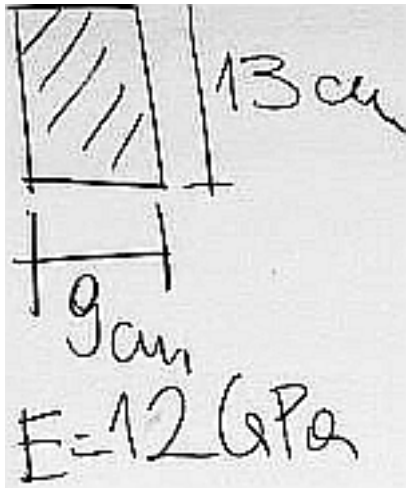
Wyznaczyć składowe macierzy sztywności elementów ramy płaskiej.
Podać postacie bloków A, B i C macierzy sztywności w lokalnym układzie współrzędnych z dokładnością do +/-0.5 [kN, kN/m, kNm]

Grupa B



$E := 12\ GPa$ $b := 9\ cm$ $h := 13\ cm$

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

$EJ = 197.730\ kN \cdot m^2$ $EA = 140400.000\ kN$

Układ bloków macierzy sztywności elementu

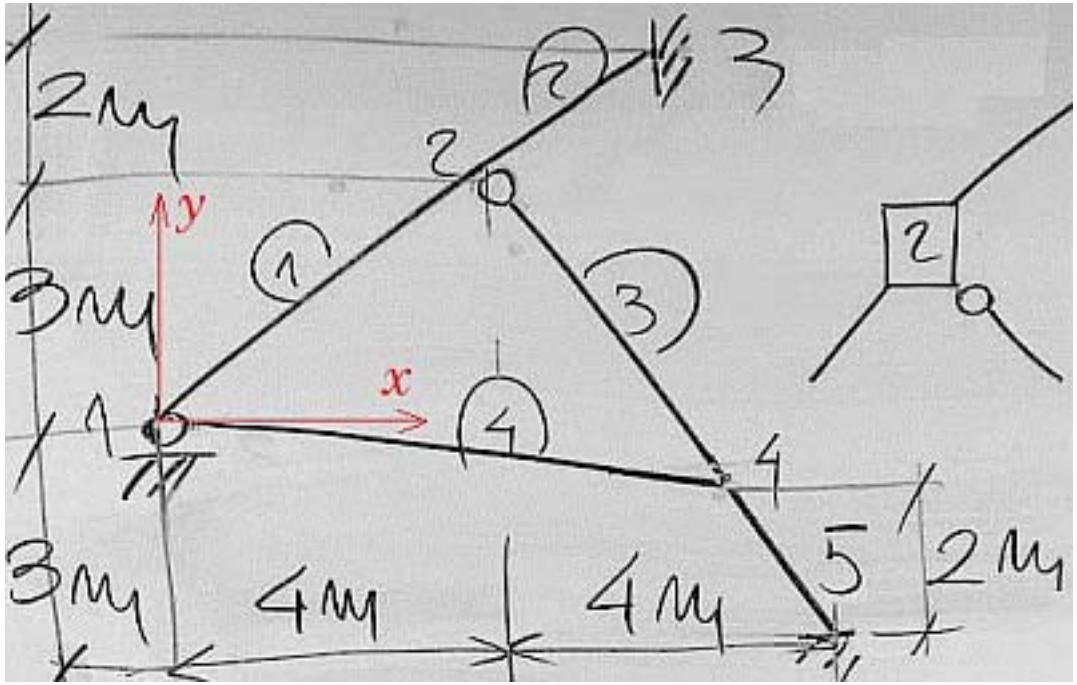
$$K = \begin{bmatrix} A & C \\ C^{\mathrm{T}} & B \end{bmatrix}$$

Warunki brzegowe (podporowe)

$u_{X1} = 0$ $u_{Y1} = 0$

$u_{X3} = 0$ $u_{Y3} = 0$ $\varphi_3 = 0$

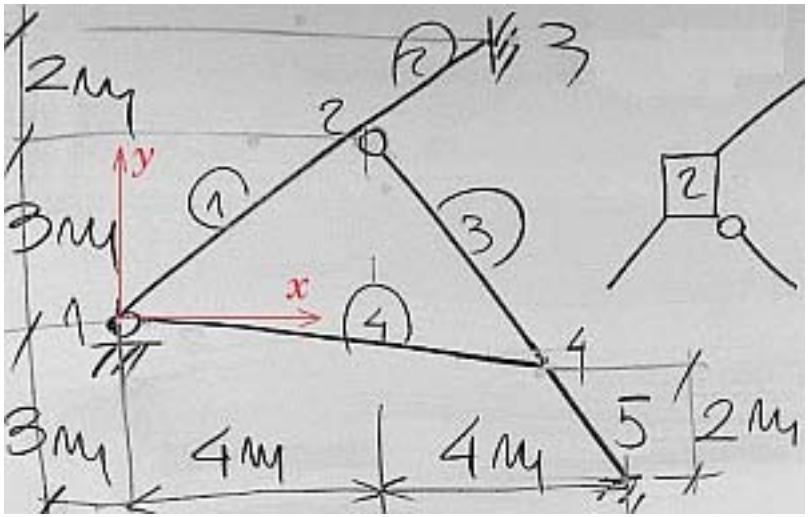
$u_{X5} = 0$ $u_{Y5} = 0$ $\varphi_5 = 0$



$X3 := 4\ m \cdot \frac{5}{3} = 6.6667\ m$

$X4 := 8\ m - 4\ m \cdot \frac{2}{6} = 6.6667\ m$

Element "1" - Bloki macierzy elementu bez przegubów



$Lx := 4\ m = 4\ m \qquad Ly := 3\ m = 3\ m \qquad L := \sqrt{(Lx)^2 + (Ly)^2} = 5.000000\ m$

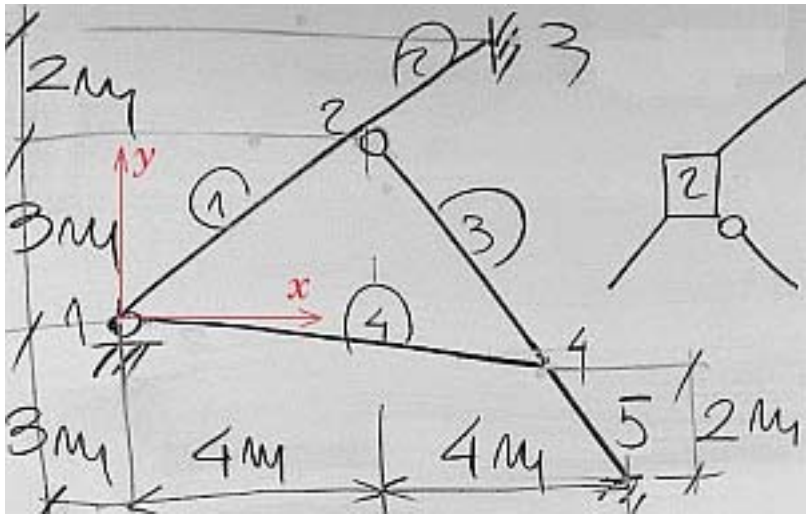
$$A := \begin{bmatrix} \frac{EA}{L} & 0 & 0 \\ 0 & \frac{12\ EJ}{L^3} & \frac{6\ EJ}{L^2} \\ 0 & \frac{6\ EJ}{L^2} & \frac{4\ EJ}{L} \end{bmatrix} \qquad A = \begin{bmatrix} 28080\ \frac{1}{m} & 0 & 0 \\ 0 & 19\ \frac{1}{m} & 47 \\ 0 & 47 & 158\ m \end{bmatrix} kN$$

$$B := \begin{bmatrix} \frac{EA}{L} & 0 & 0 \\ 0 & \frac{12\ EJ}{L^3} & \frac{-6\ EJ}{L^2} \\ 0 & \frac{-6\ EJ}{L^2} & \frac{4\ EJ}{L} \end{bmatrix} \qquad B = \begin{bmatrix} 28080\ \frac{1}{m} & 0 & 0 \\ 0 & 19\ \frac{1}{m} & -47 \\ 0 & -47 & 158\ m \end{bmatrix} kN$$

$$C := \begin{bmatrix} \frac{-EA}{L} & 0 & 0 \\ 0 & \frac{-12\ EJ}{L^3} & \frac{6\ EJ}{L^2} \\ 0 & \frac{-6\ EJ}{L^2} & \frac{2\ EJ}{L} \end{bmatrix} \qquad C = \begin{bmatrix} -28080\ \frac{1}{m} & 0 & 0 \\ 0 & -19\ \frac{1}{m} & 47 \\ 0 & -47 & 79\ m \end{bmatrix} kN$$

Element "2" - Bloki macierzy elementu bez przegubów

$Lx := X3 - 4\ m = 2.667\ m$ $\quad Ly := 2\ m = 2\ m$ $\quad L := \sqrt{(Lx)^2 + (Ly)^2} = 3.333333\ m$



$$A := \begin{bmatrix} \frac{EA}{L} & 0 & 0 \\ 0 & \frac{12\ EJ}{L^3} & \frac{6\ EJ}{L^2} \\ 0 & \frac{6\ EJ}{L^2} & \frac{4\ EJ}{L} \end{bmatrix} \qquad A = \begin{bmatrix} 42120\ \frac{1}{m} & 0 & 0 \\ 0 & 64\ \frac{1}{m} & 107 \\ 0 & 107 & 237\ m \end{bmatrix} kN$$

$$B := \begin{bmatrix} \frac{EA}{L} & 0 & 0 \\ 0 & \frac{12\ EJ}{L^3} & \frac{-6\ EJ}{L^2} \\ 0 & \frac{-6\ EJ}{L^2} & \frac{4\ EJ}{L} \end{bmatrix} \qquad B = \begin{bmatrix} 42120\ \frac{1}{m} & 0 & 0 \\ 0 & 64\ \frac{1}{m} & -107 \\ 0 & -107 & 237\ m \end{bmatrix} kN$$

$$C := \begin{bmatrix} \frac{-EA}{L} & 0 & 0 \\ 0 & \frac{-12\ EJ}{L^3} & \frac{6\ EJ}{L^2} \\ 0 & \frac{-6\ EJ}{L^2} & \frac{2\ EJ}{L} \end{bmatrix} \qquad C = \begin{bmatrix} -42120\ \frac{1}{m} & 0 & 0 \\ 0 & -64\ \frac{1}{m} & 107 \\ 0 & -107 & 119\ m \end{bmatrix} kN$$

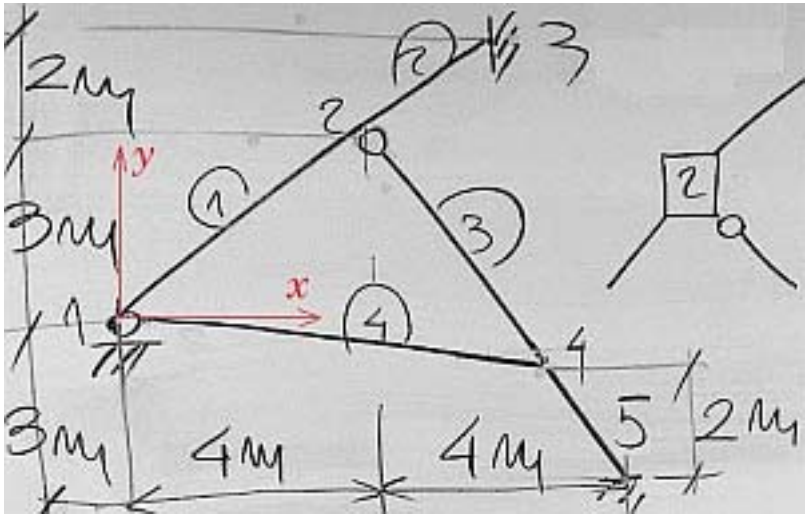
Element "3" - Bloki macierzy elementu z przegubem w węźle początkowym

$Lx := X4 - 4\ m = 2.667\ m \quad Ly := -4\ m = -4\ m \quad L := \sqrt{(Lx)^2 + (Ly)^2} = 4.807402\ m$

$$A := \begin{bmatrix} \frac{EA}{L} & 0 & 0 \\ 0 & \frac{3\ EJ}{L^3} & 0 \\ 0 & 0 & 0 \end{bmatrix} \qquad A = \begin{bmatrix} 29205 & 0 & 0 \\ 0 & 5 & 0 \\ 0 & 0 & 0 \end{bmatrix} \frac{kN}{m}$$

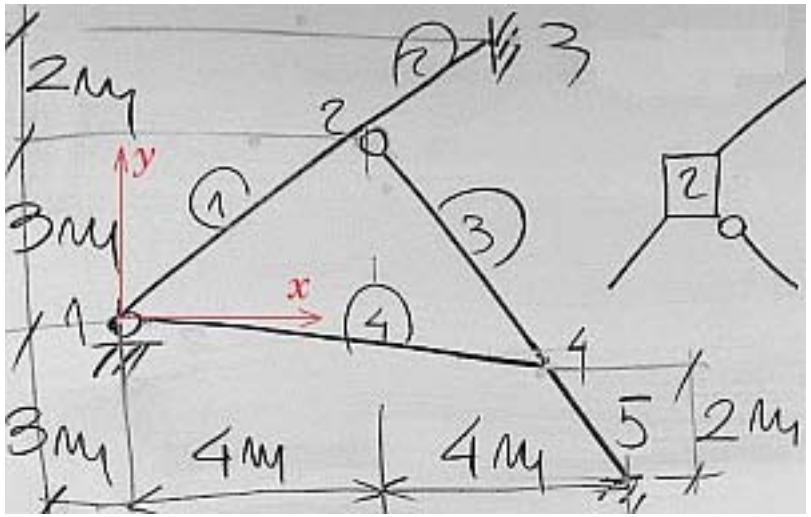
$$B := \begin{bmatrix} \frac{EA}{L} & 0 & 0 \\ 0 & \frac{3\ EJ}{L^3} & \frac{-3\ EJ}{L^2} \\ 0 & \frac{-3\ EJ}{L^2} & \frac{3\ EJ}{L} \end{bmatrix} \qquad B = \begin{bmatrix} 29205 \frac{1}{m} & 0 & 0 \\ 0 & 5 \frac{1}{m} & -26 \\ 0 & -26 & 123\ m \end{bmatrix} kN$$

$$C := \begin{bmatrix} \frac{-EA}{L} & 0 & 0 \\ 0 & \frac{-3\ EJ}{L^3} & \frac{3\ EJ}{L^2} \\ 0 & 0 & 0 \end{bmatrix} \qquad C = \begin{bmatrix} -29205 & 0 & 0 \\ 0 & -5\ 26\ m & \\ 0 & 0 & 0 \end{bmatrix} \frac{kN}{m}$$



Element "4" - Bloki macierzy elementu z przegubem w węźle początkowym

$Lx := X4 = 6.667\ m$ $\quad Ly := -1\ m = -1\ m$ $\quad L := \sqrt{(Lx)^2 + (Ly)^2} = 6.741249\ m$



$$A := \begin{bmatrix} \frac{EA}{L} & 0 & 0 \\ 0 & \frac{3\ EJ}{L^3} & 0 \\ 0 & 0 & 0 \end{bmatrix} \qquad A = \begin{bmatrix} 20827 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 0 \end{bmatrix} \frac{kN}{m}$$

$$B := \begin{bmatrix} \frac{EA}{L} & 0 & 0 \\ 0 & \frac{3\ EJ}{L^3} & \frac{-3\ EJ}{L^2} \\ 0 & \frac{-3\ EJ}{L^2} & \frac{3\ EJ}{L} \end{bmatrix} \qquad B = \begin{bmatrix} 20827 & 0 & 0 \\ 0 & 2 & -13\ m \\ 0 & -13\ m & 88\ m^2 \end{bmatrix} \frac{kN}{m}$$

$$C := \begin{bmatrix} \frac{-EA}{L} & 0 & 0 \\ 0 & \frac{-3\ EJ}{L^3} & \frac{3\ EJ}{L^2} \\ 0 & 0 & 0 \end{bmatrix} \qquad C = \begin{bmatrix} -20827 & 0 & 0 \\ 0 & -2 & 13\ m \\ 0 & 0 & 0 \end{bmatrix} \frac{kN}{m}$$