

Grupa A2

Zad 1

$$\underline{L} := 5\text{m} \quad P_0 := 15\text{kN} \quad b := 13\text{cm} \quad h := 17\text{cm} \quad \underline{g} := 3\text{cm} \quad h_1 := h - 2g \quad b_1 := b - g$$

$$\underline{D} := \begin{pmatrix} 6 \\ -2 \\ -3 \end{pmatrix} \text{m} \quad - \text{współrzędne punktu przez który przechodzi kierunek siły}$$

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

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

$$\underline{k} = \begin{pmatrix} 1 \\ -2 \\ -3 \end{pmatrix} \text{m}$$

$$L_k := \sqrt{(k_1)^2 + (k_2)^2 + (k_3)^2} = 3.74166 \text{ m} \quad - \text{moduł (długość) wektora kierunkowego}$$

$$\underline{c} := \frac{1}{L_k} \cdot \underline{k} = \begin{pmatrix} 0.267261 \\ -0.534522 \\ -0.801784 \end{pmatrix} \quad - \text{kosinusy kierunkowe wektora siły } P$$



$$P := P_0 \cdot c \quad - \text{składowe wektora siły} \quad P = \begin{pmatrix} 4.009 \\ -8.018 \\ -12.027 \end{pmatrix} \cdot \text{kN}$$

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

$$N = 4.00892 \cdot \text{kN} \quad T_2 = -8.01784 \cdot \text{kN} \quad T_3 = -12.02676 \cdot \text{kN}$$

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

$$M_2 = 60.13378 \cdot \text{kN} \cdot \text{m} \quad M_3 = -40.08919 \cdot \text{kN} \cdot \text{m}$$

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

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

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



Naprężenia w punkcie A

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

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

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

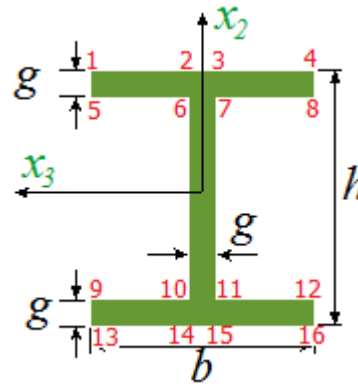
$$\sigma_{11} := \frac{N}{A} - \frac{M3 \cdot y}{J3} + \frac{M2 \cdot z}{J2} = 400.675 \cdot \text{MPa}$$

$$\tau_{12} := \frac{T2 \cdot S3}{a3 \cdot J3} = -0.400 \cdot \text{MPa}$$

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

$$\sigma_{\text{HMH}} := \sqrt{\sigma_{11}^2 + 3 \cdot (\tau_{12}^2 + \tau_{13}^2)} = 400.68 \cdot \text{MPa}$$

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

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

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

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

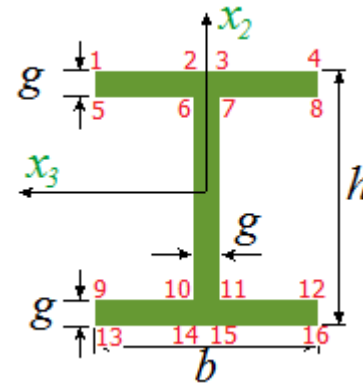
$$\underline{\sigma_{11}} := \frac{N}{A} - \frac{M3 \cdot y}{J3} + \frac{M2 \cdot z}{J2} = -428.497 \cdot \text{MPa}$$

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

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

$$\underline{\sigma_{HHH}} := \sqrt{\sigma_{11}^2 + 3 \cdot (\tau_{12}^2 + \tau_{13}^2)} = 428.50 \cdot \text{MPa}$$

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



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

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

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

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

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

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

Naprężenia w punkcie C

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

S3 := St3_{id} S2 := St2_{id}

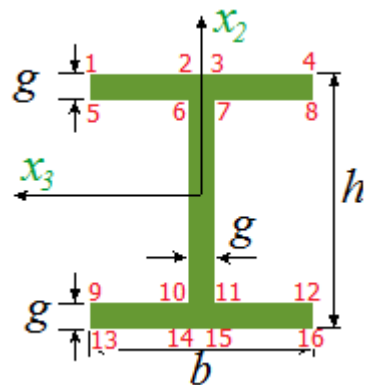
$$\underline{\sigma_{11}} := \frac{N}{A} - \frac{M_3 \cdot y}{J_3} + \frac{M_2 \cdot z}{J_2} = 28.332 \cdot \text{MPa}$$

$$\tau_{12} := \frac{T_2 \cdot S_3}{a_3 \cdot J_3} = -1.732 \cdot \text{MPa}$$

$$\tau_{13} := \frac{T_3 \cdot S_2}{a_2 \cdot J_2} = -2.141 \cdot \text{MPa}$$

$$\sigma_{\text{HMH}} := \sqrt{\sigma_{11}^2 + 3 \cdot (\tau_{12}^2 + \tau_{13}^2)} = 28.73 \cdot \text{MPa}$$

```
id := 10
```



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

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

$$a_2 = 6 \cdot \text{cm}$$

$$a_3 = 3 \cdot \text{cm}$$

$$S_2 = 120 \cdot \text{cm}^3$$

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