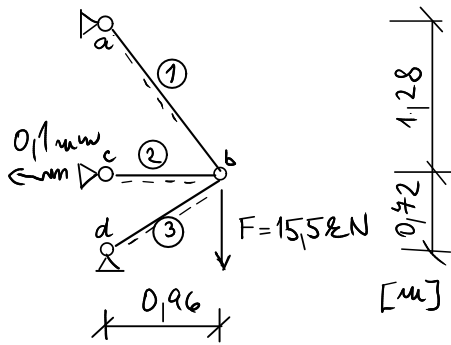
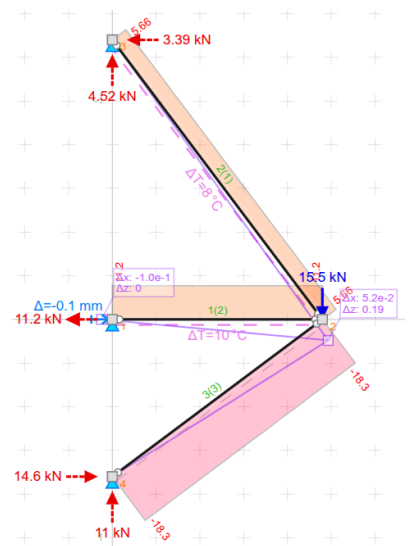




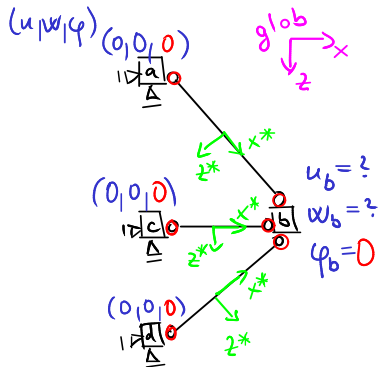
$$A_1 = 8 \cdot 10^{-4} \text{ m}^2; A_2 = 9.6 \cdot 10^{-4} \text{ m}^2; A_3 = 15 \cdot 10^{-4} \text{ m}^2$$

$$E = 2 \cdot 10^8 \text{ kPa}, \alpha_T = 10^{-5} \text{ } ^\circ\text{C}^{-1}$$

$$\Delta T_{D,ab} = 8^\circ\text{C} \quad \Delta T_{D,cb} = 10^\circ\text{C}$$



- model,  $n_p$ ,  $\{n\}$ ,  $\{S\}$

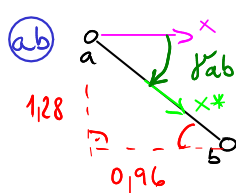


$$n_p = 2 \times$$

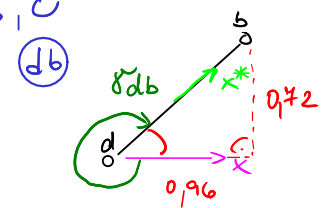
$$\{n\} = \begin{Bmatrix} u_b \\ w_b \end{Bmatrix}$$

$$\{S\} = \begin{Bmatrix} 0 \\ 15.5 \end{Bmatrix} \text{ [kN]}$$

- lokální souřadné soustavy  $\Rightarrow S, C$



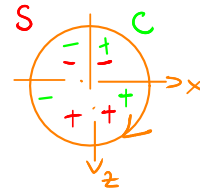
(cb) glob  $\equiv$  lok.



$$l_{ab} = \sqrt{1.28^2 + 0.96^2} = 1.6 \text{ m}$$

$$s_{ab} = + \frac{1.28}{1.6} = + \frac{4}{5} = + 0.8$$

$$c_{ab} = + \frac{0.96}{1.6} = + \frac{3}{5} = + 0.6$$



$$l_{db} = \sqrt{0.96^2 + 0.72^2} = 1.2 \text{ m}$$

$$s_{db} = - \frac{0.72}{1.2} = - \frac{3}{5} = - 0.6$$

$$c_{db} = + \frac{0.96}{1.2} = + \frac{4}{5} = + 0.8$$

- matice tuhosti

$$[k_{ab}] = \begin{bmatrix} 36 & 48 & -36 & -48 \\ 48 & 64 & -48 & -64 \\ -36 & -48 & 36 & 48 \\ -48 & -64 & 48 & 64 \end{bmatrix} \cdot 10^3 \quad [k_{cb}] = \begin{bmatrix} 200 & 0 & -200 & 0 \\ 0 & 0 & 0 & 0 \\ -200 & 0 & 200 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \cdot 10^3 \quad [k_{db}] = \begin{bmatrix} 160 & -120 & -160 & 120 \\ -120 & 90 & 120 & -90 \\ -160 & 120 & 160 & -120 \\ 120 & -90 & -120 & 90 \end{bmatrix} \cdot 10^3$$

- primární vektor koncových sil

$$\{\bar{R}_{ab}^*\} = \begin{Bmatrix} 12.8 \\ 0 \\ -12.8 \\ 0 \end{Bmatrix} \quad \{\bar{R}_{ab}\} = [T_{ab}]^T \{\bar{R}_{ab}^*\} = \begin{bmatrix} 0.6 & -0.8 & 1 & 0 \\ 0.8 & 0.6 & 0 & 1 \\ 0.6 & -0.8 & 0 & 0 \\ 0.8 & 0.6 & 0 & 0 \end{bmatrix} \begin{Bmatrix} 12.8 \\ 0 \\ -12.8 \\ 0 \end{Bmatrix} = \begin{Bmatrix} 7.68 \\ 10.24 \\ -7.68 \\ -10.24 \end{Bmatrix}$$

$$\{\bar{R}_{cb}^*\} = \begin{Bmatrix} 19.2 \\ 0 \\ -19.2 \\ 0 \end{Bmatrix}$$

$$\{\bar{R}_{cb}\} = \begin{Bmatrix} 19.2 \\ 0 \\ -19.2 \\ 0 \end{Bmatrix}$$

$$\{\tilde{R}_{cb}\} = [k_{cb}] \cdot \{\tilde{R}_{cb}\} = \begin{bmatrix} 200 & 0 & -200 & 0 \\ 0 & 0 & 0 & 0 \\ -200 & 0 & 200 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \cdot 10^3 \cdot \begin{Bmatrix} -10^{-4} \\ 0 \\ 0 \\ 0 \end{Bmatrix} = \begin{Bmatrix} -20 \\ 0 \\ 20 \\ 0 \end{Bmatrix}$$

$$[k] \cdot \{u\} = \{F\}$$

$$\{F\} = \{S\} - \{\bar{R}\} - \{\hat{R}\} = \begin{Bmatrix} 0 \\ 15,5 \end{Bmatrix} - \begin{Bmatrix} -7,68 + (-19,2) \\ -10,24 + 0 \end{Bmatrix} - \begin{Bmatrix} 20 \\ 0 \end{Bmatrix} = \begin{Bmatrix} 6,88 \\ 25,74 \end{Bmatrix}$$

$$[k] = \left[ \begin{array}{cc|cc} 36 + 200 & 48 + 0 & & \\ + 160 & -120 & & \\ \hline 48 + 0 & 64 + 0 & & \\ -120 & + 90 & & \end{array} \right] \cdot 10^3 = \begin{bmatrix} 396 & -72 \\ -72 & 154 \end{bmatrix} \cdot 10^3$$

$$\begin{bmatrix} 396 & -72 \\ -72 & 154 \end{bmatrix} \cdot 10^3 \begin{Bmatrix} u_b \\ w_b \end{Bmatrix} = \begin{Bmatrix} 6,88 \\ 25,74 \end{Bmatrix}$$

$$\begin{bmatrix} 396 & -72 & | & 6,88 \cdot 10^{-3} \\ -72 & 154 & | & 25,74 \cdot 10^{-3} \end{bmatrix} \cdot 72 +$$

$$\begin{bmatrix} 396 & -72 & | & 6,88 \cdot 10^{-3} \\ & 55800 & | & 10,6884 \end{bmatrix} \Rightarrow \begin{cases} u_b = 52,2 \cdot 10^{-6} \text{ m} \\ w_b = 191,548 \cdot 10^{-6} \text{ m} \end{cases}$$

- celkové koncové síly  $\{R\} = \{\bar{R}\} + \{\hat{R}\} = \{\bar{R}\} + [k] \cdot \{u\}$

$$\{R_{ab}\} = \begin{Bmatrix} 7,68 \\ 10,24 \\ -7,68 \\ -10,24 \end{Bmatrix} + \begin{bmatrix} \cdot & \cdot & -36 & -48 \\ \cdot & \cdot & -48 & -64 \\ \cdot & \cdot & 36 & 48 \\ \cdot & \cdot & 48 & 64 \end{bmatrix} \cdot 10^3 \cdot \begin{Bmatrix} 0 \\ 0 \\ 52,2 \cdot 10^{-6} \\ 191,548 \cdot 10^{-6} \end{Bmatrix} = \begin{Bmatrix} -3,394 \\ -4,525 \\ 3,394 \\ 4,525 \end{Bmatrix}$$

$$\{R_{ab}^*\} = [T_{ab}] \{R_{ab}\} = \begin{bmatrix} 0,6 & 0,8 & | & \cdot \\ -0,8 & 0,6 & | & \cdot \\ \hline \cdot & \cdot & 0,6 & 0,8 \\ \cdot & \cdot & -0,8 & 0,6 \end{bmatrix} \cdot \begin{Bmatrix} -3,394 \\ -4,525 \\ 3,394 \\ 4,525 \end{Bmatrix} = \begin{Bmatrix} -5,656 \\ 0 \\ 5,656 \\ 0 \end{Bmatrix}$$

$$\{R_{cb}\} = \begin{Bmatrix} 19,2 \\ 0 \\ -19,2 \\ 0 \end{Bmatrix} + \begin{bmatrix} 200 & \cdot & -200 & 0 \\ 0 & \cdot & 0 & 0 \\ -200 & \cdot & 200 & 0 \\ 0 & \cdot & 0 & 0 \end{bmatrix} \cdot 10^3 \cdot \begin{Bmatrix} -0,1 \cdot 10^{-3} \\ 0 \\ 52,2 \cdot 10^{-6} \\ 191,548 \cdot 10^{-6} \end{Bmatrix} = \begin{Bmatrix} -11,24 \\ 0 \\ 11,24 \\ 0 \end{Bmatrix}$$

$$\{R_{db}\} = \emptyset + \begin{bmatrix} \cdot & \cdot & -160 & 120 \\ \cdot & \cdot & 120 & -90 \\ \cdot & \cdot & 160 & -120 \\ \cdot & \cdot & -120 & 90 \end{bmatrix} \cdot 10^3 \cdot \begin{Bmatrix} 0 \\ 0 \\ 52,2 \cdot 10^{-6} \\ 191,548 \cdot 10^{-6} \end{Bmatrix} = \begin{Bmatrix} 14,634 \\ -10,975 \\ -14,634 \\ 10,975 \end{Bmatrix}$$

$$\{R_{db}^*\} = [T_{db}] \{R_{db}\} = \begin{bmatrix} 0,8 & -0,6 & | & \cdot \\ 0,6 & 0,8 & | & \cdot \\ \hline \cdot & \cdot & 0,8 & -0,6 \\ \cdot & \cdot & -0,6 & 0,8 \end{bmatrix} \cdot \begin{Bmatrix} 14,634 \\ -10,975 \\ -14,634 \\ 10,975 \end{Bmatrix} = \begin{Bmatrix} 18,292 \\ 0 \\ -18,292 \\ 0 \end{Bmatrix}$$

- kontrola rovnováhy sil na prutu a styčnicích

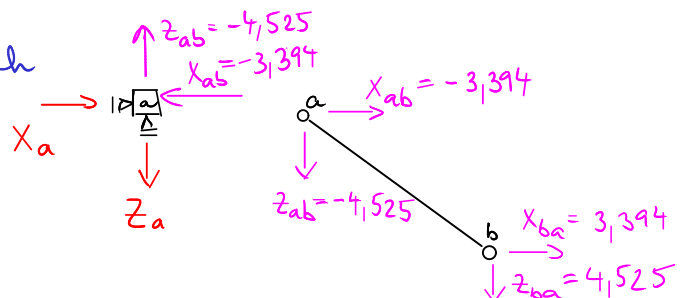
$$\sum F_{xi} = 0 \checkmark$$

$$\sum F_{yi} = 0 \checkmark$$

$$\sum F_{xi} = 0 \oplus \rightarrow$$

$$X_a - X_{ab} = 0$$

$$X_a = X_{ab} = -3,394 \text{ kN}$$



$$\sum F_{zi} = 0 \oplus \uparrow$$

$$z_{ab} - z_a = 0 \Rightarrow \underline{z_a = z_{ab} = -4,525 \text{ kN}}$$

$$\begin{aligned} X_{ba} &= 3,394 \\ X_{bc} &= 11,24 \\ X_{bd} &= -14,634 \\ z_{ba} &= 4,525 \\ F &= 15,5 \\ z_{bd} &= 10,975 \\ \sum F_{xi} &= 0 \checkmark \\ \sum F_{zi} &= 0 \checkmark \end{aligned}$$

-vnitru silu

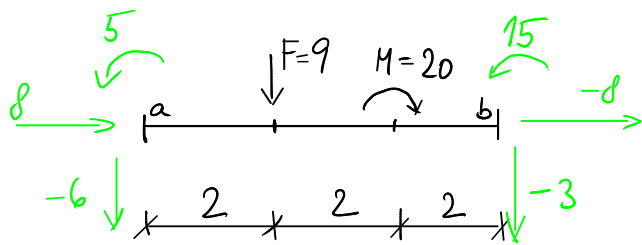
$$\begin{aligned} X_c &= -11,24 \\ z_c &= 0 \\ X_{cb} &= -11,24 \end{aligned}$$

$$\begin{aligned} X_d &= 14,634 \\ X_{ds} &= 14,634 \\ z_d &= -10,975 \\ z_{db} &= -10,975 \end{aligned}$$

$$\begin{aligned} X_{cb} &= -11,24 \\ X_{bc} &= 11,24 \end{aligned}$$

$$\begin{aligned} X_{db} &= 14,634 \\ X_{bd} &= -14,634 \\ z_{db} &= -10,975 \\ z_{bd} &= 10,975 \end{aligned}$$

$$\begin{aligned} X_{ab}^* &= -5,656 \\ X_{ba}^* &= 5,656 \\ N_1 &= +5,656 \text{ kN (tah)} \\ X_{cs}^* &= -11,24 \\ X_{bc}^* &= 11,24 \\ N_2 &= +11,24 \text{ kN (tah)} \\ X_{db}^* &= 18,292 \\ X_{bd}^* &= -18,292 \\ N_3 &= -18,292 \text{ kN (tak)} \end{aligned}$$



$$\{R_{ab}\} = \begin{Bmatrix} 8 \\ -6 \\ 5 \\ -8 \\ -3 \\ 15 \end{Bmatrix}$$

