

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 $K = \begin{pmatrix} A & C \\ C^T & B \end{pmatrix}$

$$E := 11 \text{ GPa} \quad b := 9 \text{ cm} \quad h := 13 \text{ cm}$$

$$J := \frac{b \cdot h^3}{12} = 1647.750 \cdot \text{cm}^4 \quad A := b \cdot h = 117.000 \cdot \text{cm}^2$$

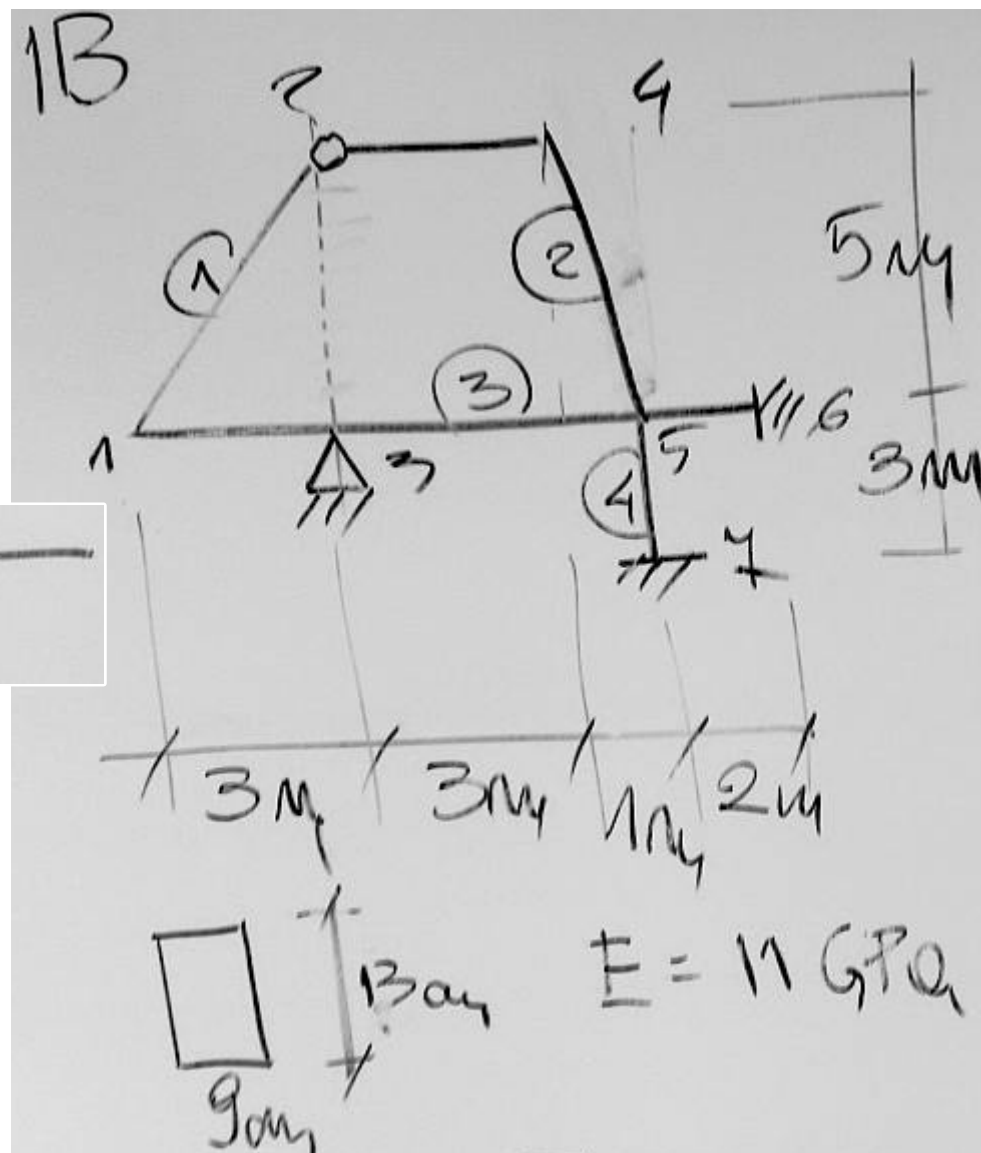
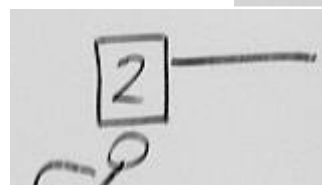
$$EJ = 181.253 \cdot \text{kN} \cdot \text{m}^2 \quad EA = 128700.000 \cdot \text{kN}$$

Warunki brzegowe (podporowe)

$$u_{x3} = 0, u_{y3} = 0$$

$$u_{x6} = 0, u_{y6} = 0, \varphi_6 = 0$$

$$u_{x7} = 0, u_{y7} = 0, \varphi_7 = 0$$



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

$$L_x := 3\text{m} \quad L_y := 5\text{m} \quad L := \sqrt{(L_x)^2 + (L_y)^2} = 5.830952\text{m}$$

$$A := \text{Blok_A10}(EA, EJ, L, 1\text{m}) \quad A = \begin{pmatrix} 2.2072 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 2.7428 \times 10^0 & 1.5993 \times 10^1 \\ 0.0000 \times 10^0 & 1.5993 \times 10^1 & 9.3254 \times 10^1 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$B := \text{Blok_B10}(EA, EJ, L, 1\text{m}) \quad B = \begin{pmatrix} 2.2072 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 2.7428 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$C := \text{Blok_C10}(EA, EJ, L, 1\text{m}) \quad C = \begin{pmatrix} -2.2072 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & -2.7428 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & -1.5993 \times 10^1 & 0.0000 \times 10^0 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

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

$$\underline{L_x} := 1\text{m} \quad \underline{L_y} := -5\text{m} \quad \underline{L} := \sqrt{(\underline{L_x})^2 + (\underline{L_y})^2} = 5.099020\text{m}$$

$$A := \text{Blok_A11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad A = \begin{pmatrix} 2.5240 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 1.6406 \times 10^1 & 4.1828 \times 10^1 \\ 0.0000 \times 10^0 & 4.1828 \times 10^1 & 1.4219 \times 10^2 \end{pmatrix} \cdot \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$B := \text{Blok_B11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad B = \begin{pmatrix} 2.5240 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 1.6406 \times 10^1 & -4.1828 \times 10^1 \\ 0.0000 \times 10^0 & -4.1828 \times 10^1 & 1.4219 \times 10^2 \end{pmatrix} \cdot \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$C := \text{Blok_C11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad C = \begin{pmatrix} -2.5240 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & -1.6406 \times 10^1 & 4.1828 \times 10^1 \\ 0.0000 \times 10^0 & -4.1828 \times 10^1 & 7.1093 \times 10^1 \end{pmatrix} \cdot \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

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

$$\underline{L_x} := 4\text{m} \quad \underline{L_y} := 0\text{m} \quad \underline{L} := \sqrt{(\underline{L_x})^2 + (\underline{L_y})^2} = 4.000000\text{m}$$

$$A := \text{Blok_A11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad A = \begin{pmatrix} 3.2175 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 3.3985 \times 10^1 & 6.7970 \times 10^1 \\ 0.0000 \times 10^0 & 6.7970 \times 10^1 & 1.8125 \times 10^2 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$B := \text{Blok_B11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad B = \begin{pmatrix} 3.2175 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 3.3985 \times 10^1 & -6.7970 \times 10^1 \\ 0.0000 \times 10^0 & -6.7970 \times 10^1 & 1.8125 \times 10^2 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$C := \text{Blok_C11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad C = \begin{pmatrix} -3.2175 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & -3.3985 \times 10^1 & 6.7970 \times 10^1 \\ 0.0000 \times 10^0 & -6.7970 \times 10^1 & 9.0626 \times 10^1 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

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

$$\underline{L_x} := 0 \quad \underline{L_y} := 3\text{m} \quad \underline{L} := \sqrt{(\underline{L_x})^2 + (\underline{L_y})^2} = 3.000000\text{m}$$

$$A := \text{Blok_A11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad A = \begin{pmatrix} 4.2900 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 8.0557 \times 10^1 & 1.2084 \times 10^2 \\ 0.0000 \times 10^0 & 1.2084 \times 10^2 & 2.4167 \times 10^2 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$B := \text{Blok_B11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad B = \begin{pmatrix} 4.2900 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & 8.0557 \times 10^1 & -1.2084 \times 10^2 \\ 0.0000 \times 10^0 & -1.2084 \times 10^2 & 2.4167 \times 10^2 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$

$$C := \text{Blok_C11}(\underline{EA}, \underline{EJ}, \underline{L}, 1\text{m}) \quad C = \begin{pmatrix} -4.2900 \times 10^4 & 0.0000 \times 10^0 & 0.0000 \times 10^0 \\ 0.0000 \times 10^0 & -8.0557 \times 10^1 & 1.2084 \times 10^2 \\ 0.0000 \times 10^0 & 1.2084 \times 10^2 & 1.2084 \times 10^2 \end{pmatrix} \rightarrow \begin{pmatrix} \frac{\text{kN}}{\text{m}} & 0 & 0 \\ 0 & \frac{\text{kN}}{\text{m}} & \text{kN} \\ 0 & \text{kN} & \text{kNm} \end{pmatrix}$$