

Wyznaczyć składowe macierzy sztywności elementów ramy płaskiej.  
 Podać postacie bloków A, B i C macierzy sztywności w lokalnym układzie współrzędnych z dokładnością do 5-ciu miejsc znaczących

Układ bloków macierzy sztywności elementu  $K = \begin{pmatrix} A & C \\ C^T & B \end{pmatrix}$

$$E := 19 \text{ GPa} \quad r := \frac{17}{2} \text{ cm}$$

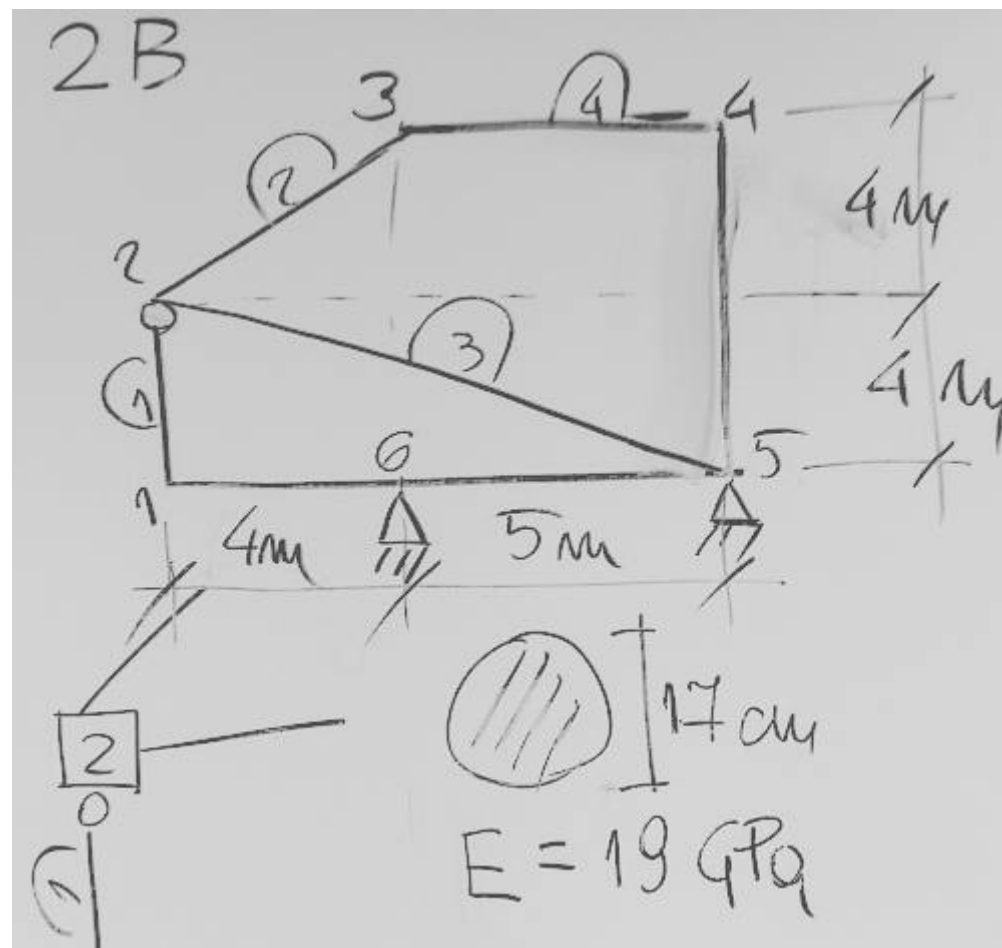
$$J := \frac{\pi \cdot r^4}{4} = 4099.828 \cdot \text{cm}^4 \quad A := \pi \cdot r^2 = 226.980 \cdot \text{cm}^2$$

$$EJ = 778.967 \cdot \text{kN} \cdot \text{m}^2 \quad EA = 431262.132 \cdot \text{kN}$$

Warunki brzegowe (podporowe)

$$u_{x5} = 0, u_{y5} = 0$$

$$u_{x6} = 0, u_{y6} = 0$$



Element "1" - bloki macierzy sztywności w lokalnym układzie współrzędnych

$$L_x := 0\text{m} \quad L_y := 4\text{m}$$

$$L := \sqrt{(L_x)^2 + (L_y)^2} = 4.000000\text{m}$$

$$A := \text{Blok\_A10}(EA, EJ, L, 1\text{m}) \quad A = \begin{pmatrix} 1.0782 \times 10^5 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 3.6514 \times 10^1 & 1.4606 \times 10^2 \\ 0.0000 \times 10^0 & 1.4606 \times 10^2 & 5.8423 \times 10^2 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$B := \text{Blok\_B10}(EA, EJ, L, 1\text{m}) \quad B = \begin{pmatrix} 1.0782 \times 10^5 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 3.6514 \times 10^1 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$C := \text{Blok\_C10}(EA, EJ, L, 1\text{m}) \quad C = \begin{pmatrix} -1.0782 \times 10^5 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & -3.6514 \times 10^1 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & -1.4606 \times 10^2 & 0.0000 \times 10^0 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

Element "2" - bloki macierzy sztywności w lokalnym układzie współrzędnych

$$\underline{L_x} := 4\text{m} \quad \underline{L_y} := 4\text{m} \quad \underline{L} := \sqrt{(\underline{L_x})^2 + (\underline{L_y})^2} = 5.656854\text{m}$$

$$A := \text{Blok\_A11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad A = \begin{pmatrix} 7.6237 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 5.1639 \times 10^1 & 1.4606 \times 10^2 \\ 0.0000 \times 10^0 & 1.4606 \times 10^2 & 5.5081 \times 10^2 \end{pmatrix} \cdot \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$B := \text{Blok\_B11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad B = \begin{pmatrix} 7.6237 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 5.1639 \times 10^1 & -1.4606 \times 10^2 \\ 0.0000 \times 10^0 & -1.4606 \times 10^2 & 5.5081 \times 10^2 \end{pmatrix} \cdot \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$C := \text{Blok\_C11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad C = \begin{pmatrix} -7.6237 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & -5.1639 \times 10^1 & 1.4606 \times 10^2 \\ 0.0000 \times 10^0 & -1.4606 \times 10^2 & 2.7541 \times 10^2 \end{pmatrix} \cdot \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

Element "3" - bloki macierzy sztywności w lokalnym układzie współrzędnych

$$\underline{L_x} := 9\text{m} \quad \underline{L_y} := -4\text{m} \quad \underline{L} := \sqrt{(\underline{L_x})^2 + (\underline{L_y})^2} = 9.848858\text{m}$$

$$A := \text{Blok\_A11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad A = \begin{pmatrix} 4.3788 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 9.7846 \times 10^0 & 4.8184 \times 10^1 \\ 0.0000 \times 10^0 & 4.8184 \times 10^1 & 3.1637 \times 10^2 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$B := \text{Blok\_B11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad B = \begin{pmatrix} 4.3788 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 9.7846 \times 10^0 & -4.8184 \times 10^1 \\ 0.0000 \times 10^0 & -4.8184 \times 10^1 & 3.1637 \times 10^2 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$C := \text{Blok\_C11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad C = \begin{pmatrix} -4.3788 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & -9.7846 \times 10^0 & 4.8184 \times 10^1 \\ 0.0000 \times 10^0 & 4.8184 \times 10^1 & 1.5818 \times 10^2 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

*Element "4" - bloki macierzy sztywności w lokalnym układzie współrzędnych*

$$\underline{L_x} := 5\text{m} \quad \underline{L_y} := 0\text{m} \quad \underline{L} := \sqrt{(\underline{L_x})^2 + (\underline{L_y})^2} = 5.000000\text{m}$$

$$A := \text{Blok\_A11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad A = \begin{pmatrix} 8.6252 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 7.4781 \times 10^1 & 1.8695 \times 10^2 \\ 0.0000 \times 10^0 & 1.8695 \times 10^2 & 6.2317 \times 10^2 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$B := \text{Blok\_B11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad B = \begin{pmatrix} 8.6252 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 7.4781 \times 10^1 & -1.8695 \times 10^2 \\ 0.0000 \times 10^0 & -1.8695 \times 10^2 & 6.2317 \times 10^2 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$C := \text{Blok\_C11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad C = \begin{pmatrix} -8.6252 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & -7.4781 \times 10^1 & 1.8695 \times 10^2 \\ 0.0000 \times 10^0 & -1.8695 \times 10^2 & 3.1159 \times 10^2 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$