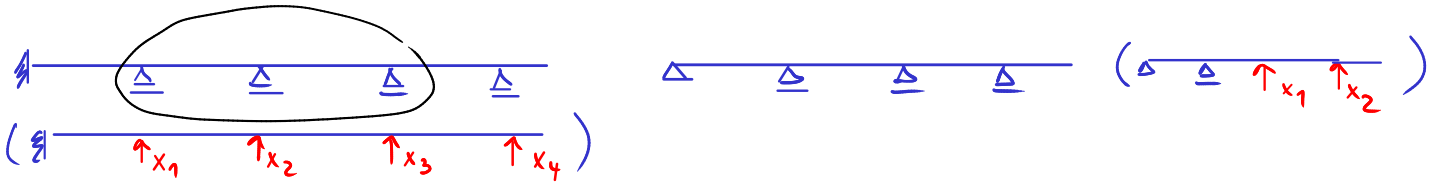
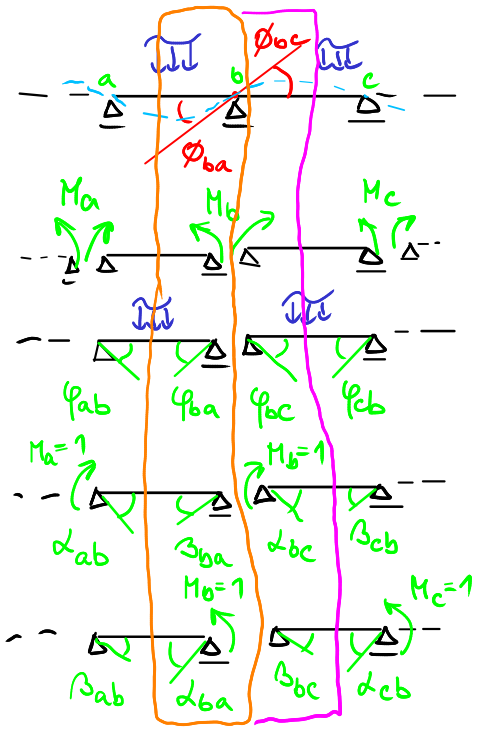
SPOJITÉ NOSNÍKY – METODA TŘÍMOMENTOVÝCH ROVNIC (MTR)



ZSUS

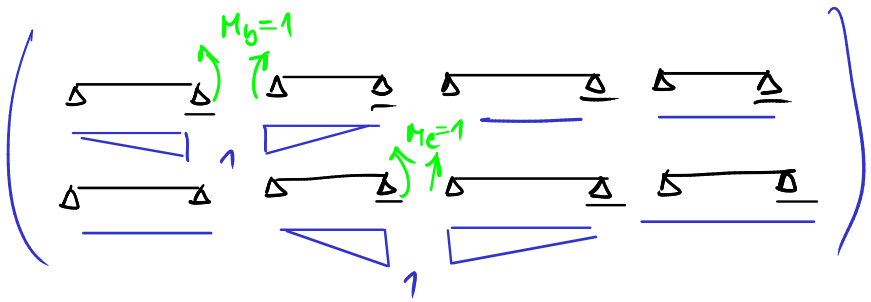


$$\varphi_{ba} = -\varphi_{bc}$$

$$\varphi_{ba} = \varphi_{ba} + \beta_{ba} \cdot M_a + \alpha_{ba} \cdot M_b$$

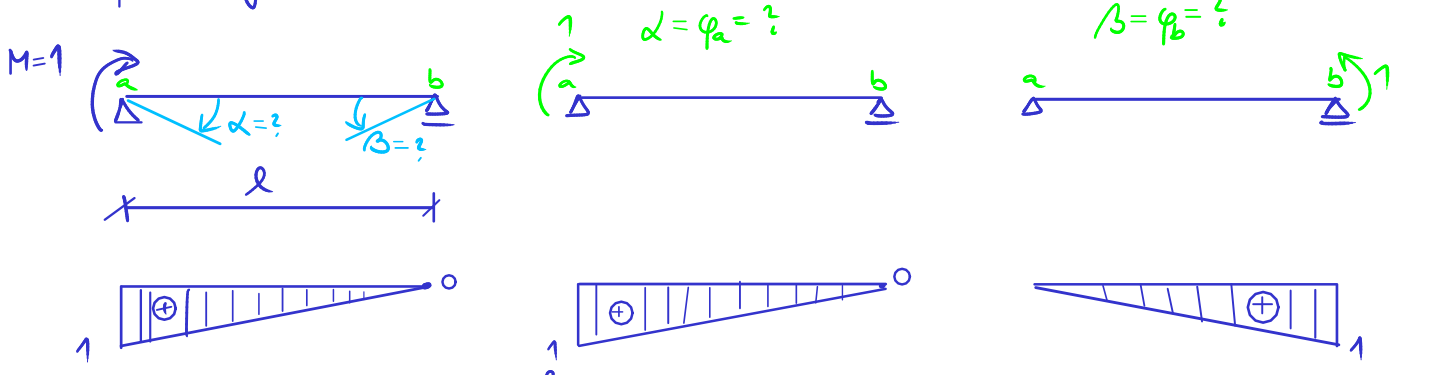
$$\varphi_{bc} = \varphi_{bc} + \alpha_{bc} \cdot M_b + \beta_{bc} \cdot M_c$$

$$\beta_{ba} M_a + (\alpha_{ba} + \alpha_{bc}) M_b + \beta_{bc} M_c + \varphi_{ba} + \varphi_{bc} = 0$$



Výpočet α a β – pootočení od jednotkového momentu

α … přilehlý β … protilehlý



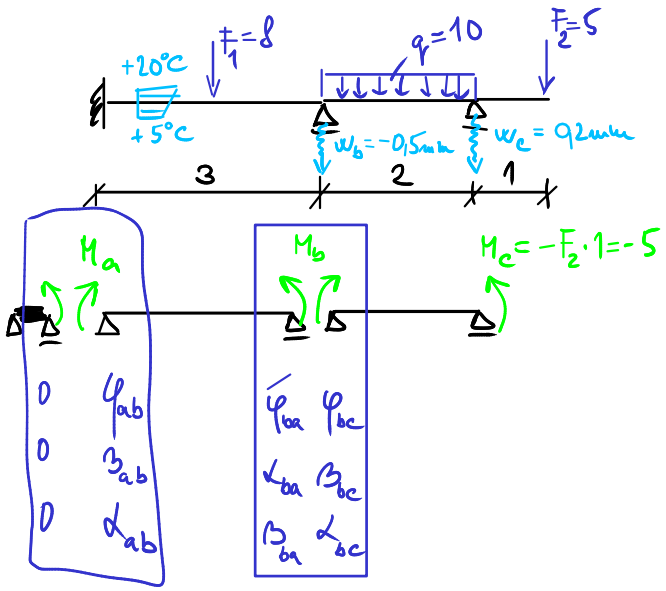
$$\alpha = \int_0^l \frac{M\bar{M}}{EI} dx = \frac{1}{EI}\left[\frac{1}{2} l \cdot 1 \cdot \left(\frac{2}{3} 1\right)\right]$$

$$\alpha = \frac{l}{3EI}$$

$$\beta = \frac{1}{EI}\left[\frac{1}{2} l \cdot 1 \cdot \left(\frac{1}{3} 1\right)\right]$$

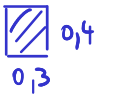
$$\beta = \frac{l}{6EI}$$

[kN, kNm, kN/m, m]



$\alpha_T = 10^{-5}\ °C^{-1}$ $\quad EI = 64000\ kPa\ m^4$

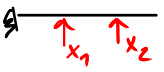
$E = 40\ GPa$



$A =$

$I = \frac{1}{12} b h^3 = 1{,}6 \cdot 10^{-3}\ m^4$

1) $n_s = 2$



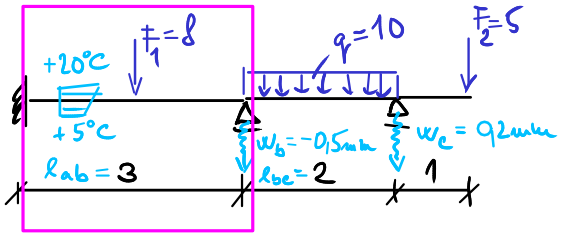
2) ZSUS z prostých nosníků | soustava rovnic

podpora (b) $\quad \phi_{ba} = -\phi_{bc}$

$$\beta_{ba} M_a + (\alpha_{ba} + \alpha_{bc}) M_b + \beta_{bc} M_c + \varphi_{ba} + \varphi_{bc} = 0$$

podpora (a) $\quad \phi_{ab} = -\phi_{aa} \qquad \phi_{aa} = 0$

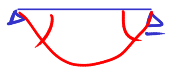
$$\phi_{ab} + 0 = 0 : \varphi_{ab} + \beta_{ab} \cdot M_b + \alpha_{ab} \cdot M_a = 0$$



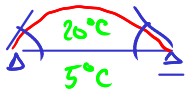
POLE a–b :

$$\alpha_{ba} = \alpha_{ab} = \frac{l_{ab}}{3EI} = |5.13a| = \frac{3}{3EI} = \frac{1}{EI}$$

$$\beta_{ab} = \beta_{ba} = \frac{l_{ab}}{6EI} = |5.13b| = \frac{1}{2EI}$$

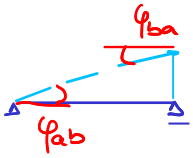


$$\varphi_{ab|F} = \varphi_{ba|F} = |5.9a| = \frac{F l_{ab}^2}{16EI} = \frac{8 \cdot 3^2}{16 \cdot EI} = \frac{4{,}5}{EI}$$



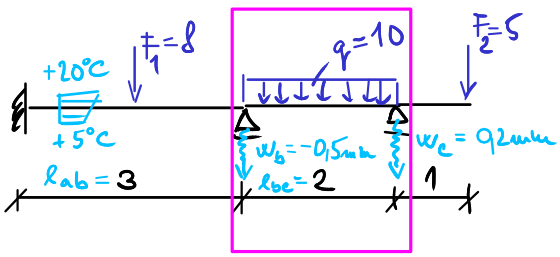
$$\varphi_{ab|t} = \varphi_{ba|t} = \left| 5.20 \ \Delta t_1 = t_d - t_h = 5 - 20 = -15 \right| = \frac{\alpha_T \Delta t_1 l_{ab}}{2h} =$$

$$= \frac{10^{-5} \cdot (-15) \cdot 3}{2 \cdot 0{,}4} = -5{,}625 \cdot 10^{-4}$$



$$\varphi_{ab|P} = |5.21a| = \frac{w_b - w_a}{l_{ab}} = \frac{-0{,}5 \cdot 10^{-3} - 0}{3} = -\frac{1}{6000}$$

$$\varphi_{ba|P} = |5.21b| = \frac{w_a - w_b}{l_{ab}} = +\frac{1}{6000}$$



POLE b–c :

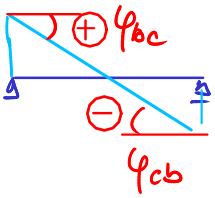
$$\alpha_{bc} = \alpha_{cb} = |5.13a| = \frac{l_{bc}}{3EI} = \frac{2}{3EI}$$

$$\beta_{bc} = \beta_{cb} = |5.13b| = \frac{l_{bc}}{6EI} = \frac{1}{3EI}$$

$$\varphi_{bc|q} = \varphi_{cb|q} = |5.14| = \frac{q l_{bc}^3}{24EI} = \frac{10 \cdot 2^3}{24EI} = \frac{10}{3EI}$$

$$\varphi_{bc|P} = |5.21a| = \frac{w_c - w_b}{l_{bc}} = \frac{[0{,}2 - (-0{,}5)] \cdot 10^{-3}}{2} = 0{,}35 \cdot 10^{-3}$$

$$\left(\varphi_{cb|P} = |5.21b| = \frac{w_b - w_c}{l_{bc}} = -0{,}35 \cdot 10^{-3} \right)$$



$$M_a \alpha_{ab} + M_b \beta_{ab} + \varphi_{ab} = 0$$

$$M_a \beta_{ba} + M_b (\alpha_{ba} + \alpha_{bc}) + M_c \beta_{bc} + \varphi_{ba} + \varphi_{bc} = 0$$

$$\varphi_{ab} = \varphi_{ab,t} + \varphi_{ab,p} + \varphi_{ab,F}$$
$$\varphi_{ba} \quad \varphi_{ba} \quad \varphi_{ba} \quad \varphi_{ba}$$

$$\varphi_{bc} = \varphi_{bc,p} + \varphi_{bc,q}$$

$$M_a \cdot \frac{1}{EI} + M_b \frac{1}{2EI} - 5{,}625 \cdot 10^{-4} - \frac{1}{6000} + \frac{4{,}5}{EI} = 0$$

$$M_a \cdot \frac{1}{2EI} + M_b \left(\frac{1}{EI} + \frac{2}{3EI}\right) - 5 \cdot \frac{1}{3EI} - 5{,}625 \cdot 10^{-4} + \frac{1}{6000} + \frac{4{,}5}{EI} + 0{,}35 \cdot 10^{-3} + \frac{10}{3EI} = 0$$

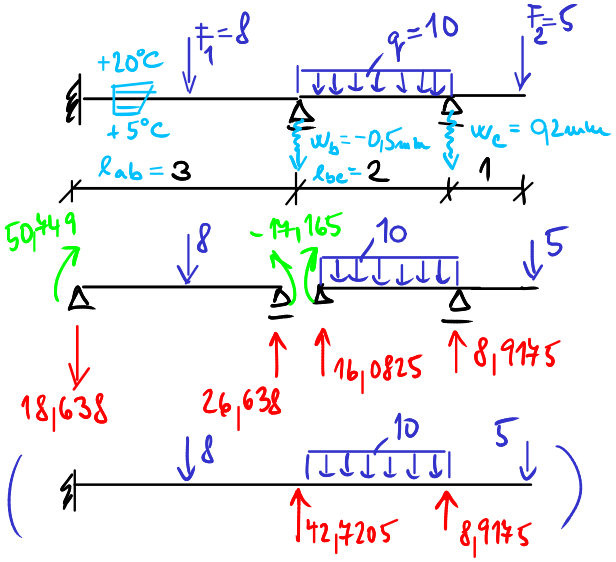
$$M_a + \frac{1}{2} M_b = 42{,}16\overline{6}$$

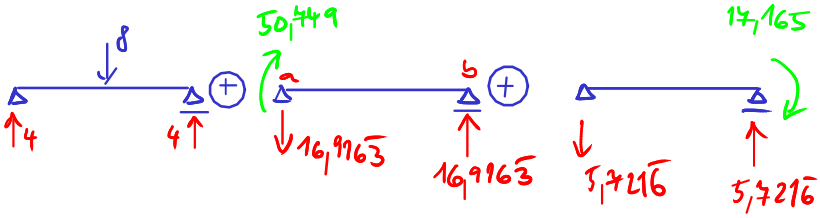
$$\frac{1}{2} M_a + \frac{5}{3} M_b = -3{,}2\overline{3}$$

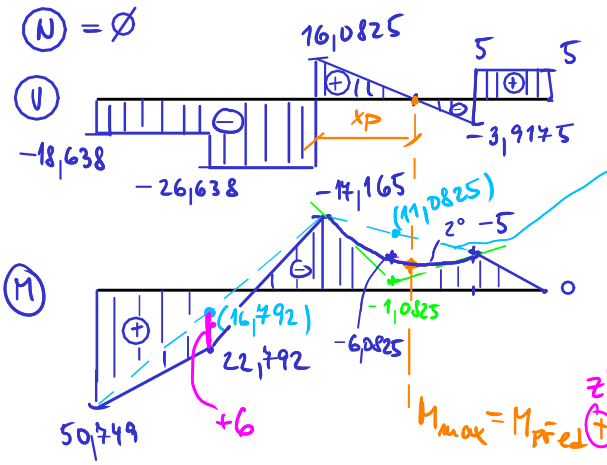
$$\begin{bmatrix} 1 & \frac{1}{2} \\ \frac{1}{2} & \frac{5}{3} \end{bmatrix} \begin{Bmatrix} M_a \\ M_b \end{Bmatrix} = \begin{Bmatrix} 42{,}16\overline{6} \\ -3{,}2\overline{3} \end{Bmatrix}$$

$$M_b = -14{,}165 \text{ kNm}$$

$$M_a = 50{,}449 \text{ kNm}$$

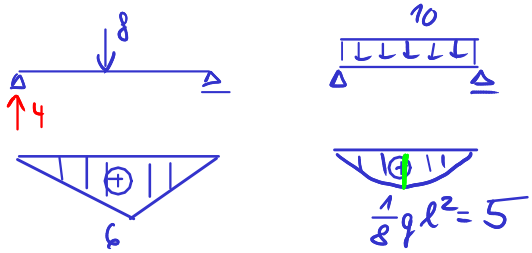






$$x_p = \frac{16{,}0825}{q} = 1{,}60825 \text{ m}$$

→ odsunutá střelnice



$$M_{max} = M_{před} \oplus \int_{x_p}^{\text{zleva}} v\,dx = -14{,}165 + \frac{1}{2} 1{,}60825 \cdot 16{,}0825 = -4{,}232 \text{ kNm}$$

$M_{před} \ominus \int_{x_p}^{\text{zprava}} v\,dx$