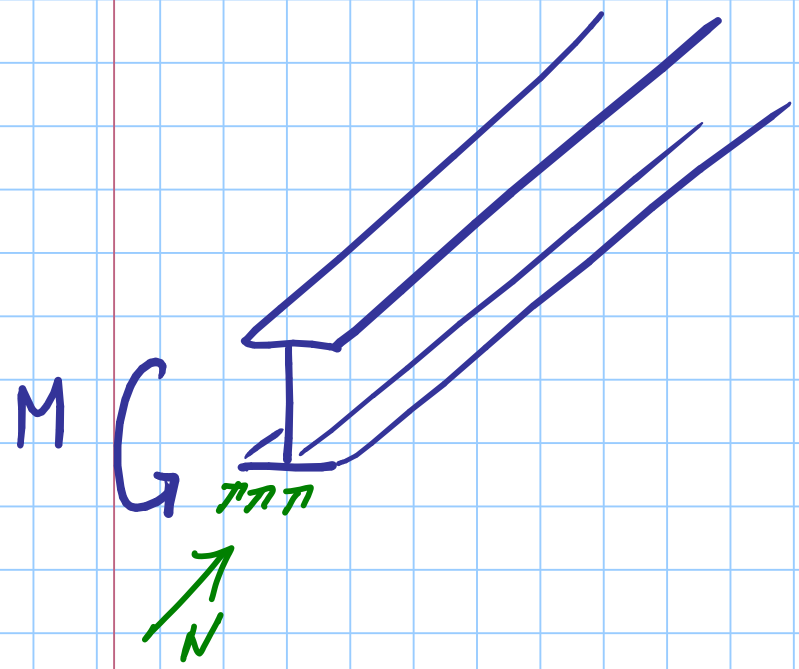
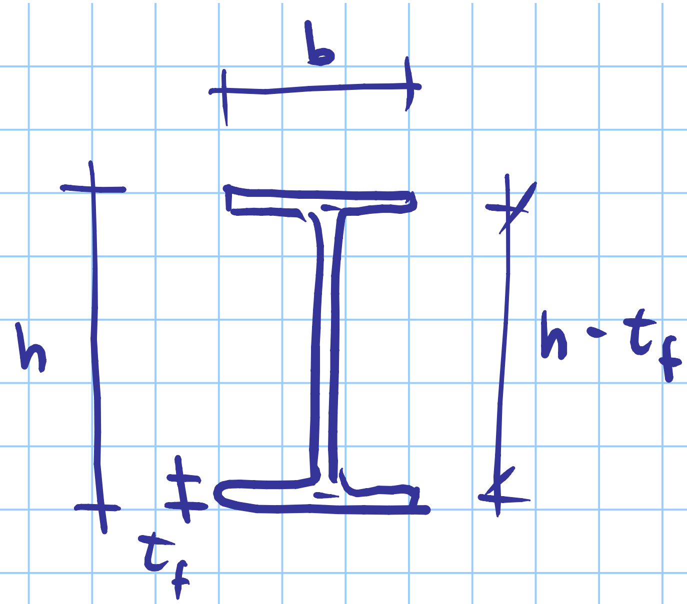
Titolo nota

11/12/2013





$$N \simeq \frac{M}{h - t_f}$$

$$N_{cr} = \frac{\pi^2 E I}{\ell_0^2}$$

$$I = \frac{t_f\, b^3}{12}$$

$$N_{cr} = \frac{\pi^2 E \ t_f b^3}{12 \ \ell_0}$$

$$M_{cr} = N_{cr} \left(h - t_f \right)$$

$$M_{cr} = \sqrt{\frac{\pi^2 E I_z}{\ell^2} \left(G I_t + \frac{\pi^2 E I_w}{\ell^2} \right)}$$

$$= \frac{\pi}{\ell} \sqrt{E I_z G I_t} \sqrt{1 + \frac{\pi^2 E I_w}{\ell^2 G I_t}}$$

$$\bar{\lambda}_{LT} = \sqrt{\frac{W_y \, f_y}{M_{cr}}}$$

$$\phi_{LT} = 0.5\left[1 + \alpha\left(\bar{\lambda}_{LT} - \overset{\bar{\lambda}_{LT,0}}{0.2}\right) + \overset{\beta}{}\bar{\lambda}_{LT}^{2}\right]$$

$$\chi_{LT} = \frac{1}{\phi_{LT} + \sqrt{\phi_{LT}^{2} - \underset{\beta}{}\bar{\lambda}_{LT}^{2}}}$$

$$\bar{\lambda}_{LT,0} = 0.4$$

$$\beta = 0.75$$

$$M_{cr} = 18.87 \text{ KNm}$$

$$\bar{\lambda}_{LT} = \sqrt{\frac{W_y f_y}{M_{cr}}} = \sqrt{\frac{123.9 \times 10^3 \times 275}{18.87 \times 10^6}} = 1.344$$

$$\alpha_{LT} = 0.34$$

$$\phi = 0.5 \left[1 + 0.34 (1.344 - 0.2) + 1.344^2 \right] = 1.60$$

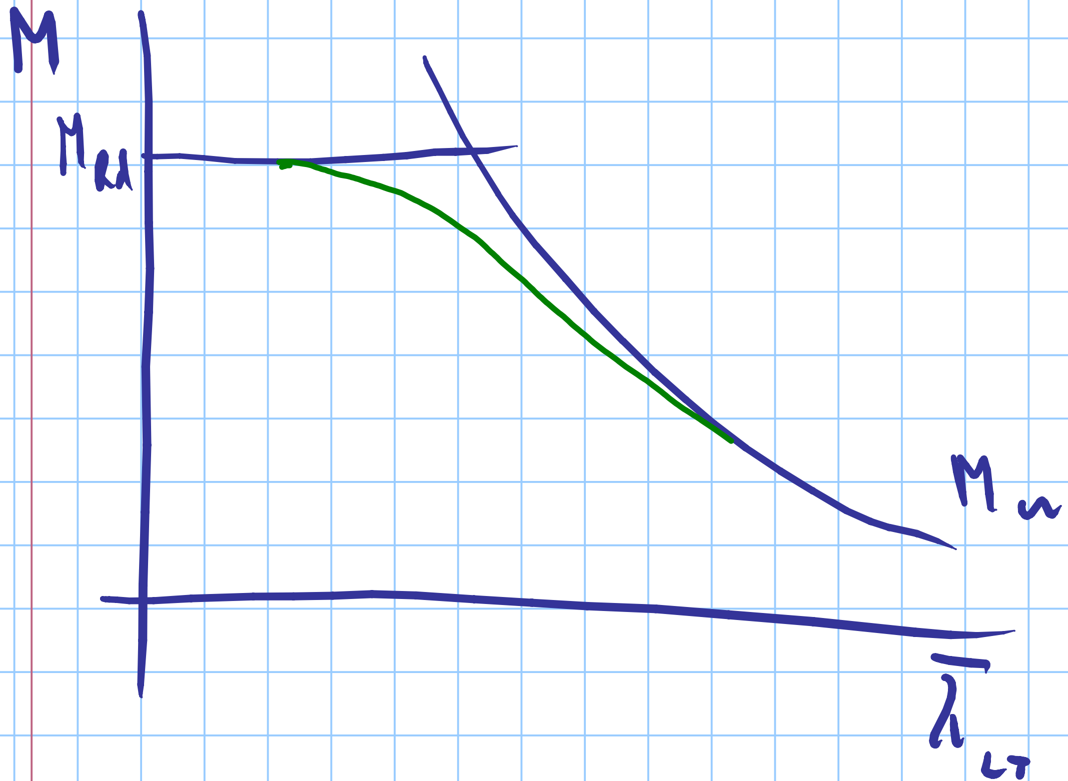
$$0.5 \left[1 + 0.34 (1.344 - 0.4) + 0.75 \times 1.344^2 \right] = 1.34$$

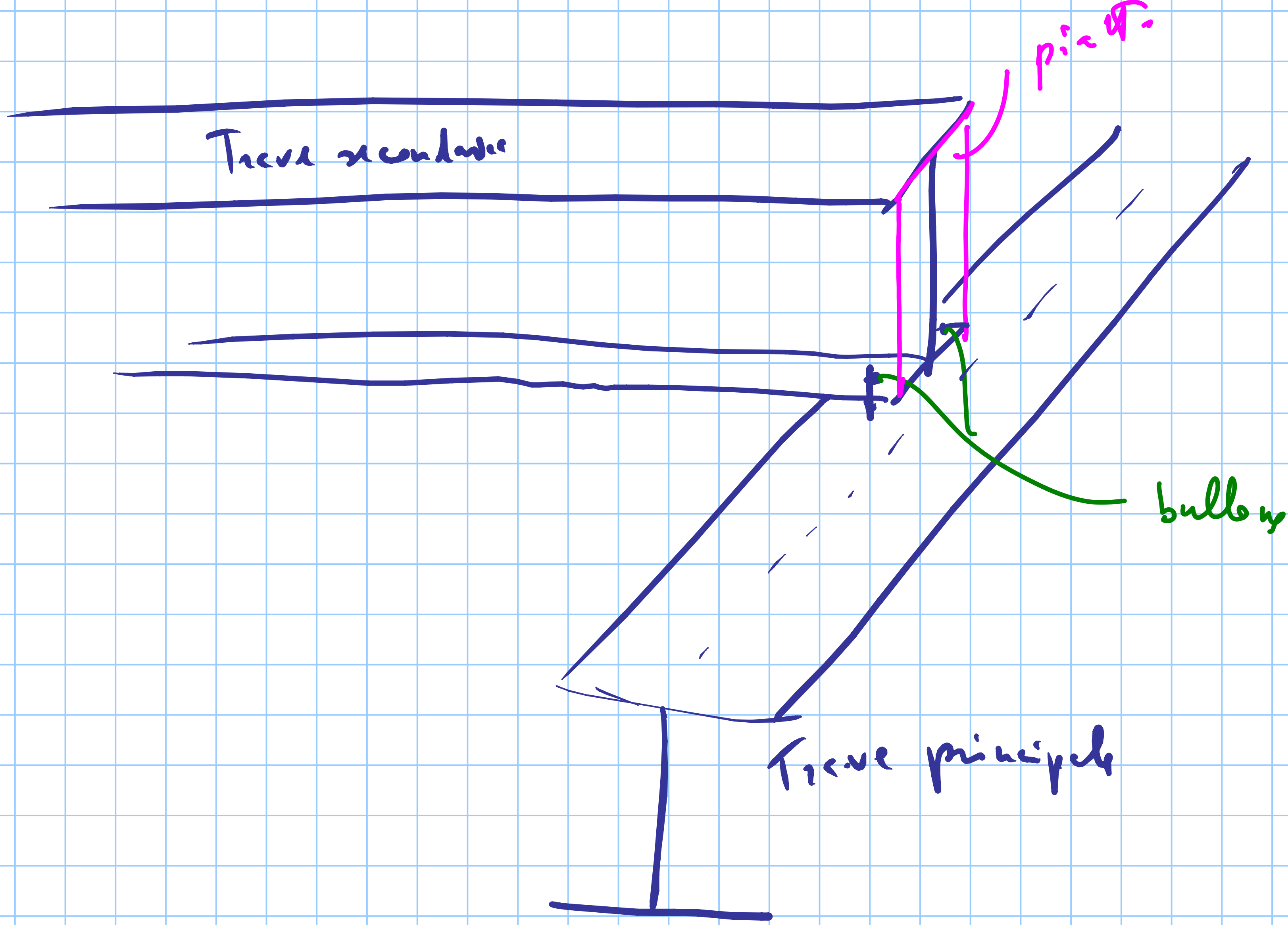
$$\chi = \frac{1}{1.60 + \sqrt{1.60^2 - 1.344^2}} = 0.406$$

$$\frac{1}{1.34 + \sqrt{1.34^2 - 0.75 \times 1.344^2}} = 0.501$$

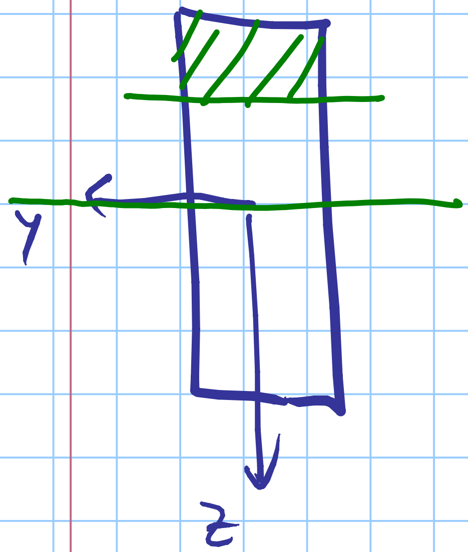
senza instabilità $\quad M_{Rd} = 32.5 \text{ kNm}$

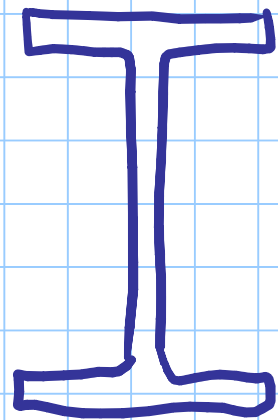
con instabilità $\quad M_{Rd} = 13.2 \text{ kNm} \quad$ opp. 16.2 kNm


M
M_Rd
M_cr
λ̄_LT


piatti
Trave secondaria
bulloni
Trave principale

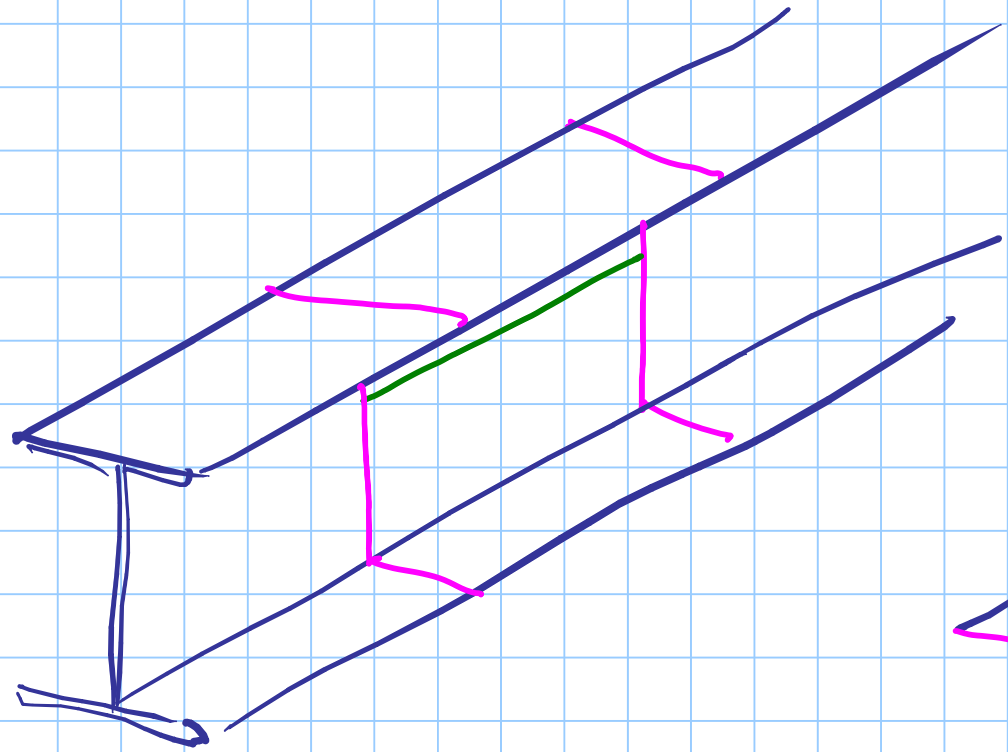
TAGLIO

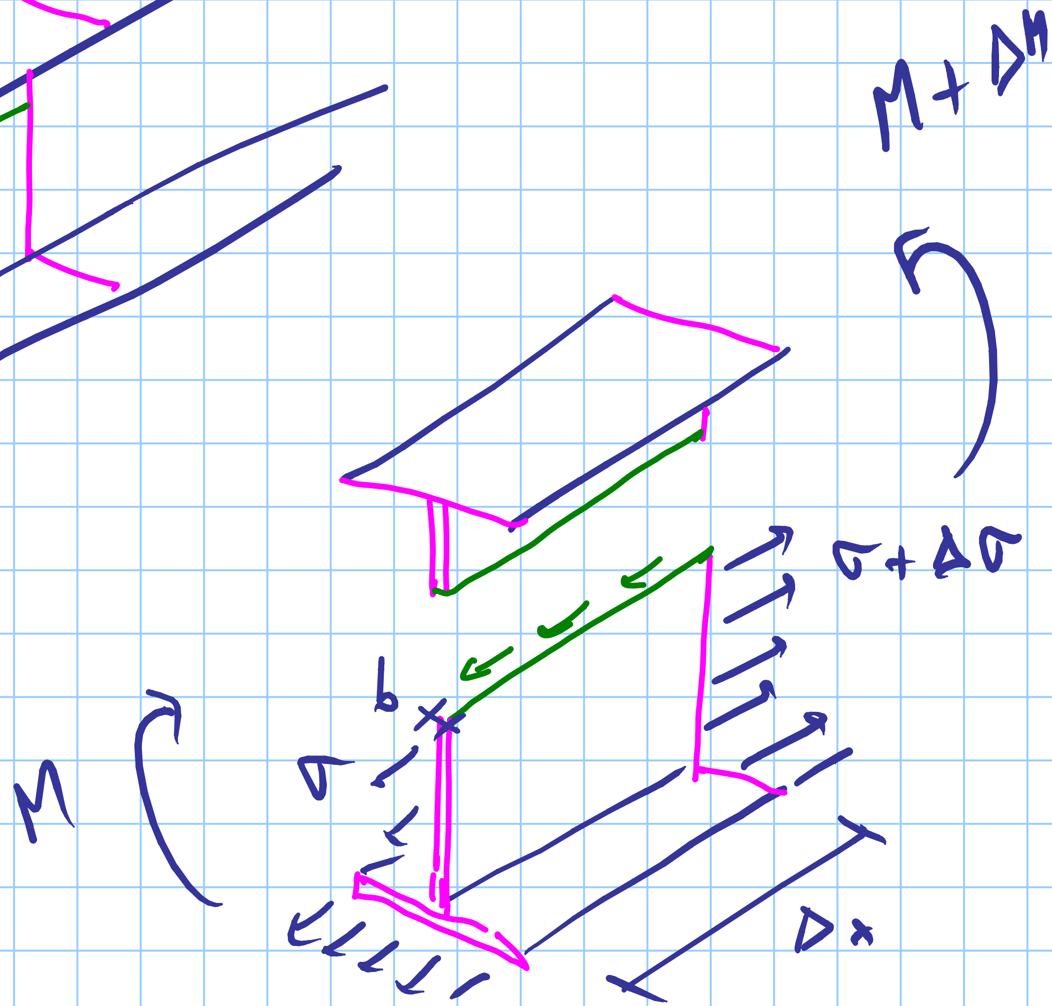




JOURAWSKI

$$\tau_{zx} = \frac{V_z\, S}{I_y\, b}$$





$$\sigma = \frac{M}{I} z$$

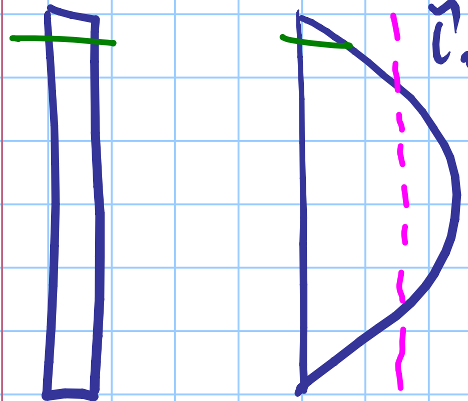
$$\Delta\sigma = \frac{\Delta M_y}{I} z = \frac{V \cdot \Delta x}{I} z$$

$$\int \Delta\sigma \, dA = \int \frac{V \, \Delta x}{I} z \, dA = \frac{V \, \Delta x}{I} \overbrace{\int z \, dA}^{S}$$

$$\tau \, \Delta x \, b$$

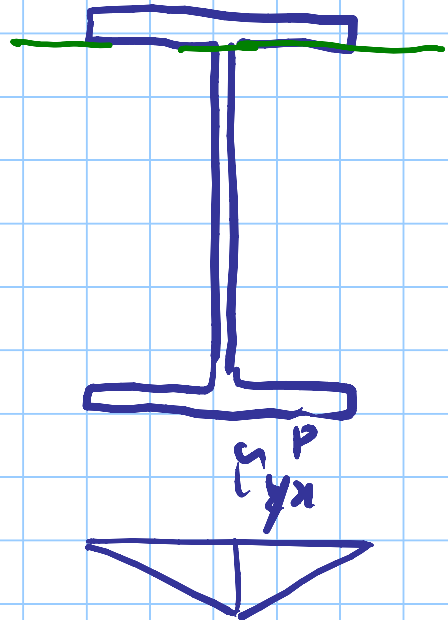
$$\frac{V \, \cancel{\Delta x}}{I} S = \tau \, \cancel{\Delta x} \, b \Rightarrow \tau = \frac{V S}{I b}$$

τ



$\tau_{max} = \frac{3}{2} \frac{V}{A}$

parabola

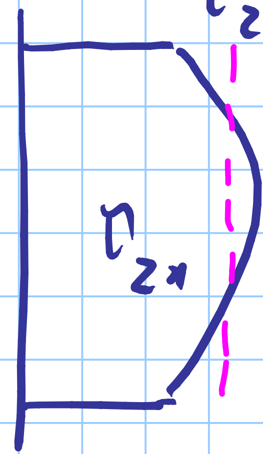


τ_{yx}^{p}

τ_{yx}

τ

τ_{zx}^{p}



τ_{zx}

$$V_z = \int \tau_{zx} \, dA$$

modello elastico lineare

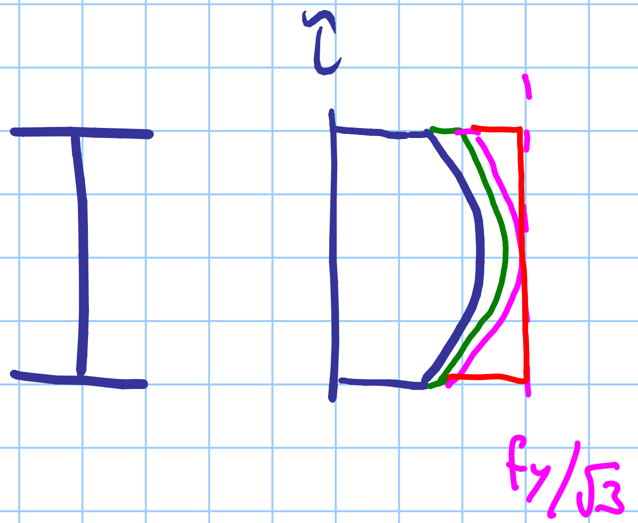
$\sigma_x \qquad \tau_{zx}$

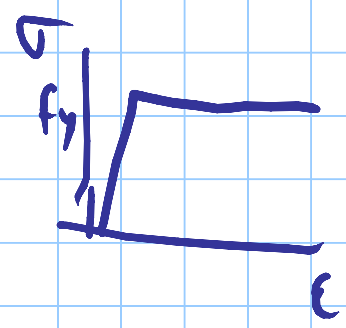
$$\sigma_{id} = \sqrt{\sigma^2 + 3\tau^2} \leq \bar{\sigma}$$

se ci sono solo τ

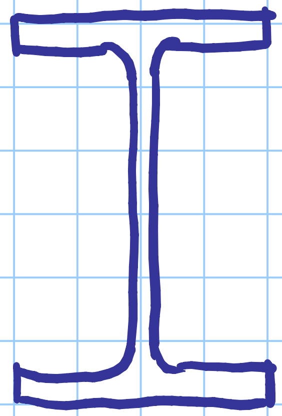
$$\tau_{max} \leq \frac{\bar{\sigma}}{\sqrt{3}}$$

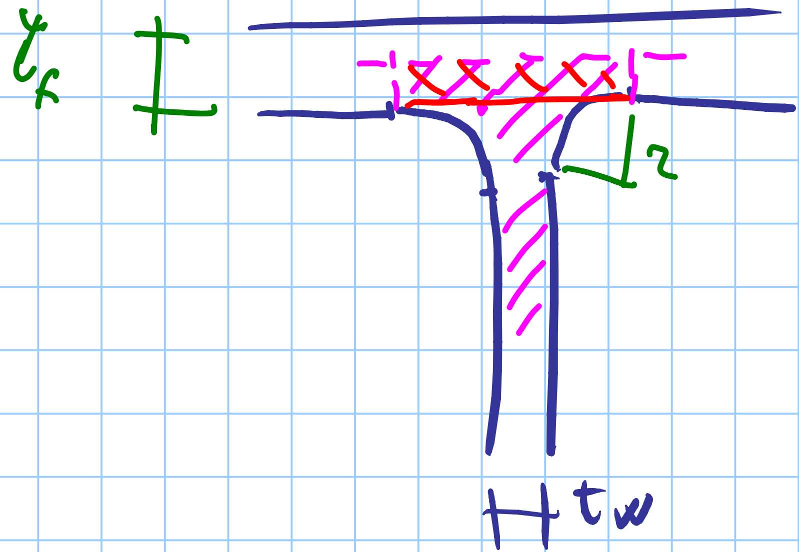
modello non lineare   rel. σ



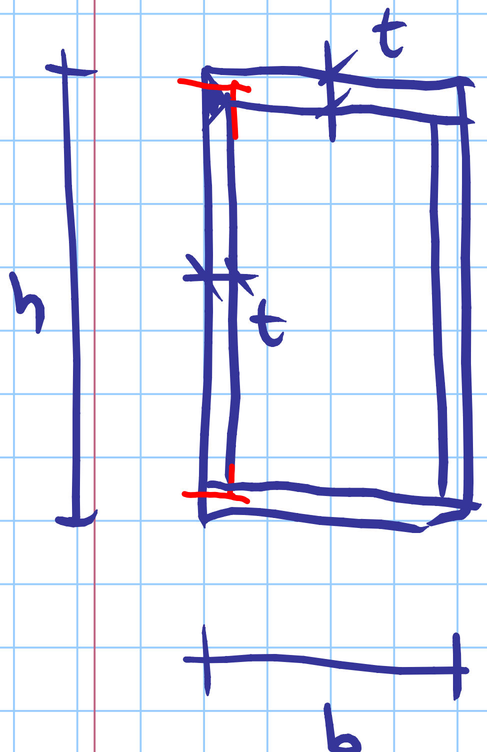


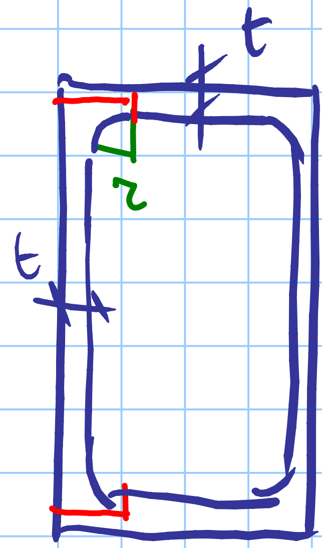
$$V_{Rd} = A_v \frac{f_y/\sqrt{3}}{\gamma_{M0}}$$





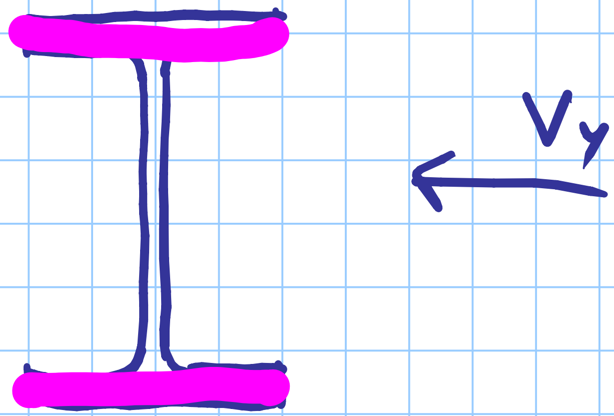
$$A_v = A - 2bt_f + (2r + t_w)\,t_f$$





$$A_v = A - 2bt + (t+r)2t$$

$$A_v = 2t(h-t)$$


V_y

IPE 160 S 275

$$A_v = A - 2\, b\, t_f + (2r + t_w)\, t_f =$$

$$= 2010 - 2 \times 82 \times 7.4 + (2 \times 9 + 5) \times 7.4 = 966.6 \text{ mm}$$

$$V_{Rd} = A_v \frac{f_y/\sqrt{3}}{\gamma_{M0}} = \frac{966.6 \times 275/\sqrt{3}}{1.05} \times 10^{-3} = 146.2 \text{ kN}$$

$$M_{y,Rd} = 32.45 \text{ KNm}$$

$l = 5.00$ m $\qquad g_d + q_d = 10$ kN/m

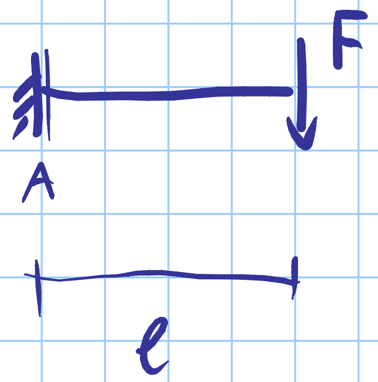
$$M_{Ed} = \frac{ql^2}{8} = \frac{10 \times 5^2}{8} = 31.25 \text{ kNm}$$

OK IPE 160

$$V_{Ed} = \frac{ql}{2} = \frac{10 \times 5}{2} = 25 \text{ kN}$$

	Ed	Rd	
M	31.25	32.45	kNm
V	25	146.2	kN

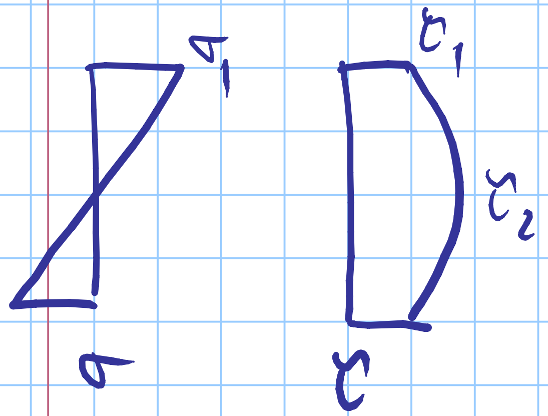
TAGLIO + FLESSIONE



$$M_{Ed,\,max} = F\ell$$

$$V_{Ed} = F$$

con modello lineare



$$\sqrt{\sigma_1^2 + 3\,\tau_1^2} \leq \bar{\sigma}$$

$$\tau_2 \leq \frac{\bar{\sigma}}{\sqrt{3}}$$

$F_k = 12$ kN per TA

$\ell = 2.00$ m

$M_{max} = 24$ kNm

$V_{max} = 12$ kN

IPE160

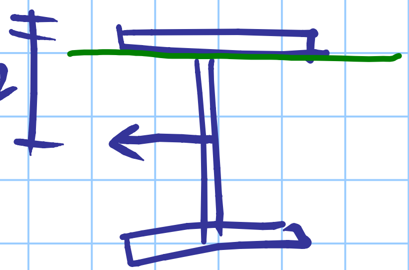
S355

$\sigma_1 = \frac{M}{W_d} = \frac{24 \times 10^6}{108.7 \times 10^3} = 220.8$ MPa OK

$\bar{\sigma} = 240$ MPa

$\tau_1 \quad \frac{VS}{Ib}$

S $\frac{h}{2}$



$S = b\, t_f \left(\frac{h}{2} - \frac{t_f}{2}\right)$

$= 46.3 \times 10^3$ mm^3

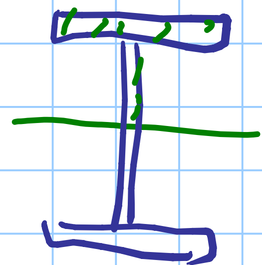
$I = 869 \times 10^4$

$b = t_w = 5$ mm

$$\tau_1 = \frac{12 \times \cancel{10^3} \times 46.3 \times \cancel{10^3}}{8{,}69 \times \cancel{10^4} \times 5} = 12.8 \text{ MPa}$$

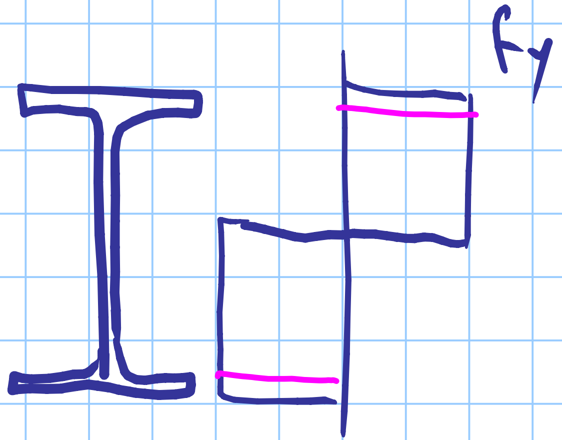
$$\sigma_{id} = \sqrt{220.8^2 + 3 \times 12.8^2} = 221.9 \text{ MPa} \qquad \text{ok}$$

$$\tau_2 = \frac{V S}{I b} \qquad S$$



$$S_{1/2\,m} = \frac{W_{pl}}{2} = \frac{123.9 \times 10^3}{2} = 61.95 \times 10^3$$

TAGLIO + MOM. FLETTENTE SLU



nell'anima $\sqrt{\sigma^2 + 3\tau^2} = f_y$

$$\sigma^2 = f_y^2 - 3\tau^2 \qquad \sigma = f_y \sqrt{1 - \frac{3\tau^2}{f_y^2}}$$

$$V_{Rd} = A_v \, f_y/\sqrt{3}$$

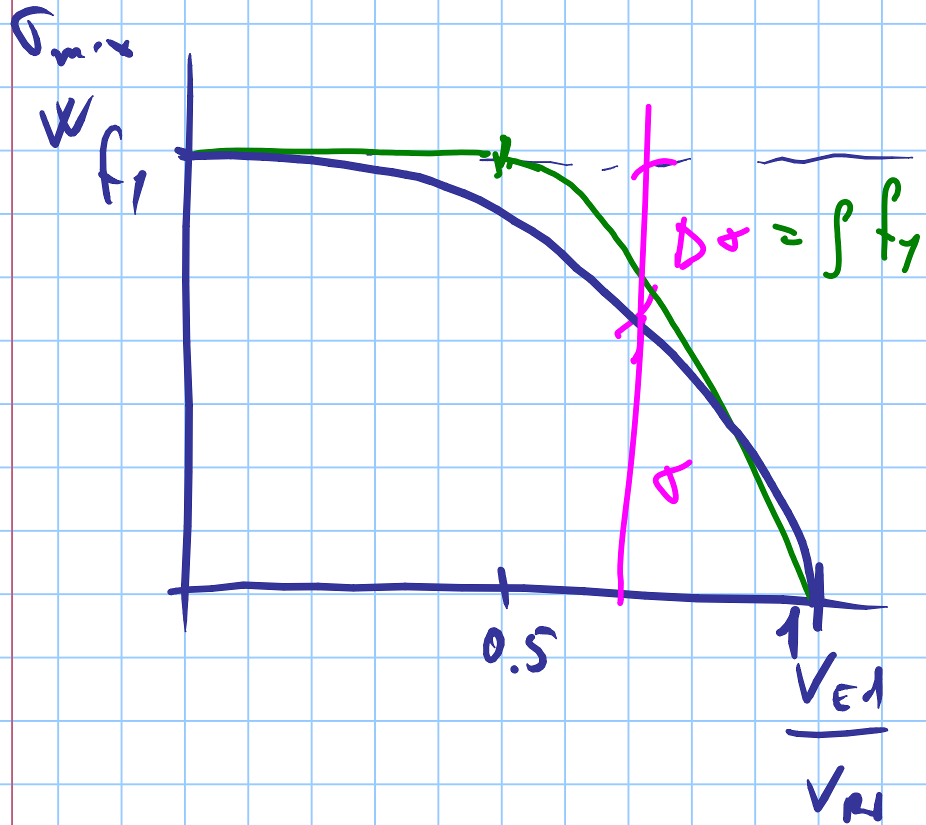
$$\frac{\tau}{f_y/\sqrt{3}} = \frac{V_{Ed}}{V_{Rd}}$$

$$V_{Ed} = A_v \, \tau_{(medio)}$$

$$\frac{3\tau^2}{f_y^2} = \left(\frac{V_{Ed}}{V_{Rd}}\right)^2$$

$$\sigma = f_y \sqrt{1 - \left(\frac{V_{Ed}}{V_{Rd}}\right)^2} = f_y - \Delta\sigma$$

$$\Delta\sigma = f_y \underbrace{\left[1 - \sqrt{1 - \left(\frac{V_{Ed}}{V_{Rd}}\right)^2}\right]}_{\rho}$$



NORMATIVA

se $V_{Ed} \leq \frac{1}{2} V_{Rd}$

la riduzione è trascurabile

se $V_{Ed} > \frac{1}{2} V_{Rd}$

$$\rho = \left(2 \frac{V_{Ed}}{V_{Rd}} - 1\right)^2$$

$$\frac{A_v^2}{4\,t_w}$$

$$M_{pl} = \left(W_{pl} - \rho\, 2S_{1/2w}\right)\frac{f_y}{\gamma_{M0}}$$

$$W_{pl,w} = 2\,S_{1/2w} = \frac{t_w h^2}{4} = \frac{t_w^2 h^2}{4\,t_w} = \frac{A_v^2}{4\,t_w}$$