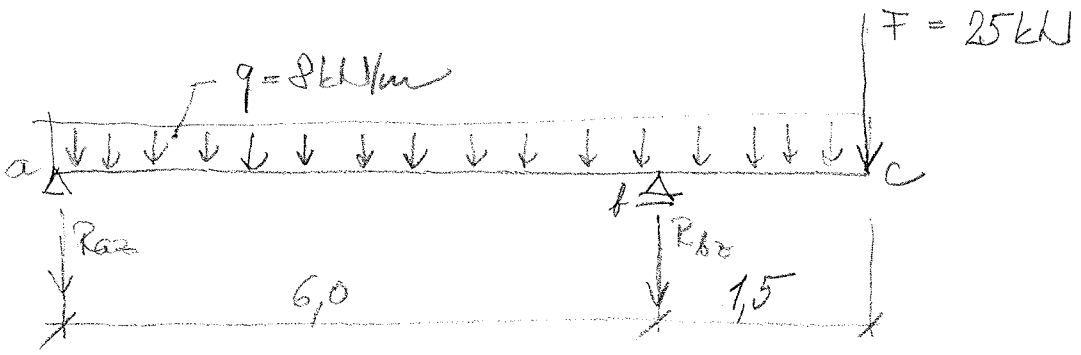
PŘÍKLAD

Určete průhyb v bodě c



PRŮBĚH MOMENTŮ

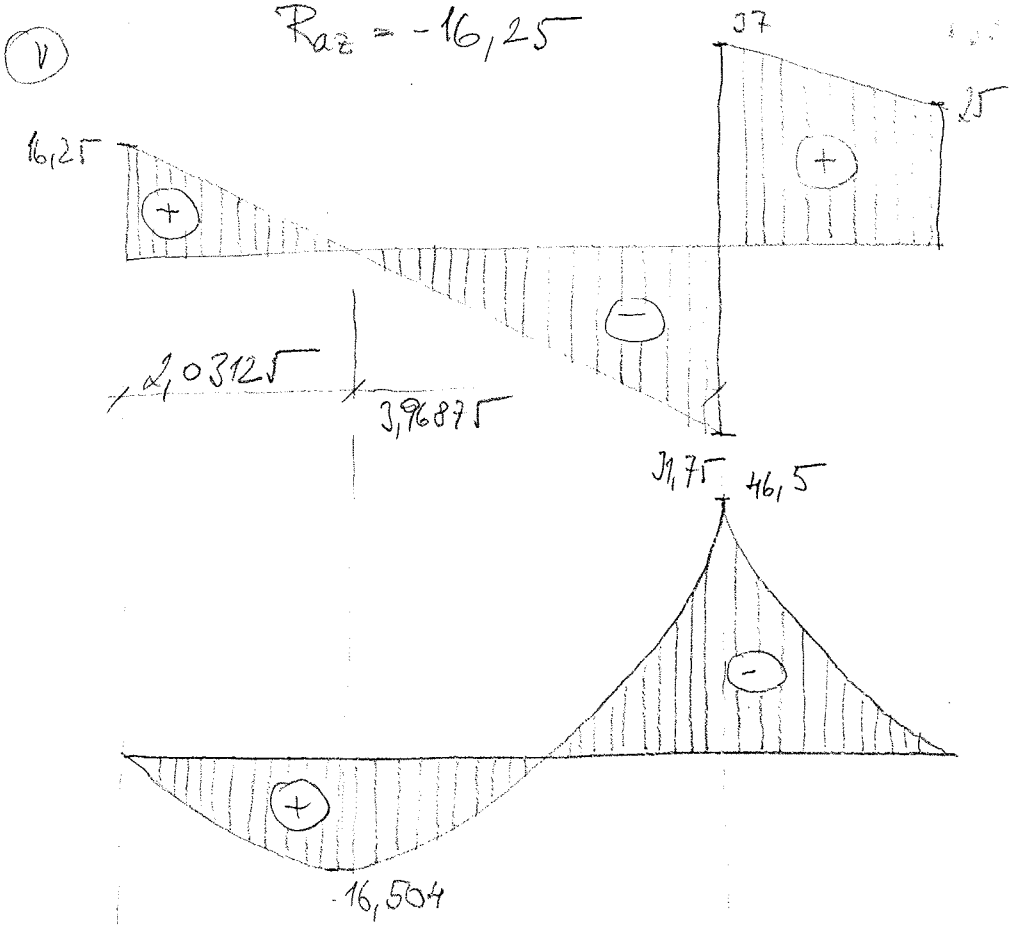
$\Sigma M_{ia} = 0$: $7,5 \cdot 8 \cdot \frac{7,5}{2} + R_{bz} \cdot 6 + 25 \cdot 7,5 = 0$

$R_{bz} = -68,75\,kN$

$\Sigma M_{it} = 0$: $R_{az} \cdot 6 + \frac{1}{2} \cdot 8 \cdot 6^2 - \frac{1}{2} \cdot 1,5^2 \cdot 8 - 25 \cdot 1,5 = 0$

$R_{az} = -16,25$

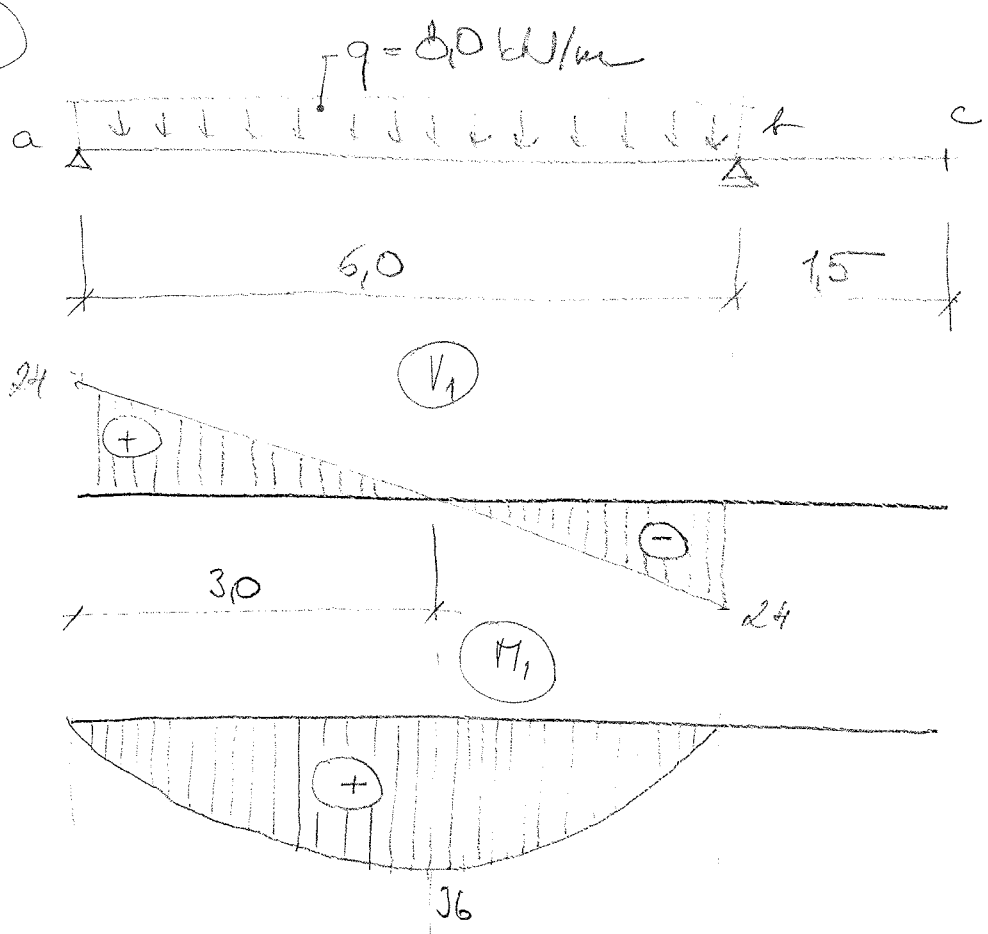
(V)



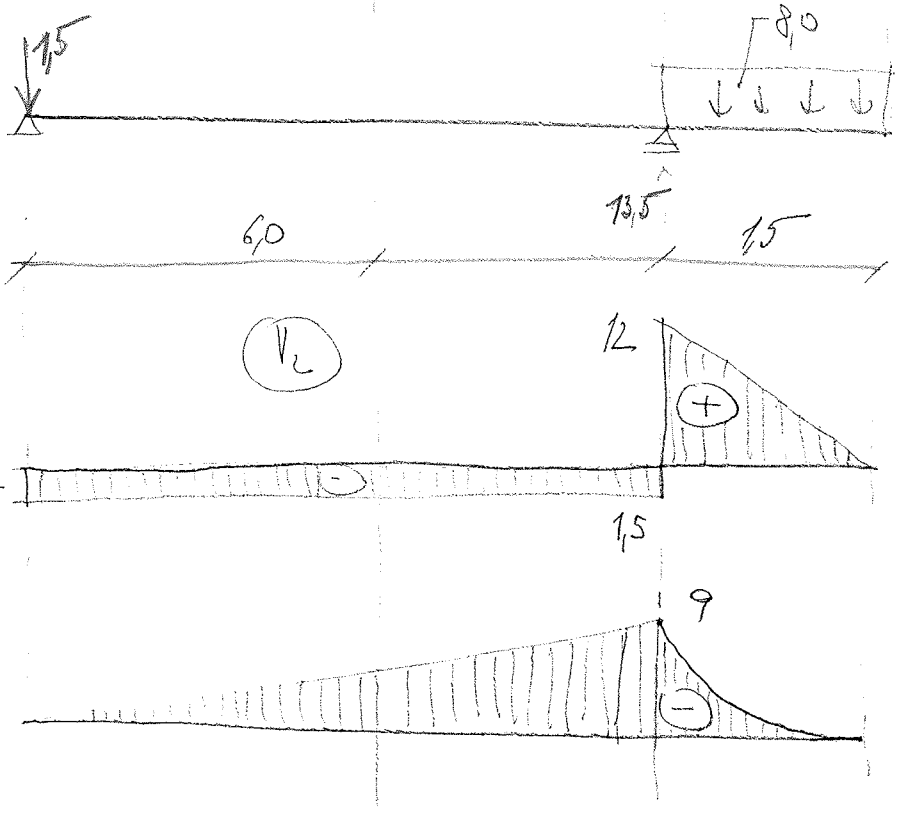
- Průběh vnitřních sil je příliš složitý - řešíme rozkladem

Rozklad na jednotlivá zatížení:

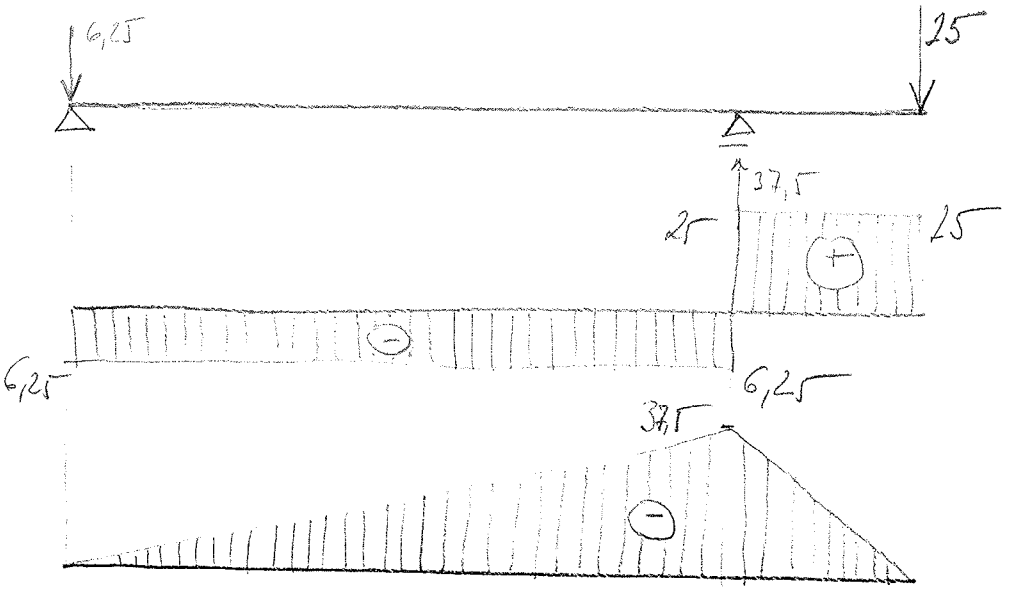
(1)



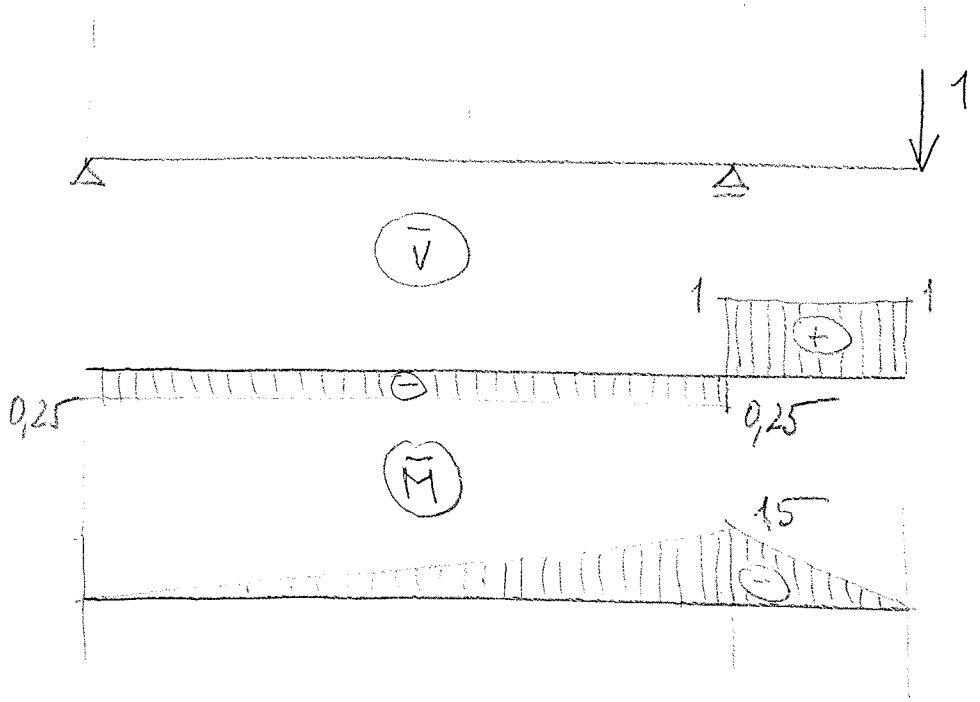
(2)



3)



VIRTUÁLNÍ ZATÍŽENÍ



VLIV JEDNOTLIVÝCH ZATÍŽENÍ:

$$w_{CDH} = \frac{1}{EI} \cdot \left\{ \underbrace{\frac{1}{3} \cdot 36 \cdot 10^3 \cdot (-1{,}5) \cdot 6}_{M_1 \bar{M}} + \underbrace{\frac{1}{3} \cdot (-9000) \cdot (-1{,}5)\, 6 +}_{} \right.$$

$$+ \underbrace{\frac{1}{4} \cdot (-9000) \cdot (-1{,}5) \cdot 1{,}5}_{M_2 \bar{M}} + \frac{1}{3} \cdot (-37500) \cdot (-1{,}5) \cdot 6 +$$

$$\left. + \frac{1}{3} \cdot (-37500) \cdot (-1{,}5) \cdot 1{,}5 \right] \quad M_3 \cdot \bar{M}$$

$$w_{c,M} = \frac{1}{EI}\left\{-108000 + 27000 + 5062{,}5 + 12500 + 28125\right\} = \frac{1}{EI}\cdot 64687{,}5$$

$E = 26 \cdot 10^9$ Pa

$I = 21{,}4 \cdot 10^{-6}$ m^4

$$w_{c,OH} = 0{,}014394\ m = 14{,}394\ mm$$

$$w_{c,SMYK} = \frac{1}{GA_{sc}}\cdot\left\{\frac{1}{2}\cdot 16250\cdot(-0{,}25)\cdot 2{,}03125 + \frac{1}{2}(-11750)\cdot(-0{,}25)\cdot 3{,}96875 + \frac{1}{2}\cdot 1\cdot(37000+25000)\cdot 1{,}5\right\} = \frac{1}{GA_{sc}}\cdot\left\{-4125{,}98 + 15750{,}98 + 46500\right\} = \frac{1}{GA_{sc}}\cdot 58125$$

$G = 80{,}77$ GPa

$A_{sc} = \left(\frac{\text{stojina } I}{1{,}2}\right) = \frac{9075\cdot 0{,}2}{1{,}2} = 0{,}0125\ m^2$

$$w_{c,SMYK} = \frac{1}{80{,}77\cdot 10^9\cdot 0{,}0125}\cdot 58125 = 0{,}05757\cdot 10^{-3}\ m = 0{,}05757\ mm$$

CELKOVÝ PRŮHYB: 14,4516 mm

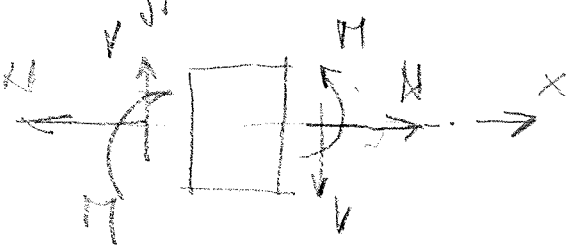
NORM. NAPĚTÍ: 99,6%

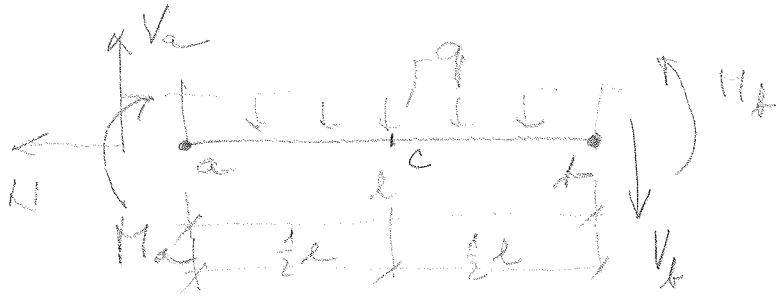
SMYK: 0,4%

JINÝ ZPŮSOB VYJÁDŘENÍ:

Každá kvadratická křivka, která prochází z rovnoměrného spoj. zatížení sedá vyjádřit:

KONVENCE VNITŘNÍCH SIL:



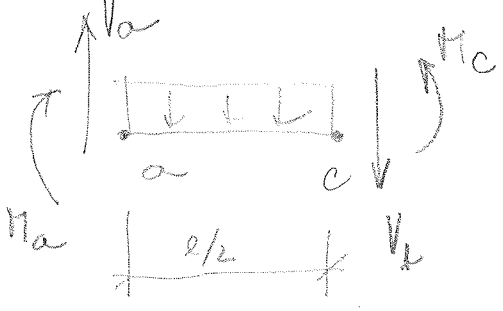


$\sum F_{iz} = 0$ $\quad V_b + q \cdot l - V_a = 0$

$V_b = V_a - q \cdot l$

$\sum M_{ib} = 0$ $\quad M_b + \frac{1}{2} \cdot q \cdot l^2 - V_a \cdot l - M_a = 0$

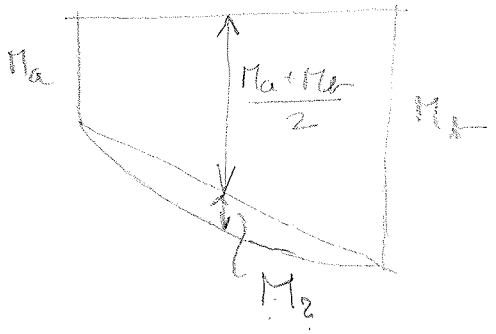
$M_b = M_a + V_a \cdot l - \frac{1}{2} \cdot q \cdot l^2$



$\sum M_{ic} = 0$

$M_c - M_a - V_a \cdot l/2 + \frac{1}{2} \cdot q \cdot l \cdot \frac{1}{4} l = 0$

$M_c = M_a + V_a \cdot l/2 - \frac{1}{8} q l^2$



$\frac{M_a + M_b}{2} = \frac{M_a + M_a + V_a \cdot l - \frac{1}{2} q l^2}{2} =$

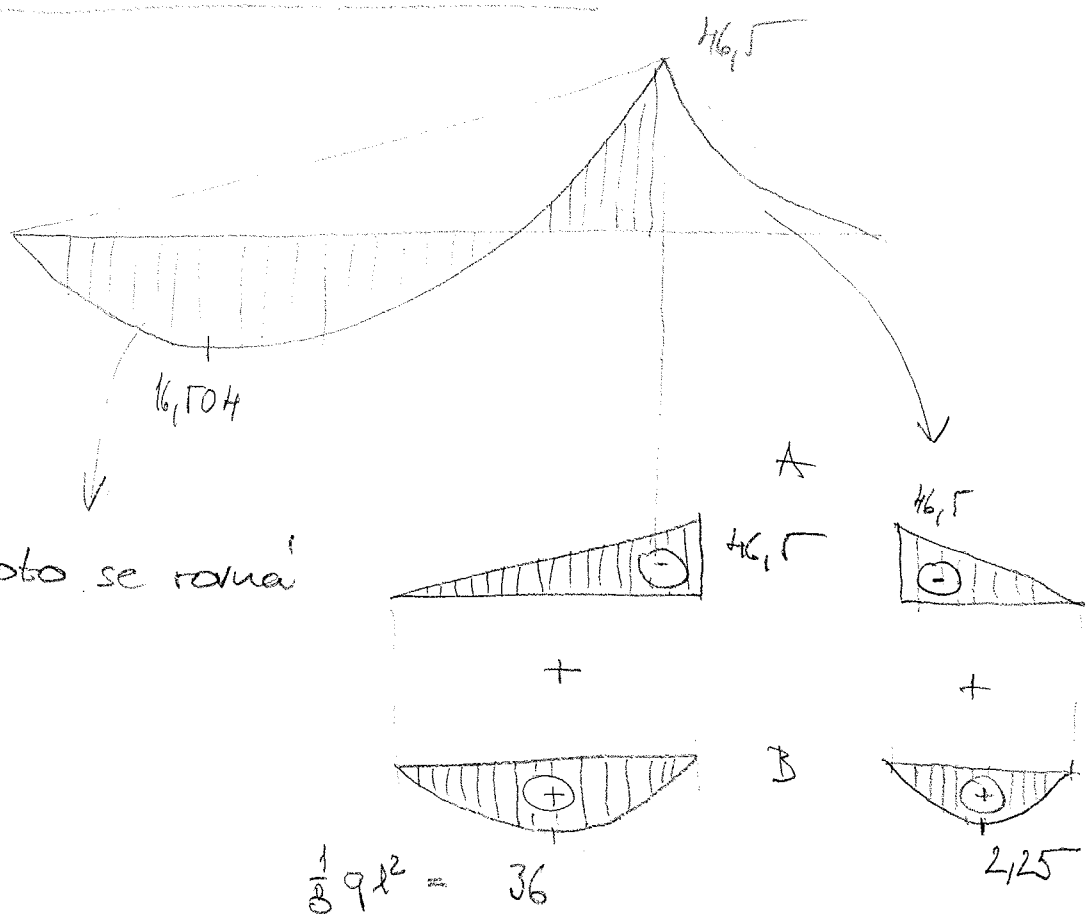
$= M_a + V_a \cdot \frac{l}{2} - \frac{1}{4} q l^2$

$M_2 = M_c - \frac{M_a + M_b}{2} = M_a + V_a \cdot \frac{l}{2} - \frac{1}{8} q l^2 - (M_a + V_a \cdot \frac{l}{2}$

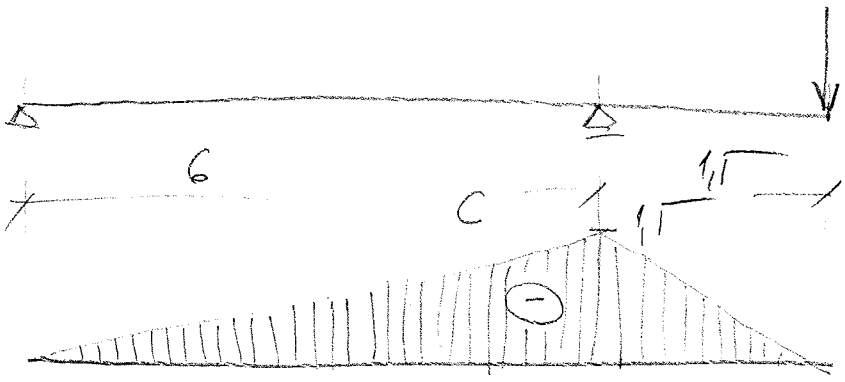
$- \frac{1}{4} q l^2) = M_a + V_a \cdot \frac{l}{2} - \frac{1}{8} q l^2 - M_a - V_a \cdot \frac{l}{2} + \frac{1}{4} q l^2 =$

$= \frac{1}{8} q l^2$

PŘETVOŘENÍ PRÍKLADU



VIRTUÁLNÍ MOMENT:



$$\delta_{1OH} = \frac{1}{EI}\int_0^l (A+B)\cdot C\,dx = \frac{1}{EI}\left\{\int_0^{l'} AC\,dx + \int_0^{l''} BC\,dx\right\} =$$

$$= \frac{1}{EI}\cdot\left\{\frac{1}{3}\cdot(-46{,}5\cdot 10^3)\cdot(-1{,}5)\cdot 6 + \frac{1}{3}\cdot(-46{,}5\cdot 10^3)\cdot(-1{,}1)\cdot 1{,}1 + \right.$$

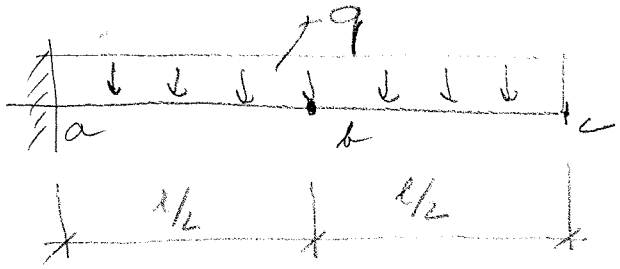
$$\left. + \frac{1}{3}\cdot(36\cdot 10^3)\cdot(-1{,}5)\cdot 6 + \frac{1}{3}\cdot(2{,}25\cdot 10^3)\cdot(-1{,}1)\cdot 1{,}1\right\}$$

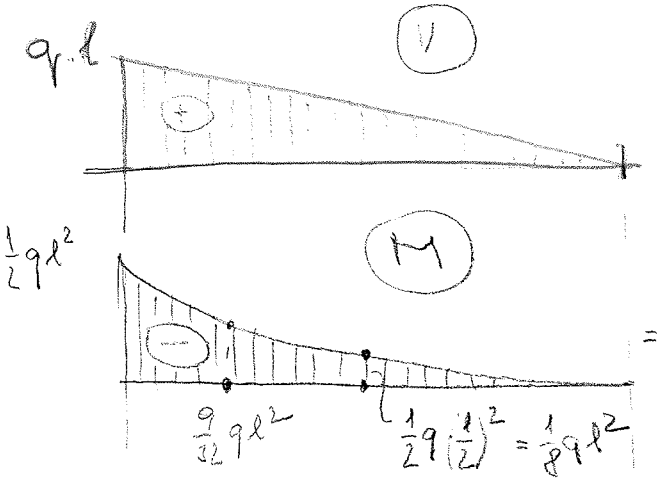
$$w_{c,OH} = \frac{1}{EI} \cdot \{139500 + 34875 - 108000 - 1687,5\} =$$

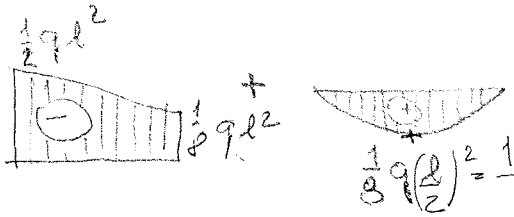
$$= \frac{1}{EI} \cdot 64\,687,5 \quad \ldots \text{ stejné jak předchozí.}$$

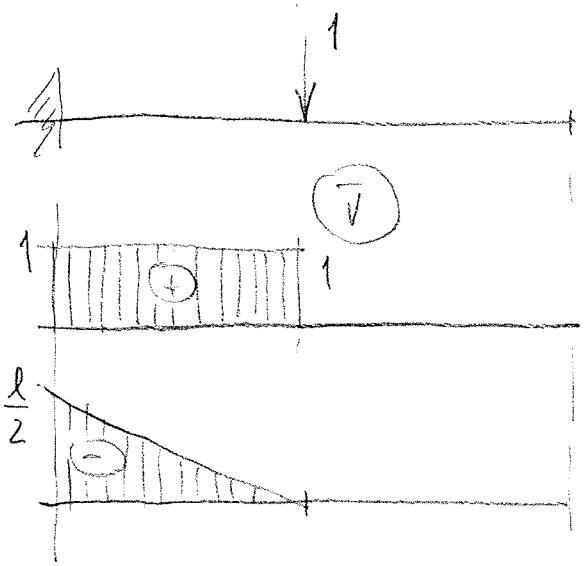
JINÝ PŘÍKLAD

Spočtěte průhyb a pootočení v bodě b









$$w_{c,OH} = \frac{1}{EI} \cdot \left\{ \frac{1}{2} \cdot \frac{l}{2} \cdot \left(2 \cdot \frac{1}{2} ql^2 + \right. \right.$$

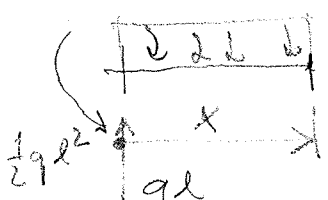
$$\left. \left. + \frac{1}{8} ql^2 \right) \cdot \frac{l}{2} + \frac{1}{3} \cdot \frac{l}{2} \cdot \frac{9l^2}{32} \cdot \frac{l}{2} \right\} =$$

$$= \frac{1}{EI} \left\{ \frac{1}{2} \cdot l \cdot \frac{8ql^2 + ql^2}{8} \cdot \frac{l}{2} + \right.$$

$$\left. + \frac{9l^4}{384} \right\} = \frac{16\,ql^4 + 9ql^4}{384} =$$

$$= \frac{1}{EI} \cdot \frac{17}{384} ql^4 = \frac{17\,ql^4}{384EI}$$

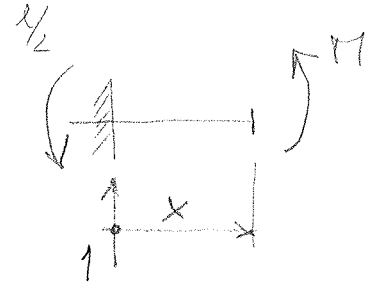
ANALYTICKY:



$$\Sigma M_{ix} = 0$$

$$M + \frac{1}{2}ql^2 - ql \cdot x + \frac{1}{2}qx^2 = 0$$

$$M = -\frac{1}{2}ql^2 + qlx - \frac{1}{2}qx^2$$



$$\sum M_{1x} = 0$$

$$M + \frac{l}{2} - x = 0$$

$$M = x - \frac{l}{2}$$

$$w_x = \frac{1}{EI} \cdot \int_0^{l/2} \left(-\frac{1}{2}ql^2 + qlx - \frac{1}{2}qx^2\right)\cdot\left(x - \frac{l}{2}\right) dx =$$

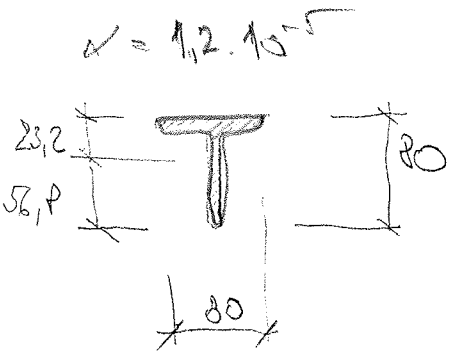
$$= \frac{q}{EI} \cdot \int_0^{l/2} \left(-\frac{1}{2}l^2x + lx^2 - \frac{1}{2}x^3 + \frac{1}{4}l^3 - \frac{l^2}{2}x + \frac{lx^2}{4}\right) dx =$$

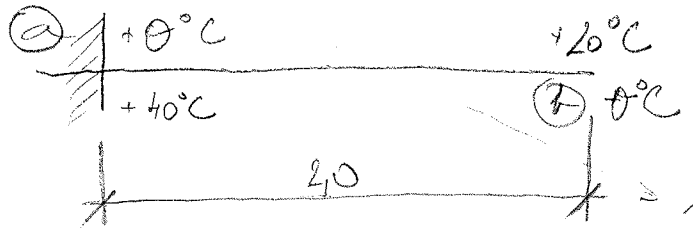
$$= \frac{q}{EI} \cdot \int_0^{l/2} \left(-l^2x + \frac{5}{4}lx^2 - \frac{x^3}{2} + \frac{l^3}{4}\right) dx = \frac{q}{EI}\left(-\frac{l^2}{2}\cdot\left[x^2\right]_0^{\frac{l}{2}} + \frac{5}{12}\cdot l\left[x^3\right]_0^{\frac{l}{2}}\right.$$

$$\left. - \frac{1}{8}\left[x^4\right]_0^{\frac{l}{2}} + \frac{l^3}{4}\left[x\right]_0^{\frac{l}{2}}\right) = \frac{q}{EI}\left(-\frac{l^4}{8} + \frac{5l^4}{96} - \frac{l^4}{128} + \frac{l^4}{8}\right) =$$

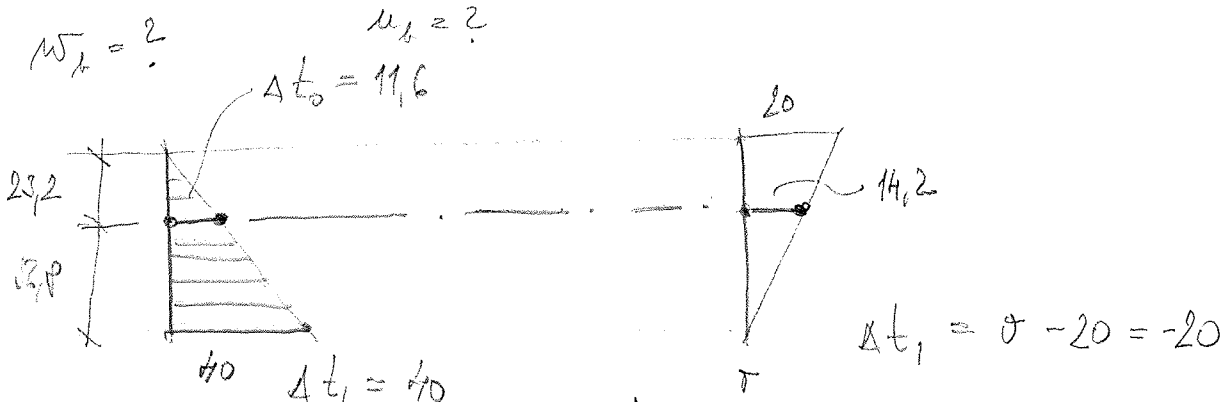
$$= \frac{ql^4}{EI} \cdot \frac{-48 + 20 - 3 + 48}{384} = \frac{17}{384}\,\frac{ql^4}{EI}$$

PŘÍKLAD – TEPLOTA

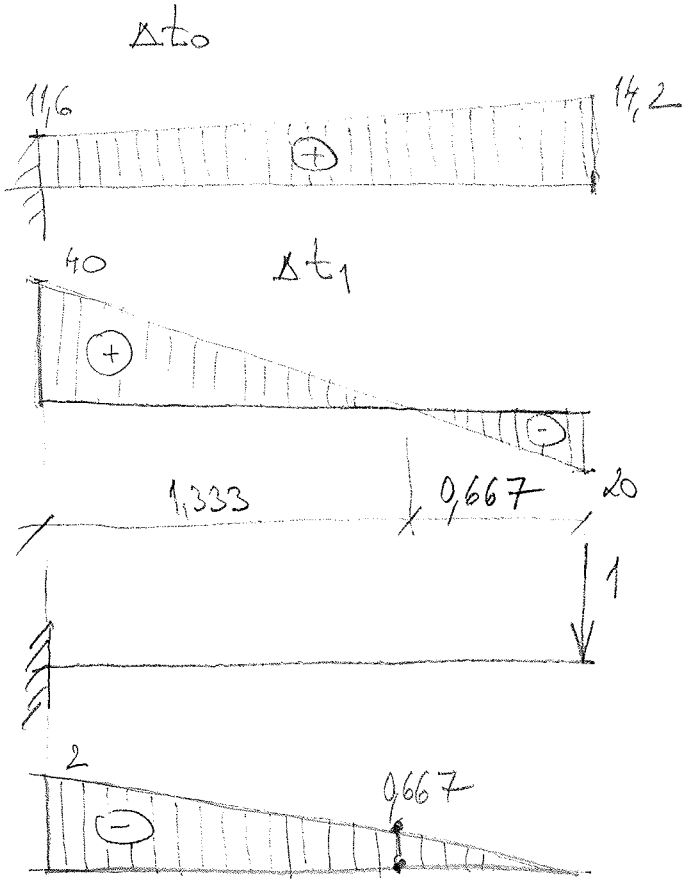




= lineární změna teploty



PRŮBĚH PŘETV. OD. TEPL.



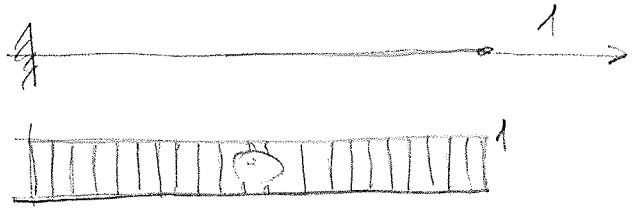
$$w_1 = \int_0^l \kappa \frac{\Delta t_1}{h} \cdot \bar{M} \cdot dx = \frac{1,2\,10^{-5}}{0,08} \cdot \left\{ \frac{1}{6} \cdot 40 \cdot \left[(-2)\,2 - 0,667 \right) \cdot 1,333 \right.$$

$$\left. + \frac{1}{6} (-0,667)(-20) \cdot 0,667 \right\} = 0,00015 \cdot \left\{ -41,474 + 1,4816 \right\} =$$

$$= 0,00015 \cdot \left\{ -39,992 \right\} = -0,005999\,m \doteq -6\,mm$$

$$w_1 = \frac{1,2 \cdot 10^{-5}}{0,08} \cdot \left\{ \frac{1}{6} \cdot (-2) \cdot \left(2 \cdot 40 + (-20) \right) \cdot 2 \right\} = 0,00015 \cdot (+40) = \underline{-6\,mm}$$

Určete podorovný posun bodu b:

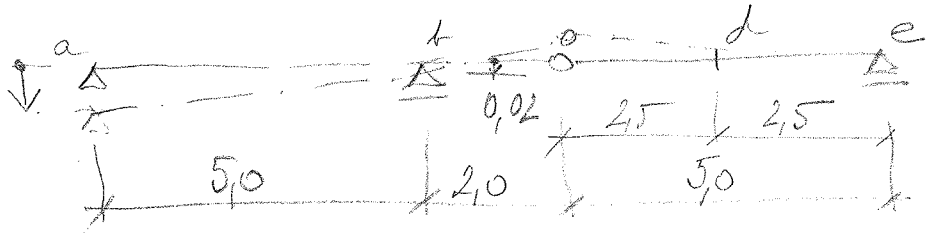


$$u_1 = \int \kappa \cdot \Delta t_0 \cdot \bar{N} \cdot dx =$$

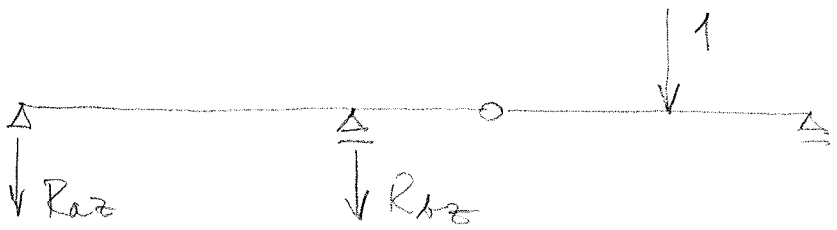
$$= 1,2 \cdot 10^{-5} \cdot \frac{1}{2} \cdot 1 \cdot (11,6 + 14,2) \cdot 2 =$$

$$= 0,0003096\,m = 0,3096\,mm$$

POSUKI PALETOR:



Podpora a poklesne o 0,1 m, podpora b o 0,02.
Vypočítejte svislý posun bodu d

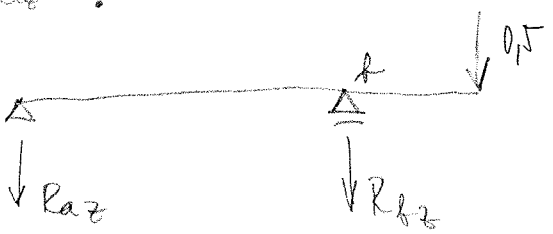


$R_{az} = ?$

$\sum M_{ib} = 0$

$R_{az} \cdot 5 - 2 \cdot 0{,}5 = 0$

$R_{az} = \frac{1}{5}$



$\sum M_{ia} = 0$

$R_{bz} \cdot 5 + 0{,}5 \cdot 7 = 0$

$R_{bz} = -\frac{7}{10}$

$w_d = -\sum \bar{R}_{iz} \cdot w_i =$

$= -\frac{1}{5} \cdot 0{,}1 - \left(-\frac{7}{10}\right) \cdot 0{,}02 =$

$= \underline{-0{,}006\ m}$