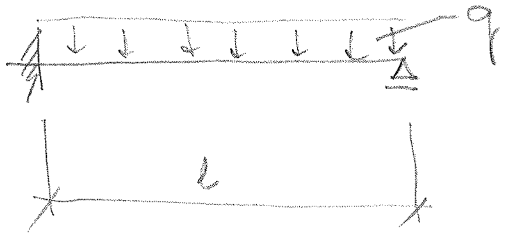
SILOVÁ METODA

- problém jsou veličiny, které nemůžeme určit z podmínek rovnováhy.

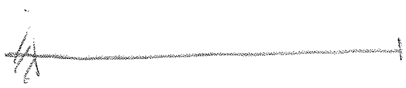
PODSTATA:

1. Vytvořím základní staticky určitou soustavu – nesmí to být mechanismus.

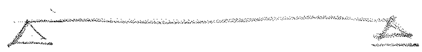


EI = konst.

⇓

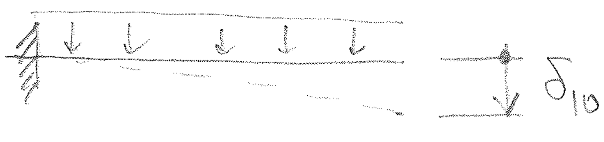


nebo



2. Napíše se deformační podmínka:

$$\delta_{10} + \delta_{11} \cdot X_1 = 0$$ ← PŘEMÍSTĚNÍ V MÍSTĚ PODPORY

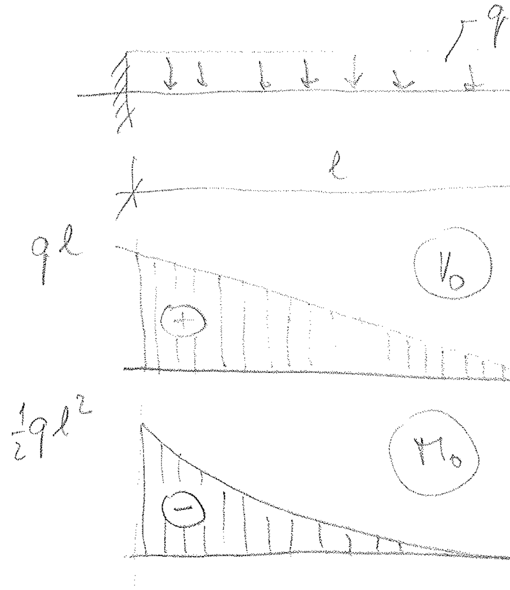


PŘÍČINA

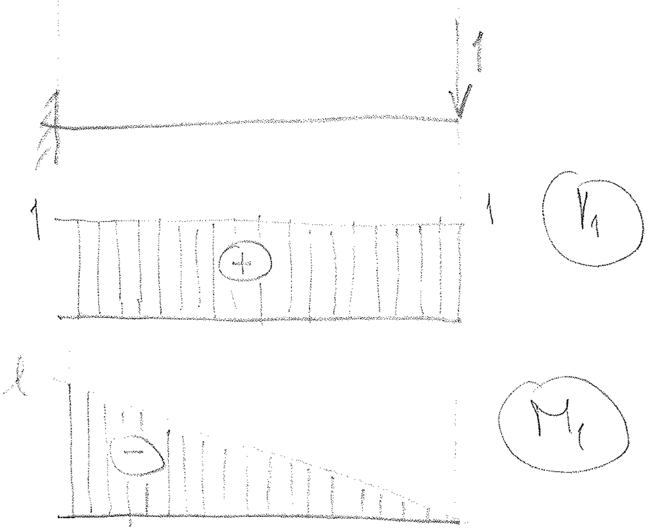
δ_{AB}

MÍSTO A SMĚR PŘEMÍSTĚNÍ

VÝPOČET δ_{10}



VIRTUÁLNÍ (JEDNOTKOVÉ) ZATÍŽENÍ

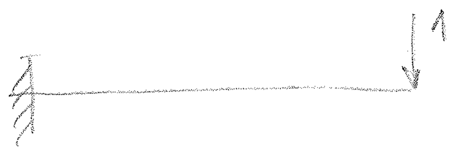


to je stejné!

$$\delta_{10} = \frac{1}{GA_k} \cdot \left\{ \frac{1}{2} \cdot (ql) \cdot 1 \right\} + \frac{1}{EI} \cdot \left\{ \frac{1}{3} \left(-\frac{1}{2} q l^2\right) l \left(-\frac{3}{4} l\right) \right\} =$$

$$= \frac{1}{GA_k} \cdot \frac{1}{2} q l + \frac{1}{EI} \cdot \frac{1}{8} q l^4$$

JEDNOTKOVÉ ZATÍŽENÍ



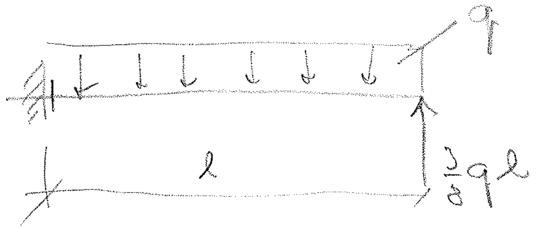
$$\delta_{11} = \frac{1}{GA_k} \cdot \left\{ 1 \cdot 1 \cdot l \right\} + \frac{1}{EI} \cdot \left\{ \frac{1}{2} \cdot (-l) \cdot l \cdot \frac{2}{3} (-l) \right\} = \frac{l}{GA_k} + \frac{l^3}{3EI}$$

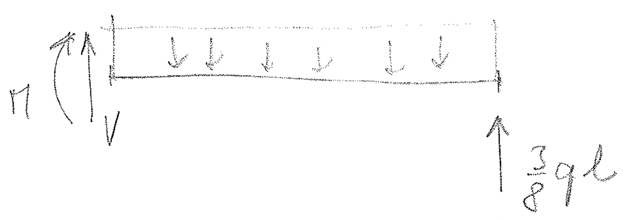
ZANEDBÁVÁME - LI PRÁCI POS. SIL

$$\frac{1}{EI}\cdot\frac{1}{8}ql^4+\frac{l^3}{3EI}\cdot X_1=0 \quad /\cdot EI$$

$$\frac{l^3}{3}\cdot X_1=-\frac{1}{8}ql^4 \quad /\cdot\frac{3}{l^3}$$

$$X_1=-\frac{3}{8}ql$$





$\sum M_{ia}=0$

$$-\frac{3}{8}ql\cdot l+\frac{1}{2}ql^2+M=0$$

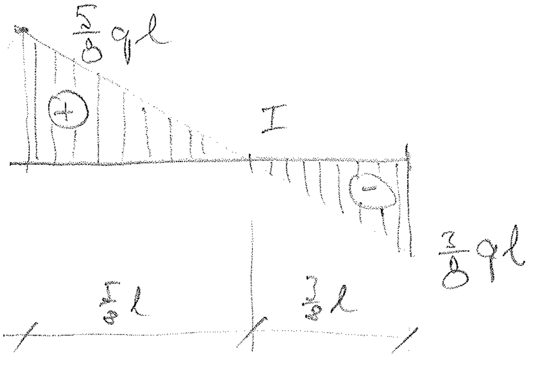
$$M=-\frac{1}{2}ql^2+\frac{3}{8}ql^2$$

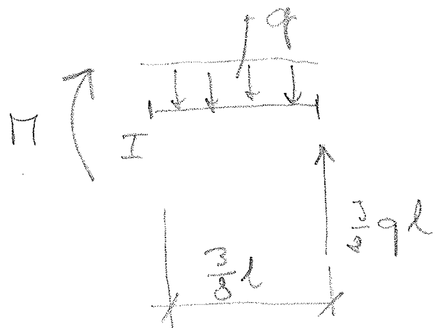
$$M=ql^2\cdot\left(\frac{-4+3}{8}\right)=-\frac{1}{8}ql^2$$

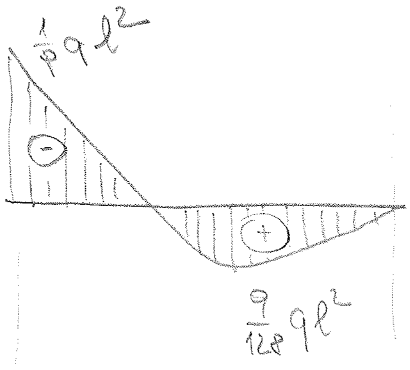
$\sum F_{iz}=0$

$$V-q\cdot l+\frac{3}{8}\cdot ql=0$$

$$V=+\frac{5}{8}ql$$



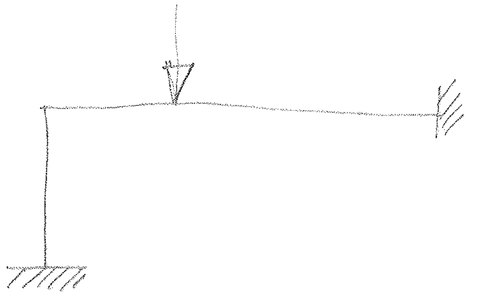




$$\sum M_{iI}=0: \quad M-\frac{3}{8}ql\cdot\frac{3}{8}l+$$
$$+\frac{1}{2}q\cdot\left(\frac{3}{8}l\right)^2=0$$

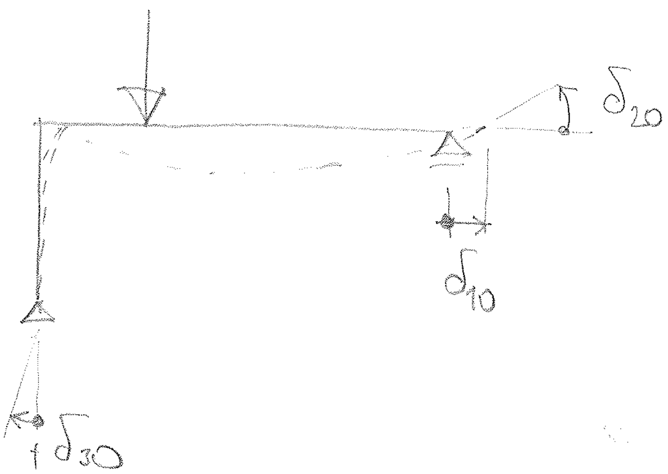
$$M=\frac{9}{64}ql^2-\frac{9}{128}ql^2=\frac{9}{128}ql^2$$

SLOŽITĚJŠÍ K-CE

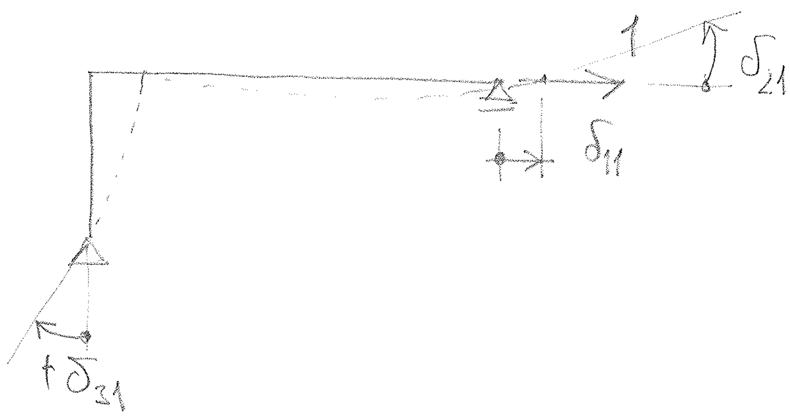


ZÁKLADNÍ STAT. URČ. K-CE

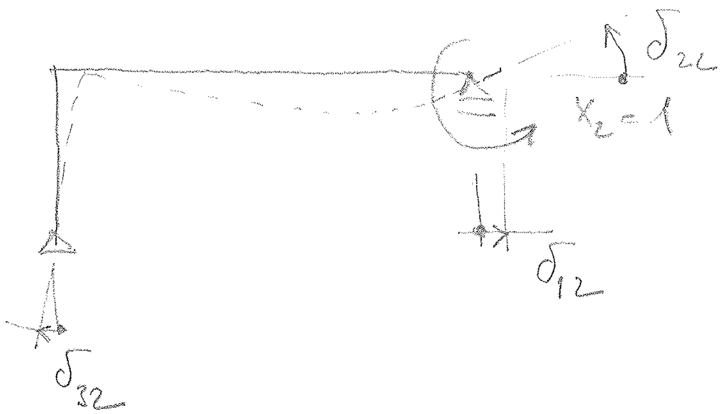
OR. ZAT.



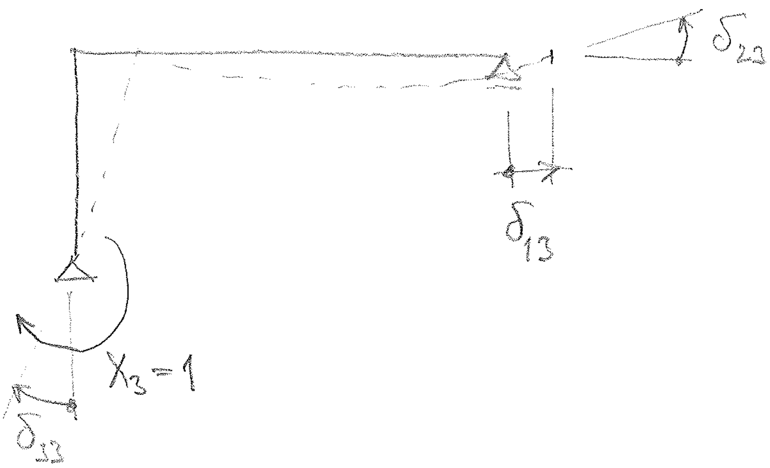
SÍLA $X_1 = 1$



MOMENT $X_2 = 1$



MOMENT $X_3 = 1$



KANONICKÉ ROVNICE:

Posun ve směru X_1:

$$\delta_{10} + \delta_{11} \cdot X_1 + \delta_{12} \cdot X_2 + \delta_{13} \cdot X_3 = 0$$

Pootočení ve směru X_2:

$$\delta_{20} + \delta_{21} \cdot X_1 + \delta_{22} \cdot X_2 + \delta_{23} \cdot X_3 = 0$$

Pootočení ve směru X_3:

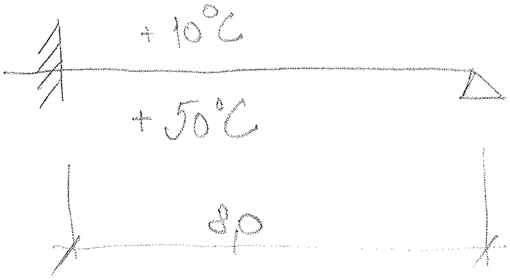
$$\delta_{30} + \delta_{31} \cdot X_1 + \delta_{32} \cdot X_2 + \delta_{33} \cdot X_3 = 0$$

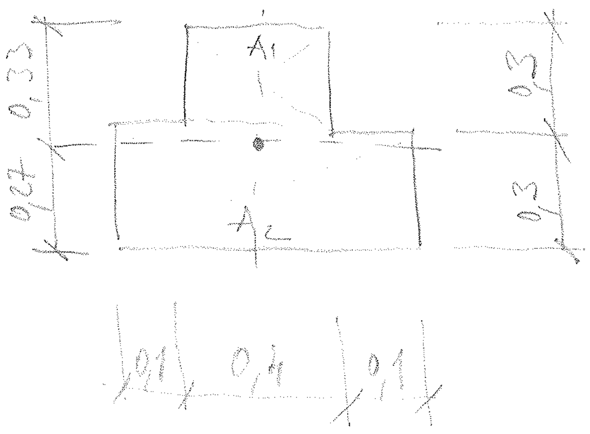
Řešením získám reakce a řeším vnitřní síly na stat. urč. k-ci

ZMĚNA TEPLOTY

$\alpha = 1{,}2 \cdot 10^{-5}\ K^{-1}$

PRŮŘEZ: $E = 30\ GPa$





$A_1 = 0{,}3 \cdot 0{,}4 = 0{,}12\ m^2$

$A_2 = 0{,}6 \cdot 0{,}3 = 0{,}18\ m^2$

$A = 0{,}30\ m^2$

$t = \frac{S}{A} = \frac{0{,}081}{0{,}3} = 0{,}27\ m$

$S_1 = 0{,}12 \cdot 0{,}45 = 0{,}054$

$S_2 = 0{,}18 \cdot 0{,}15 = 0{,}027$

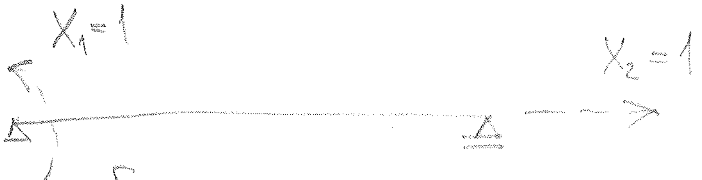
$S = 0{,}081\ m^3$

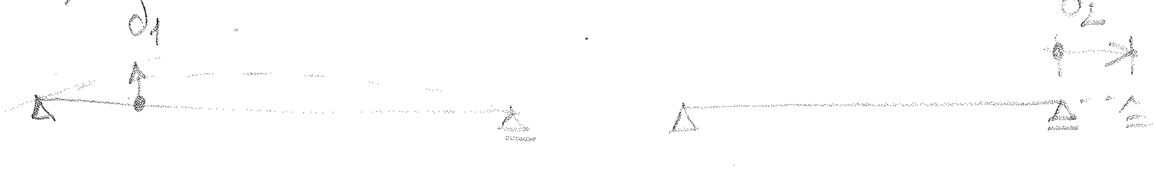
$I_1 = \frac{1}{12}\, 0{,}4 \cdot 0{,}3^3 + 0{,}12 \cdot 0{,}18^2 = 4{,}788 \cdot 10^{-3}\ m^4$

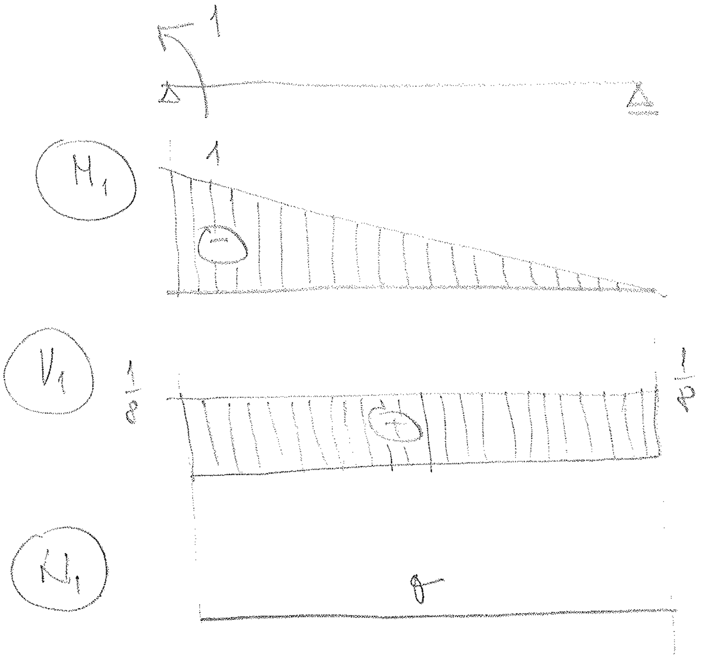
$I_2 = \frac{1}{12} \cdot 0{,}6 \cdot 0{,}3^3 + 0{,}18 \cdot 0{,}12^2 = 3{,}942 \cdot 10^{-3}\ m^4$

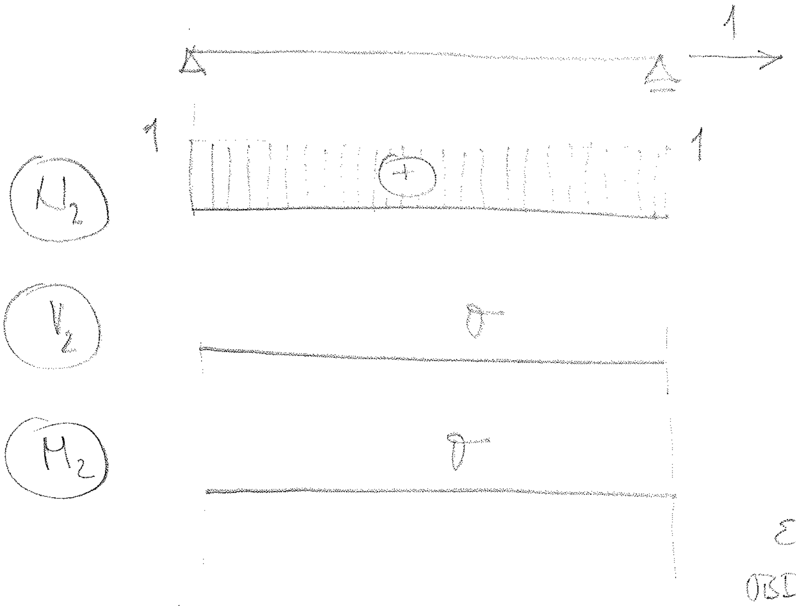
$I = 8{,}73 \cdot 10^{-3}\ m^4$

Základní stat. určitá soustava









Em = 8

$$\delta_{10} = \underbrace{\int_0^8 32 \cdot 1{,}2 \cdot 10^{-5} \cdot 0 \cdot dx}_{0} + \underbrace{\int_0^8 \overbrace{1{,}2 \cdot 10^{-5} \cdot \frac{40}{0{,}6}}^{\text{OBDELNÍK}} \cdot \overbrace{\overline{M}_1(x)} \cdot dx}_{\text{INTEGRÁL OBDELNÍKU A TROJ.}}$$

$$\delta_{10} = \frac{1}{2} \cdot 0{,}0008 \cdot (-1) \cdot 8 = -0{,}0032$$

$$\delta_{20} = \int_0^8 \underbrace{32 \cdot 1{,}2 \cdot 10^{-5}}_{\text{OBD.}} \cdot \underbrace{1}_{\text{OBD}} \cdot dx + \int_0^8 \underbrace{1{,}2 \cdot 10^{-5} \cdot \frac{40}{0{,}6} \cdot 0 \cdot dx}_{0} = 0{,}003072$$

$$\delta_{11} = \frac{1}{EI} \cdot \frac{1}{3} \cdot (-1)\,(-1) \cdot l = \frac{l}{3EI}$$

$$\delta_{22} = \frac{1}{EA} \cdot 1 \cdot 1 \cdot l = \frac{l}{EA}$$

$$\delta_{12} = 0 = \delta_{21}$$

$$-0{,}0032 + \frac{l}{3EI} \cdot X_1 + 0 \cdot X_2 = 0$$

$$0{,}003072 + 0 \cdot X_1 + \frac{l}{EA} \cdot X_2 = 0$$

$$EI = 30 \cdot 10^9 \cdot 8{,}73 \cdot 10^{-3} = 261{,}9 \cdot 10^6$$

$$EA = 30 \cdot 10^9 \cdot 0{,}3 = 9 \cdot 10^9$$

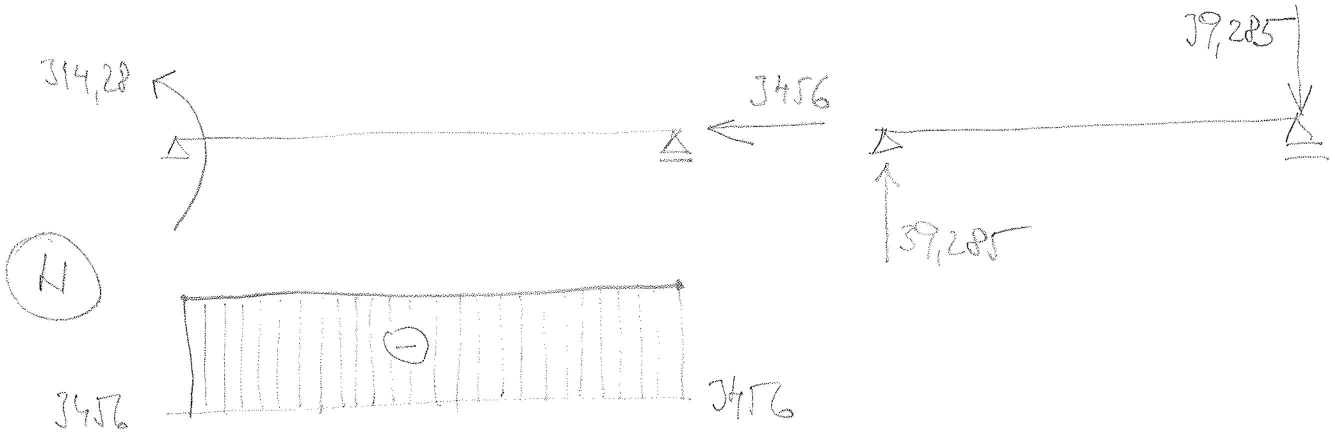
$$\frac{8}{3 \cdot 261{,}9 \cdot 10^6} \cdot X_1 = 0{,}0032$$

$$X_1 = 314{,}28 \text{ kNm}$$

$$0{,}003072 + \frac{8}{9 \cdot 10^9} \cdot X_2 = 0$$

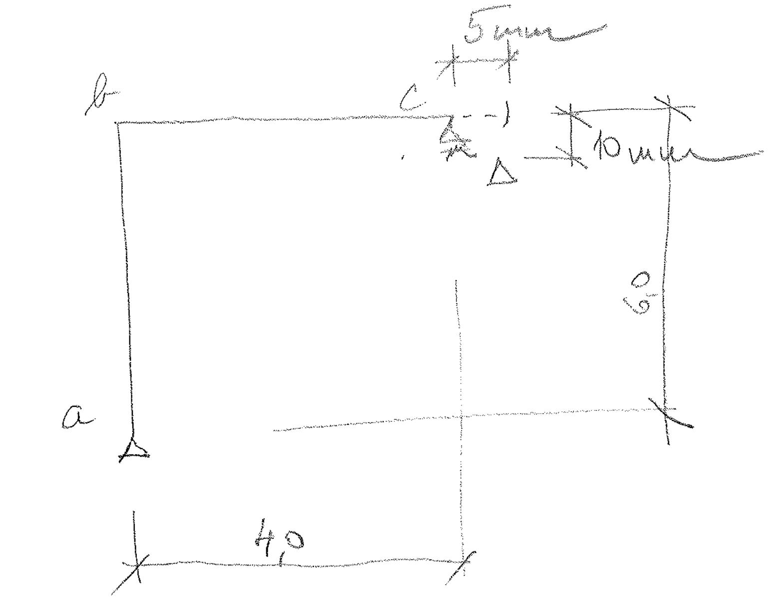
$$X_2 = -3{,}456 \text{ MN}$$

POTOM:



POKLES PODPOR

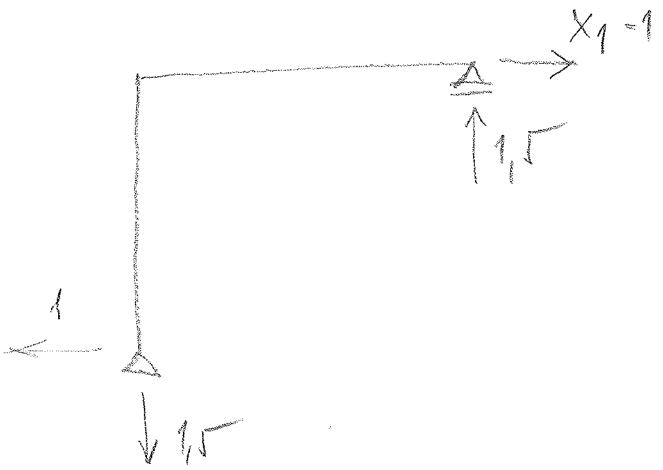
$EI = 4{,}5 \cdot 10^6$



$(M_0) = 0$

$\delta_{10} + \delta_{11} \cdot X_1 = u_c$

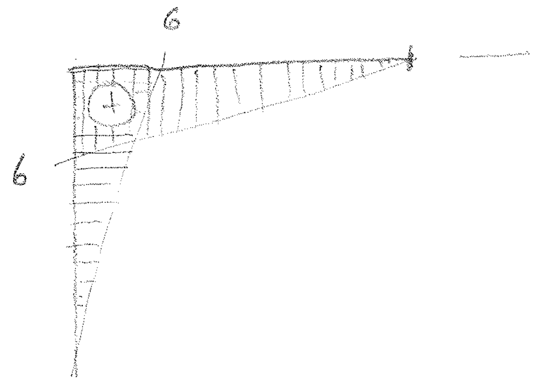
δ_{10} … posun ve směru X_1 vyvolaný původním zatížením.



$\delta_{10} = -\sum R_z \cdot w =$

$= -R_{cz} \cdot w_c =$

$= 1{,}5 \cdot 0{,}01 = 0{,}015 \ m$



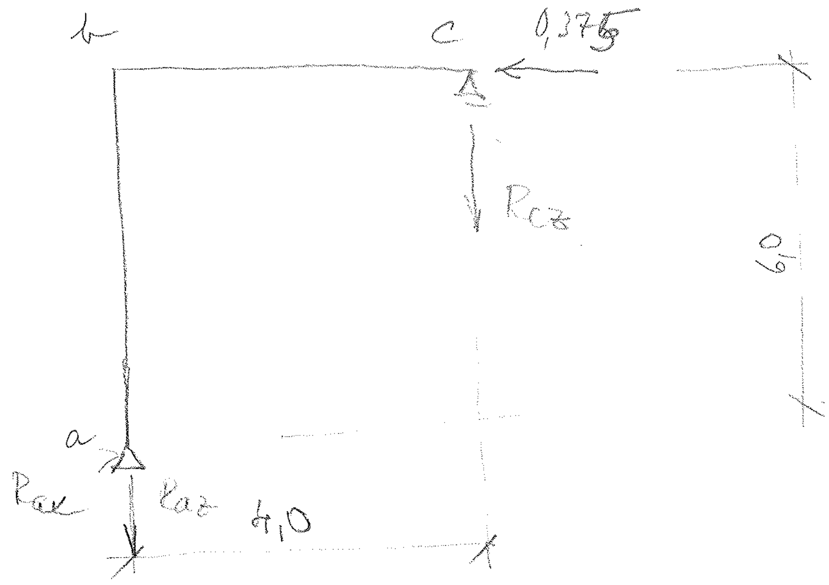
$\delta_{11} = \frac{1}{EI} \cdot \left\{ \frac{1}{3} \cdot 6 \cdot 6 \cdot 4 + \frac{1}{3} \cdot 6 \cdot 6 \cdot 6 \right\}$

$= \frac{1}{EI} \cdot 120 = 2{,}666 \cdot 10^{-5} \ m$

$0{,}015 + 2{,}666 \cdot 10^{-5} X_1 = 0{,}005$

$2{,}666 \cdot 10^{-5} \cdot X_1 = -0{,}01$

$X_1 = -375{,}0941 \doteq -0{,}375 \ kN$



$\sum F_{ix} = 0: \quad R_{ax} - 0{,}375 = 0 \qquad R_{ax} = 0{,}375\ kN$

$\sum M_{ia} = 0: \quad -R_{cz} \cdot 4 + 0{,}375 \cdot 6 = 0 \qquad R_{cz} = 0{,}5625\ kN$