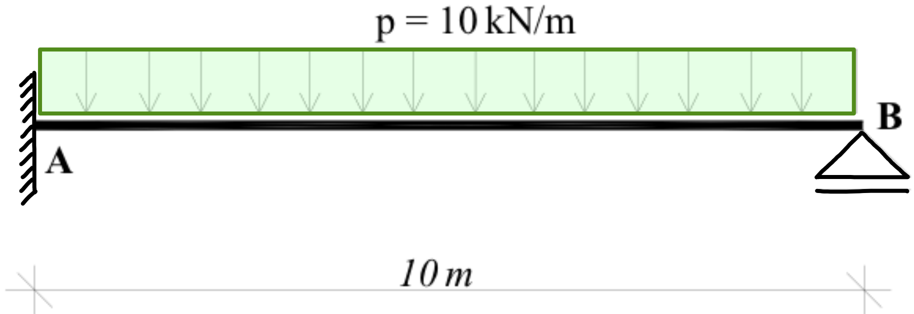
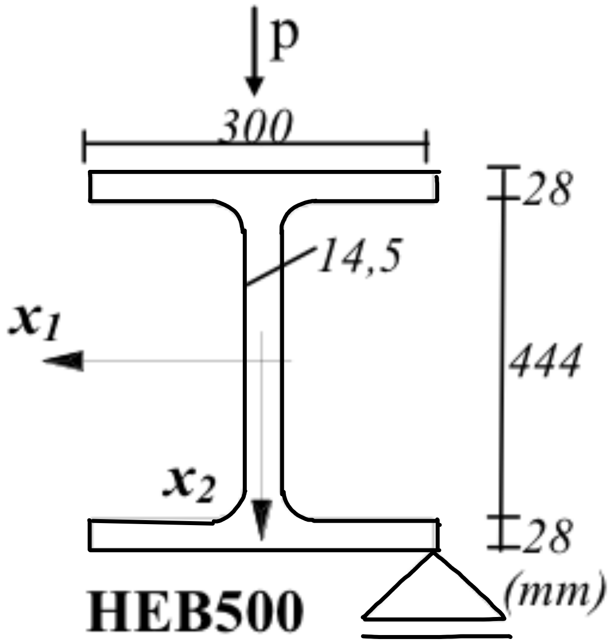
E = 210 GPa
G = 81 GPa



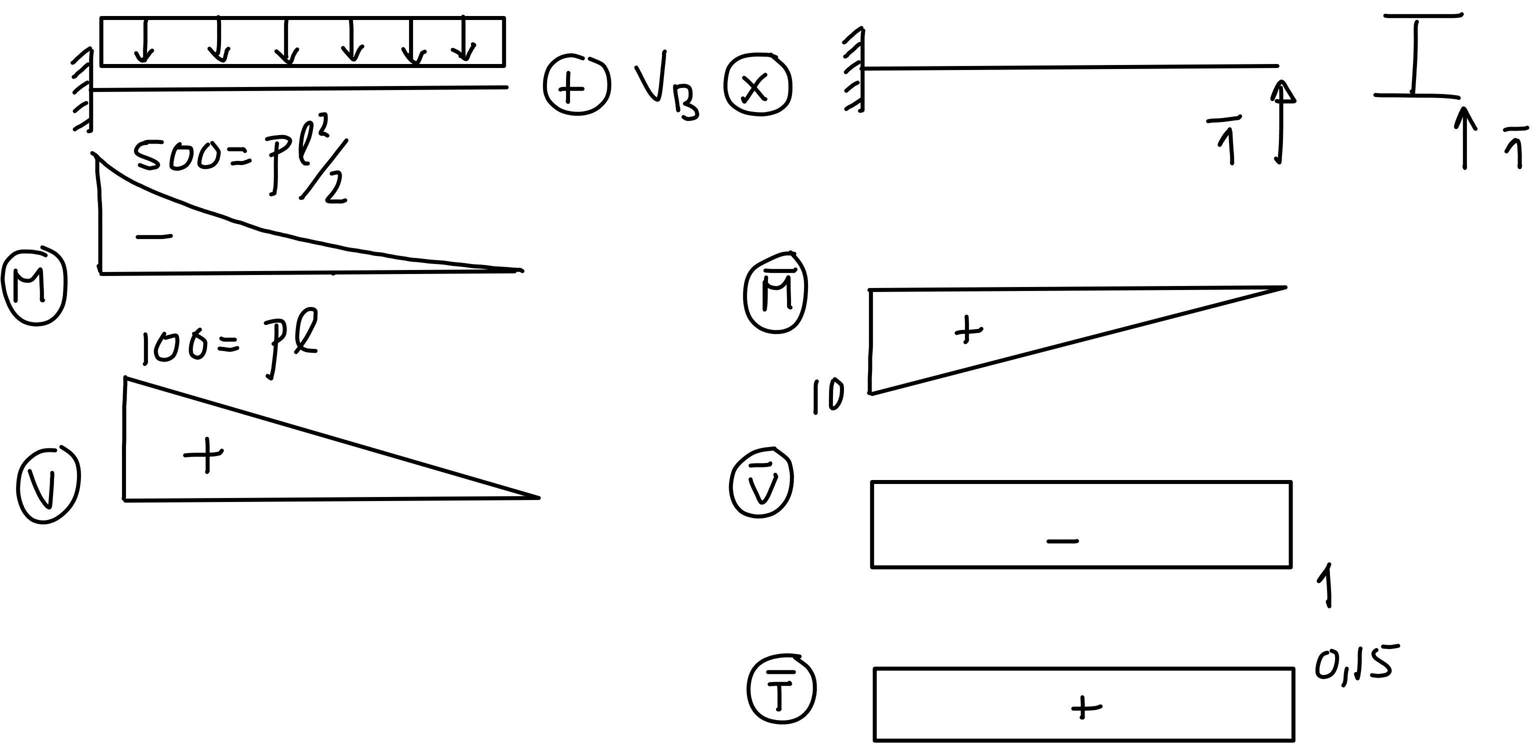


$I_1 = 1072 \times 10^6\ mm^4$

$Av = 8982\ mm^2$

$$J = \frac{1}{3}\left[300 \times 28^3 \times 2 + (500-28) \times 14,5^3\right] = 4870 \times 10^3\ mm^4$$

Método das Forças



$$\delta_p = \frac{1}{EI}\int \; dx + \frac{1}{GA_v}\int \; dx$$

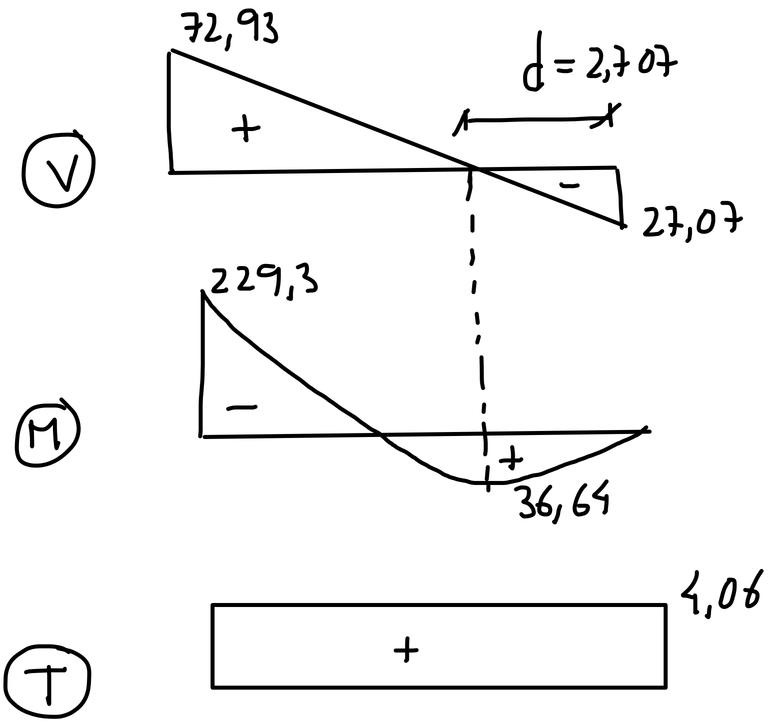
$$= -\frac{1}{210 \times 1072} \times 500 \times 10 \times \frac{1}{4} \times 10 - \frac{1}{81 \times 8982}\, 100 \times 10\,\frac{1}{2} = -(55,53 + 0,687) \times 10^{-3}$$

$$\delta_c = \frac{1}{EI}\int (\;)^2 dx + \frac{1}{GA_v}\int (\;)^2 dx + \frac{1}{GJ}\int (\;)^2 dx$$

$$= \frac{1}{210 \times 1072}\, 1,481 \times 10^{-3} + 0,01374 \times 10^{-3} + 0,57 \times 10^{-3}) = (2,051 + 0,01374) \times 10^{-3}$$

$$\delta_p + V_B\ \delta_c = 0 \Rightarrow \begin{cases} V_B = 27{,}23\ kN & (c/\ corte) \\ V_B = 27{,}07\ kN & (s/\ corte) \end{cases}$$

a. As reacções nos apoios e os diagramas de todos os esforços.

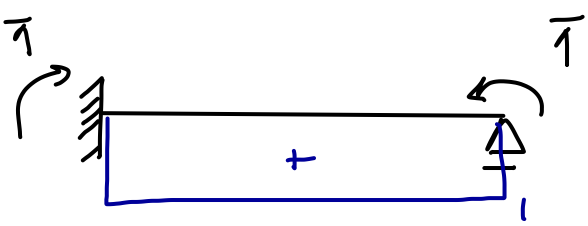


d — 27,07

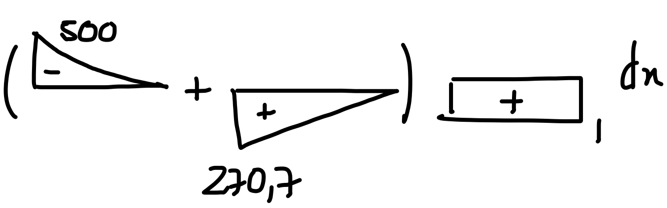
10 — 100

c. As rotações da secção sobre o apoio **B**.

$$\varphi = \frac{4{,}06}{81\times10^{6}\times 4870\times10^{-9}} \times 10 = 0{,}1029\ rad = 5{,}897^{\circ}\ (\longrightarrow\!\!\!\!\!\!\rightarrow)$$



$$\theta_B = \frac{1}{EI}\int \left(\ldots + \ldots \right) \ldots\, dx$$



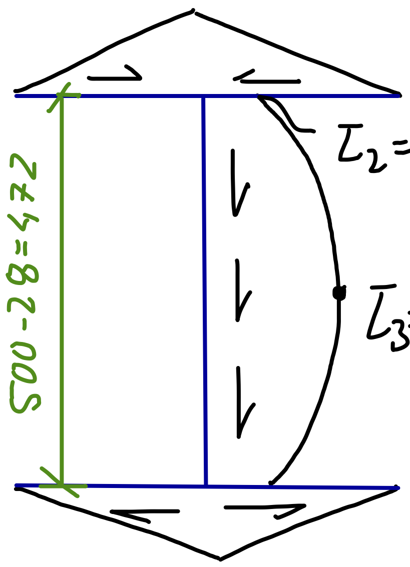
$$= \frac{1}{210\times10^{7}2}\left(-500\times10\times\frac{1}{3} + 270{,}7\times10\,\frac{1}{2}\right) =$$

$$= -1{,}39\times10^{-3}\ rad = -0{,}0797^{\circ}$$

b. A tensão tangencial máxima e a tensão de comparação máxima no perfil, segundo o critério de Von Mises.

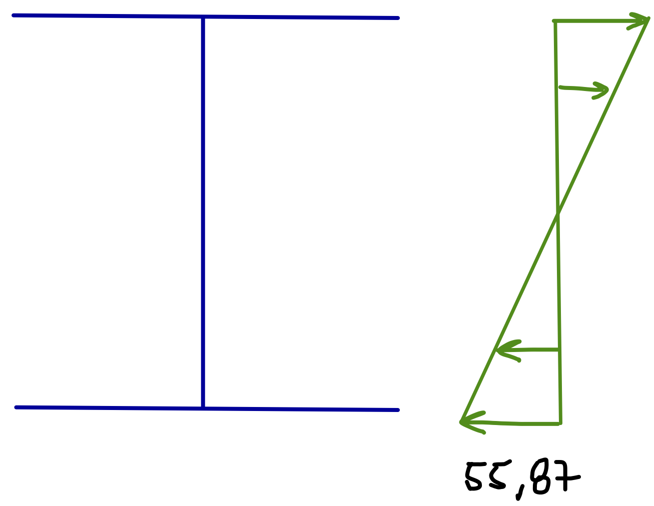
[MPa]

$$\tau_1 = 72{,}93 \times 10^3 \; \frac{150 \times \frac{472}{2}}{1072 \times 10^6} = 2{,}41$$

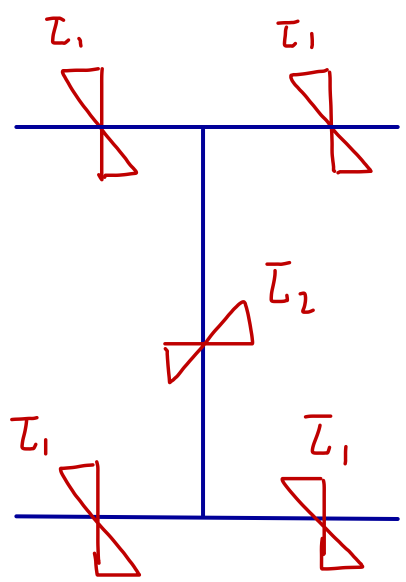


$$\tau_2 = 2\,\tau_1 \,\frac{28}{14{,}5} = 9{,}3$$

$$\tau_3 = 9{,}3 + \frac{\left(\frac{472}{2}\right)^2 / 2}{1072 \times 10^6}\, 72{,}93 \times 10^3 = 11{,}19$$



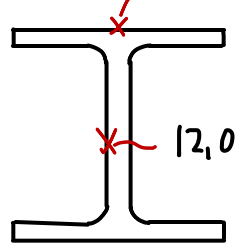
$$\sigma = \frac{229{,}3}{1072} \times 250 = 53{,}47$$



$$\tau_1 = \frac{4{,}06 \times 10^6}{4870 \times 10^3} \times 28 = 23{,}34 \text{ MPa}$$

$$\tau_2 = 23{,}34 \times \frac{14{,}5}{28} = 12{,}09$$

23,34+ 2,41 = 25,75



12,09+ 11,19= 23,28

$$\sigma_{vm} = \sqrt{53{,}47^2 + 3 \times 25{,}75^2} = \underline{\underline{69{,}63}}$$