frac{1}{EA_x}\, a\sqrt{2}\cdot\frac{\sqrt{2}}{2}\cdot\frac{\sqrt{2}}{2}$$

$$a_{11} = \frac{a^3}{3EI_y}(1+\sqrt{2}) + \frac{a\sqrt{2}}{2EA_x}$$

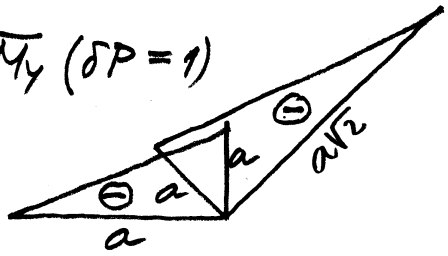
$$b_1 = -\alpha_T \Delta T\, \frac{\sqrt{2}}{2}\cdot a\sqrt{2} \longrightarrow b_1 = -\alpha_T \Delta T\, a$$

$$X_1 = -\frac{b_1}{a_{11}} \longrightarrow \boxed{X_1 = \frac{6\alpha_T E A_x I_y}{3\sqrt{2}\, I_y + 2a^2 A_x (1+\sqrt{2})}\,\Delta T}$$

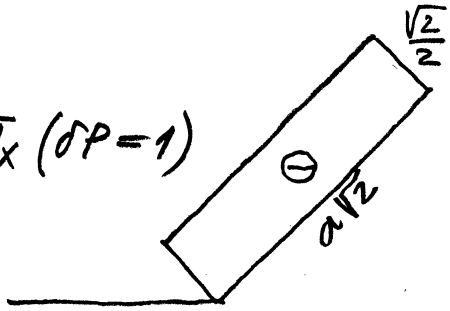
$$\boxed{X_1 = 0{,}233\ EN}$$



$\overline{M_y}\ (\delta P=1)$



$\overline{N_x}\ (\delta P=1)$



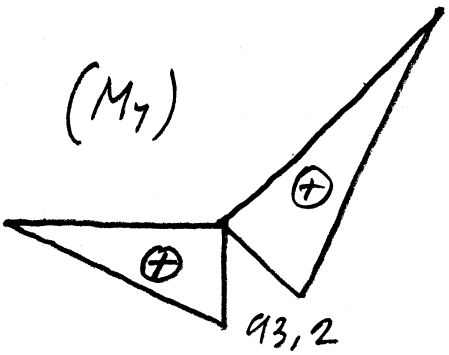
$$w_C = \frac{X_1}{EI_y}\left(-\frac{a^2}{2}\cdot\frac{2a}{3} - \frac{a^2\sqrt{2}}{2}\cdot\frac{2a}{3}\right) +$$

$$+ \frac{X_1}{EA_x}\cdot\frac{\sqrt{2}}{2}\cdot a\sqrt{2}\cdot\frac{\sqrt{2}}{2} - \alpha_T\,\Delta T\,\frac{\sqrt{2}}{2}\,a\sqrt{2}$$

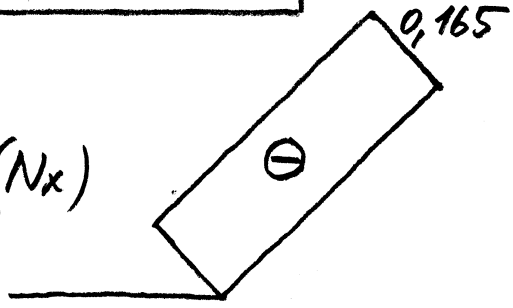
$$\boxed{w_C = X_1\left[\frac{a\sqrt{2}}{2EA_x} - \frac{a^3}{3EI_y}(1+\sqrt{2})\right] - a\,\alpha_T\,\Delta T}$$

$$\boxed{w_C = -0{,}3\ \text{cm}}$$

(M_y)



(N_x)



Ad 2.) $A_s = 0{,}6 \cdot 0{,}8 \longrightarrow A_s = 0{,}48\ m^2$

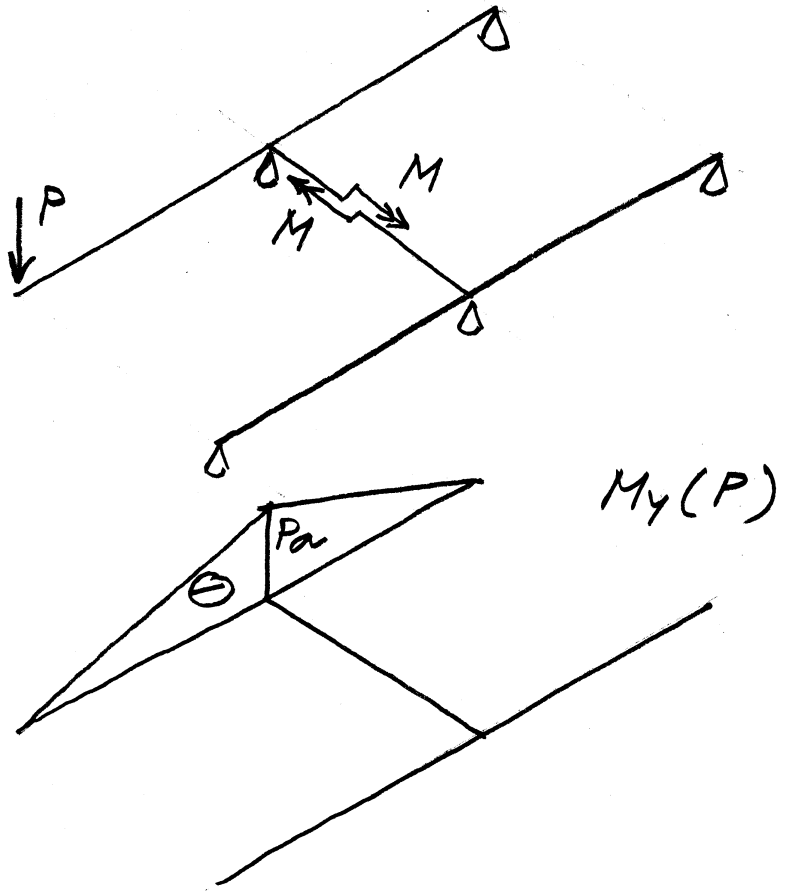
$$\oint_{C_s} \frac{ds}{\delta} = 2\left(\frac{0{,}8}{0{,}05} + \frac{0{,}6}{0{,}06}\right) = 52$$

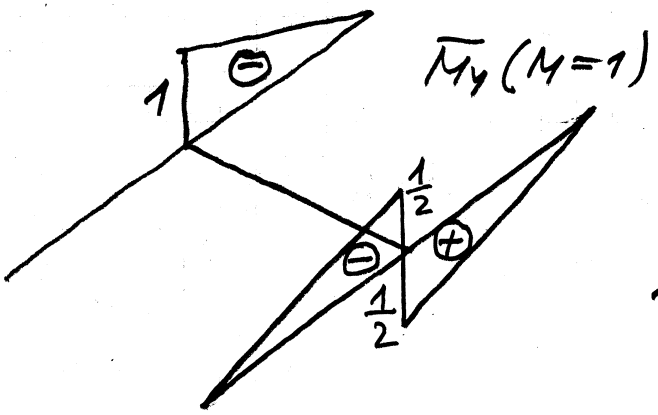
$$I_x = \frac{4A_s^2}{\oint_{C_s} \frac{ds}{\delta}} = \frac{4 \cdot 0{,}48^2}{52} \longrightarrow \boxed{I_x = 0{,}017723\ m^4}$$

$$I_y = \frac{1}{12}\left(0{,}65 \cdot 0{,}86^3 - 0{,}55 \cdot 0{,}74^3\right)$$

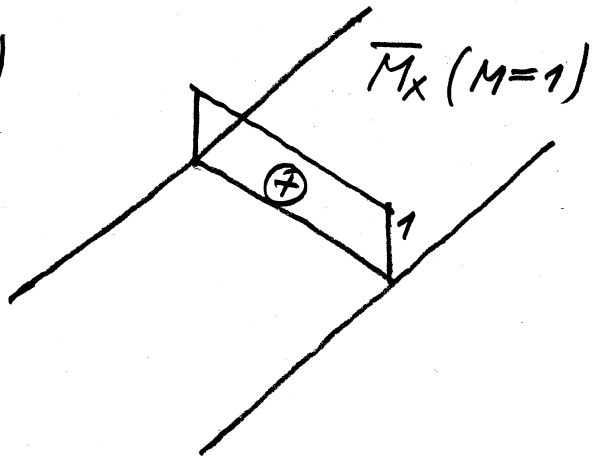
$$\boxed{I_y = 0{,}015880\ m^4}$$

$$\boxed{\begin{aligned} E I_y &= 3722\ MN m^2 \\ G I_x &= 1772\ MN m^2 \end{aligned}}$$





$\overline{M_y}\,(M=1)$



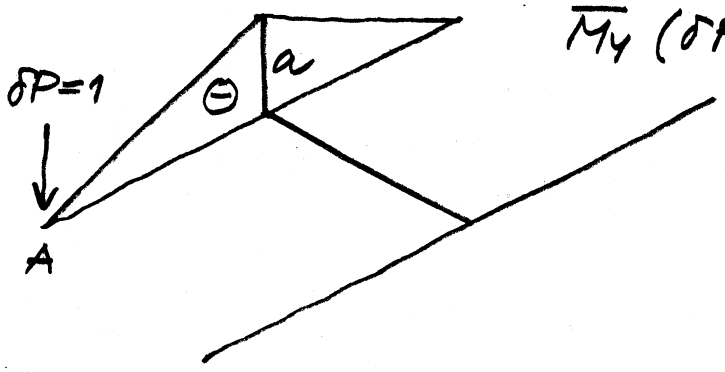
$\overline{M_x}\,(M=1)$

$$a_{11} = \frac{1}{EI_y}\left(\frac{a}{2}\cdot\frac{2}{3} + 2\cdot\frac{1}{2}\cdot\frac{a}{2}\cdot\frac{2}{3}\cdot\frac{1}{2}\right) + \frac{a}{GI_x}$$

$$\boxed{a_{11} = \frac{a}{2EI_y} + \frac{a}{GI_x}} \qquad \boxed{b_1 = P\,\frac{a^2}{3EI_y}}$$

$$M = -\frac{b_1}{a_{11}} \longrightarrow \boxed{M = -P\,\frac{2aGI_x}{3(2EI_y + GI_x)}}$$

$$\boxed{M = -0{,}154\ MNm}$$



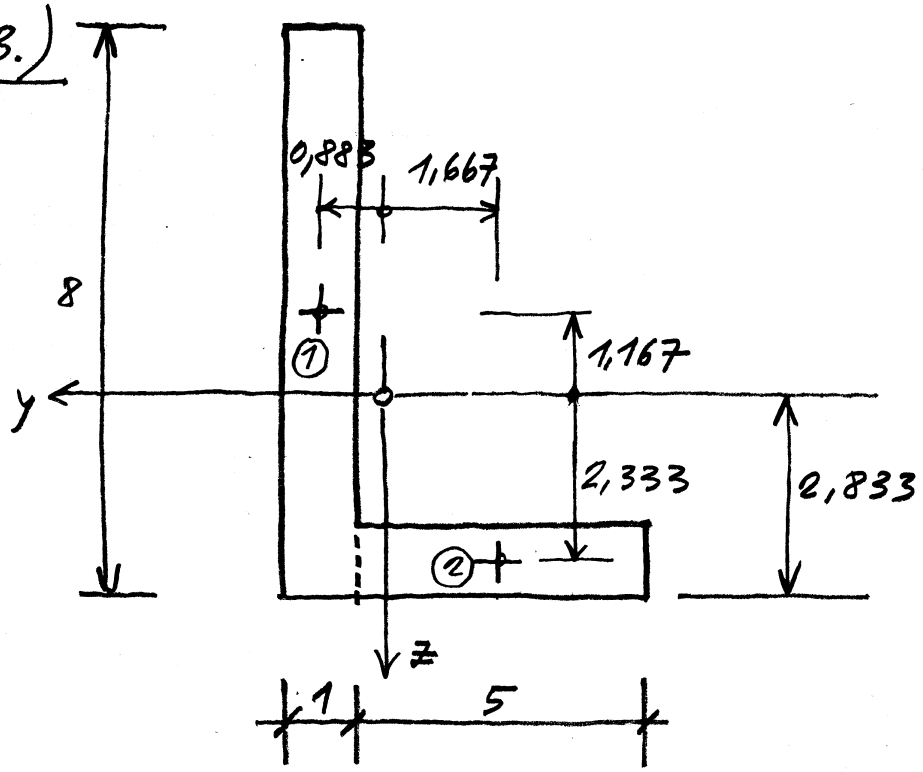
$\overline{M_y}\,(\delta P=1)$

$$w_A = \frac{1}{EI_y}\left(2\cdot P\,\frac{a^2}{2}\cdot\frac{2a}{3} + M\,\frac{a^2}{2}\cdot\frac{2}{3}\right)$$

$$\boxed{w_A = \frac{a^2}{3EI_y}(2Pa + M)}$$

$$\boxed{w_A = P\,\frac{4a^3}{9EI_y}\cdot\frac{GI_x + 3EI_y}{GI_x + 2EI_y}} \qquad \boxed{w_A = 0{,}029\ m}$$

Ad 3.)



$A_x = 1 \cdot 8 + 4 \cdot 1 \longrightarrow A_x = 12 \text{ cm}^2$

$y_T = \frac{1}{12}(8 \cdot 0{,}5 + 4 \cdot 3) \longrightarrow y_T = 1{,}333 \text{ cm}$

$z_T = \frac{1}{12}(8 \cdot 4 + 4 \cdot 0{,}5) \longrightarrow z_T = 2{,}833 \text{ cm}$

$I_y = \frac{1}{12}(1 \cdot 8^3 + 4 \cdot 1^3) + 8 \cdot 1{,}167^2 + 4 \cdot 2{,}333^2$

$I_y = 75{,}667 \text{ cm}^4$

$I_z = \frac{1}{12}(8 \cdot 1^3 + 1 \cdot 4^3) + 8 \cdot 0{,}833^2 + 4 \cdot 1{,}667^2$

$I_z = 22{,}667 \text{ cm}^4$

$I_{yz} = -(-8 \cdot 1{,}167 \cdot 0{,}833 - 4 \cdot 1{,}667 \cdot 2{,}333)$

$I_{yz} = 23{,}333 \text{ cm}^4$

$$I_{11,22} = \frac{1}{2}(75{,}667 + 22{,}667) \pm \sqrt{\left(\frac{75{,}667 - 22{,}667}{2}\right)^2 + 23{,}333^2}$$

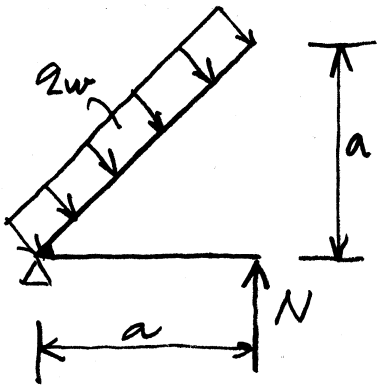
$I_{11} = 84,475\ cm^4$

$$I_{22} = 13,858\ cm^4 = I_{min}$$

$$N_{kr} = \frac{\pi^2 E I_{min}}{l_u^2} \longrightarrow$$

$$N_{kr} = 16,282\ kN$$

$$l_u = 0,7a$$



$$q_w \cdot a\sqrt{2} \cdot \frac{a\sqrt{2}}{2} - Na = 0$$

$$N = q_w a = 6 \cdot 2 = 12\ kN$$

$$\nu = \frac{N_{kr}}{N} = \frac{16,282}{12}$$

$$\nu = 1,36$$