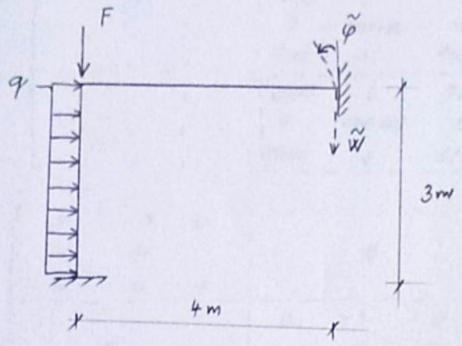


DEFORMAČNÍ ZATÍŽENÍ : teplota (minule)
: dané nepružné přemístění podpor ($\tilde{u}, \tilde{w}, \tilde{\varphi}$)
⊕ → ↓ ↺

Pr.: řešte ODM:

(10 min)

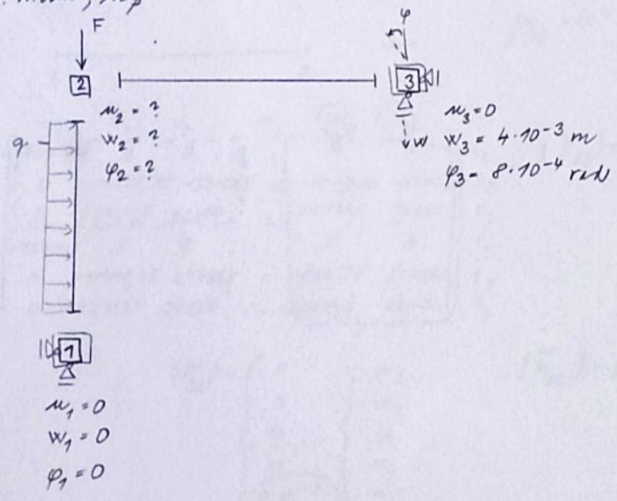


$F = 4,375 \text{ kN}$
 $q = 40 \text{ kN/m}$
 $w = 4 \cdot 10^{-3} \text{ m (l)}$
 $\varphi = 8 \cdot 10^{-4} \text{ rad (r)}$

průřez $0,3 \times 0,5 \text{ m}$
 plocha $0,3 \times 0,3 \text{ m}^2$
 $E = 2 \cdot 10^7 \text{ kPa}$

$EA_{pr} = 3 \cdot 10^6 \text{ kPa} \cdot \text{m}^2$
 $EI_{pr} = 62,5 \cdot 10^3 \text{ kPa} \cdot \text{m}^4$
 $EA_{st} = 1,8 \cdot 10^6 \text{ kPa} \cdot \text{m}^2$
 $EI_{st} = 13,5 \cdot 10^3 \text{ kPa} \cdot \text{m}^4$

1) výp. model, n_p
(5 min)



$n_p = 3$

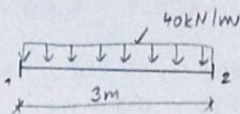
2) $\{r\}, \{S\}$:

$\{r\} = \{u_2; w_2; \varphi_2\}^T$
 $\{S\} = \{0; 4,375; 0\}^T$
 $\begin{matrix} x_2 & z_2 & \theta_2 \end{matrix}$

3) Analýza prutu : $[k_{ab}]$; $\{\bar{r}_{ab}^*\} \rightarrow \{\bar{r}_{ab}\}$
(5 min + 25 min) ! + globální vektory druzích složek přemístění $\{\tilde{r}_{ab}\}$
(vliv nepružného přemístění zřevádíme na primární učiněk, i když to reálný primární učiněk není)

$\{\tilde{r}_{ab}\} = [k_{ab}] \cdot \{\tilde{r}_{ab}\}$... def. vztah se
 popuštěnými podpor

Prut 1-2:



$$\gamma_{12} = 270^\circ$$

$$\sin \gamma_{12} = -1$$

$$\cos \gamma_{12} = 0$$

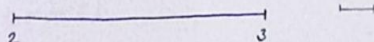


$$[k_{12}] = \begin{bmatrix} \mu_1 & w_1 & \varphi_1 & \mu_2 & w_2 & \varphi_2 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \end{bmatrix} = \begin{bmatrix} -6000 & 0 & -9000 \\ 0 & -600000 & 0 \\ 9000 & 0 & 9000 \\ \hline 6000 & 0 & -9000 \\ 0 & 600000 & 0 \\ 19000 & 0 & 19000 \end{bmatrix} \begin{matrix} x_1 \\ z_1 \\ \eta_1 \\ x_2 \\ z_2 \\ \eta_2 \end{matrix}$$

$$[T_{12}] = \begin{bmatrix} 0 & -1 & 0 & \vdots & \vdots & \vdots \\ 1 & 0 & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & -1 & \vdots & \vdots & \vdots \\ \hline \vdots & \vdots & \vdots & 0 & -1 & 0 \\ \vdots & \vdots & \vdots & 1 & 0 & 0 \\ \vdots & \vdots & \vdots & 0 & 0 & 1 \end{bmatrix}$$

$$\{\bar{R}_{12}^*\} = \begin{Bmatrix} 0 \\ -60 \\ -30 \\ 0 \\ -60 \\ -30 \end{Bmatrix} \begin{matrix} x_1 \\ z_1 \\ \eta_1 \\ x_2 \\ z_2 \\ \eta_2 \end{matrix} \rightarrow \{\bar{R}_{12}\} = \begin{Bmatrix} -60 \\ 0 \\ 30 \\ -60 \\ 0 \\ -30 \end{Bmatrix} \begin{matrix} x_1 \\ z_1 \\ \eta_1 \\ x_2 \\ z_2 \\ \eta_2 \end{matrix}$$

Prut 2-3:



$$\gamma_{23} = 0^\circ$$

$$\sin \gamma_{23} = 0$$

$$\cos \gamma_{23} = 1$$

$$[k_{23}^*]$$

$$[k_{23}] = \begin{bmatrix} \mu_2 & w_2 & \varphi_2 & \mu_3 & w_3 & \varphi_3 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \end{bmatrix} = \begin{bmatrix} 750000 & 0 & 0 & 1 & 0 & 0 \\ 0 & 11717,75 & -23437,5 & 0 & 0 & 0 \\ 0 & -23437,5 & 62500 & 0 & 0 & 0 \\ \hline -750000 & 0 & 0 & 0 & 1 & 0 \\ 0 & 11717,75 & 23437,5 & 0 & 0 & 0 \\ 0 & -23437,5 & 31250 & 0 & 0 & 0 \end{bmatrix} \begin{matrix} x_2 \\ z_2 \\ \eta_2 \\ x_3 \\ z_3 \\ \eta_3 \end{matrix}$$

$$\{\bar{R}_{23}^*\} = \{\bar{R}_{23}\} = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix} \begin{matrix} x_2 \\ z_2 \\ \eta_2 \\ x_3 \\ z_3 \\ \eta_3 \end{matrix}$$

$$\{\tilde{R}_{23}^*\} = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 4 \cdot 10^{-3} \\ 8 \cdot 10^{-4} \end{Bmatrix} \begin{matrix} \mu_2 \\ w_2 \\ \varphi_2 \\ \mu_3 \\ w_3 \\ \varphi_3 \end{matrix}$$

$$\{\tilde{R}_{23}\} = [k_{23}] \{\tilde{R}_{23}^*\} = \begin{Bmatrix} 0 \\ -65,625 \\ 117,75 \\ 0 \\ 65,625 \\ 143,75 \end{Bmatrix} \begin{matrix} x_2 \\ z_2 \\ \eta_2 \\ x_3 \\ z_3 \\ \eta_3 \end{matrix}$$

4) $[K]; \{\bar{R}\} + \{\tilde{R}\}; \{F\}$
(10 min)

$$[K] = \begin{bmatrix} \mu_2 & w_2 & \varphi_2 \\ \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots \end{bmatrix} = \begin{bmatrix} 756000 & 0 & 9000 \\ 0 & 611717,75 & -23437,5 \\ 9000 & -23437,5 & 80500 \end{bmatrix} \begin{matrix} x_2 \\ z_2 \\ \eta_2 \end{matrix}$$

$$\{\bar{R}\} = \begin{Bmatrix} -60 \\ 0 \\ -30 \end{Bmatrix} \begin{matrix} x_2 \\ z_2 \\ \eta_2 \end{matrix}$$

$$\{\tilde{R}\} = \begin{Bmatrix} 0 \\ -65,625 \\ 117,75 \end{Bmatrix} \begin{matrix} x_2 \\ z_2 \\ \eta_2 \end{matrix}$$

$$\{F\} = \{S\} - \{\bar{R}\} - \{\tilde{R}\} = \begin{Bmatrix} 0 \\ 4,375 \\ 0 \end{Bmatrix} - \begin{Bmatrix} -60 \\ 0 \\ -30 \end{Bmatrix} - \begin{Bmatrix} 0 \\ -65,625 \\ 117,75 \end{Bmatrix} = \begin{Bmatrix} 60 \\ 70 \\ -88,75 \end{Bmatrix} \begin{matrix} x_2 \\ z_2 \\ \eta_2 \end{matrix}$$

5) $[K] \cdot \{r\} = \{F\} \rightarrow \{r\} = [K^{-1}] \cdot \{F\}$
(10 min)

$$\begin{bmatrix} 756000 & 0 & 9000 \\ 0 & 611718,75 & -23437,5 \\ 9000 & -23437,5 & 80500 \end{bmatrix} \begin{Bmatrix} u_2 \\ v_2 \\ \varphi_2 \end{Bmatrix} = \begin{Bmatrix} 60 \\ 70 \\ -88,75 \end{Bmatrix}$$

$$\begin{Bmatrix} u_2 \\ v_2 \\ \varphi_2 \end{Bmatrix} = \begin{bmatrix} 1,38453 \cdot 10^{-6} & -5,73774 \cdot 10^{-7} & -1,49755 \cdot 10^{-7} \\ -5,73774 \cdot 10^{-7} & 1,6532 \cdot 10^{-6} & 4,8117 \cdot 10^{-7} \\ -1,49755 \cdot 10^{-7} & 4,8117 \cdot 10^{-7} & 1,25774 \cdot 10^{-5} \end{bmatrix} \begin{Bmatrix} 60 \\ 70 \\ -88,75 \end{Bmatrix}$$

$$\begin{Bmatrix} u_2 \\ v_2 \\ \varphi_2 \end{Bmatrix} = \begin{Bmatrix} 9,236 \\ 7,261 \\ -107,167 \end{Bmatrix} \cdot 10^{-5}$$

6) $\{\hat{R}_{ab}\} \rightarrow \{R_{ab}\} \rightarrow \{R_{ab}^*\}$:
(20 min)

$$\{r_{12}\} = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 9,236 \cdot 10^{-5} \\ 7,261 \cdot 10^{-5} \\ -107,167 \cdot 10^{-5} \end{Bmatrix} \quad \{\hat{r}_{12}\} = [k_{12}] \cdot \{r_{12}\} = \begin{Bmatrix} 7,271 \\ -43,566 \\ -1,994 \\ -7,271 \\ 43,566 \\ -18,819 \end{Bmatrix}$$

$$\{R_{12}\} = \{\bar{R}_{12}\} + \{\hat{r}_{12}\} = \begin{Bmatrix} -59,729 \\ -43,566 \\ 21,006 \\ -69,271 \\ 43,566 \\ -48,819 \end{Bmatrix} \rightarrow \{R_{12}^*\} = \begin{Bmatrix} 43,566 \\ -59,729 \\ 21,006 \\ -43,566 \\ -69,271 \\ -48,819 \end{Bmatrix} \begin{matrix} x_1^* \\ z_1^* \\ \eta_1^* \\ x_2^* \\ z_2^* \\ \eta_2^* \end{matrix}$$

! vč. zvlášť nepr. prevnístev

$$\{r_{23}\} = \begin{Bmatrix} 9,236 \cdot 10^{-5} \\ 7,261 \cdot 10^{-5} \\ -107,167 \cdot 10^{-5} \\ 0 \\ 4 \cdot 10^{-3} \\ 8 \cdot 10^{-4} \end{Bmatrix} \quad \{\hat{r}_{23}\} = [k_{23}] \cdot \{r_{23}\} = \begin{Bmatrix} 69,270 \\ -39,188 \\ 48,819 \\ -69,270 \\ 39,188 \\ 107,934 \end{Bmatrix}$$

$$\{R_{23}\} = \{\bar{R}_{23}\} + \{\hat{r}_{23}\} \rightarrow \{R_{23}^*\} = \begin{Bmatrix} 69,270 \\ -39,188 \\ 48,819 \\ -69,270 \\ 39,188 \\ 107,934 \end{Bmatrix} \begin{matrix} x_2^* \\ z_2^* \\ \eta_2^* \\ x_3^* \\ z_3^* \\ \eta_3^* \end{matrix}$$

7) Vykrešlení :
(10 min)

