

## Grupa A1

### Zad 1

$$\underline{L} := 7\text{m} \quad P_0 := 11\text{kN} \quad b := 13\text{cm} \quad h := 17\text{cm} \quad \underline{g} := 3\text{cm} \quad h_1 := h - 2g \quad b_1 := b - g$$

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

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

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

$$\underline{k} = \begin{pmatrix} -4 \\ 2 \\ -3 \end{pmatrix} \text{m}$$

$$L_k := \sqrt{(k_1)^2 + (k_2)^2 + (k_3)^2} = 5.38516 \text{m} \quad - \text{moduł (długość) wektora kierunkowego}$$

$$\underline{c} := \frac{1}{L_k} \cdot \underline{k} = \begin{pmatrix} -0.742781 \\ 0.371391 \\ -0.557086 \end{pmatrix} \quad - \text{kosinusy kierunkowe wektora siły P}$$



$$P := P_0 \cdot c \quad - \text{składowe wektora siły} \quad P = \begin{pmatrix} -8.171 \\ 4.085 \\ -6.128 \end{pmatrix} \cdot \text{kN}$$

$$\underline{N} := P_1 \quad T_2 := P_2 \quad T_3 := P_3$$

$$N = -8.17059 \cdot \text{kN} \quad T_2 = 4.0853 \cdot \text{kN} \quad T_3 = -6.12795 \cdot \text{kN}$$

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

$$M_2 = 42.89562 \cdot \text{kN} \cdot \text{m} \quad M_3 = 28.59708 \cdot \text{kN} \cdot \text{m}$$

$$\underline{A} := h \cdot b - h_1 \cdot b_1 = 111 \cdot \text{cm}^2$$

$$J_3 := \frac{b \cdot h^3}{12} - \frac{b_1 \cdot h_1^3}{12} = 4213.25 \cdot \text{cm}^4$$

$$J_2 := \frac{b^3 \cdot g}{6} + \frac{h_1 \cdot g^3}{12} = 1123.25 \cdot \text{cm}^4$$



## Naprężenia w punkcie A

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

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

$$S3 = 273 \cdot \text{cm}^3 \quad S2 = 0 \cdot \text{cm}^3$$

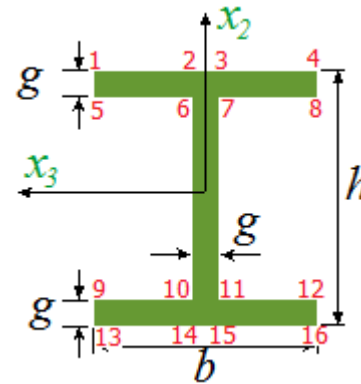
$$\sigma_{11} := \frac{N}{A} - \frac{M3 \cdot y}{J3} + \frac{M2 \cdot z}{J2} = 210.161 \cdot \text{MPa}$$

$$\tau_{12} := \frac{T2 \cdot S3}{a3 \cdot J3} = 0.204 \cdot \text{MPa}$$

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

$$\sigma_{\text{HMH}} := \sqrt{\sigma_{11}^2 + 3 \cdot (\tau_{12}^2 + \tau_{13}^2)} = 210.16 \cdot \text{MPa}$$

id := 5



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

$$z = 6.5 \cdot \text{cm}$$

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

$$a3 = 13 \cdot \text{cm}$$

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

$$S3 = 273 \cdot \text{cm}^3$$

## Naprężenia w punkcie B

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

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

$$S3 = 0 \cdot \text{cm}^3 \quad S2 = 0 \cdot \text{cm}^3$$

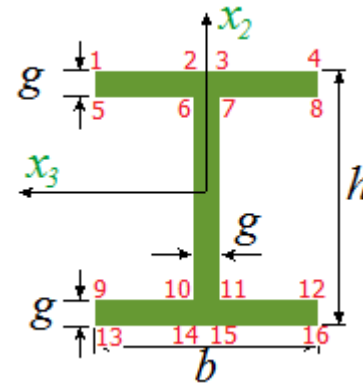
$$\underline{\sigma_{11}} := \frac{N}{A} - \frac{M3 \cdot y}{J3} + \frac{M2 \cdot z}{J2} = -191.271 \cdot \text{MPa}$$

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

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

$$\underline{\sigma_{HMH}} := \sqrt{\sigma_{11}^2 + 3 \cdot (\tau_{12}^2 + \tau_{13}^2)} = 191.27 \cdot \text{MPa}$$

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



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

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

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

$$a3 = 13 \cdot \text{cm}$$

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

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

## Naprężenia w punkcie C

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

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

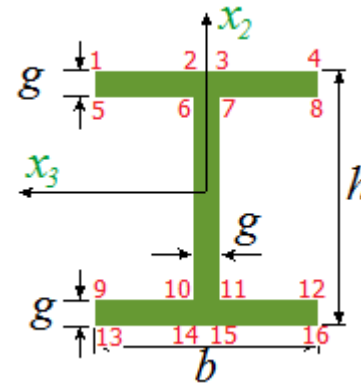
$$\underline{\sigma_{11}} := \frac{N}{A} - \frac{M3 \cdot y}{J3} + \frac{M2 \cdot z}{J2} = 93.878 \cdot \text{MPa}$$

$$\underline{\tau_{12}} := \frac{T2 \cdot S3}{a3 \cdot J3} = 0.882 \cdot \text{MPa}$$

$$\underline{\tau_{13}} := \frac{T3 \cdot S2}{a2 \cdot J2} = -1.091 \cdot \text{MPa}$$

$$\underline{\sigma_{HHH}} := \sqrt{\sigma_{11}^2 + 3 \cdot (\tau_{12}^2 + \tau_{13}^2)} = 93.91 \cdot \text{MPa}$$

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



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

$$z = 1.5 \cdot \text{cm}$$

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

$$a3 = 3 \cdot \text{cm}$$

$$S2 = 120 \cdot \text{cm}^3$$

$$S3 = 273 \cdot \text{cm}^3$$