

Grupa A

Zad 1

$$\underline{L} := 7\text{m} \quad P_0 := 5\text{kN} \quad b := 15\text{cm} \quad h := 17\text{cm} \quad \underline{g} := 2\text{cm}$$

$$\underline{D} := \begin{pmatrix} -2 \\ 3 \\ -1 \end{pmatrix} \text{m} \quad - \text{współrzędne punktu przez który przechodzi kierunek siły}$$

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

$$\underline{k} := \underline{D} - \underline{K} \quad - \text{wektor kierunkowy siły}$$

$$\underline{k} = \begin{pmatrix} -9 \\ 3 \\ -1 \end{pmatrix} \text{m}$$

$$L_k := \sqrt{(k_1)^2 + (k_2)^2 + (k_3)^2} = 9.53939 \text{m} \quad - \text{moduł (długość) wektora kierunkowego}$$

$$\underline{c} := \frac{1}{L_k} \cdot \underline{k} = \begin{pmatrix} -0.943456 \\ 0.314485 \\ -0.104828 \end{pmatrix} \quad - \text{kosinusy kierunkowe wektora siły P}$$



$$P := P_0 \cdot c \quad - \text{składowe wektora siły} \quad P = \begin{pmatrix} -4.717 \\ 1.572 \\ -0.524 \end{pmatrix} \cdot \text{kN}$$

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

$$N = -4.71728 \cdot \text{kN} \quad T_2 = 1.57243 \cdot \text{kN} \quad T_3 = -0.52414 \cdot \text{kN}$$

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

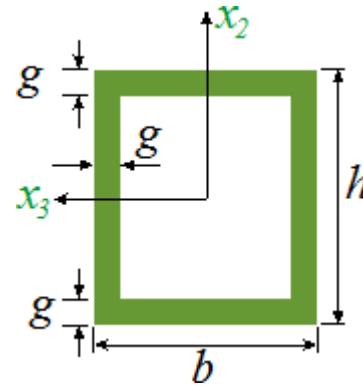
$$M_2 = 3.66900 \cdot \text{kN} \cdot \text{m} \quad M_3 = 11.00699 \cdot \text{kN} \cdot \text{m}$$

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

$$A := h \cdot b - h_1 \cdot b_1 = 112 \cdot \text{cm}^2$$

$$J_3 := \frac{b \cdot h^3}{12} - \frac{b_1 \cdot h_1^3}{12} = 4.12733 \times 10^3 \cdot \text{cm}^4$$

$$J_2 := \frac{h \cdot b^3}{12} - \frac{h_1 \cdot b_1^3}{12} = 3.33933 \times 10^3 \cdot \text{cm}^4$$



Naprężenia w punkcie A

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

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

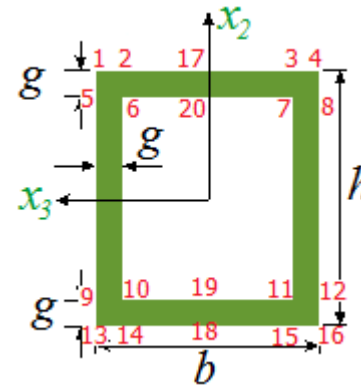
$$\sigma_{11} := \frac{N}{A} - \frac{M3 \cdot y}{J3} + \frac{M2 \cdot z}{J2} = -14.849 \cdot \text{MPa}$$

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

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

$$\sigma_{\text{HMH}} := \sqrt{\sigma_{11}^2 + 3 \cdot (\tau_{12}^2 + \tau_{13}^2)} = 14.849 \cdot \text{MPa}$$

id := 1



$$y = 8.5 \cdot \text{cm}$$

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

$$a2 = 17 \cdot \text{cm}$$

$$a3 = 15 \cdot \text{cm}$$

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

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

Naprężenia w punkcie B

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

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

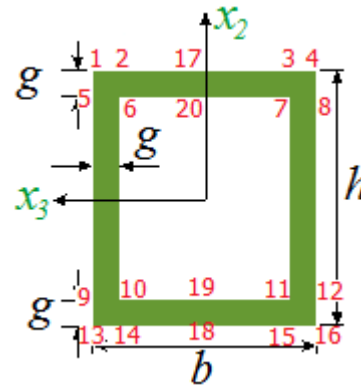
$$\underline{\sigma_{11}} := \frac{N}{A} - \frac{M3 \cdot y}{J3} + \frac{M2 \cdot z}{J2} = 22.956 \cdot \text{MPa}$$

$$\underline{\tau_{12}} := \frac{T2 \cdot S3}{a3 \cdot J3} = 0.214 \cdot \text{MPa}$$

$$\underline{\tau_{13}} := \frac{T3 \cdot S2}{a2 \cdot J2} = -0.087 \cdot \text{MPa}$$

$$\underline{\sigma_{HMH}} := \sqrt{\sigma_{11}^2 + 3 \cdot (\tau_{12}^2 + \tau_{13}^2)} = 22.960 \cdot \text{MPa}$$

$$\underline{id} := 10$$



$$y = -6.5 \cdot \text{cm}$$

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

$$a2 = 4 \cdot \text{cm}$$

$$a3 = 4 \cdot \text{cm}$$

$$S2 = 221 \cdot \text{cm}^3$$

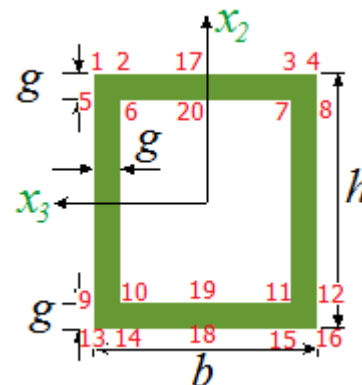
$$S3 = 225 \cdot \text{cm}^3$$

Naprężenia w punkcie C

$$\text{id} := 12$$

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

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



$$y = -6.5 \cdot \text{cm}$$

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

$$a2 = 17 \cdot \text{cm}$$

$$a3 = 4 \cdot \text{cm}$$

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

$$S3 = 225 \cdot \text{cm}^3$$

$$\sigma_{11} := \frac{N}{A} - \frac{M3 \cdot y}{J3} + \frac{M2 \cdot z}{J2} = 8.673 \cdot \text{MPa}$$

$$\tau_{12} := \frac{T2 \cdot S3}{a3 \cdot J3} = 0.214 \cdot \text{MPa}$$

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

$$\sigma_{\text{HMH}} := \sqrt{\sigma_{11}^2 + 3 \cdot (\tau_{12}^2 + \tau_{13}^2)} = 8.681 \cdot \text{MPa}$$