

$$A = \pi r^2 = \pi \cdot \left(\frac{0,03}{2}\right)^2 = 0,7069 \cdot 10^{-4} \text{ m}^2$$

$$m = A \cdot \rho = 7,069 \cdot 10^{-4} \cdot 7850 = 5,549 \text{ kg/m}$$

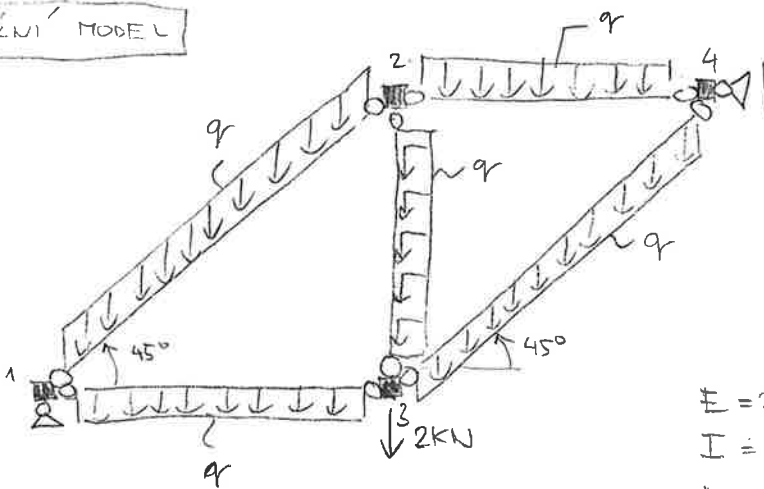
$$q = m \cdot g = 54,43 \text{ N/m}$$

$$I = \frac{\pi d^4}{64} = \frac{\pi (0,03)^4}{64} = 3,976 \cdot 10^{-8} \text{ m}^4$$

POTOČENÍ

$$\{ \varphi_{12}; \varphi_{21} \mid \varphi_{13}; \varphi_{31} \mid \varphi_{23}; \varphi_{32} \mid \varphi_{24}; \varphi_{42} \mid \varphi_{34}; \varphi_{43} \}$$

MINIMÁLNÍ MODEL



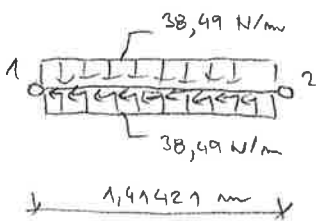
$$\{r\} = \begin{Bmatrix} w_2 \\ w_2 \\ w_3 \\ w_3 \\ w_{t1} \end{Bmatrix} = \begin{Bmatrix} 1,517 \cdot 10^{-5} \\ 5,807 \cdot 10^{-5} \\ -4,426 \cdot 10^{-7} \\ 7,261 \cdot 10^{-5} \\ 7,430 \cdot 10^{-5} \end{Bmatrix}$$

$$E = 210 \text{ GPa}$$

$$I = 3,976 \cdot 10^{-8} \text{ m}^4$$

$$A = 7,069 \cdot 10^{-4} \text{ m}^2$$

PRUT 12



$$[K_{12}^*] =$$

$$\begin{bmatrix} 1,050 \cdot 10^8 & 0 & 0 & -1,050 \cdot 10^8 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1,050 \cdot 10^8 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{Bmatrix} w_1^* \\ w_1^* \\ \varphi_1^* \\ w_2^* \\ w_2^* \\ \varphi_2^* \end{Bmatrix} = \begin{Bmatrix} 27 \\ -27 \\ 0 \\ 27 \\ -27 \\ 0 \end{Bmatrix}$$

SYMETRIE

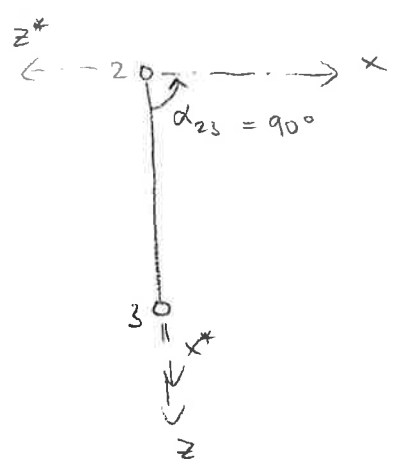
PRUT 13

METRICKÁ TRANSFORMOVAT

$$[K_{13}] = [K_{13}^*]$$

$$\{R_{13}\} = \{R_{13}^*\}$$

PRUT 23



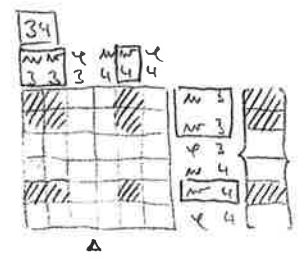
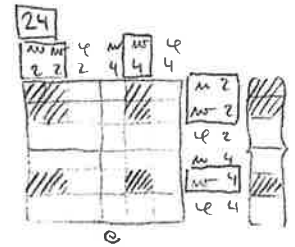
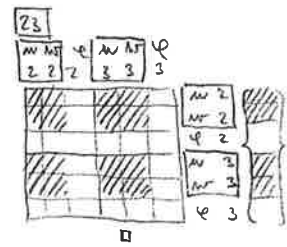
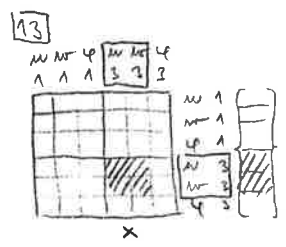
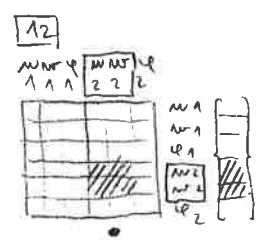
$$[K_{23}] =$$

0	0	0	0	0	0	w_2	0
1,484	0	0	0	-1,484	0		
108	0	0	0	-108	0	φ_2	0
0	0	0	0	0	0		
0	0	0	0	0	0	w_3	-27,215
0	0	0	0	0	0		

PRUT 24, PRUT 34

TOTOŽNÉ S PRUT 13, PRUT 12

SESTAVENÍ SOUSTAVY



	w_2	w_2	w_3	w_3	w_4		
w_2	0	0	0	0	0	w_2	0
w_2	0	0	0	0	0	w_2	0
w_3	0	0	0	0	0	w_3	0
w_3	0	0	0	0	0	w_3	0
w_4	0	0	0	0	0	w_4	0

[K]

	w_2	w_2	w_3	w_3	w_4
w_2	$5,248 \cdot 10^7$ 0 $1,485 \cdot 10^8$ $2,010 \cdot 10^8$	$-5,248 \cdot 10^7$ 0 $-5,248 \cdot 10^7$	0 0	0 0	0 0
w_2		$5,248 \cdot 10^7$ $1,484 \cdot 10^8$ $2,010 \cdot 10^8$	0 0	$-1,484 \cdot 10^8$ 0 $-1,484 \cdot 10^8$	0 0
w_3			0 $5,248 \cdot 10^7$ $2,010 \cdot 10^8$ $-5,248 \cdot 10^7$	0 $-5,248 \cdot 10^7$	$5,248 \cdot 10^7$ $5,248 \cdot 10^7$
w_3				$1,484 \cdot 10^8$ $5,248 \cdot 10^7$ $2,010 \cdot 10^8$ $-5,248 \cdot 10^7$	$-5,248 \cdot 10^7$ $-5,248 \cdot 10^7$
w_4					0 $5,248 \cdot 10^7$ $5,248 \cdot 10^7$

{R}

w_2	0 0 -38 -27	0 0 -27 -93 0
w_3	0 0 -27	0 0 -27
w_1	-27 -38	-93 -93
w_4	-38	-27 -66

{S}

0
0
0
2000
0

{F} = {S} - {R}

0
93
0
2093
66

$$\begin{bmatrix} 2,010 \cdot 10^8 & -5,248 \cdot 10^7 & 0 & 0 & 0 \\ 2,010 \cdot 10^8 & 0 & -1,484 \cdot 10^8 & 0 & 0 \\ 2,010 \cdot 10^8 & -5,248 \cdot 10^7 & 5,248 \cdot 10^7 & 0 & 0 \\ 2,010 \cdot 10^8 & -5,248 \cdot 10^7 & 0 & 0 & 0 \\ 0 & 0 & 0 & 5,248 \cdot 10^7 & 0 \end{bmatrix} \begin{Bmatrix} w_2 \\ w_2 \\ w_3 \\ w_3 \\ w_4 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 93 \\ 0 \\ 2093 \\ 66 \end{Bmatrix} ; \begin{Bmatrix} w_2 \\ w_2 \\ w_3 \\ w_3 \\ w_4 \end{Bmatrix} = \begin{Bmatrix} 1,517 \cdot 10^{-5} \\ 5,807 \cdot 10^{-5} \\ -4,426 \cdot 10^{-7} \\ 7,261 \cdot 10^{-5} \\ 7,430 \cdot 10^{-5} \end{Bmatrix}$$

PŘÍKŮ V A 3 DESÍTNÁ MÍST

$$\{r\} = \{1,506 \cdot 10^{-5}; 5,767 \cdot 10^{-5}; -4,444 \cdot 10^{-7}; 7,216 \cdot 10^{-5}; 7,386 \cdot 10^{-5}\} \text{ m}$$

ZPĚTNÁ TRANSFORMACE

$$\begin{Bmatrix} 0 \\ 0 \\ 0 \\ 1,517 \cdot 10^{-5} \\ 5,807 \cdot 10^{-5} \\ 0 \end{Bmatrix} \begin{Bmatrix} 0 \\ 0 \\ 0 \\ -4,426 \cdot 10^{-7} \\ 7,261 \cdot 10^{-7} \\ 0 \end{Bmatrix} \begin{Bmatrix} 1,517 \cdot 10^{-5} \\ 5,807 \cdot 10^{-5} \\ 0 \\ -4,426 \cdot 10^{-7} \\ 7,261 \cdot 10^{-7} \\ 0 \end{Bmatrix} \begin{Bmatrix} 1,517 \cdot 10^{-5} \\ 5,807 \cdot 10^{-5} \\ 0 \\ 0 \\ 7,430 \cdot 10^{-5} \\ 0 \end{Bmatrix} \begin{Bmatrix} -4,426 \cdot 10^{-7} \\ 7,261 \cdot 10^{-5} \\ 0 \\ 0 \\ 7,430 \cdot 10^{-5} \\ 0 \end{Bmatrix} ; [T_{12}] \{r_{12}\} = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ -3,033 \cdot 10^{-5} \\ 5,179 \cdot 10^{-5} \\ 0 \end{Bmatrix}$$

$$\{r_{13}^*\} = \{r_{13}\}; [T_{23}] \{r_{23}\} = \begin{Bmatrix} 5,807 \cdot 10^{-5} \\ -1,517 \cdot 10^{-5} \\ 0 \\ 7,261 \cdot 10^{-5} \\ 4,426 \cdot 10^{-7} \\ 0 \end{Bmatrix} = \{r_{23}^*\}; \{r_{24}^*\} = \{r_{24}\}; [T_{34}] \{r_{34}\} = \begin{Bmatrix} -5,166 \cdot 10^{-5} \\ 5,163 \cdot 10^{-5} \\ 0 \\ -5,254 \cdot 10^{-5} \\ 5,254 \cdot 10^{-5} \\ 0 \end{Bmatrix} (\{r_{34}^*\})$$

VÝPOČET SEKUNDAŘNÍCH KONCOVÝCH SIL

$$[K_{12}^*] \{v_{12}^*\} = \begin{Bmatrix} \hat{R}_{12}^* \\ 3185 \\ 0 \\ 0 \\ -3185 \\ 0 \\ 0 \end{Bmatrix}; [K_{13}^*] \{v_{13}^*\} = \begin{Bmatrix} \hat{R}_{13}^* \\ 66 \\ 0 \\ 0 \\ -66 \\ 0 \\ 0 \end{Bmatrix}; [K_{23}^*] \{v_{23}^*\} = \begin{Bmatrix} \hat{R}_{23}^* \\ -2159 \\ 0 \\ 0 \\ 2159 \\ 0 \\ 0 \end{Bmatrix}$$

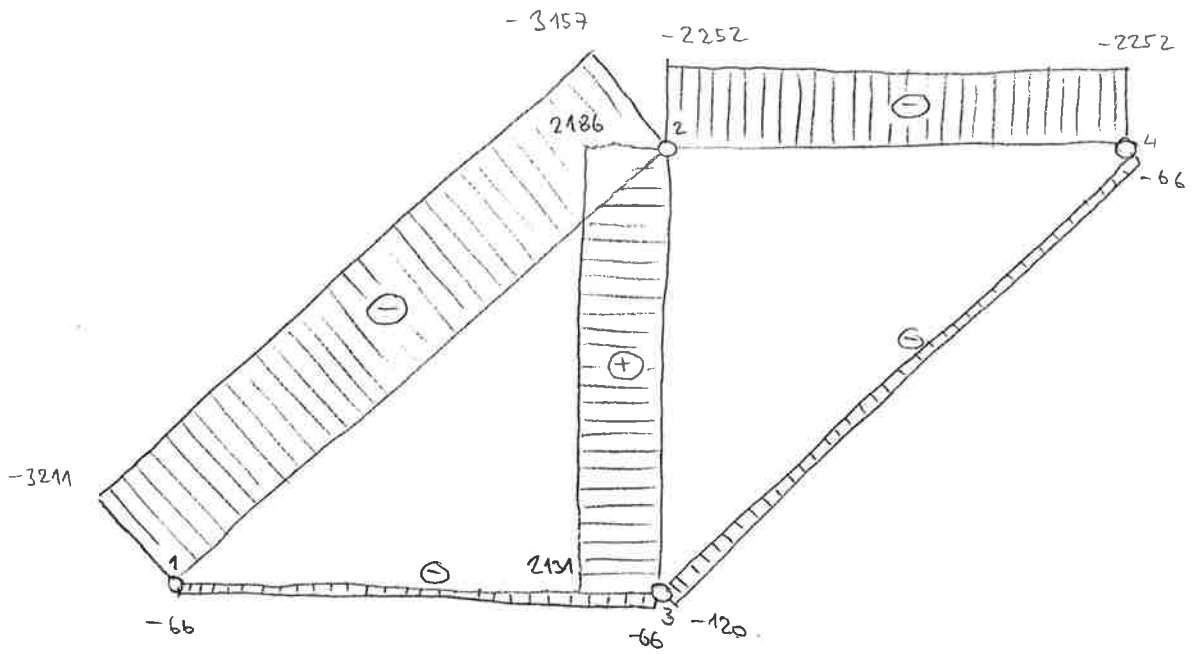
$$[K_{24}^*] \{v_{24}^*\} = \begin{Bmatrix} \hat{R}_{24}^* \\ +2253 \\ 0 \\ 0 \\ -2253 \\ 0 \\ 0 \end{Bmatrix}; [K_{34}^*] \{v_{34}^*\} = \begin{Bmatrix} 92 \\ 0 \\ 0 \\ -92 \\ 0 \\ 0 \end{Bmatrix}$$

VÝPOČET CELKOVÝCH KONCOVÝCH SIL

$$\{R_{ab}^*\} = \{\hat{R}_{ab}^*\} + \{\bar{R}_{ab}^*\}$$

$\{R_{12}^*\}$	$\{R_{13}^*\}$	$\{R_{23}^*\}$	$\{R_{24}^*\}$	$\{R_{34}^*\}$
$\begin{Bmatrix} 3211 \\ -27 \\ 0 \\ -3157 \\ -27 \\ 0 \end{Bmatrix}$	$\begin{Bmatrix} 66 \\ -27 \\ 0 \\ -66 \\ -27 \\ 0 \end{Bmatrix}$	$\begin{Bmatrix} -2186 \\ 0 \\ 0 \\ 2131 \\ 0 \\ 0 \end{Bmatrix}$	$\begin{Bmatrix} 2252 \\ -27 \\ 0 \\ -2252 \\ -27 \\ 0 \end{Bmatrix}$	$\begin{Bmatrix} 120 \\ -27 \\ 0 \\ -66 \\ -27 \\ 0 \end{Bmatrix}$

(N)



DOPLŇEK - PŮSOČEMÍ

$$\varphi_{12} = -5,799 \cdot 10^{-4} \text{ rad}$$

$$\varphi_{24} = -2,879 \cdot 10^{-4} \text{ rad}$$

$$\varphi_{21} = +5,016 \cdot 10^{-4} \text{ rad}$$

$$\varphi_{42} = +2,554 \cdot 10^{-4} \text{ rad}$$

$$\varphi_{13} = -3,442 \cdot 10^{-4} \text{ rad}$$

$$\varphi_{34} = -5,443 \cdot 10^{-4} \text{ rad}$$

$$\varphi_{31} = +1,990 \cdot 10^{-4} \text{ rad}$$

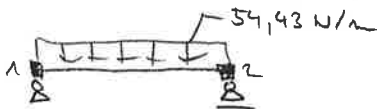
$$\varphi_{43} = +5,422 \cdot 10^{-4} \text{ rad}$$

$$\varphi_{23} = -1,561 \cdot 10^{-5} \text{ rad}$$

$$\varphi_{32} = -1,561 \cdot 10^{-5} \text{ rad}$$

(TKP
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V/SLEDEK)

$$\varphi_{22} = (\omega_3 - \omega_2) / l_{23} = (-4,426 \cdot 10^{-7} - 1,517 \cdot 10^{-5}) / 1 = -1,561 \cdot 10^{-5} \text{ RAD}$$



$$\tilde{\varphi}_{12} = -2,716 \cdot 10^{-4} \text{ rad}$$

$$\tilde{\varphi}_{21} = 2,716 \cdot 10^{-4} \text{ rad}$$

$$\begin{aligned} \text{MAPA: } \varphi_{31} &= -\omega_3 / l_{13} + \tilde{\varphi}_{21} = -7,261 \cdot 10^{-5} / 1 + 2,716 \cdot 10^{-4} \\ &= 1,990 \cdot 10^{-4} \text{ rad} \end{aligned}$$