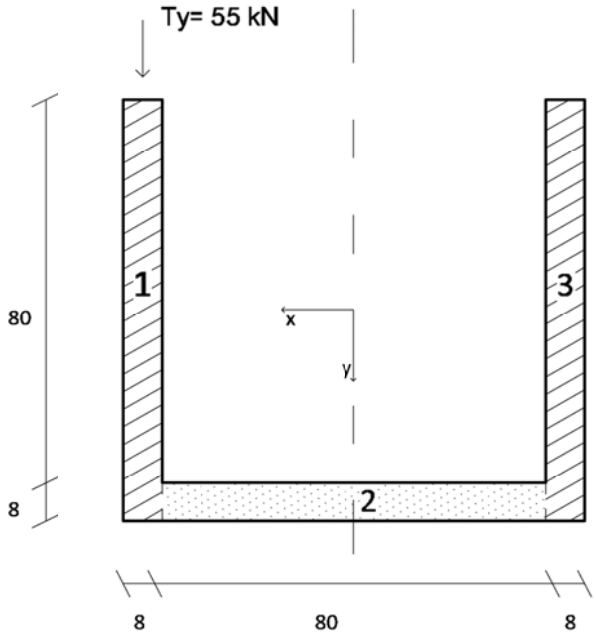
$\boldsymbol{T_y = 55\ kN}$



$A_1 = 704cm^2$
$A_2 = 640cm^2$
$A_3 = 704cm^2$
$A_{TOT} = 2048cm^2$

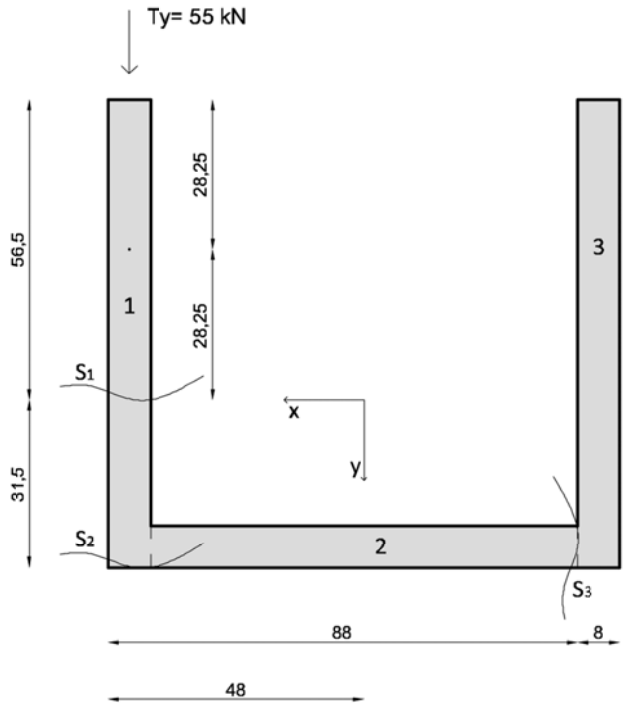
$G_1(4|44) \quad G_2(48|4) \quad G_3(92|44)$

$S_{x1} = S_{x3} = 30976cm^3 \quad S_{x2} = 2560cm^3$
$S_{xTOT} = 64512cm^3$
$S_{y1} = 2816cm^3 \quad S_{y2} = 30720cm^3$
$S_{y3} = 64768m^3 \quad S_{yTOT} = 30976cm^3$

$X_G = \frac{S_{yTot}}{A_{Tot}} = 48 \qquad Y_G = \frac{S_{xTot}}{A_{Tot}} = 31{,}5$

$$I_{x1} = I_{x3} = \frac{8 \cdot 88^3}{12} + 704 \cdot (31{,}5 - 44)^2 = 564314cm^4$$
$$I_{x2} = \frac{80 \cdot 8^3}{12} + 640 \cdot (31{,}5 - 4)^2 = 487412cm^4$$
$$I_{xTOT} = 1616040cm^4$$

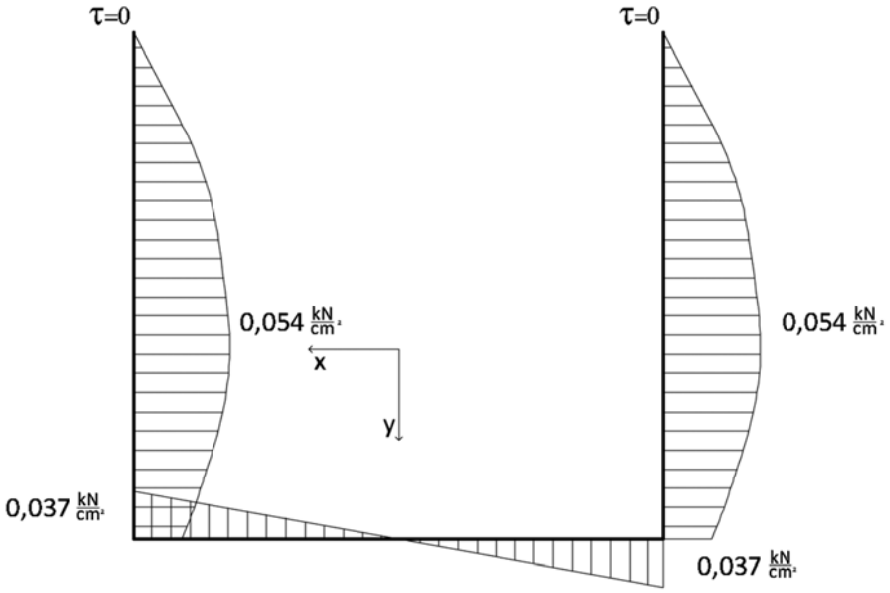
$$\boldsymbol{T_{sz} = \frac{T_y \cdot S_{xn}}{b \cdot I_{xTot}}}$$



Sez. 1
$S_x = -12769 \quad \tau = \frac{55 \cdot -12769}{8 \cdot 1616040} = 0{,}054\ \frac{kN}{cm^2}$

Sez. 2
$S_x = -8800 \quad \tau = \frac{55 \cdot -8800}{8 \cdot 1616040} = 0{,}037\ \frac{kN}{cm^2}$

Sez. 3
$S_x = 8800 \quad \tau = \frac{55 \cdot 8800}{8 \cdot 1616040} = 0{,}037\ \frac{kN}{cm^2}$



Torsione:

$$\boldsymbol{\tau = \frac{M_{zn}}{I_{\tau n}} \cdot b}$$

$$M_{zn} = M_{zTot} \cdot \frac{I_{\tau n}}{I_{\tau Tot}}$$

$$\gg \quad M_{zTot} = 55kN \cdot 44cm = 2420\ kNcm$$

$$\gg \quad I_{\tau 1} = I_{\tau 3} = \frac{1}{3} \cdot l \cdot b^3 = 15018{,}66cm^4$$

$$I_{\tau 2} = \frac{1}{3} \cdot l \cdot b^3 = 13653{,}33cm^4$$

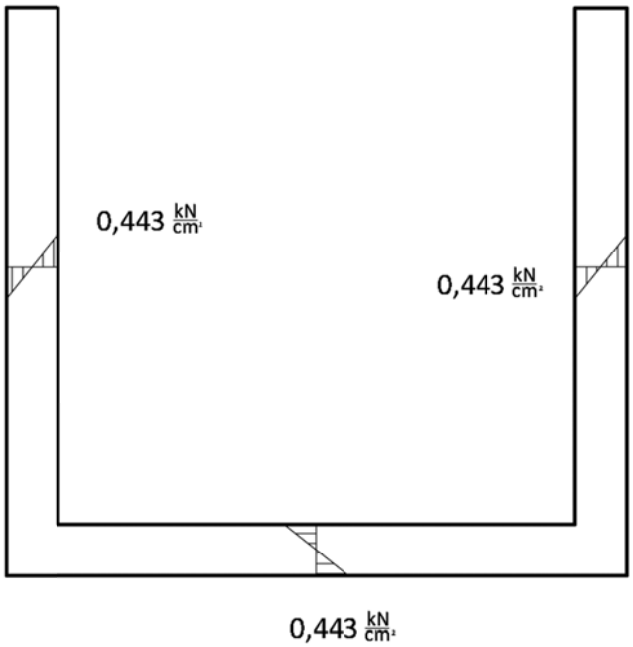
$$I_{\tau Tot} = 43690{,}65cm^4$$

$$\gg \quad M_{z1} = M_{z3} = 831{,}87\ kN/cm$$

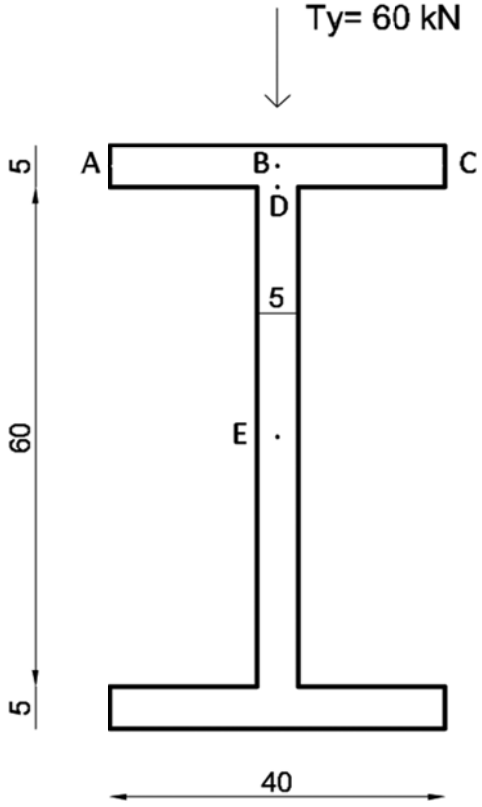
$$M_{z2} = 756{,}25\ kN/cm$$

$$\tau_1 = \tau_3 = \frac{831{,}87}{15018{,}66} \cdot 8 = 0{,}443 \frac{kN}{cm^2}$$

$$\tau_2 = \frac{756{,}25}{13653{,}33} \cdot 8 = 0{,}443 \frac{kN}{cm^2}$$



$\boldsymbol{T_y = 60\ kN}$



$$I_x = \frac{5 \cdot 60^3}{12} + 2 \cdot \frac{40 \cdot 5^3}{12} + 2 \cdot 40 \cdot 5 \cdot 32{,}5^2 =$$

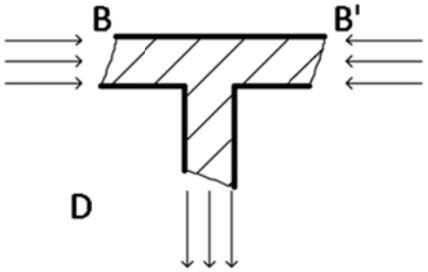
$$= 513333{,}3\ cm^4$$

$$\tau(A) = 0 = \tau(C)$$

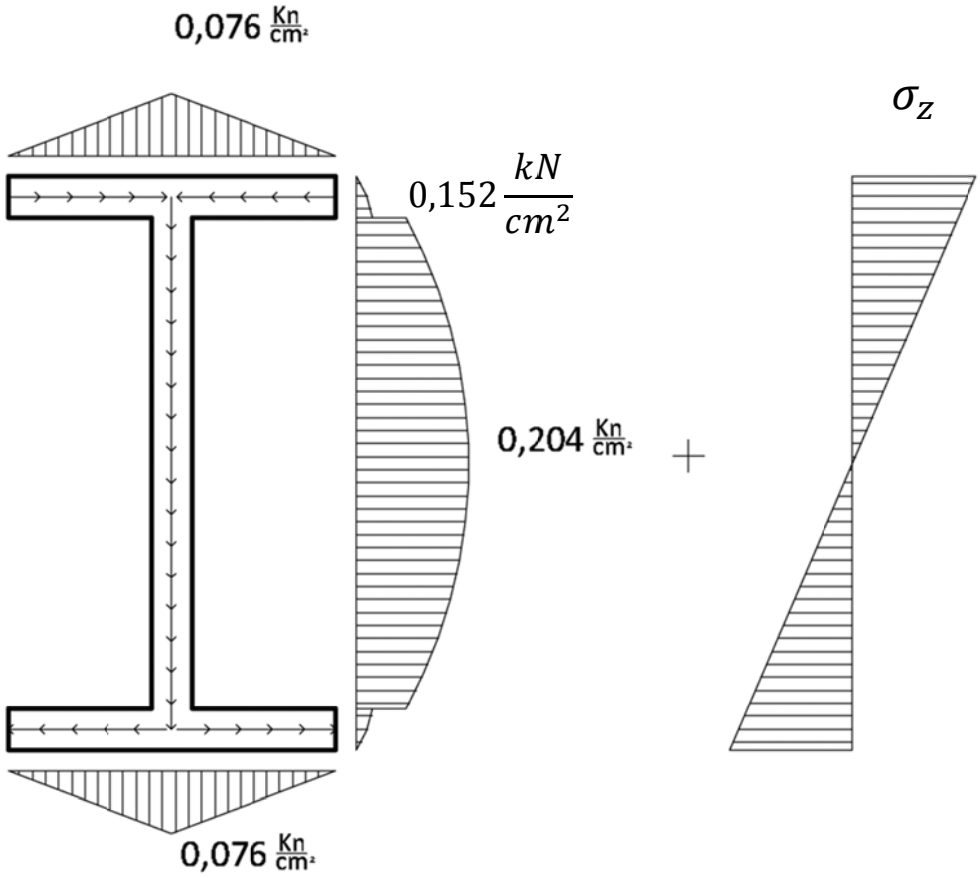
$$\tau(B) = \frac{60 \cdot (20 \cdot 5 \cdot 32{,}5)}{5 \cdot 513333{,}3} = 0{,}0760\,\frac{kN}{cm^2}$$

$$\tau(D) = \frac{60 \cdot (40 \cdot 5 \cdot 32{,}5)}{5 \cdot 513333{,}3} = 0{,}151\,\frac{kN}{cm^2}$$

$$\tau(E) = \frac{60 \cdot (40 \cdot 5 \cdot 32{,}5 + 50 \cdot 30 \cdot 15)}{5 \cdot 513333{,}3} = 0{,}204\,\frac{kN}{cm^2}$$



$$q = -\frac{T_y S_x}{I_x} = (+) \rightarrow flusso\ uscente$$



valore medio nell'anima:

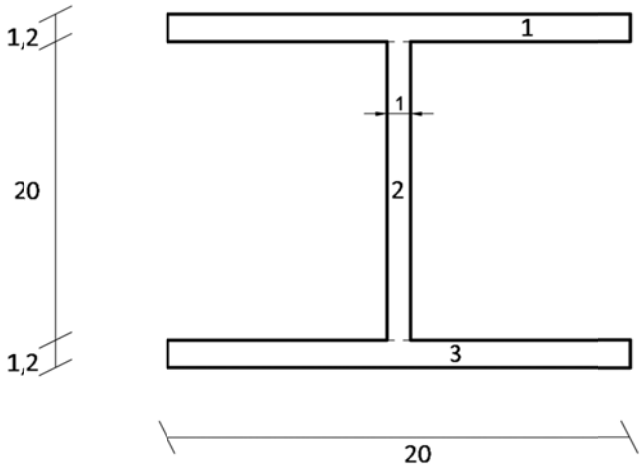
$$\frac{T_y}{5 \cdot 60} = 0{,}2$$

Criterio di Von Mises:

$$\sigma_{id} = \sqrt{\sigma_x^2 + 3\tau_{yz}^2 + \sigma_y^2 - \sigma_x\sigma_y} < \sigma_P$$

Esempio Torsione:

$\boldsymbol{M_z = 4\ kNm} = 400\ kNcm$



1)

$I_{t1} = \frac{1}{3} \cdot 1,2^3 \cdot 20 = \frac{34,56}{3} = 11,52cm^4$

$I_{t3} = I_{t1}$

$I_{t2} = \frac{1}{3} \cdot 1^3 \cdot 20 = \frac{20}{3} = 6,66cm^4$

$\Sigma I_t = 29,7cm^4$

2)

$M_{z1} = 400 \cdot \frac{11,52}{29,7} = 155,15\ kNcm$

$M_{z3} = M_{z1}$

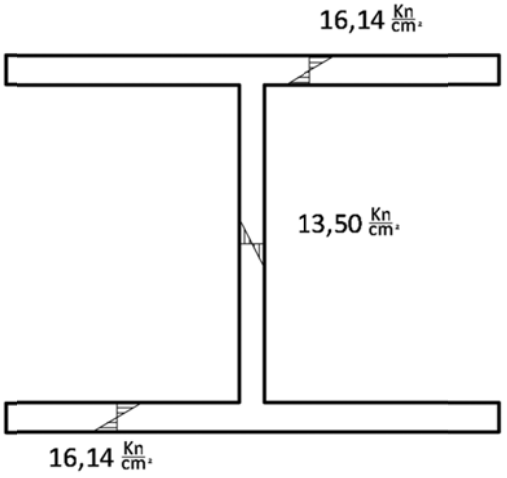
$M_{z2} = 400 \cdot \frac{6,66}{29,7} = 89,69\ kNcm$

3)

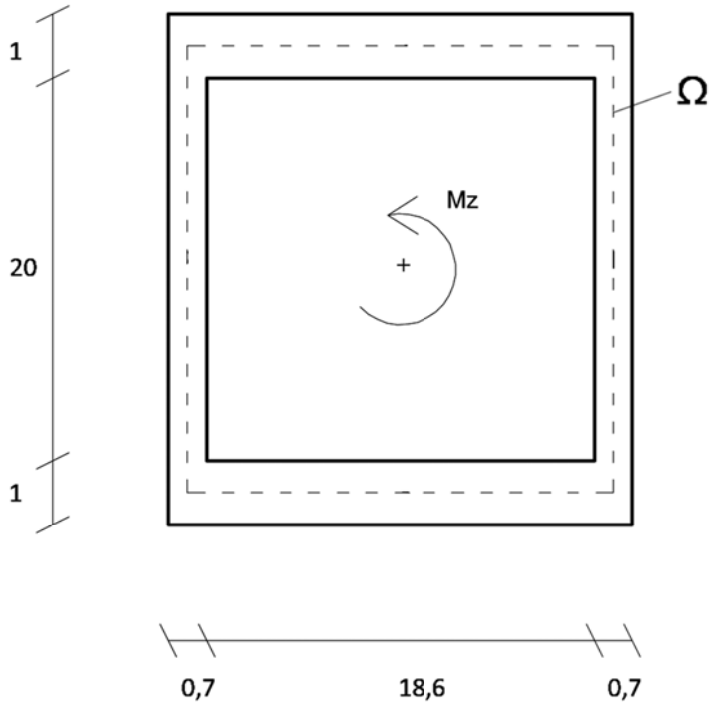
$\tau_{max1} = \frac{155 \cdot 1,2}{11,52} = 16,14\ kN/cm^2$

$\tau_{max3} = \tau_{max1}$

$\tau_{max2} = \frac{90 \cdot 1}{6,66} = 13,5\ kN/cm^2$



$\boldsymbol{M_z = 40KNm} = 4000\ KNcm$



$\Omega = 405{,}3cm \implies area\ interna\ alla\ linea\ media$

$$\tau_{verticali} = \frac{M_z}{(2 \cdot \Omega) \cdot b_{vert.}} = \frac{4000kNcm}{810{,}6cm^2 \cdot 0{,}7cm} = 7{,}05kN/cm^2$$

$$\tau_{orizzontali} = \frac{M_z}{(2 \cdot \Omega) \cdot b_{orizz.}} = 4{,}93kN/cm^2$$