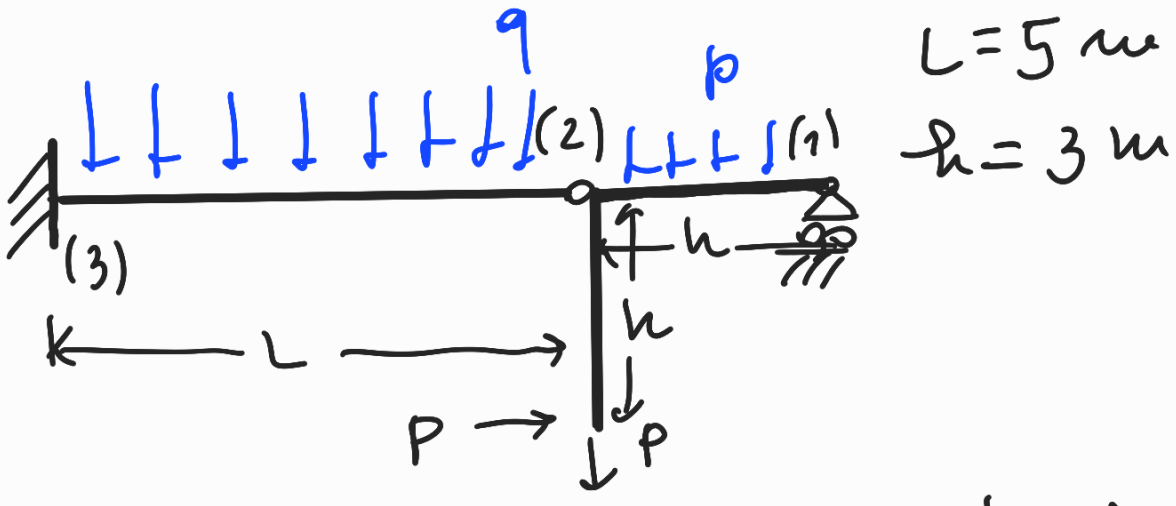
1) • Verifica se la struttura è isostatica

$n_{aste} = 2$ $\quad$ $\nu = 3+2+1 = 6$

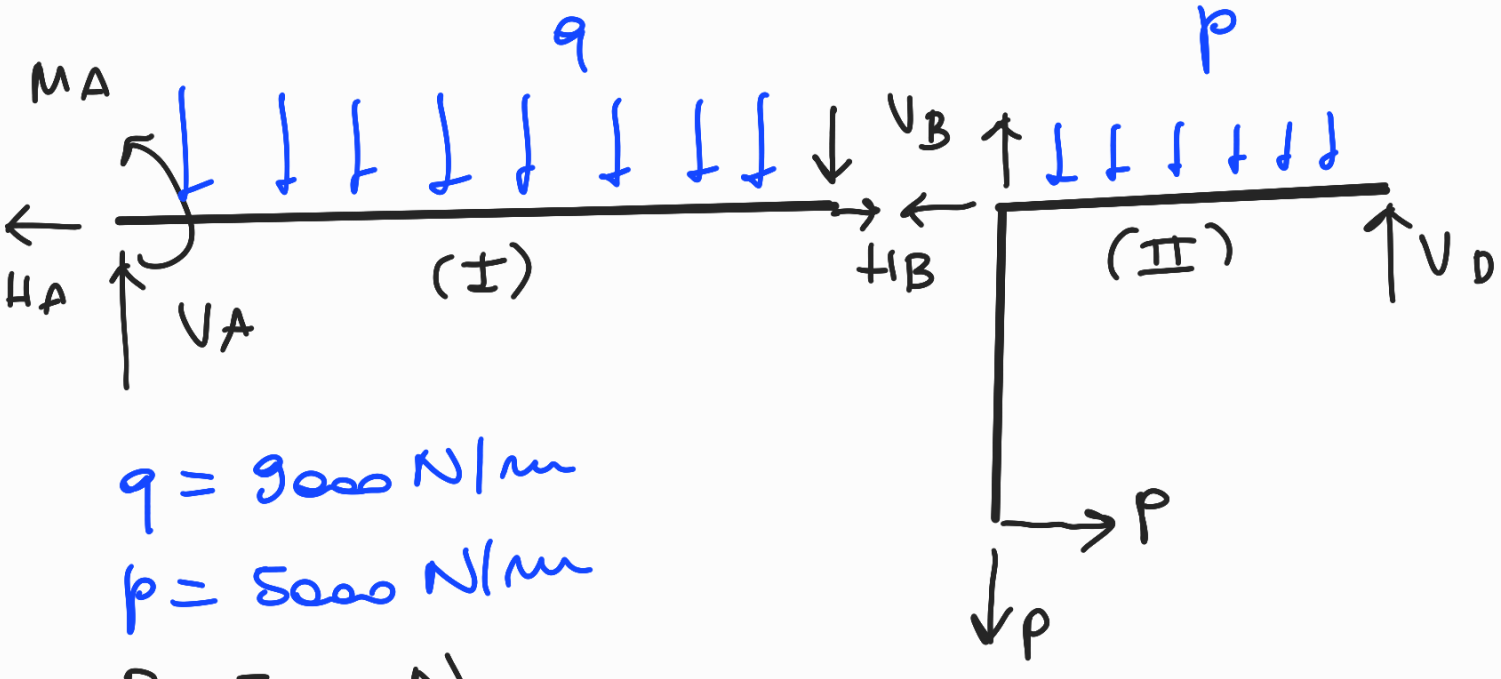
$g = 2 \cdot 3 = 6$ $\quad$ $\rightarrow$ isostatica



$L = 5\ m$

$h = 3\ m$

• Calcolo delle reazioni vincolari



$q = 9000\ N/m$

$p = 5000\ N/m$

$P = 5000\ N$

Equilibri delle aste:

I $\begin{cases} \overset{+}{\rightarrow} -H_A + H_B = 0 \\ \uparrow \quad V_A - V_B - qL = 0 \\ \curvearrowright_A : -M_A + \frac{qL^2}{2} + V_B \cdot L = 0 \end{cases}$

$H_A = 5000\ N$

II $\begin{cases} \rightarrow + -H_B + P = 0 \\ \uparrow \quad V_B - ph + V_D - P = 0 \\ \curvearrowright_B : p\frac{h^2}{2} - V_D \cdot h - Ph = 0 \end{cases}$

$H_B = P = 5'000\ N$

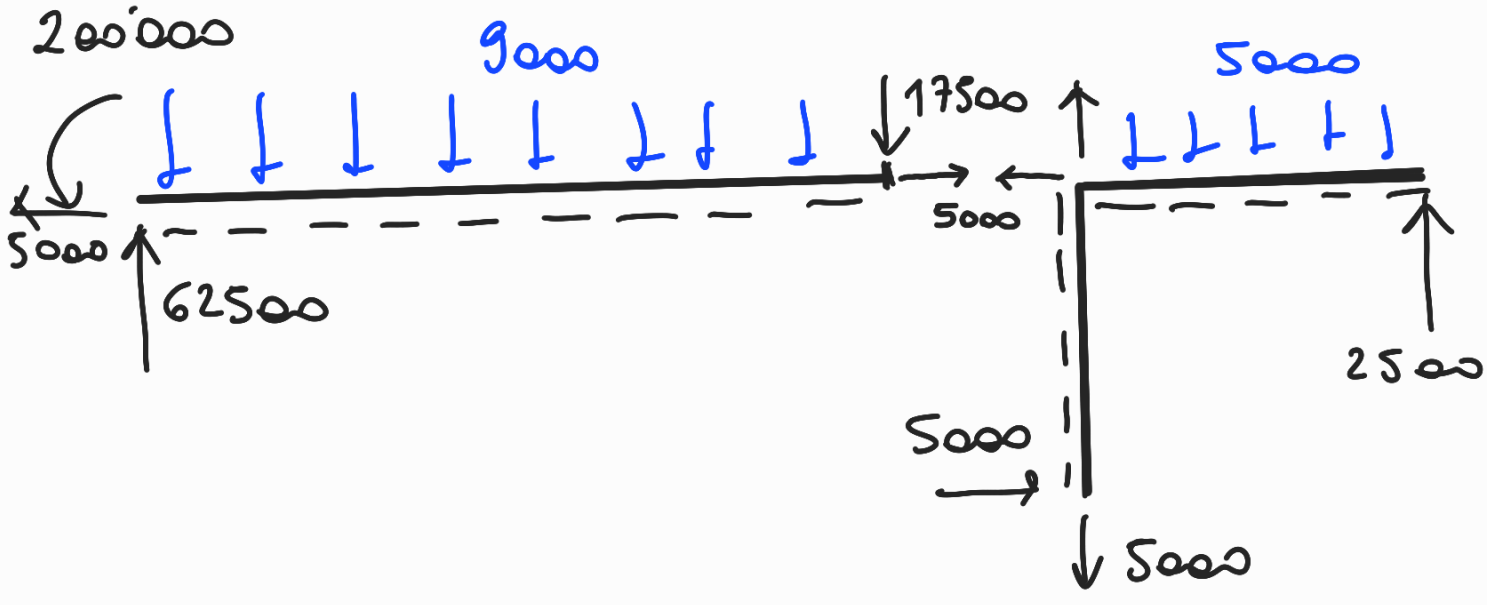
$V_D = p\frac{h}{2} - P = 2500\ N$

$V_B = ph + P - V_D = 17500\ N$

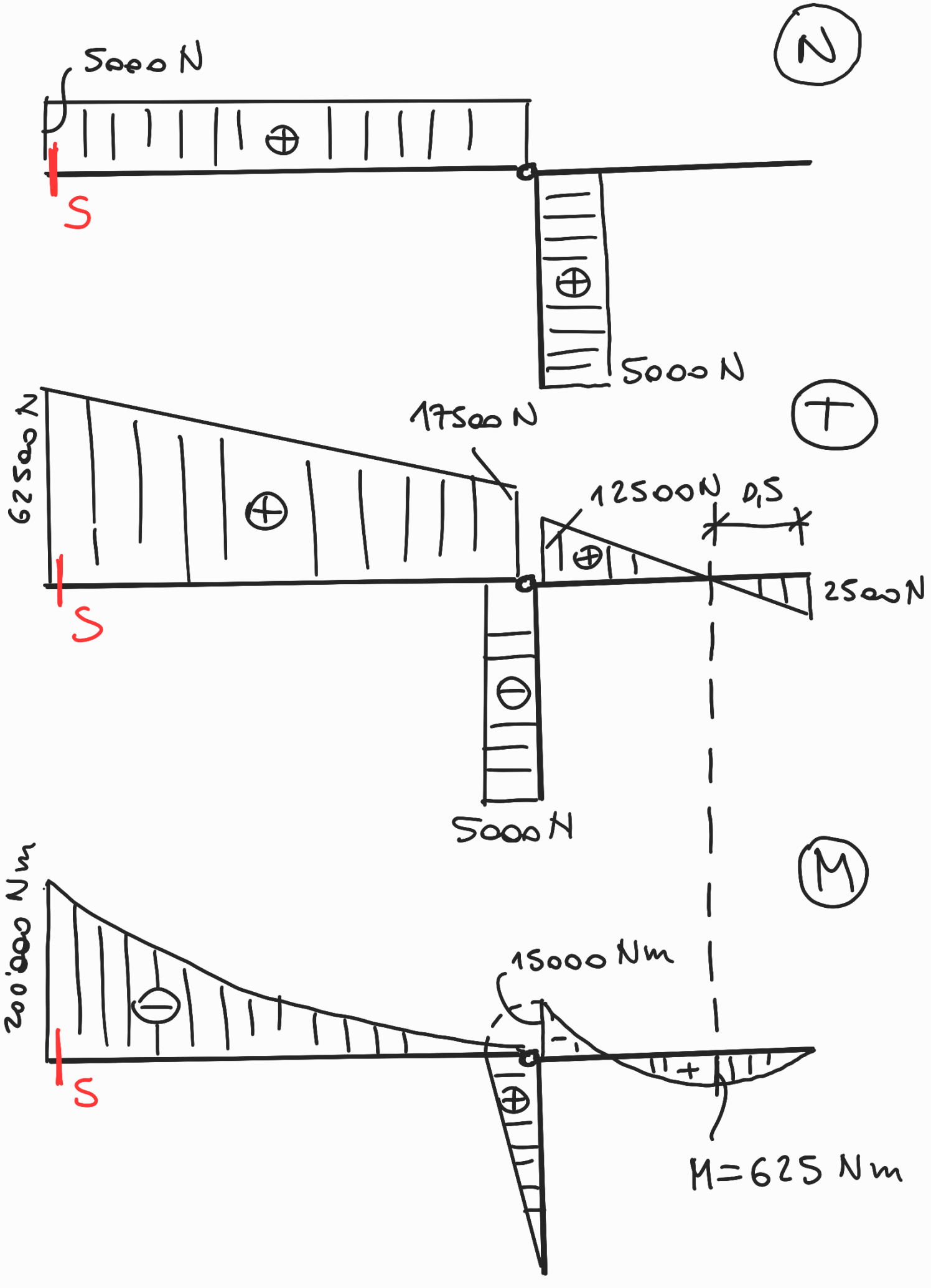
$V_A = qL + V_B = 62500\ N$

$M_A = \frac{qL^2}{2} + V_B \cdot L = 200000\ Nm$

Schema finale delle forze:

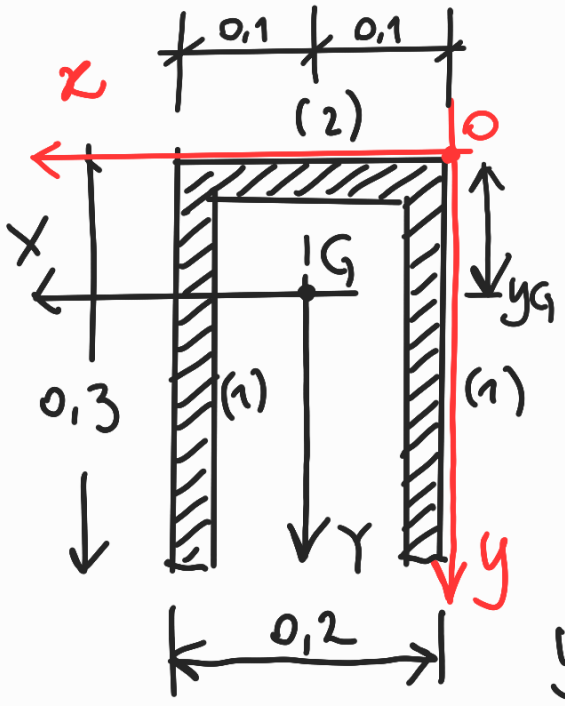


• Diagrammi delle azioni interne



2)

- Caratteristiche geometriche della sezione



$$A = 0,3 \cdot 0,01 \cdot 2 + 0,2 \cdot 0,01 = 0,008\,m^2$$

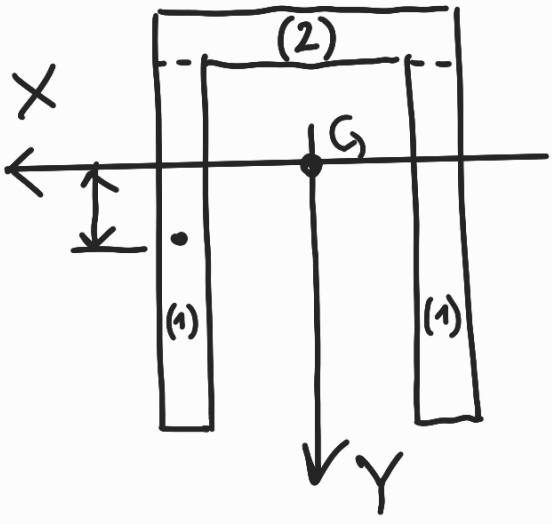
$$S_x \cong 0,3 \cdot 0,15 \cdot 0,01 \cdot 2 = 0,0009\,m^3$$

$$S_x = S_x^{(1)} \cdot 2 + \underbrace{S_x^{(2)}}_{\text{trascurabile}}$$

$$y_G = \frac{S_x}{A} = 0,1125\,m$$

Momento d'inerzia I_x:

$$I_x = I_x^{(1)} \cdot 2 + I_x^{(2)}$$



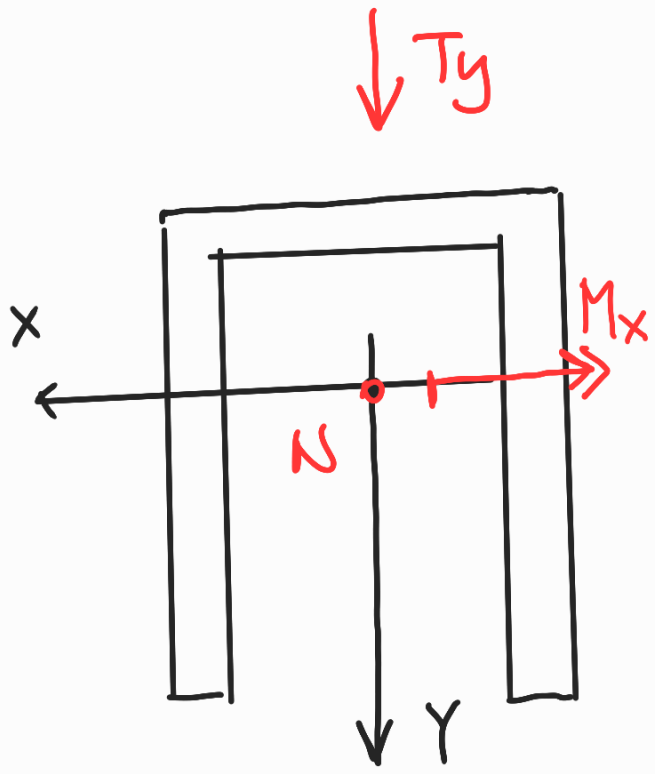
$$= \left[\frac{0,01 \cdot 0,3^3}{12} + 0,3 \cdot 0,01 \cdot 0,0375^2\right] 2 + \text{(trascurabile)}$$

$$+ \frac{0,2 \cdot 0,01^3}{12} + 0,2 \cdot 0,01 \cdot 0,1125^2 =$$

$$= 5,34 \cdot 10^{-5} + 2,53 \cdot 10^{-5} =$$

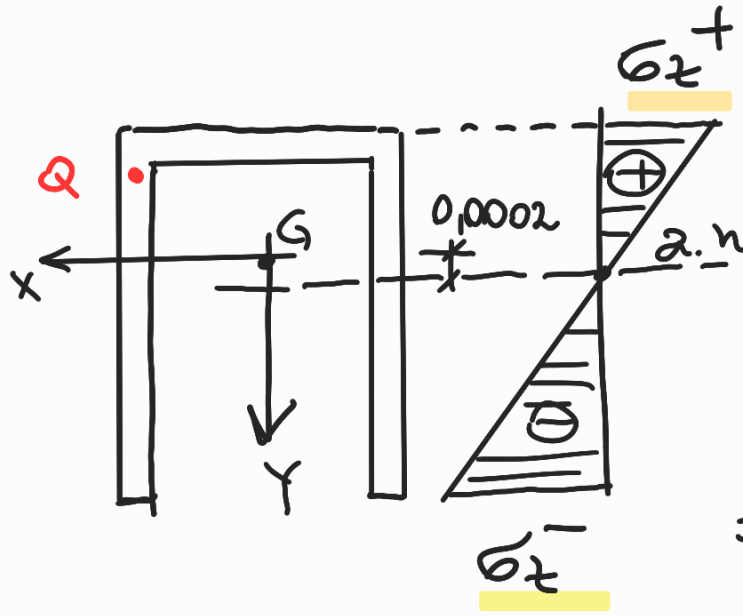
$$= 7,87 \cdot 10^{-5}\,m^4$$

• Calcolo delle Tensioni nelle sez. S



$$\begin{cases} N = +5000\ N \text{ (trazione)} \\ Ty = 62500\ N \\ Mx = 200000\ N\,m \end{cases}$$

- Tensoflessione retta



$$\sigma_z^- = \frac{N}{A} - \frac{M}{Ix} \cdot 0{,}1875 =$$

$$= \frac{5000}{9008} - \frac{200000}{7{,}87 \cdot 10^{-5}} \cdot 0{,}1875 =$$

$$= 6{,}25 \cdot 10^5 - 4{,}76 \cdot 10^8 = -4{,}75 \cdot 10^8$$

$$= -475\ MPa$$

$$\sigma_z^+ = \frac{N}{A} + \frac{M}{Ix} \cdot 0{,}1175 = 6{,}25 \cdot 10^5 + 2{,}99 \cdot 10^8 = 3{,}0 \cdot 10^8\ Pa$$

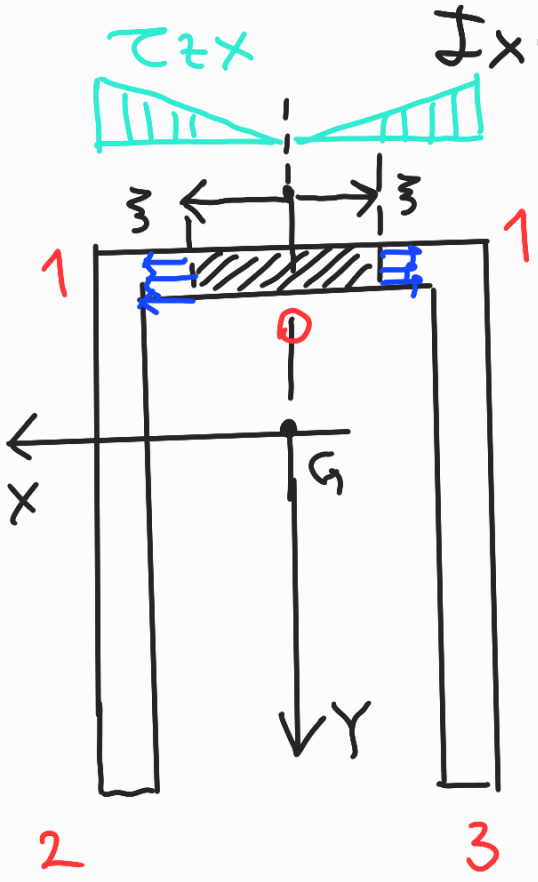
$$= 300\ MPa$$

$\sigma_z(Q) \simeq 300\ MPa$

- Taglio (formula di Jourawski)

$$\tau_{zs}(s) = -\frac{T_y \cdot S_x^*}{I_x \cdot b}$$

Tratto 0-1



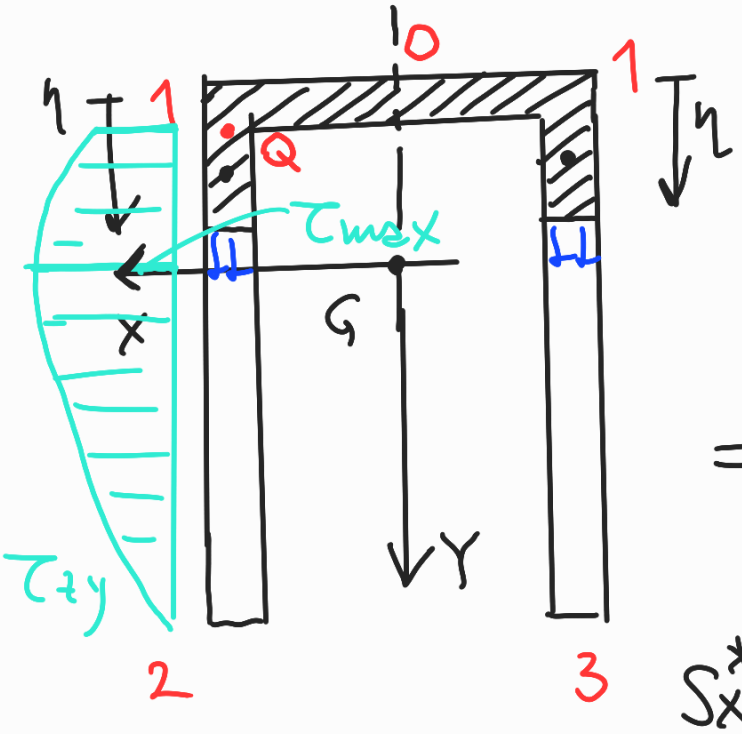
$$\tau_{zx}(\zeta) = -\frac{T_y \cdot S_x^*(\zeta)}{I_x \cdot t}$$

$$S_x^*(\zeta) = -2 \cdot \zeta \cdot 0{,}01 \cdot 0{,}1125 \ m^3$$

$$\tau_{zx}(\zeta) = \frac{-62500 \cdot (-2\zeta \cdot 0{,}01 \cdot 0{,}1125)}{7{,}87 \cdot 10^{-5} \cdot (0{,}01 + 0{,}01)}$$

$\tau_{zx}(\zeta = 0{,}1) = 8{,}93$ MPa uscenti dall'area

Tratto 1-2 / 2-3



$$S_x^*(\eta) = -(0{,}2 \cdot 0{,}01 \cdot 0{,}1125) + -2\,\eta \cdot 0{,}01 \cdot \left(0{,}1125 - \frac{\eta}{2}\right) =$$

$$= -2{,}25 \cdot 10^{-4} - 2{,}25 \cdot 10^{-3}\eta + 0{,}01\eta^2$$

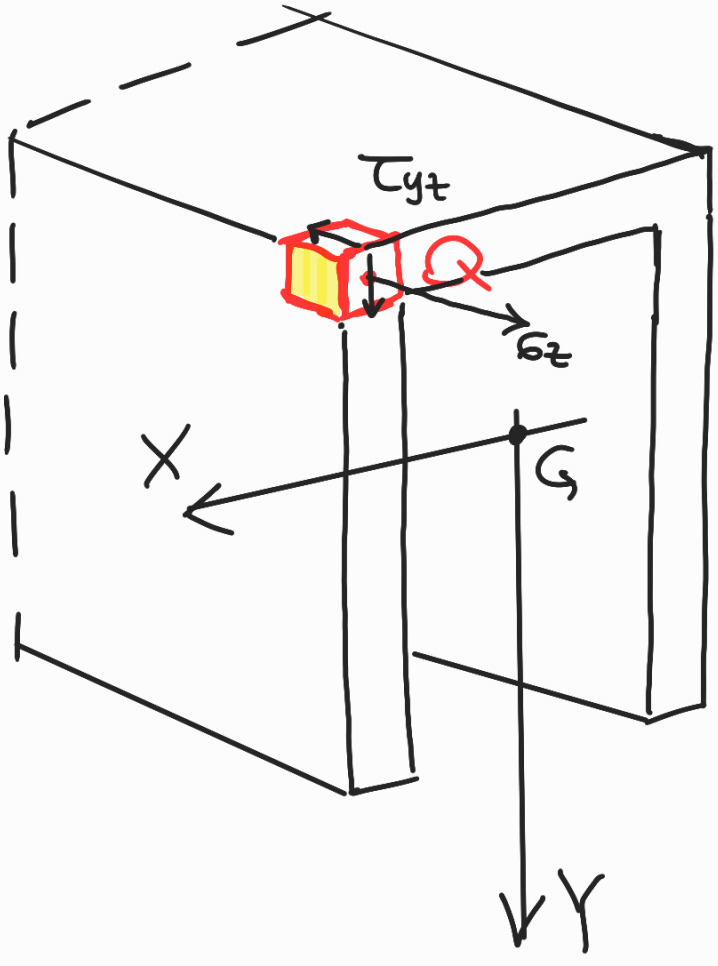
$$S_x^*(\eta = 0{,}1125) = -3{,}51 \cdot 10^{-4} \ m^3$$

$$\tau_{zy(\eta=0)} = \frac{-62500 \cdot (-2{,}25 \cdot 10^{-4})}{7{,}87 \cdot 10^{-5} \cdot 0{,}02} = 8{,}93 \text{ MPa} \quad (Q)$$

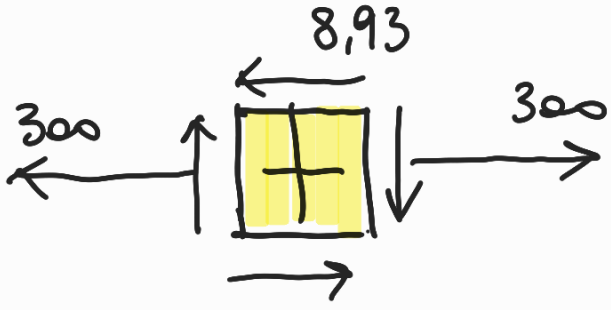
$$\tau_{zy_{max}} = \tau_{zy}(\eta = 0{,}1125) = \frac{+62500 \cdot 3{,}52 \cdot 10^{-4}}{7{,}87 \cdot 10^{-5} \cdot 0{,}02} =$$

$$= 13{,}96 \text{ MPa}$$

- Verifica di resistenza nel punto Q della sez S e cerchio di Mohr



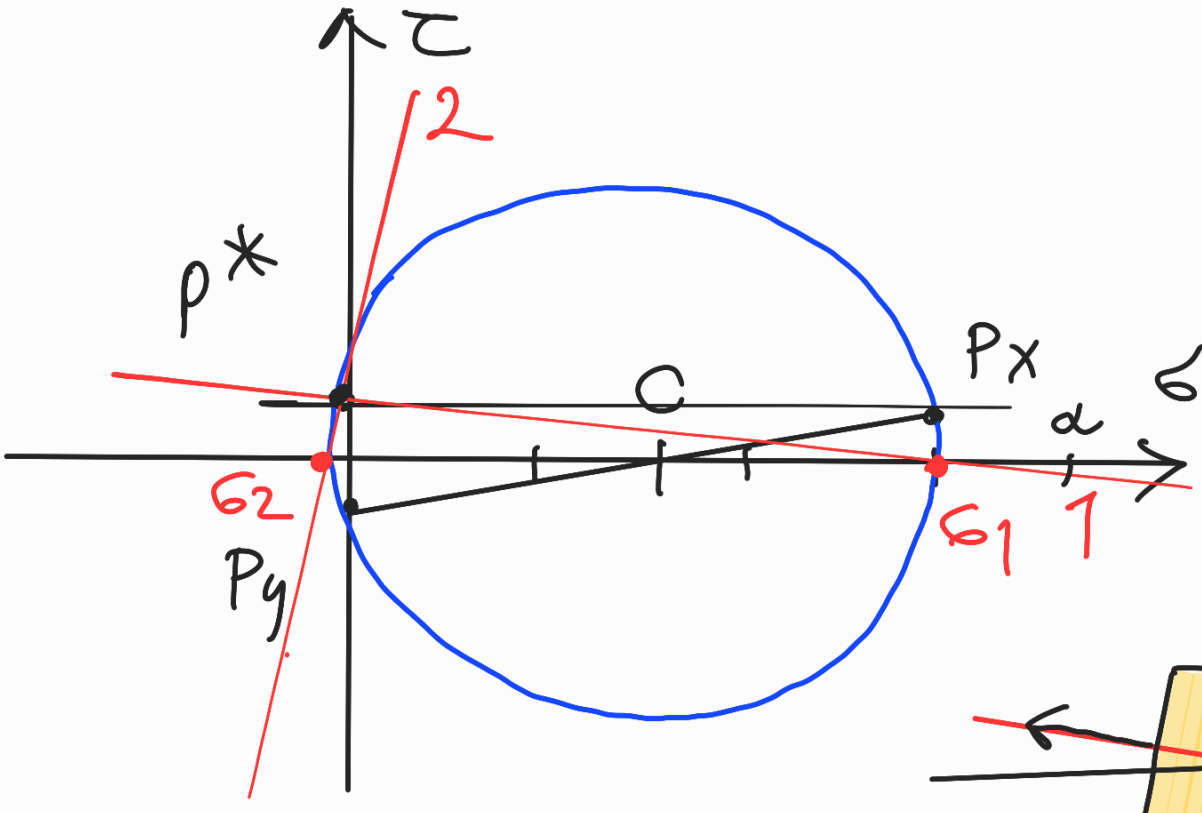
(Q)

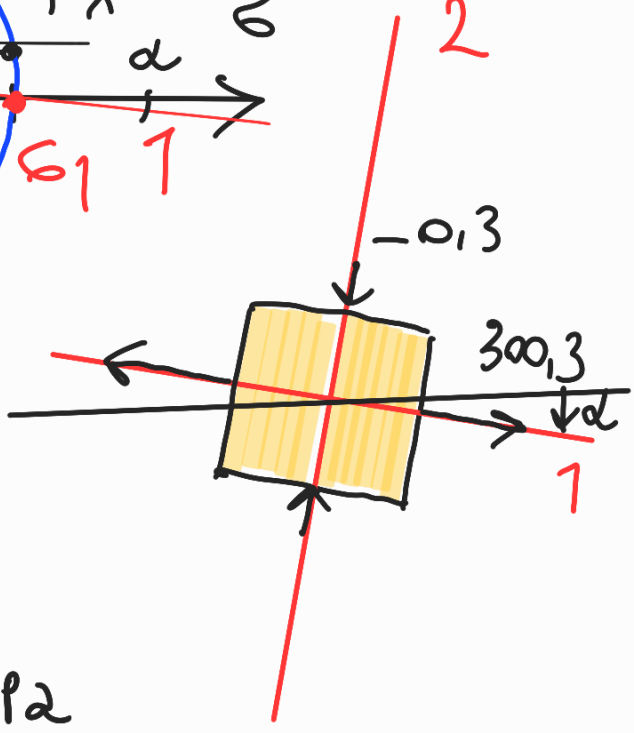


$P_x = (300 \; ; 8{,}93)$

$P_y = (0 \; ; -8{,}93)$

Cerchio di Mohr nel punto Q





$$X_C = \frac{300}{2} = 150 \text{ MPa}$$

$$R = \sqrt{150^2 + 8{,}13^2} = 150{,}3 \text{ MPa}$$

$$\sigma_1 = X_C + R = 300{,}3 \text{ MPa}$$

$$\sigma_2 = X_C - R = -0{,}3 \text{ MPa}$$

tensione amm

$\sigma_{amm} = 320 \text{ MPa}$

Verifica di resistenza
Criterio di Von Mises

$$\sigma_{eqvn} = \sqrt{\sigma_z^2 + 3\tau_{zy}^2} = \sqrt{300^2 + 3 \cdot 8{,}13^2} =$$

$$= 300{,}4 \text{ MPa} < 320 \text{ MPa}^2$$

verificato

Direzioni principali di tensione:

$$\alpha = \frac{1}{2}\,\text{arctg}\,\frac{2\tau_{zy}}{\sigma_x - \sigma_y} = -1{,}71^\circ \text{ orario}$$