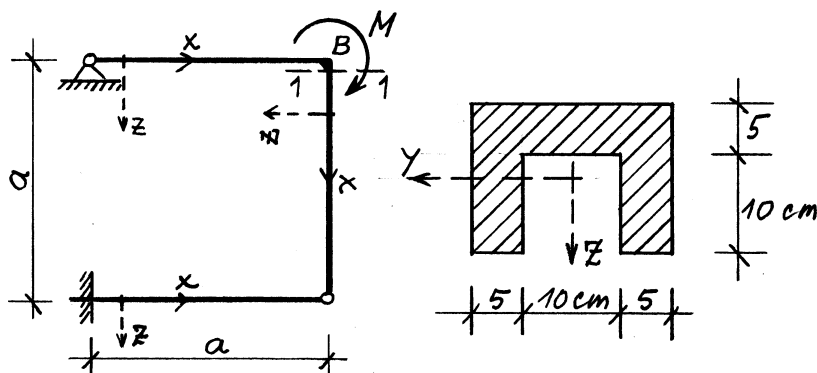


1. Vsi elementi prikazane konstrukcije imajo enak prečni prerez.
 - a. Ob predpostavki, da je vpliv osnih sil na pomike zanemarljiv, določi potek notranjih sil po konstrukciji.
 - b. Določi in skiciraj potek normalnih in strižnih napetosti v prerezu 1-1.
 - c. Določi zasuk točke B.

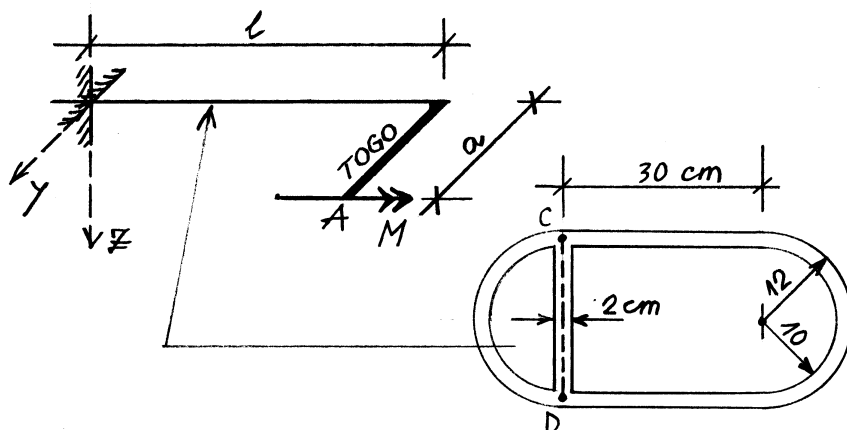


$$E = 20000 \text{ kN/cm}^2$$

$$a = 3 \text{ m}$$

$$M = 120 \text{ kNm}$$

2. Ob predpostavki, da gre za čisto torzijo, določi navpični pomik konca previsa A ter strižno napetost v rebro CD. Za koliko se spremeni poves točke A, če rebro CD odstranimo?



$$E = 24000 \text{ kN/cm}^2$$

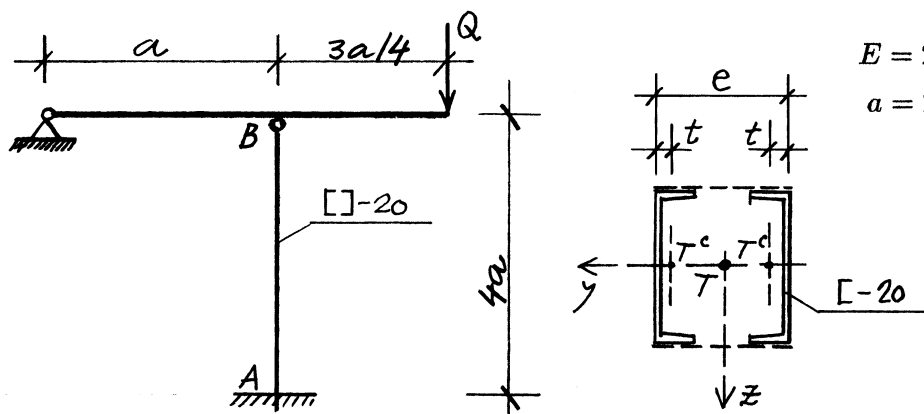
$$G = 8000 \text{ kN/cm}^2$$

$$l = 3 \text{ m}$$

$$a = 1.8 \text{ m}$$

$$M = 50 \text{ kNm}$$

3. Steber AB je narejen iz dveh C-profilov, ki sta med seboj povezana tako, da deluje kot monoliten element. Določi dimenzijo e tako, da bo uklonska varnost v smereh y in z enaka. Določi obtežbo Q_{cr} , pri kateri nastopi v stebru kritična osna sila.

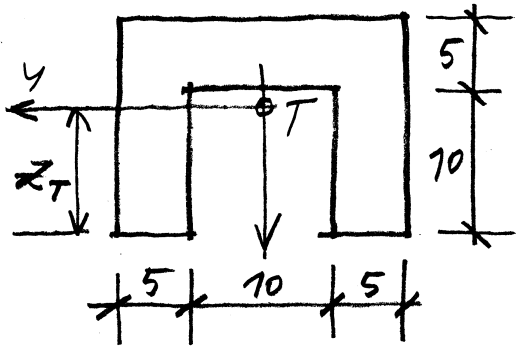


$$E = 21000 \text{ kN/cm}^2$$

$$a = 2 \text{ m}$$

Podatki o profilu C-20:

$$A_z^c = 32.2 \text{ cm}^2, \quad I_y^c = 1910 \text{ cm}^4, \quad I_z^c = 148 \text{ cm}^2, \quad t = 2.01 \text{ cm}$$

Ad 1.

$$A_x = 5 \cdot 20 + 2 \cdot 5 \cdot 10 = \underline{200 \text{ cm}^2}$$

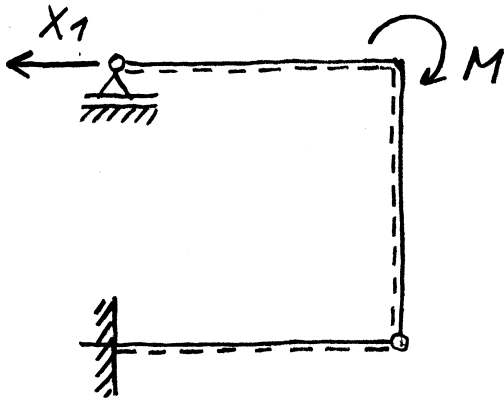
$$z_T = \frac{1}{200} (2 \cdot 50 \cdot 5 + 100 \cdot 12,5)$$

$$\underline{z_T = 8,75 \text{ cm}}$$

$$I_y = \frac{1}{12} (20 \cdot 15^3 - 10^4) + 20 \cdot 15 \cdot 1,25^2 - 10 \cdot 10 \cdot 3,75^2$$

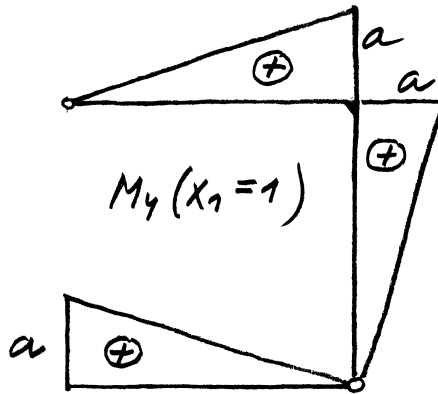
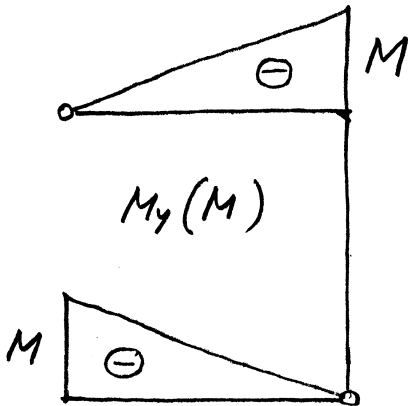
$$\underline{I_y = 3454 \text{ cm}^4}$$

a)



$$a_{11} X_1 + b_1 = 0$$

$$X_1 = - \frac{b_1}{a_{11}}$$



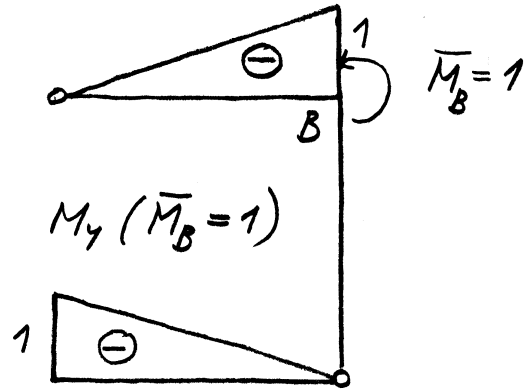
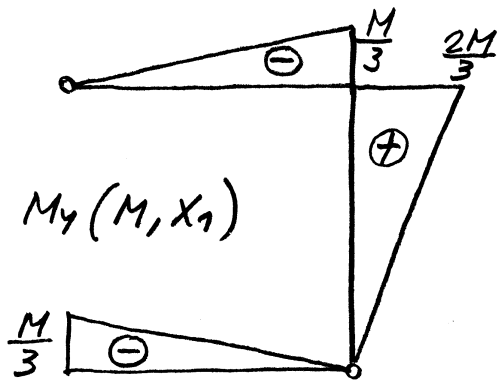
$$EI_y a_{11} = 3 \cdot \frac{a^2}{2} \cdot \frac{2a}{3} = a^3 \rightarrow a_{11} = \frac{a^3}{EI_y}$$

$$-EI_y b_1 = 2 \cdot M \frac{a}{2} \cdot \frac{2a}{3} = M \cdot \frac{2a^2}{3} \rightarrow b_1 = -M \frac{2a^2}{3EI_y}$$

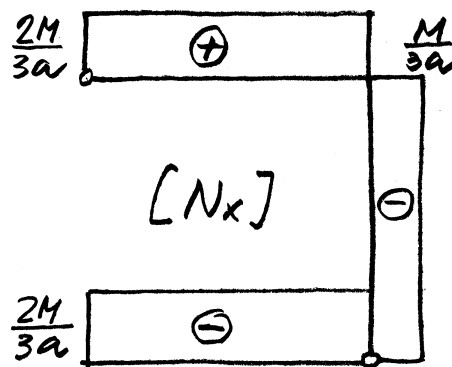
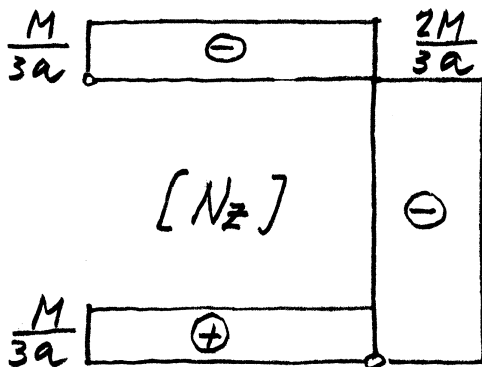
$$\boxed{X_1 = \frac{2M}{3a}}$$

$$\rightarrow X_1 = \frac{2 \cdot 120}{3 \cdot 3} \rightarrow$$

$$\boxed{X_1 = 26,67 \text{ kN}}$$



$$\omega_y(B) = \frac{1}{EI_y} \cdot 2 \cdot \frac{M}{3} \cdot \frac{a}{2} \cdot \frac{2}{3} \rightarrow \boxed{\omega_y(B) = M \cdot \frac{2a}{9EI_y}}$$



b)

$$\boxed{\omega_y(B) = 0,0104}$$

c) 1-1: $M_y = \frac{2M}{3}$, $N_x = -\frac{M}{3a}$, $N_z = -\frac{2M}{3a}$

$M_y = 8000 \text{ kNcm}$, $N_x = -13,33 \text{ kN}$

$N_z = -26,67 \text{ kN}$

$$\boxed{\sigma_{xx} = \frac{N_x}{A_x} + \frac{M_y}{I_y} z}$$

$$\sigma_{xx}^z = -\frac{13,33}{200} - \frac{8000}{3854} \cdot 6,25 \rightarrow \boxed{\sigma_{xx}^z = -13,04 \text{ kN/cm}^2}$$

$$\sigma_{xx}^s = -\frac{13,33}{200} + \frac{8000}{3854} \cdot 8,75 \rightarrow \boxed{\sigma_{xx}^s = 18,10 \text{ kN/cm}^2}$$

$$z = -1,25 \text{ cm} \rightarrow S_y^* = -100 \cdot 5,75 = -375 \text{ cm}^3$$

$$z = 0 \rightarrow S_y^* = -375 - 2 \cdot 1,25 \cdot 5 \cdot 0,625 = -382,8 \text{ cm}^3$$

$$\sigma_{xz} = -N_z \frac{S_y^*}{b^* I_y}$$

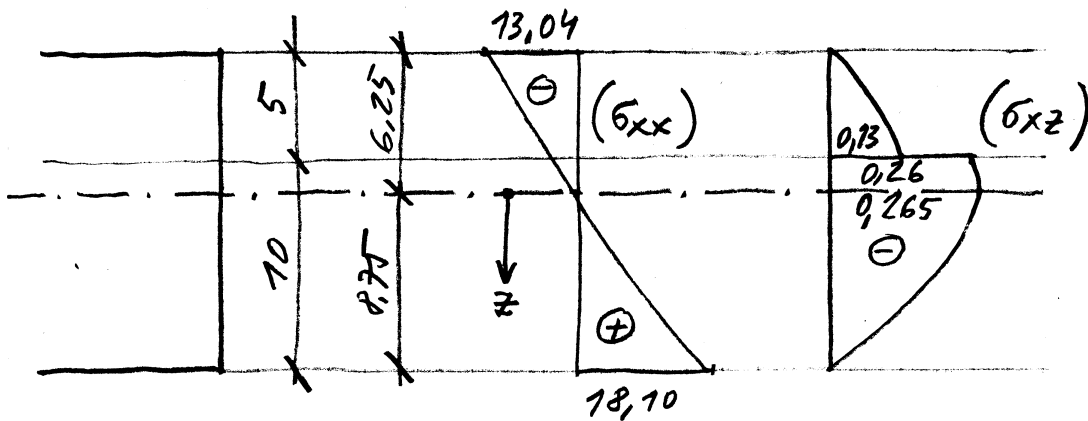
$$z = -1,25 \text{ cm} : \sigma_{xz}^P = 26,67 \cdot \frac{-375}{20 \cdot 3854} = -0,13 \text{ kN/cm}^2$$

$$b_p^* = 20 \text{ cm}$$

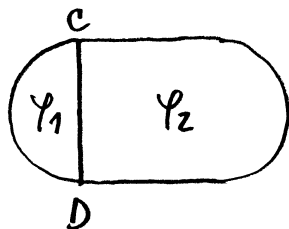
$$b_s^* = 10 \text{ cm}$$

$$\sigma_{xz}^S = -0,26 \text{ kN/cm}^2$$

$$z = 0 : \sigma_{xz}^T = 26,67 \cdot \frac{-382,8}{10 \cdot 3854} = -0,265 \text{ kN/cm}^2$$



Ad 2.)



$$A_1 = \frac{1}{2} \pi \cdot 11^2 = 190 \text{ cm}^2$$

$$A_2 = 190 + 30 \cdot 22 = 850 \text{ cm}^2$$

$$a_{11} = -\frac{1}{2} (22 + 11\pi) = -28,3$$

$$a_{22} = -\frac{1}{2} (22 + 11\pi + 2 \cdot 30) = -58,3$$

$$a_{12} = a_{21} = \frac{1}{2} \cdot 22 = 11$$

$$\left. \begin{aligned} -28,3 \varphi_1 + 11 \varphi_2 &= -380 \\ 11 \varphi_1 - 58,3 \varphi_2 &= -1700 \end{aligned} \right\}$$

$$\left. \begin{aligned} \varphi_1 &= 26,7 \\ \varphi_2 &= 34,2 \end{aligned} \right\}$$

$$I_x = 2(190 \cdot 26,7 + 850 \cdot 34,2) \rightarrow \boxed{I_x = 68286 \text{ cm}^4}$$

$$\omega_x(x=l) = M \cdot \frac{l}{G I_x} = \frac{5000 \cdot 300}{8000 \cdot 68286} = 0,00275$$

$$w_A = \omega_x(l) \cdot a = 0,00275 \cdot 180 \rightarrow \boxed{w_A = 0,494 \text{ cm}}$$

$$\tau_{cd} = \frac{M_x}{I_x} \cdot \frac{y_2 - y_1}{\delta} = \frac{5000(34,2 - 26,7)}{68286 \cdot 2}$$

$$\boxed{\tau_{cd} = 0,275 \text{ kN/cm}^2}$$

Primer brez rebra :

$$A_s = A_1 + A_2 = 190 + 850 \rightarrow A_s = 1040 \text{ cm}^2$$

$$\oint_{C_s} \frac{ds}{\delta} = (2 \cdot 11 \cdot \pi + 2 \cdot 30) \cdot \frac{1}{2} = 64,56$$

$$I_x = \frac{4 A_s^2}{\oint_{C_s} \frac{ds}{\delta}} = \frac{4 \cdot 1040^2}{64,56} \rightarrow \boxed{I_x = 67016 \text{ cm}^4}$$

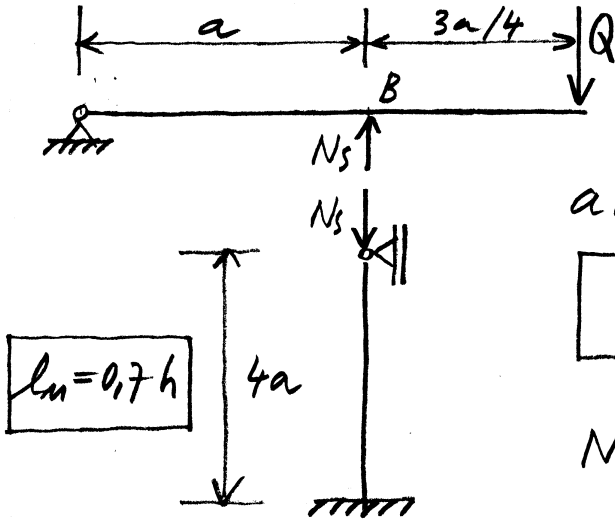
$$\omega_x(l) = \frac{5000 \cdot 300}{8000 \cdot 67016} = 0,00280$$

$$w_A = 0,00280 \cdot 180 \rightarrow \boxed{w_A = 0,504 \text{ cm}}$$

Ad 3.) $I_y = 2 \cdot I_y^c = 2 \cdot 1910 \rightarrow I_y = 3820 \text{ cm}^4$

$$I_z = 2 \cdot I_z^c + 2 \cdot A_x^c \cdot f^2 = 2 \cdot 148 + 2 \cdot 32,2 \cdot f^2 = 3820$$

$$f = 7,40 \text{ cm} \dots e = 2(f + t) \rightarrow \boxed{e = 18,82 \text{ cm}}$$



$$a N_s = Q \left(a + \frac{3a}{4} \right)$$

$$N_s = \frac{7Q}{4} \rightarrow N_s = N_{kr} !$$

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

$$N_{kr} = \frac{\pi^2 \cdot 21000 \cdot 3820}{(0,7 \cdot 4 \cdot 200)^2}$$

$$\rightarrow N_{kr} = 2524,68 \text{ kN}$$

$$N_s = N_{kr} \rightarrow Q = \frac{4}{7} \cdot 2524,68$$

$$Q_{kr} = 1442,7 \text{ kN}$$