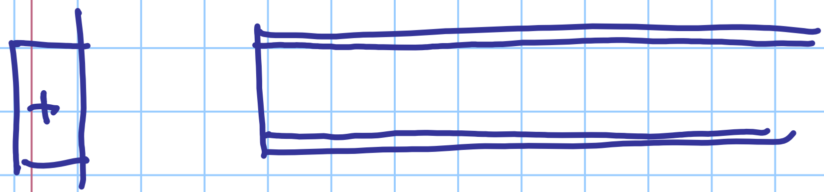
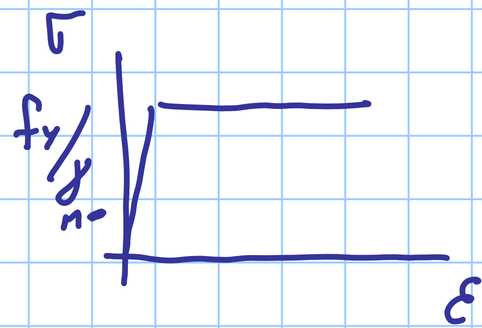


$\rightarrow N > 0$ TRAZIONE

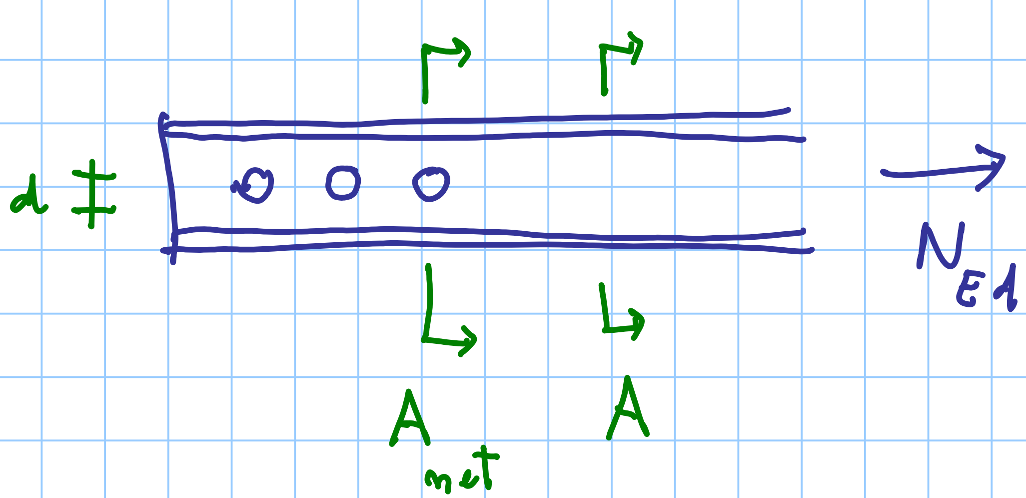
$\sigma = \frac{N}{A}$ $\qquad \sigma \le \frac{f_y}{\gamma_{M0}}$



$$N_{t,Rd} = A \frac{f_y}{\gamma_{M0}}$$

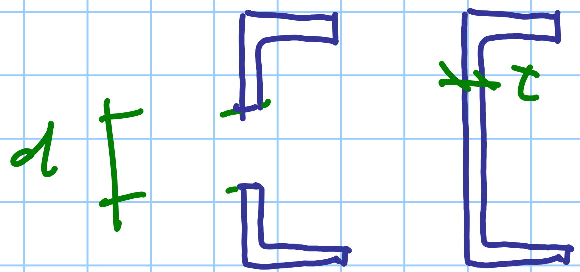
VERIFICA $N_{Ed} \le N_{Rd}$

PROGETTO $A \ge \frac{N_{Ed}\,\gamma_{M0}}{f_y}$

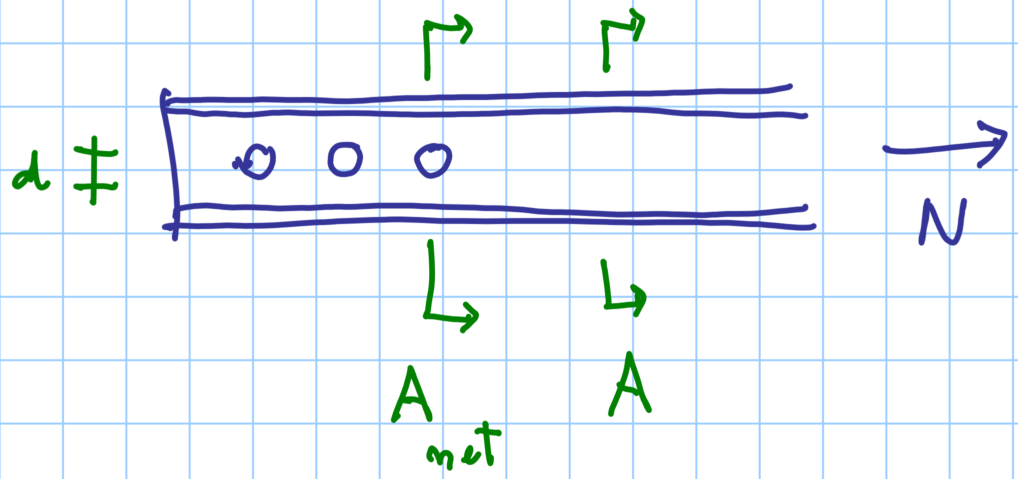


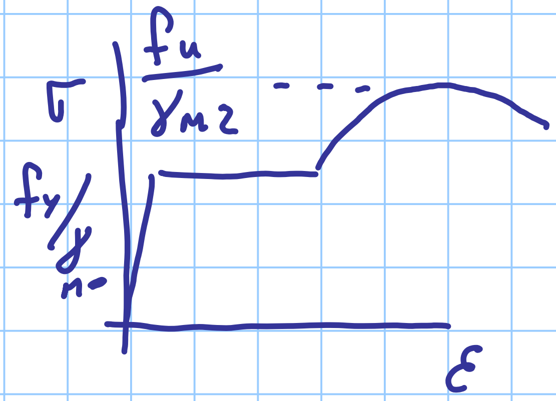
d : diametro foro

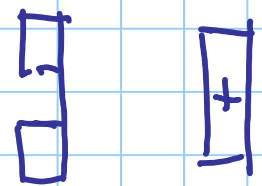
t = spessore



$$A_{net} = A - d\,t$$







$$N = A_{net} \frac{f_y}{\gamma_{M0}}$$ snervamento in corrisp. del foro

$$\sigma_2 = \frac{N}{A_{net}} \qquad \sigma_1 = \frac{N}{A}$$

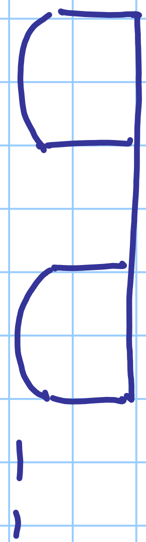
$$N_{u,Rd} = 0{,}9\, A_{net} \frac{f_u}{\gamma_{M2}}$$

$\sigma_2 > \sigma_1$

tiene conto del fatto che $\sigma \neq$ cost

Nella realtà:

$\sigma \neq \text{cost}$



$$\frac{f_u}{\gamma_{M2}}$$

$$\int \sigma \, dA < A_{net} \frac{f_u}{\gamma_{M2}}$$

$$= 0.9 \, A_{net} \frac{f_u}{\gamma_{M2}}$$

$$N_{Rd} = \mathrm{MIN}\left(N_{t,Rd} \ , \ N_{u,Rd} \right)$$

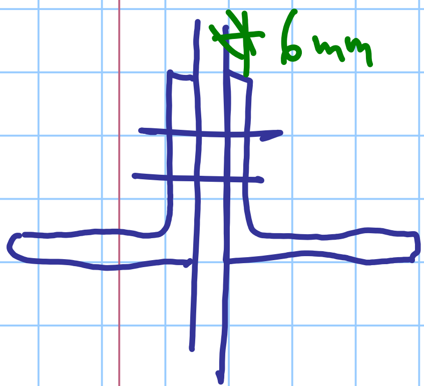
snervamento sezione standard

rottura sezione forata

se $N_{u,Rd} < N_{t,Rd}$ comportamento FRAGILE

se $N_{t,Rd} < N_{u,Rd}$ comportamento DUTTILE avevamo progett. per $N_{Ed} = 300$ KN $< N_{t,Rd}$ OK

2 L 60x60x6   fori $d_0 = 13$ mm



$$N_{t,Rd} = \underset{13.82\times10^2\ mm^2}{A}\ \frac{\overset{235}{f_y}}{\gamma_{M0}} = 309.3\ KN$$

$$A_{net} = A - 2dt = 13.82\times10^2 - 2\times13\times6 = 12.26\times10^2\ mm^2$$

$$N_{u,Rd} = 0.9\, A_{net} \frac{f_y}{\gamma_{M2}} = 0.9 \times 12.26 \times 10^2 \times \frac{360}{1.25} \times 10^{-3}$$

$$= 317.8 \text{ KN}$$

l'asta può portare $N_{Ed} = 300$ KN

comportamento duttile perché $\underset{309.3}{N_{t,Rd}} < \underset{317.8}{N_{u,Rd}}$

$$N_{t,Rd} < N_{u,Rd}$$

DUTTILE

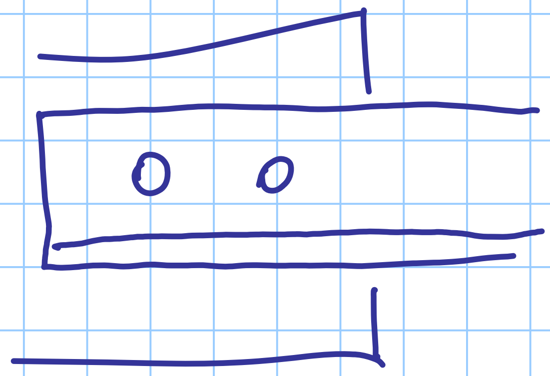
$$A \frac{f_y}{\gamma_{M0}} < 0.9 A_{net} \frac{f_u}{\gamma_{M2}}$$

$S235 = 0.863$

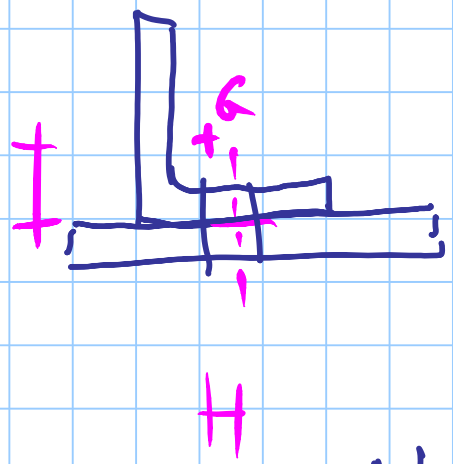
$S275 = 0.846$

$S355 = 0.921$

$$\frac{A_{net}}{A} > \frac{f_y / \gamma_{M0}}{0.9 \; f_u / \gamma_{M2}} = \frac{f_y \; \gamma_{M2}}{0.9 \; f_u \; \gamma_{M0}}$$

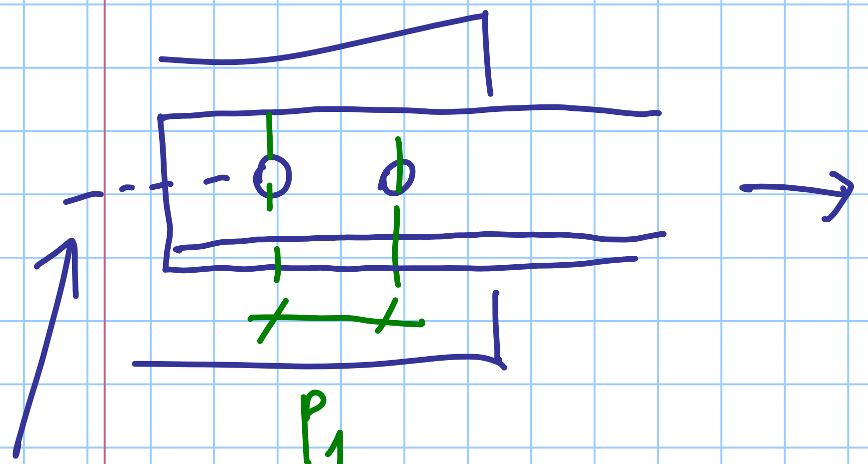


UNA SOLA L



la sezione di collegamento è soggetta a M, N

$$N_{u,Rd} = \beta A_{net} \frac{f_u}{\gamma_{M2}}$$



se vi sono 2 bulloni

ASSE DI TRUSCHINO

$\beta = \beta_2$

$p_1 \leq 2{,}5\, d_0$

$\beta_2 = 0.4$

$p_1 \geq 5\, d_0$

$\beta_2 = 0.7$

per 3 bulloni

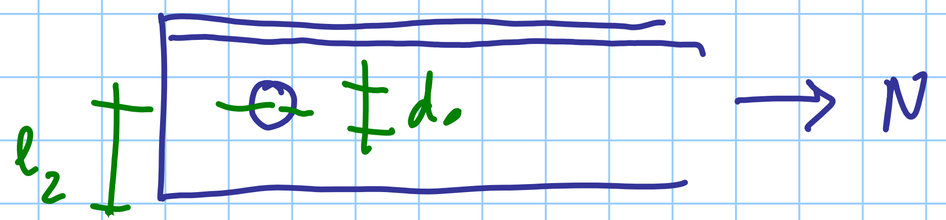
o >3

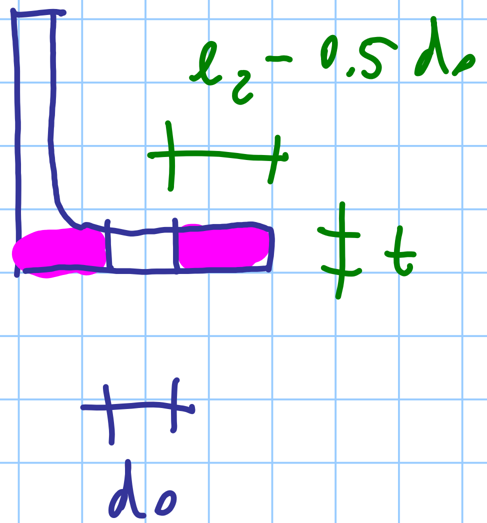
$\beta = \beta_3$

$\beta_3 = 0.5$

$\beta_3 = 0.7$

per un solo bullone





$$N_{u,Rd} = 2(\ell_2 - 0.5\, d_0)\, t \; \frac{f_u}{\gamma_{M2}}$$

FLESSIONE SEMPLICE

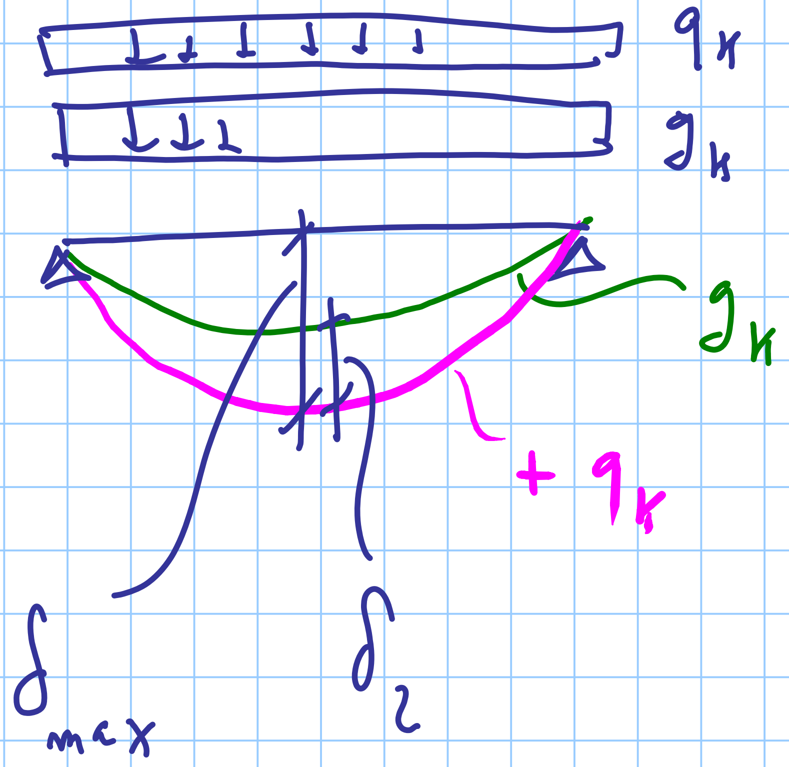
VERIFICA SLU

comportamento
condizionato da instabilità locale → classi

1 } piena
2 } plasticizz.
3 | al limite f_y
4

VERIFICA SLE

deformazioni



si accettano frecce doppie per sbalzi

	δ_{max}	δ_2
coperture	$\frac{1}{200} L$	$\frac{1}{250} L$
solaio praticabile	$\frac{1}{250} L$	$\frac{1}{300} L$
con tramezzi fragili	$\frac{1}{250} L$	$\frac{1}{350} L$

IPE 180

$L = 6.00\ m$

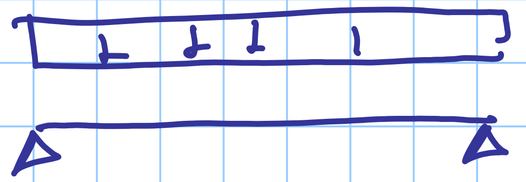
$g_k = 0.5\ kN/m$

$q_k = 1.6\ kN/m$

limiti $\quad \delta_{max} = \frac{1}{200} L = 30\ mm$ [$q = 2{,}1\ kN/m$] $\quad E = 210\,000\ MPa$

$\delta_2 = \frac{1}{250} L = 24\ mm$ [$q = 1.6\ kN/m$]

IPE 180 $\quad I_y = 1317 \times 10^4\ mm^4$



q

$$\delta = \frac{5}{384} \, \frac{q L^4}{E I}$$

$$(6 \times 10^3)^4 = 6^4 \times 10^{3\,4}$$

$$\delta_{max} = \frac{5}{384} \, \frac{2.1 \times 6.00^4 \times \cancel{10^{12}}}{210'000 \times 1'317 \times \cancel{10^{6}}} = 12.8 \text{ mm}$$

$$\delta_2 = 9.76 \text{ mm}$$

$$\frac{5}{384}\,\frac{qL^4}{EI} \leq \delta_{max}$$

$$I \geq \frac{5}{384}\,\frac{qL^4}{E\,\delta_{max}} = \frac{5 \times 2.1 \times 6^4 \times 10^{\cancel{12}\;4}}{384 \times 210000 \times 30} = 562.5 \times 10^4$$

con $\delta_2 \quad \dfrac{1.6}{24} \rightarrow$

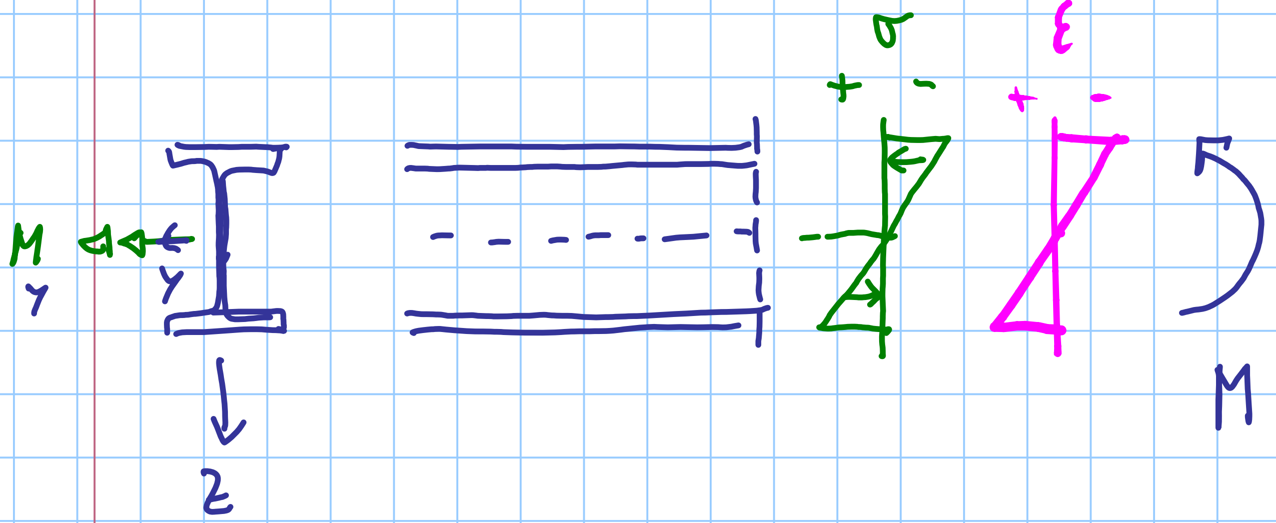
IPE 160 $\quad I = 869.3 \times 10^4$

IPE 140 $\quad I = 541.2 \times 10^4$

HE 120A $\quad I = 606.2 \times 10^4$

OK IPE 160 o HE 120 A

peso 0.158 kN/m $\qquad$ 0.199 kN/m



$\sigma = E\,\varepsilon$

elasticità lineare

$$\varepsilon = \varepsilon_G + \frac{d\varepsilon}{dy}\,y + \frac{d\varepsilon}{dz}\,z$$

χ

$\frac{1}{r}$

$$N = \int_A \sigma \, dA$$

$$M_y = \int_A \sigma z \, dA$$

$$M_z = -\int_A \sigma y \, dA$$

$$N = \int E\left(\varepsilon_G + \chi_y\, y + \chi_z\, z\right) dA =$$

$$= E\,\varepsilon_G \underbrace{\int dA}_{A} + E\,\chi_y \underbrace{\int y\, dA}_{\text{zero}} + E\,\chi_z \underbrace{\int z\, dA}_{\text{zero}}$$

$$N = E\,\varepsilon_G\, A \qquad\qquad \varepsilon_G = \frac{N}{EA}$$

$$M_y = \int E\left(\varepsilon_t + \chi_y\, y + \chi_z\, z\right) z\, dA =$$

$$= E\,\varepsilon_t \underbrace{\int z\, dA}_{\text{zero}} + E\,\chi_y \underbrace{\int y z\, dA}_{\text{zero}} + E\,\chi_z \underbrace{\int z^2\, dA}_{I_y}$$

$$M_y = E\,\chi_z\, I_y \qquad \chi_z = \frac{M_y}{E\, I_y} \qquad \chi_y = -\frac{M_z}{E\, I_z}$$

$$\varepsilon = \varepsilon_G + \chi_y \, y + \chi_z \, z =$$

$$= \frac{N}{EA} - \frac{M_z}{E I_z} y + \frac{M_y}{E I_y} z$$

$$\sigma = E \varepsilon = \frac{N}{A} + \frac{M_y}{I_y} z - \frac{M_z}{I_z} y$$

NAVIER

$$\sigma = \frac{M_y}{I_y} z$$

$$\sigma_{max} = \frac{M_y}{I_y} z_{max} = \frac{M_y}{W_y}$$

per sezioni di classe 3

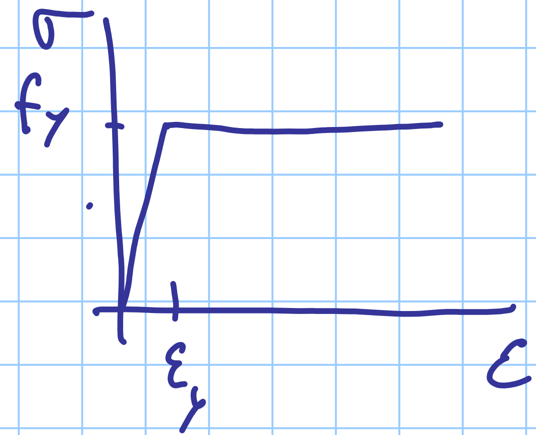
modello lineare limita $\sigma = \frac{f_y}{\gamma_{M0}}$

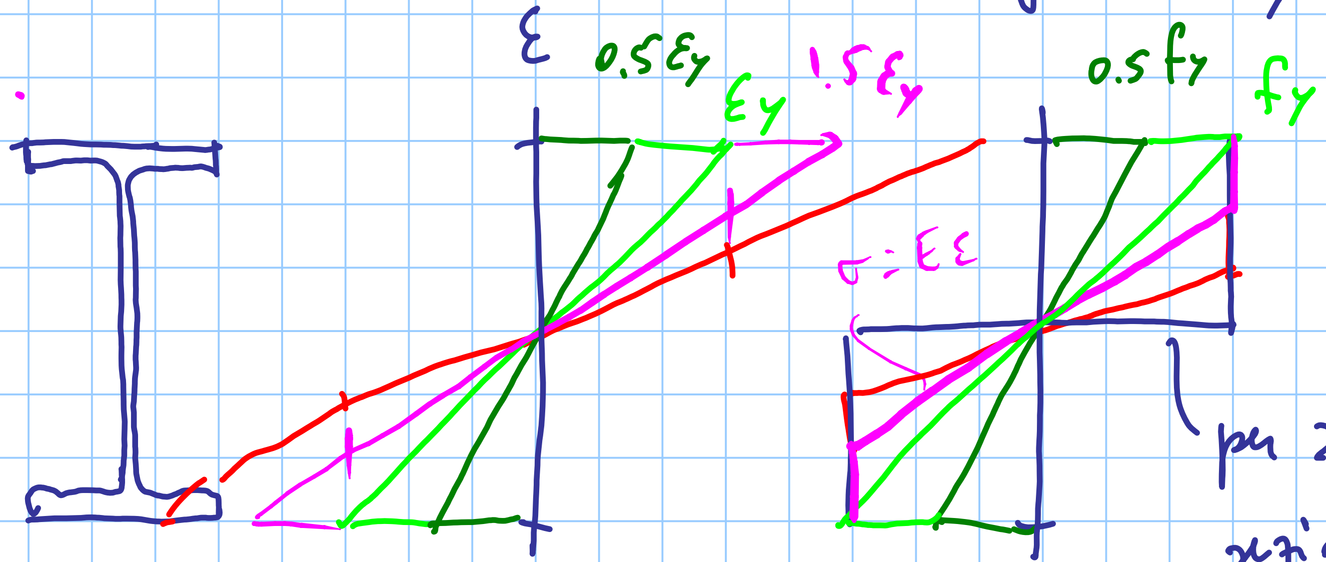
$$M_{Rd} = W_{el,y} \frac{f_y}{\gamma_{M0}}$$

classe 1 e 2 comportamento plastico

sezione piana SI

legame lineare NO





per $x \to \infty$

sezione pienamente plasticizzata