

Grupa B2

$$\underline{L} := 5\text{m} \quad P_0 := 11\text{kN} \quad b := 11\text{cm} \quad h := 15\text{cm} \quad \underline{g} := 3\text{cm}$$

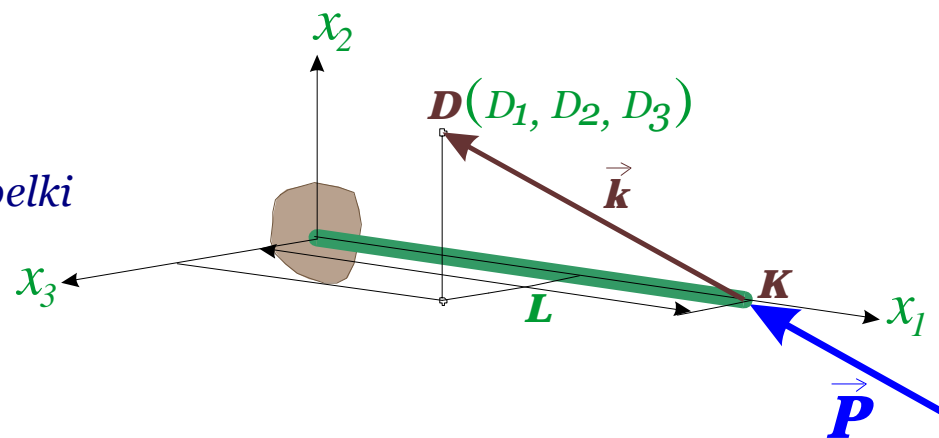
$$\underline{D} := \begin{pmatrix} 3 \\ -2 \\ 4 \end{pmatrix} \text{m} \quad - \text{współrzędne punktu przez który przechodzi kierunek siły}$$

$$\underline{K} := \begin{pmatrix} L \\ 0 \\ 0 \end{pmatrix} \quad - \text{współrzędne punktu K, obciążonego końca belki}$$

$$\underline{k} := \underline{D} - \underline{K} \quad - \text{wektor kierunkowy siły} \quad \underline{k} = \begin{pmatrix} -2 \\ -2 \\ 4 \end{pmatrix} \text{m}$$

$$L_k := \sqrt{(k_1)^2 + (k_2)^2 + (k_3)^2} = 4.89898 \text{ m} \quad - \text{moduł (długość) wektora kierunkowego}$$

$$\underline{c} := \frac{1}{L_k} \cdot \underline{k} = \begin{pmatrix} -0.408248 \\ -0.408248 \\ 0.816497 \end{pmatrix} \quad - \text{kosinusy kierunkowe wektora siły P}$$



$$P := P_0 \cdot c \quad - \text{składowe wektora siły} \quad P = \begin{pmatrix} -4.491 \\ -4.491 \\ 8.981 \end{pmatrix} \cdot \text{kN}$$

$$N := P_1 \quad T_2 := P_2 \quad T_3 := P_3$$

$$N = -4.49073 \cdot \text{kN} \quad T_2 = -4.49073 \cdot \text{kN} \quad T_3 = 8.98146 \cdot \text{kN}$$

$$M_2 := -T_3 \cdot L \quad M_3 := T_2 \cdot L$$

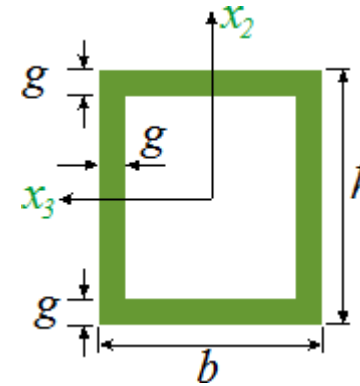
$$M_2 = -44.90731 \cdot \text{kN} \cdot \text{m} \quad M_3 = -22.45366 \cdot \text{kN} \cdot \text{m}$$

$$h_1 := h - 2g \quad b_1 := b - 2g$$

$$A := h \cdot b - h_1 \cdot b_1 = 120 \cdot \text{cm}^2$$

$$J_3 := \frac{b \cdot h^3}{12} - \frac{b_1 \cdot h_1^3}{12} = 2.79 \times 10^3 \cdot \text{cm}^4$$

$$J_2 := \frac{h \cdot b^3}{12} - \frac{h_1 \cdot b_1^3}{12} = 1.57 \times 10^3 \cdot \text{cm}^4$$



Naprężenia w punkcie A

$$y := x2_{id} \quad z := x3_{id} \quad a2 := b2_{id} \quad a3 := b3_{id}$$

$$S3 := St3_{id} \quad S2 := St2_{id}$$

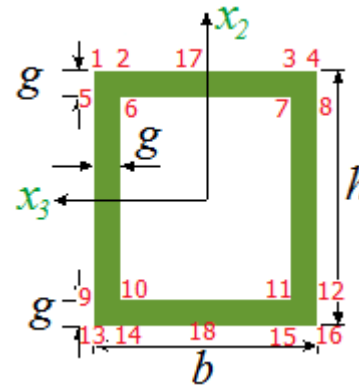
$$\sigma_{11} := \frac{N}{A} - \frac{M3 \cdot y}{J3} + \frac{M2 \cdot z}{J2} = -97.334 \cdot \text{MPa}$$

$$\tau_{12} := \frac{T2 \cdot S3}{a3 \cdot J3} = 0.000 \cdot \text{MPa}$$

$$\tau_{13} := \frac{T3 \cdot S2}{a2 \cdot J2} = 0.000 \cdot \text{MPa}$$

$$\sigma_{\text{HMH}} := \sqrt{\sigma_{11}^2 + 3 \cdot (\tau_{12}^2 + \tau_{13}^2)} = 97.334 \cdot \text{MPa}$$

id := 1



$$y = 7.5 \cdot \text{cm}$$

$$z = 5.5 \cdot \text{cm}$$

$$a2 = 15 \cdot \text{cm}$$

$$a3 = 11 \cdot \text{cm}$$

$$S2 = 0 \cdot \text{cm}^3$$

$$S3 = 0 \cdot \text{cm}^3$$

Naprężenia w punkcie B

$$\underline{y} := x2_{id} \quad \underline{z} := x3_{id} \quad \underline{a2} := b2_{id} \quad \underline{a3} := b3_{id}$$

$$\underline{S3} := St3_{id} \quad \underline{S2} := St2_{id}$$

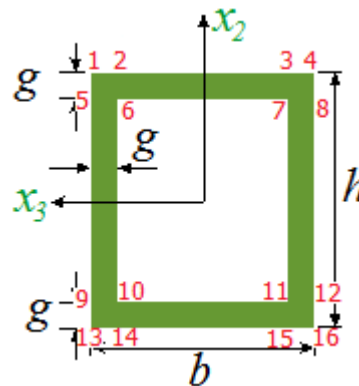
$$\underline{\sigma_{11}} := \frac{N}{A} - \frac{M3 \cdot y}{J3} + \frac{M2 \cdot z}{J2} = 107.35 \cdot \text{MPa}$$

$$\underline{\tau_{12}} := \frac{T2 \cdot S3}{a3 \cdot J3} = -0.531 \cdot \text{MPa}$$

$$\underline{\tau_{13}} := \frac{T3 \cdot S2}{a2 \cdot J2} = 1.716 \cdot \text{MPa}$$

$$\underline{\sigma_{HMH}} := \sqrt{\sigma_{11}^2 + 3 \cdot (\tau_{12}^2 + \tau_{13}^2)} = 107.395 \cdot \text{MPa}$$

$$\underline{id} := 7$$



$$y = 4.5 \cdot \text{cm}$$

$$z = -2.5 \cdot \text{cm}$$

$$a2 = 6 \cdot \text{cm}$$

$$a3 = 6 \cdot \text{cm}$$

$$S2 = 180 \cdot \text{cm}^3$$

$$S3 = 198 \cdot \text{cm}^3$$

Naprężenia w punkcie C

$$\underline{y} := x2_{id} \quad \underline{z} := x3_{id} \quad \underline{a2} := b2_{id} \quad \underline{a3} := b3_{id}$$

$$\underline{S3} := St3_{id} \quad \underline{S2} := St2_{id}$$

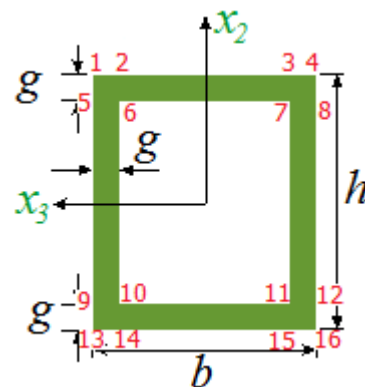
$$\underline{\sigma_{11}} := \frac{N}{A} - \frac{M3 \cdot y}{J3} + \frac{M2 \cdot z}{J2} = 96.585 \cdot \text{MPa}$$

$$\underline{\tau_{12}} := \frac{T2 \cdot S3}{a3 \cdot J3} = 0.000 \cdot \text{MPa}$$

$$\underline{\tau_{13}} := \frac{T3 \cdot S2}{a2 \cdot J2} = 0.000 \cdot \text{MPa}$$

$$\underline{\sigma_{HHH}} := \sqrt{\sigma_{11}^2 + 3 \cdot (\tau_{12}^2 + \tau_{13}^2)} = 96.585 \cdot \text{MPa}$$

$$\underline{id} := 16$$



$$y = -7.5 \cdot \text{cm}$$

$$z = -5.5 \cdot \text{cm}$$

$$a2 = 15 \cdot \text{cm}$$

$$a3 = 11 \cdot \text{cm}$$

$$S2 = 0 \cdot \text{cm}^3$$

$$S3 = 0 \cdot \text{cm}^3$$