

$$y_1 := -15 \text{ mm}$$

$$A_1 := 17 \text{ cm}^2 = (1.7 \cdot 10^3) \text{ mm}^2$$

$$x_1 := 16 \text{ mm}$$

$$y_2 := 14.5 \text{ mm}$$

$$A_2 := 11 \text{ cm}^2 = (1.1 \cdot 10^3) \text{ mm}^2$$

$$x_2 := -40 \text{ mm}$$

$$y_3 := -27.5 \text{ mm}$$

$$A_3 := 10.3 \text{ cm}^2 = (1.03 \cdot 10^3) \text{ mm}^2$$

$$x_3 := -50 \text{ mm}$$

$$y_c := \frac{y_1 \cdot A_1 + y_2 \cdot A_2 + y_3 \cdot A_3}{A_1 + A_2 + A_3} = -9.89 \text{ mm}$$

$$x_c := \frac{x_1 \cdot A_1 + x_2 \cdot A_2 + x_3 \cdot A_3}{A_1 + A_2 + A_3} = -17.83 \text{ mm}$$

$$J_{x1} := 364 \text{ cm}^4$$

$$J_{x2} := 106 \text{ cm}^4$$

$$J_{x3} := 171 \text{ cm}^4$$

$$J_{y1} := 43.2 \text{ cm}^4$$

$$J_{y2} := 19.4 \text{ cm}^4$$

$$J_{y3} := 12.2 \text{ cm}^4$$

$$J_{xc} := J_{x1} + A_1 \cdot (y_1 - y_c)^2 + J_{x2} + A_2 \cdot (y_2 - y_c)^2 + J_{x3} + A_3 \cdot (y_3 - y_c)^2 = 742.817 \text{ cm}^4$$

$$J_{yc} := J_{y1} + A_1 \cdot (x_1 - x_c)^2 + J_{y2} + A_2 \cdot (x_2 - x_c)^2 + J_{y3} + A_3 \cdot (x_3 - x_c)^2 = 430.021 \text{ cm}^4$$

$$P := 100 \text{ kN}$$

$$e_x := 85.33 \text{ mm} = 0.085 \text{ m}$$

$$e_y := 54.89 \text{ mm} = 0.055 \text{ m}$$

$$M_y := P \cdot e_x = 8.53 \text{ kN} \cdot \text{m}$$

$$M_x := P \cdot e_y = 5.49 \text{ kN} \cdot \text{m}$$

$$\sigma_x = \frac{P}{A} + \frac{M_y}{J_{yc}} \cdot x + \frac{M_x}{J_{xc}} \cdot y = 0$$

- równanie osi obojętnej

$$A := A_1 + A_2 + A_3 = 38.3 \text{ cm}^2$$

$$\frac{P}{A} = 26.11 \text{ MPa}$$

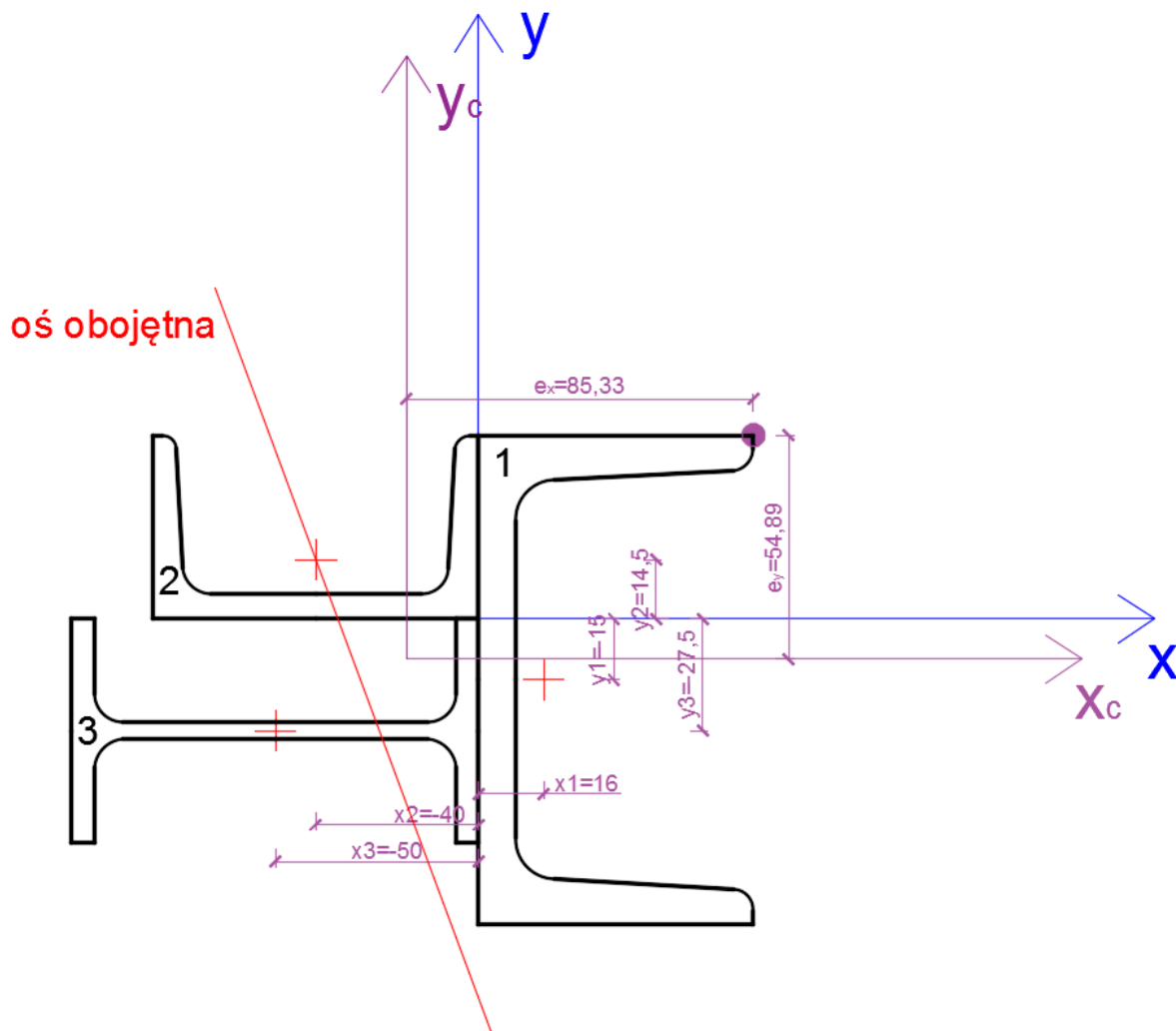
$$\frac{M_y}{J_{yc}} = 1.984 \frac{\text{MPa}}{\text{mm}}$$

$$\frac{M_x}{J_{xc}} = 0.739 \frac{\text{MPa}}{\text{mm}}$$

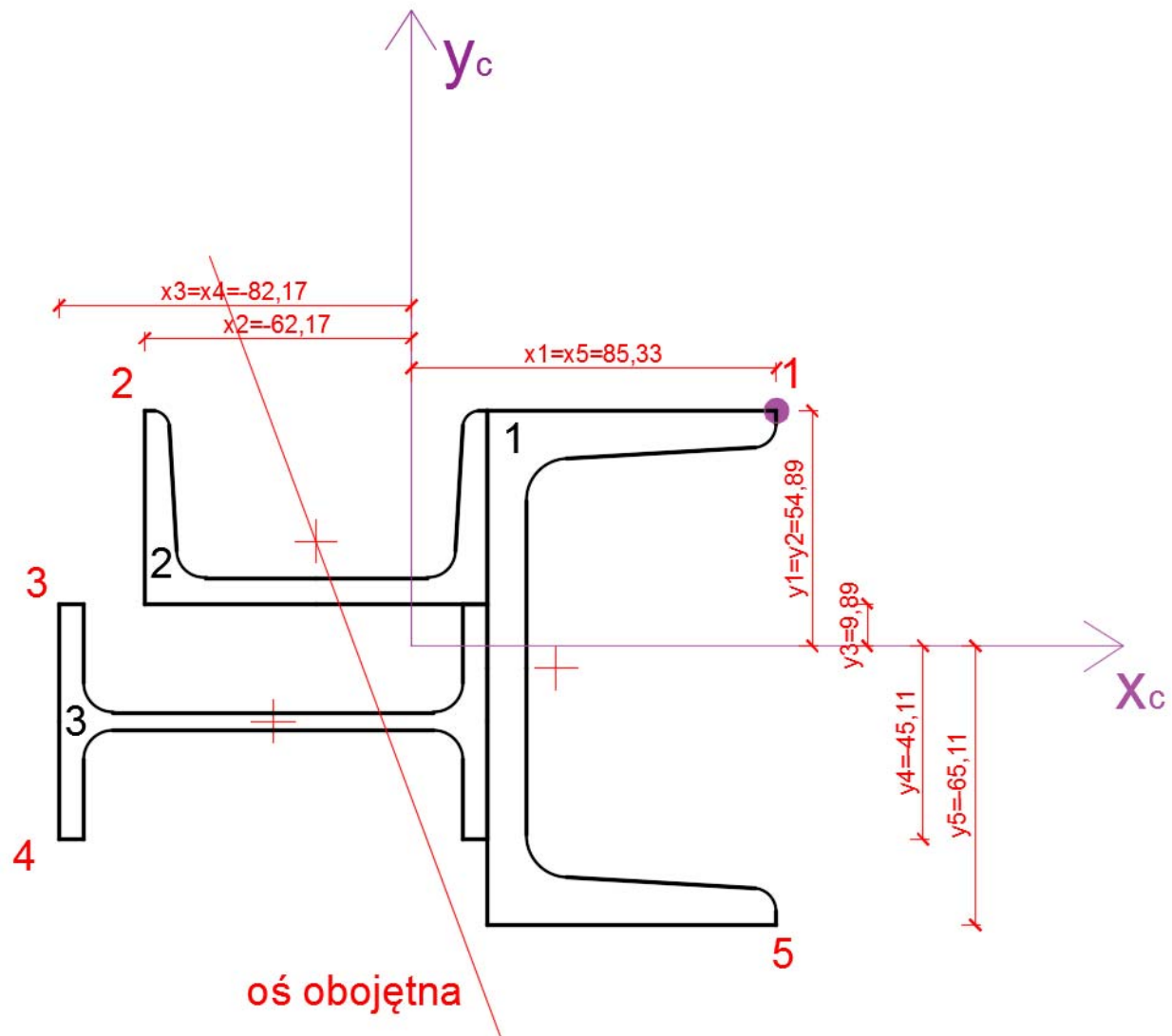
$$26.11 + 1.984 \cdot x + 0.739 \cdot y = 0$$

$$\text{dla } x=0 \quad y := \frac{26.11}{-0.739} = -35.33$$

$$\text{dla } y=0 \quad x := \frac{26.11}{-1.984} = -13.16$$



Naprężenia w narożach przekroju



$$x_1 := 85.33 \text{ mm}$$

$$y_1 := 54.89 \text{ mm}$$

$$x_2 := -62.17 \text{ mm}$$

$$y_2 := 54.89 \text{ mm}$$

$$x_3 := -82.17 \text{ mm}$$

$$y_3 := 9.89 \text{ mm}$$

$$x_4 := -82.17 \text{ mm}$$

$$y_4 := -45.11 \text{ mm}$$

$$x_5 := 85.33 \text{ mm}$$

$$y_5 := -65.11 \text{ mm}$$

$$\sigma_x = 26.11 \text{ MPa} + 1.984 \cdot x \cdot \frac{\text{MPa}}{\text{mm}} + 0.739 \cdot y \cdot \frac{\text{MPa}}{\text{mm}}$$

$$\sigma_{x1} := 26.11 \text{ MPa} + 1.984 \cdot x_1 \cdot \frac{\text{MPa}}{\text{mm}} + 0.739 \cdot y_1 \cdot \frac{\text{MPa}}{\text{mm}} = 235.97 \text{ MPa}$$

$$\sigma_{x2} := 26.11 \text{ MPa} + 1.984 \cdot x_2 \cdot \frac{\text{MPa}}{\text{mm}} + 0.739 \cdot y_2 \cdot \frac{\text{MPa}}{\text{mm}} = -56.67 \text{ MPa}$$

$$\sigma_{x3} := 26.11 \text{ MPa} + 1.984 \cdot x_3 \cdot \frac{\text{MPa}}{\text{mm}} + 0.739 \cdot y_3 \cdot \frac{\text{MPa}}{\text{mm}} = -129.61 \text{ MPa}$$

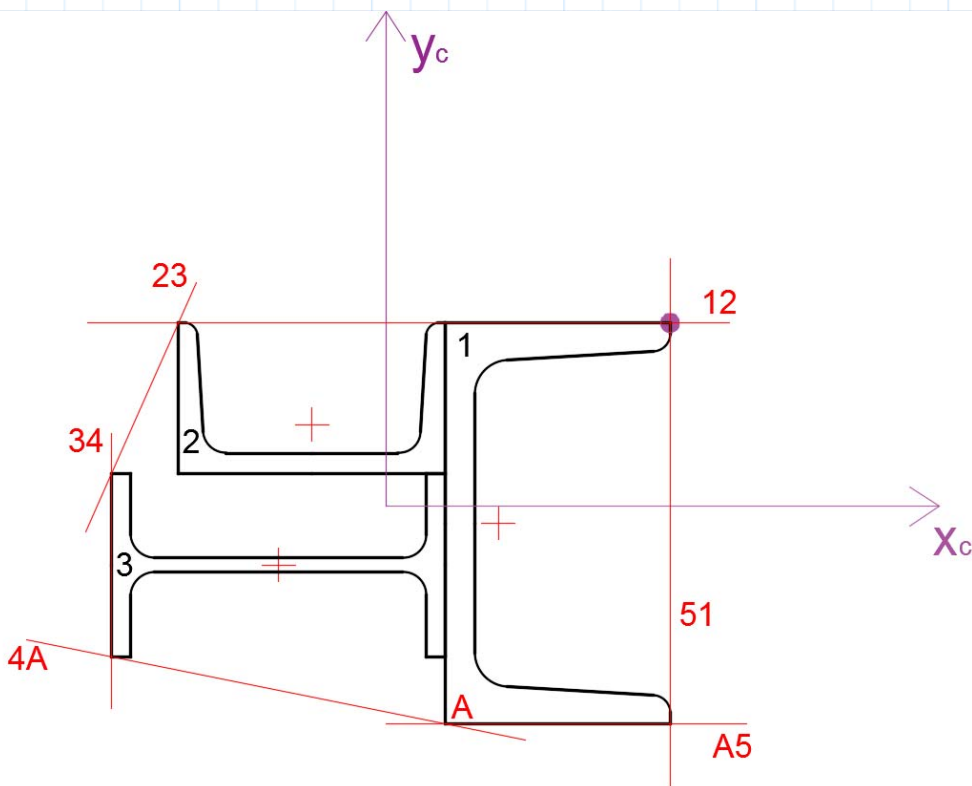
$$\sigma_{x4} := 26.11 \text{ MPa} + 1.984 \cdot x_4 \cdot \frac{\text{MPa}}{\text{mm}} + 0.739 \cdot y_4 \cdot \frac{\text{MPa}}{\text{mm}} = -170.25 \text{ MPa}$$

$$\sigma_{x5} := 26.11 \text{ MPa} + 1.984 \cdot x_5 \cdot \frac{\text{MPa}}{\text{mm}} + 0.739 \cdot y_5 \cdot \frac{\text{MPa}}{\text{mm}} = 147.29 \text{ MPa}$$

RDZEŃ PRZEKROJU

$$i_x := \frac{J_{xc}}{A} = 19.39 \text{ cm}^2$$

$$i_y := \frac{J_{yc}}{A} = 11.23 \text{ cm}^2$$



styczna 1-2

$$a_{x12} := \infty$$

$$a_{y12} := 54.89 \text{ mm}$$

$$x_{12} = -\frac{i_y}{a_{x12}} = 0$$

$$y_{12} := -\frac{i_x}{a_{y12}} = -35.33 \text{ mm}$$

styczna 2-3

$$X := \frac{y_3 - y_2}{x_3 - x_2} = 2.25$$

$$-X \cdot x_2 + y_2 = 194.77 \text{ mm}$$

$$y = 2.25 \cdot x + 194.77$$

$$a_{x23} := \frac{-X \cdot x_2 + y_2}{-X} = -86.57 \text{ mm}$$

$$a_{y23} := -X \cdot x_2 + y_2 = 194.77 \text{ mm}$$

$$x_{23} := -\frac{i_y}{a_{x23}} = 12.97 \text{ mm}$$

$$y_{23} := -\frac{i_x}{a_{y23}} = -9.96 \text{ mm}$$

styczna 3-4

$$a_{x34} := -82.17 \text{ mm}$$

$$a_{y34} := \infty$$

$$x_{34} := -\frac{i_y}{a_{x34}} = 13.66 \text{ mm}$$

$$y_{34} := -\frac{i_x}{a_{y34}} = 0$$

$$x_A := 17.83 \text{ mm}$$

$$y_A := -65.11 \text{ mm}$$

styczna 4-A

$$X := \frac{y_A - y_4}{x_A - x_4} = -0.2$$

$$-X \cdot x_4 + y_4 = -61.54 \text{ mm}$$

$$y = -0.2 \cdot x - 61.54$$

$$a_{x4A} := \frac{-X \cdot x_4 + y_4}{-X} = -307.72 \text{ mm}$$

$$a_{y4A} := -X \cdot x_4 + y_4 = -61.54 \text{ mm}$$

$$x_{4A} := -\frac{i_y}{a_{x4A}} = 3.65 \text{ mm}$$

$$y_{4A} := -\frac{i_x}{a_{y4A}} = 31.51 \text{ mm}$$

styczna A-5

$$a_{xA5} = \infty$$

$$a_{yA5} := -65.11 \text{ mm}$$

$$x_{A5} = -\frac{i_y}{a_{xA5}} = 0$$

$$y_{A5} := -\frac{i_x}{a_{yA5}} = 29.79 \text{ mm}$$

styczna 5-1

$$a_{x51} := 85.33 \text{ mm}$$

$$a_{y51} := \infty$$

$$x_{51} := -\frac{i_y}{a_{x51}} = -13.16 \text{ mm}$$

$$y_{51} := -\frac{i_x}{a_{y51}} = 0$$

