Titolo nota 13/11/2013

FLESSIONE SEMPLICE RETTA

$$M_{Rd} = W_{pl} \frac{f_y}{\gamma_{M0}}$$ SLU

$$f \leq \frac{1}{n} L$$ SLE

- influenza delle imperfezioni

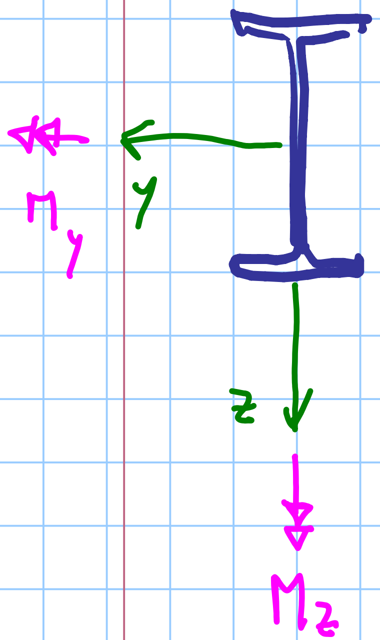
NESSUNA su M_{Rd}

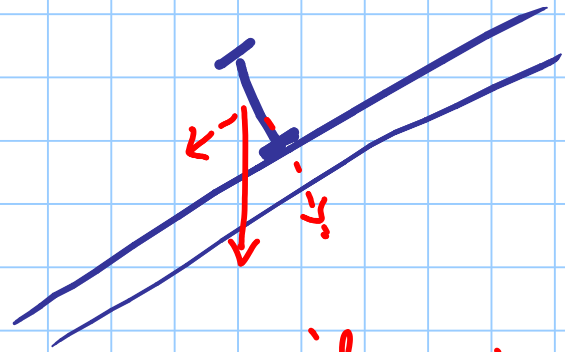
- comportamento per la presenza di fori

esaminare l'ala tesa

DUTTILE se $$0.9\, A_{f,net} \frac{f_u}{\gamma_{M2}} \geq A_f \frac{f_y}{\gamma_{M0}}$$

FLESSIONE SEMPLICE DEVIATA



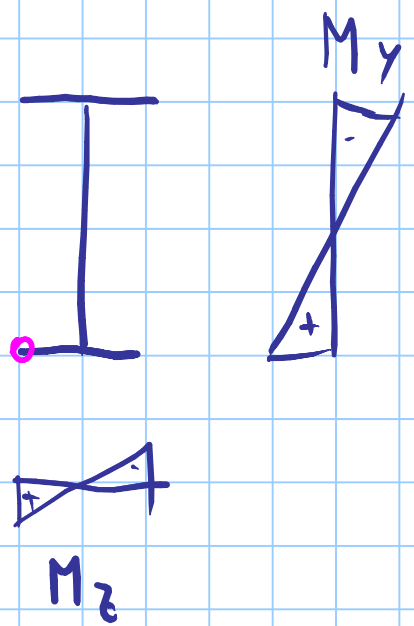


il carico genera sia M_y che M_z

modello elastico lineare

M_y $\quad$ M_z

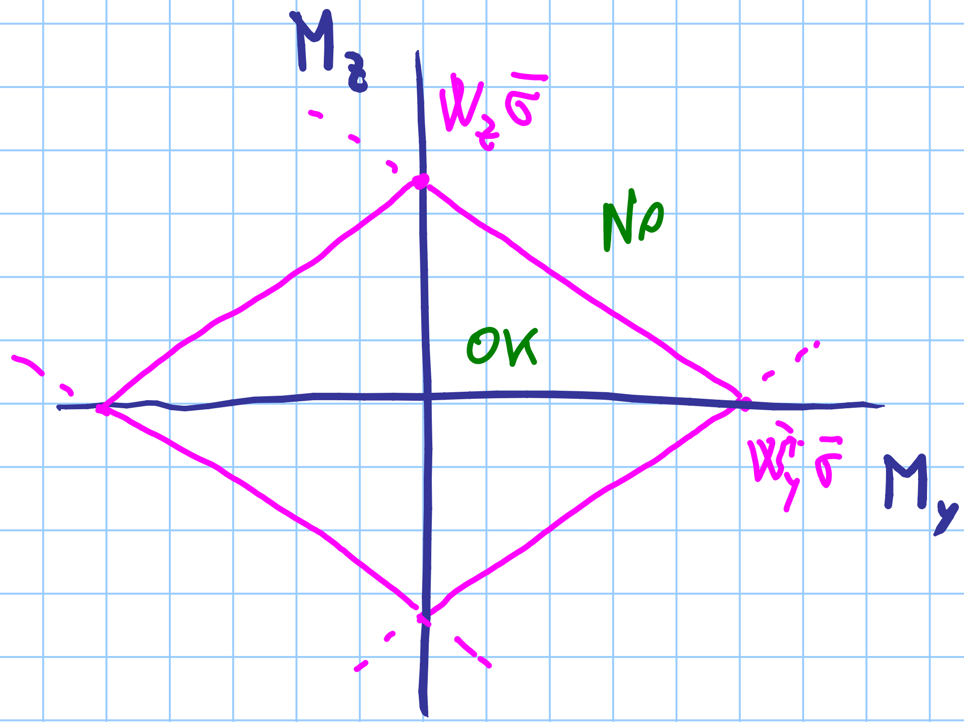
$$\sigma = \frac{M_y}{I_y} z + \frac{M_z}{I_z} y \le \bar{\sigma}$$



$$\sigma_{max} = \frac{M_y}{W_y} + \frac{M_z}{W_z} \le \bar{\sigma}$$

asse neutro $\Rightarrow$ $\frac{M_y}{I_y} z + \frac{M_z}{I_z} y = 0$

retta per G



$$\frac{|M_y|}{W_y} + \frac{|M_z|}{W_z} \leq \bar{\sigma}$$

$$\frac{M_y}{W_y \bar{\sigma}} + \frac{M_z}{W_z \bar{\sigma}} = 1$$

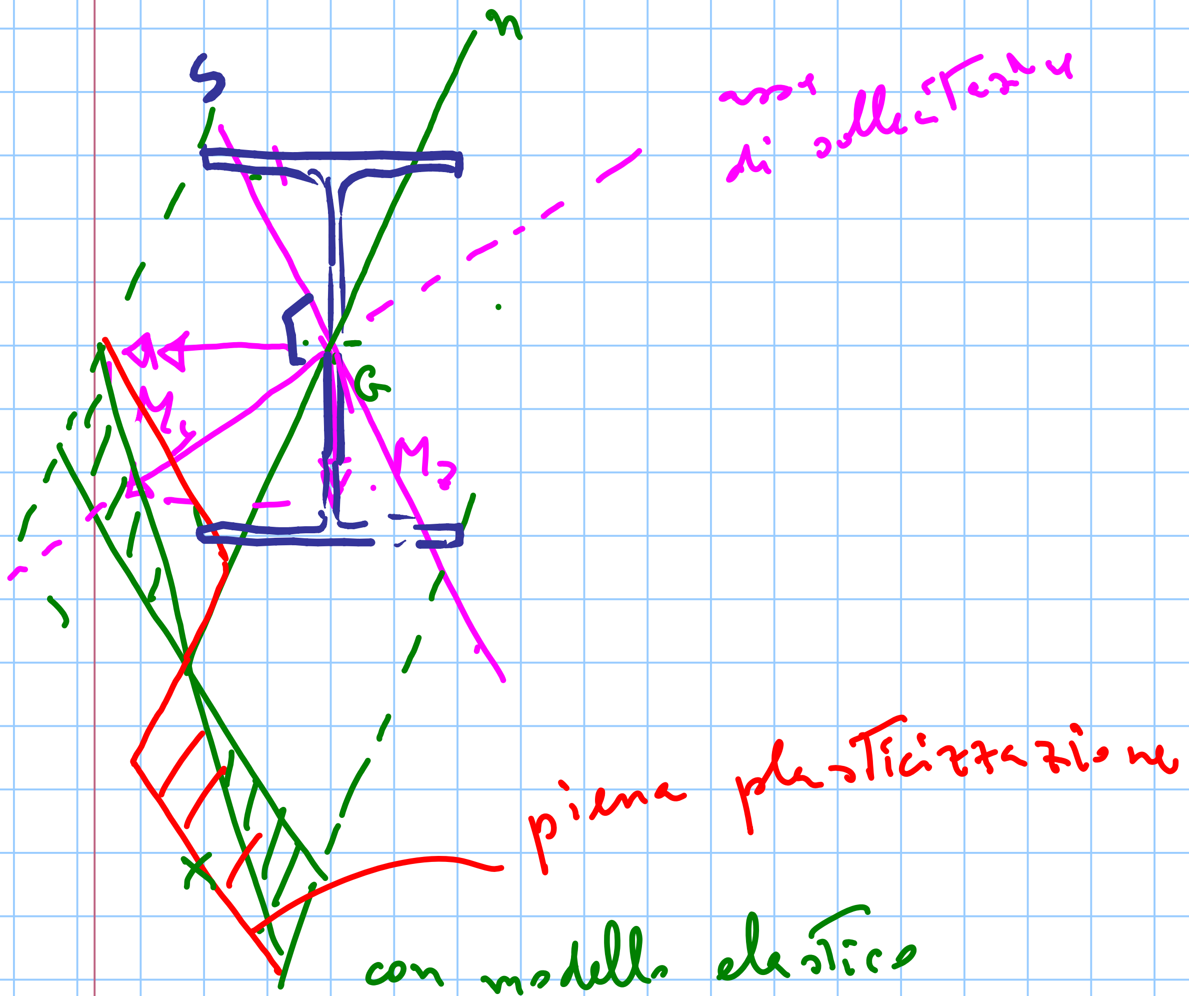
$$\Downarrow$$

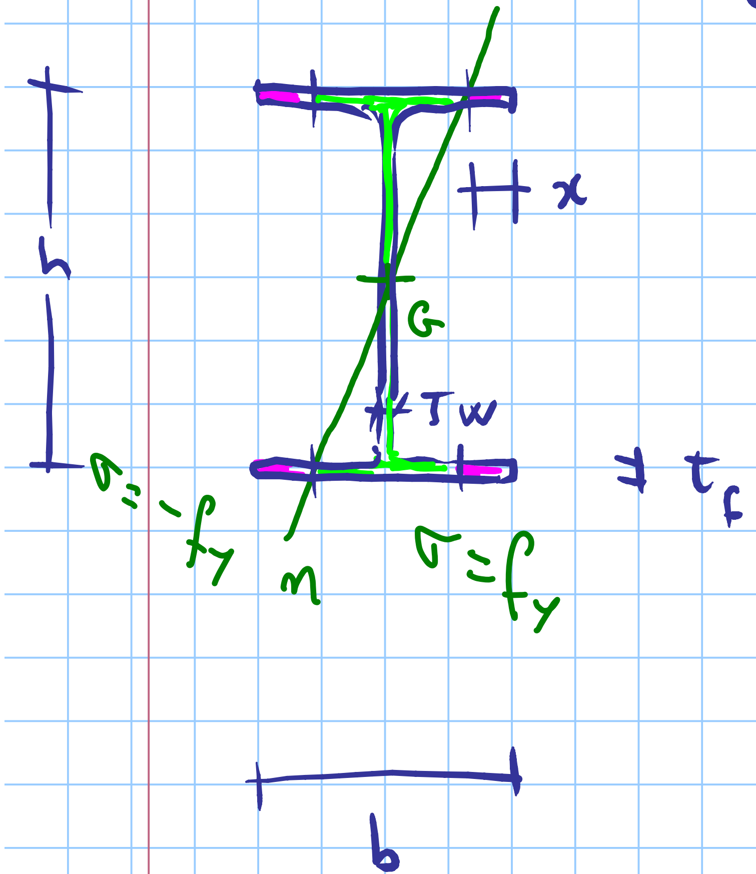
retta

DOMINIO DI RESISTENZA

opp. CURVA DI INTERAZIONE

COSA SUCCEDE oltre il limite elastico



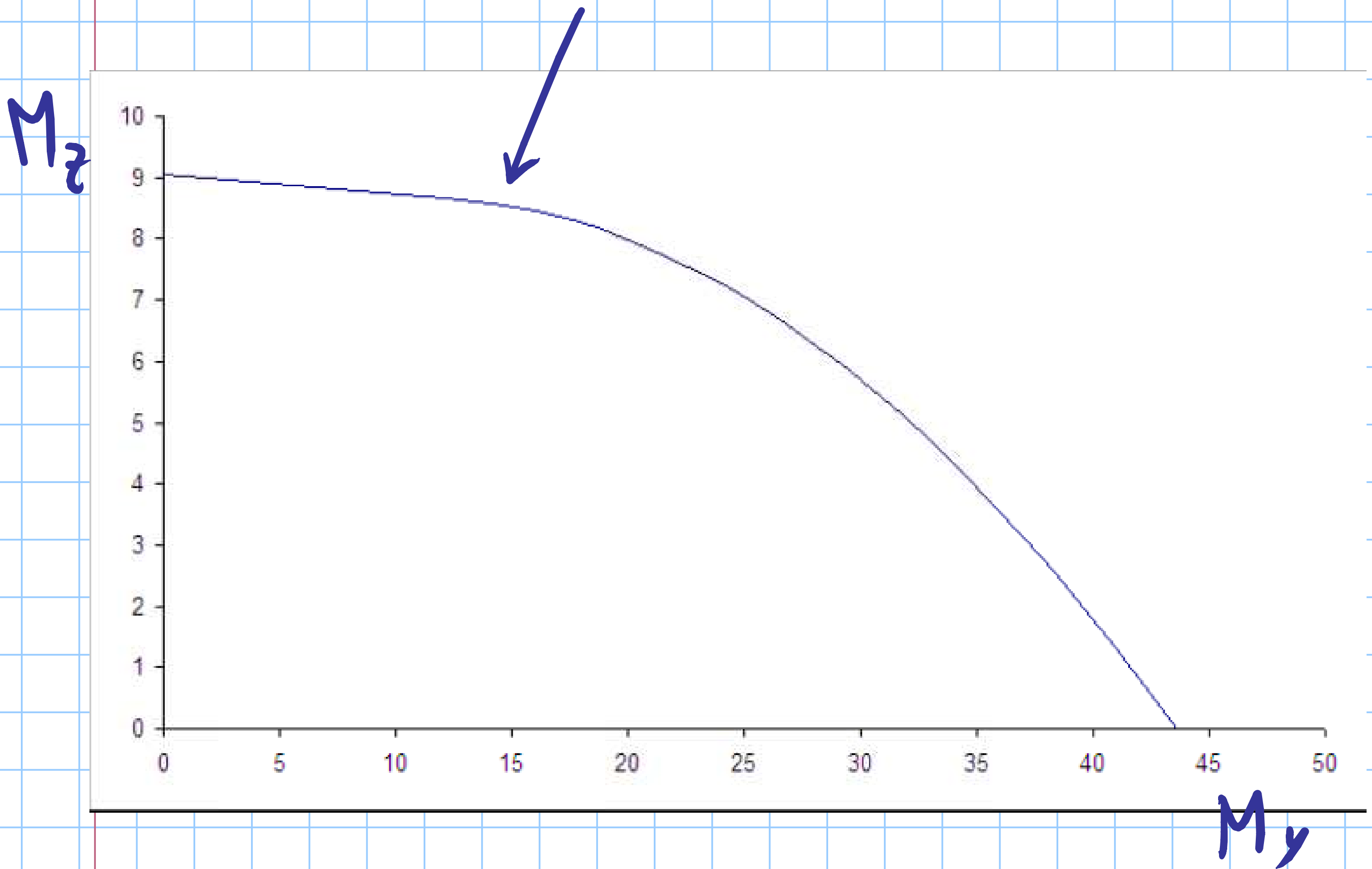


$$0 \leq x \leq \frac{b}{2}$$

$$M_y = M_{y,Rd} - 2\, x\, t_f \left(h - t_f\right) \frac{f_y}{\gamma_{M0}}$$

$$M_z = 2\, x\, t_f \,(b - x)\, \frac{f_y}{\gamma_{M0}}$$

il dominio non è lineare

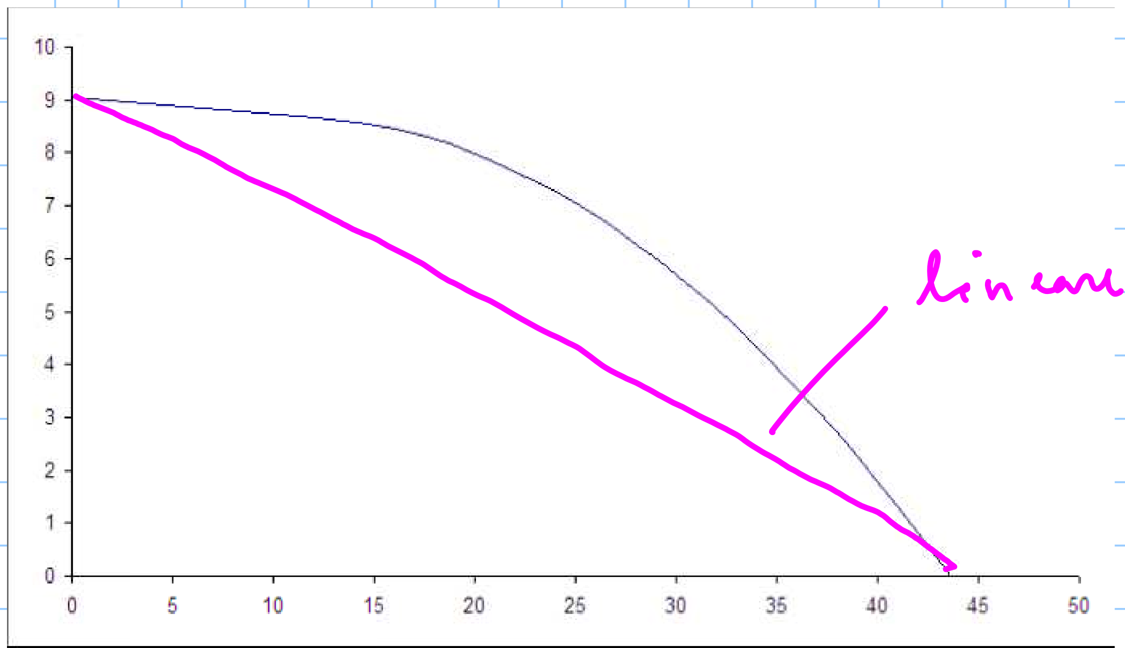


acciaio		S275
fy	MPa	275
profilo		Ipe 180
h	mm	180
b	mm	91
tw	mm	5.3
tf	mm	8
Wpl,y	mm3	166400
Wpl,z	mm3	34600
My,Rd	kNm	43.58
Mz,Rd	kNm	9.06

VERIFICA

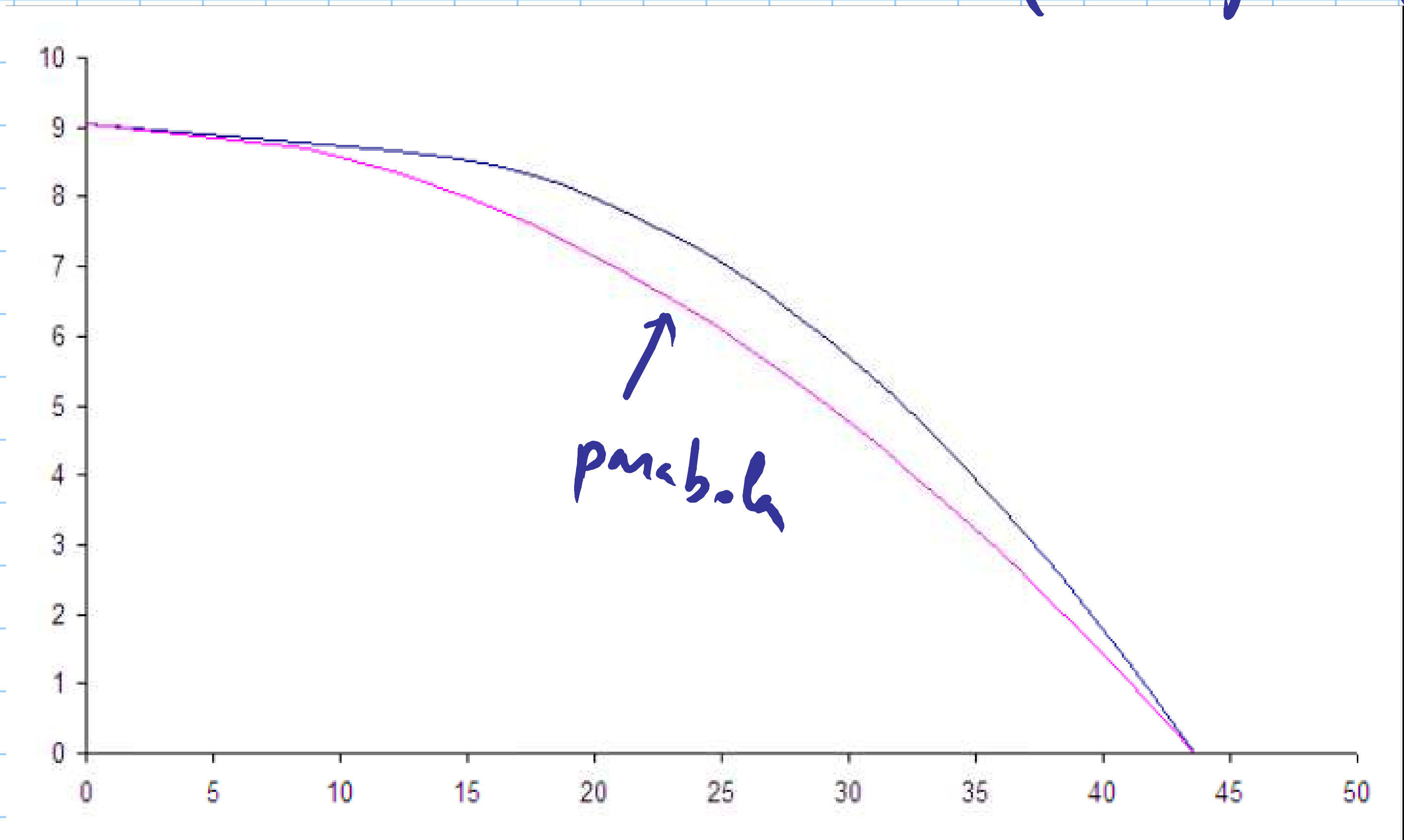
possibilità "pendente"

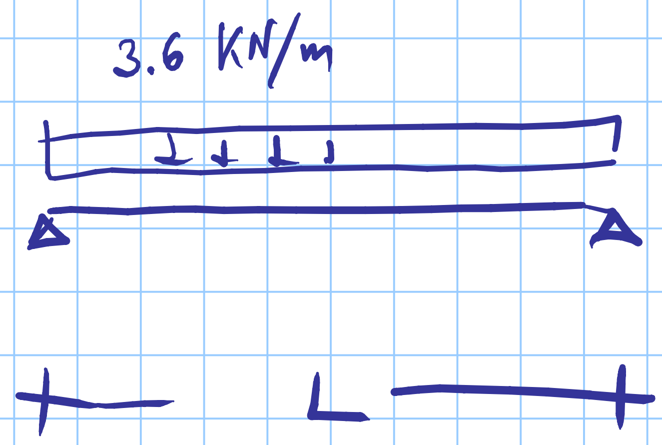
$$\frac{M_{y,Ed}}{M_{y,Rd}} + \frac{M_{z,Ed}}{M_{z,Rd}} \leq 1$$



alternativa più realistica

$$\left(\frac{M_{y,Ed}}{M_{y,Rd}}\right)^2 + \left(\frac{M_{z,Ed}}{M_{z,Rd}}\right) \leq 1$$





$g_k = 1.1$ KN/m

$q_k = 2.5$ KN/m

$L = 6.00$ m $= 6000$ mm

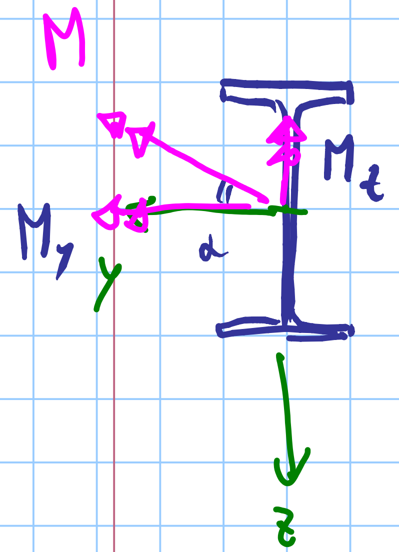
$g_d = 1.1 \times 1.3 = 1.43$ KN/m

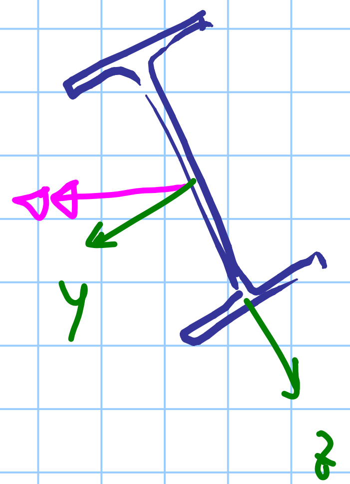
$q_d = 2.5 \times 1.5 = 3.75$ KN/m

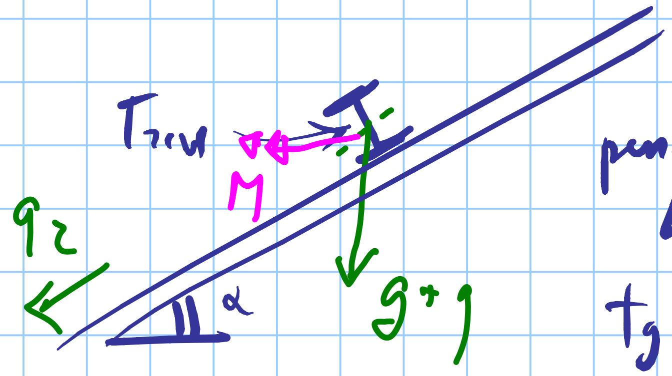
5.18 KN/m

$$M_{Ed} = \frac{ql^2}{8} = \frac{5.18 \times 6.00^2}{8} = 23.31 \text{ KNm}$$

la trave è inclinata







pendenza 45%

$tg\,\alpha = 0.45$

q_1

$\alpha = 24.2°$

2 comp. del carico

$$\delta = \sqrt{\delta_1^2 + \delta_2^2}$$

calcolo freccia

$$\delta_1 = \frac{5}{384}\,\frac{q_1 \ell^4}{E\,I_{min}}$$

$$\delta_2 = \frac{5}{384}\,\frac{q_2 \ell^4}{E\,I_{min}}$$

$$M = 23.31 \text{ KNm}$$

$$M_{y,Ed} = 23.31 \times \cos\alpha = 21.26 \text{ KNm}$$

S 275

$M_{z,Ed} = 23.31 \times \sin\alpha = 9.57$ KNm

IPE 180 va bene ?

$W_{pl,y} = 166.4 \times 10^3$ mm^3

$W_{pl,z} = 34.6 \times 10^3$ mm^3

$$M_{Rd,y} = 166.4 \times 10^3 \times \frac{275}{1.05} \times 10^{-6} = 43.58 \text{ KNm}$$

$$M_{Rd,z} = 34.6 \times 10^3 \times \frac{275}{1.05} \times 10^{-6} = 9.06 \text{ KNm}$$

VERIFICA

$$\left(\frac{21.26}{43.58}\right)^2 + \frac{9.57}{9.06} = 1.29 > 1 \qquad NO$$

proviamo a progettare

$W_{y,pl}$ nec. a flex. retta $\qquad W_{y,pl} \geq \frac{M \ \gamma_{M0}}{f_y} = 81.17 \times 10^3$ mm^3

$$W_{z,pl} \geq \frac{9.57 \times 1.05}{275} \times 10^6 = 36.54 \times 10^3 \ mm^3$$

provo IPE200 $\quad W_{pl.y} = 220.6 \times 10^3 \quad W_{pl,z} = 44.61 \times 10^3$

ragionare con M o con W è lo stesso

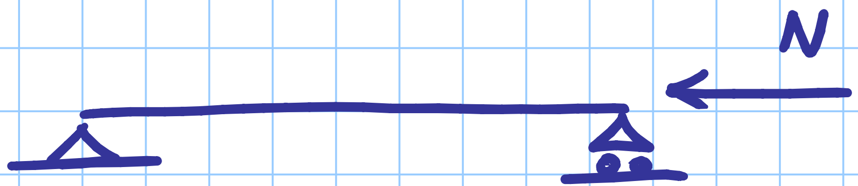
$$\left(\frac{W_{y,nec}}{W_{y,disp}}\right)^2 + \left(\frac{W_{z,nec}}{W_{z,disp}}\right) = \left(\frac{81.17}{220.6}\right)^2 + \left(\frac{36.54}{44.61}\right) = 0.954$$

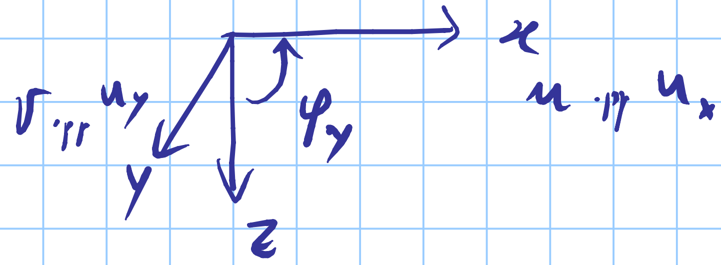
COMPRESSIONE

per la sezione è come trazione

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

fori: non ci interessano se riempiti da bulloni



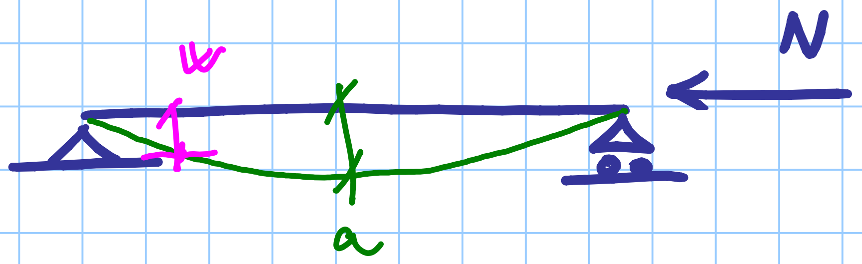


$w \to u_z$

$$\frac{d^2w}{dx^2} = -\frac{M}{EI} \left\{ \begin{aligned} \frac{dw}{dx} &= -\varphi \\ \frac{d\varphi}{dx} &= \frac{M}{EI} \end{aligned} \right.$$

$$\frac{dM}{dx} = V$$

$$\frac{dV}{dx} = -q$$



$$w = a \sin \pi \frac{x}{\ell}$$

$$\frac{d^2 w}{dx^2} = -a \frac{\pi^2}{\ell^2} \sin \pi \frac{x}{\ell}$$

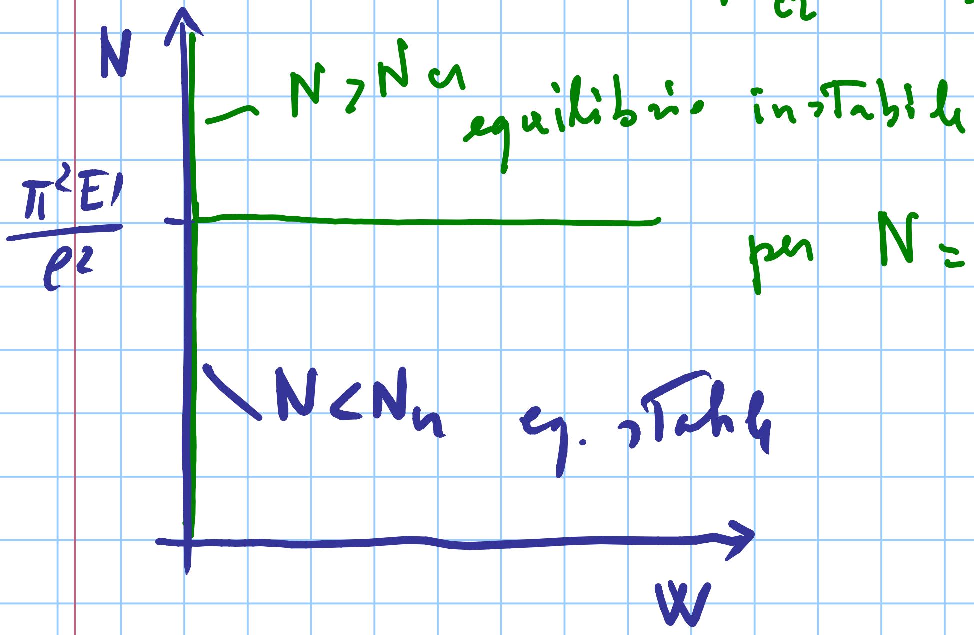
$$M = N \cdot w =$$

$$= N a \sin \pi \frac{x}{\ell}$$

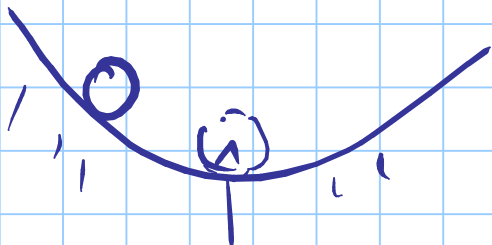
$$\frac{d^2 w}{dx^2} = -\frac{M}{EI} \Rightarrow \cancel{-} \cancel{a} \frac{\pi^2}{\ell^2} \cancel{\sin \pi \frac{x}{\ell}} = \cancel{-} \frac{1}{EI} N \cancel{a} \cancel{\sin \pi \frac{x}{\ell}}$$

$$\frac{\pi^2}{\ell^2} = \frac{N}{EI} \Rightarrow \underset{N_{cr}}{N} = \frac{\pi^2 EI}{\ell^2}$$

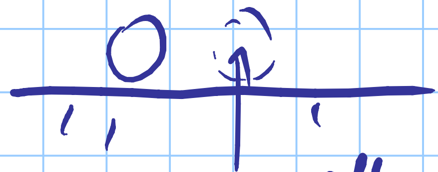
N_{cr} = sforzo normale critico (Euleriano)



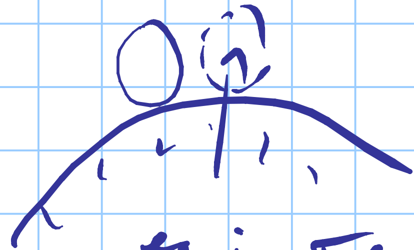
per $N = N_{cr}$ → equilibrio indifferente



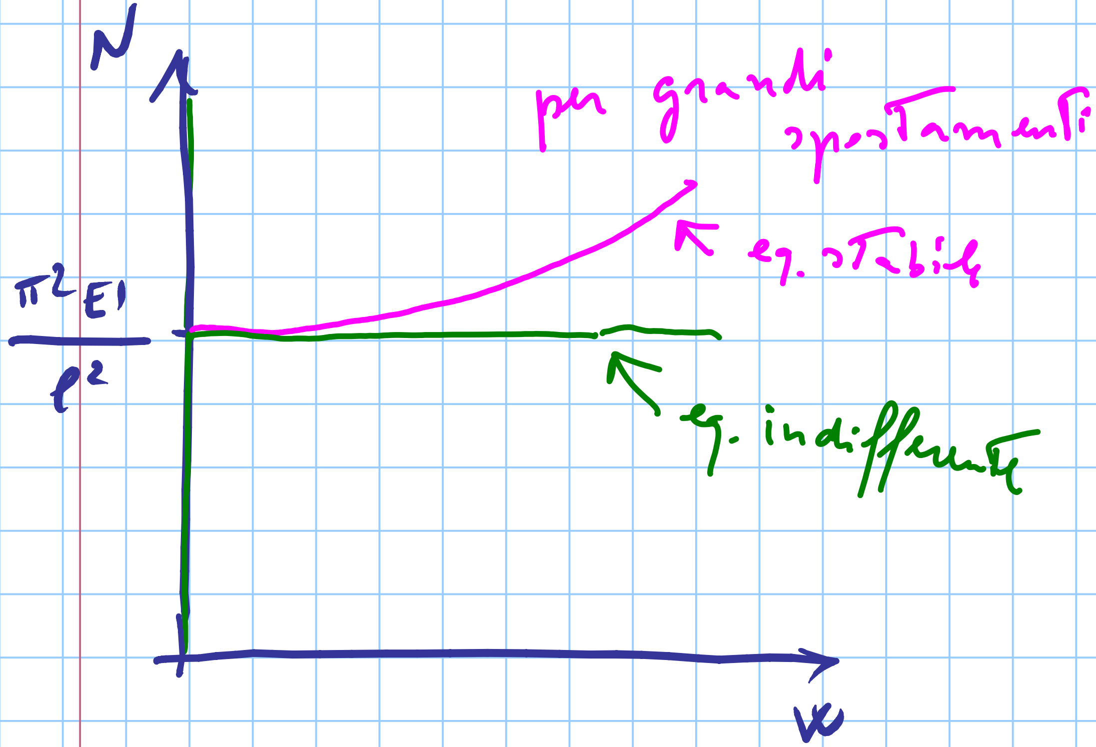
eq. stabile



eq. indifferente



eq. instabile

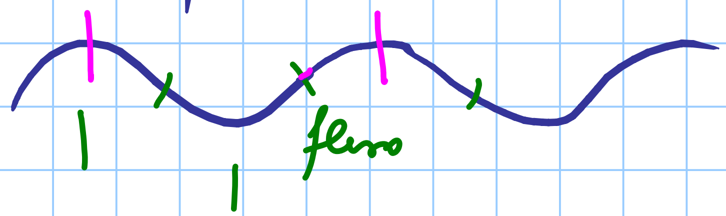


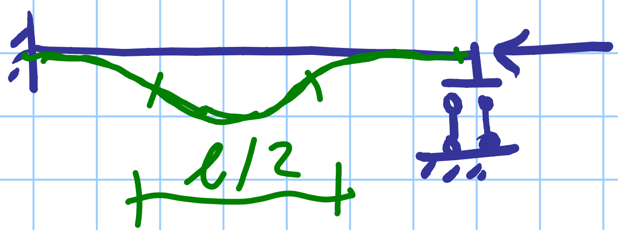
materiale elastico
(infinitamente resistente)

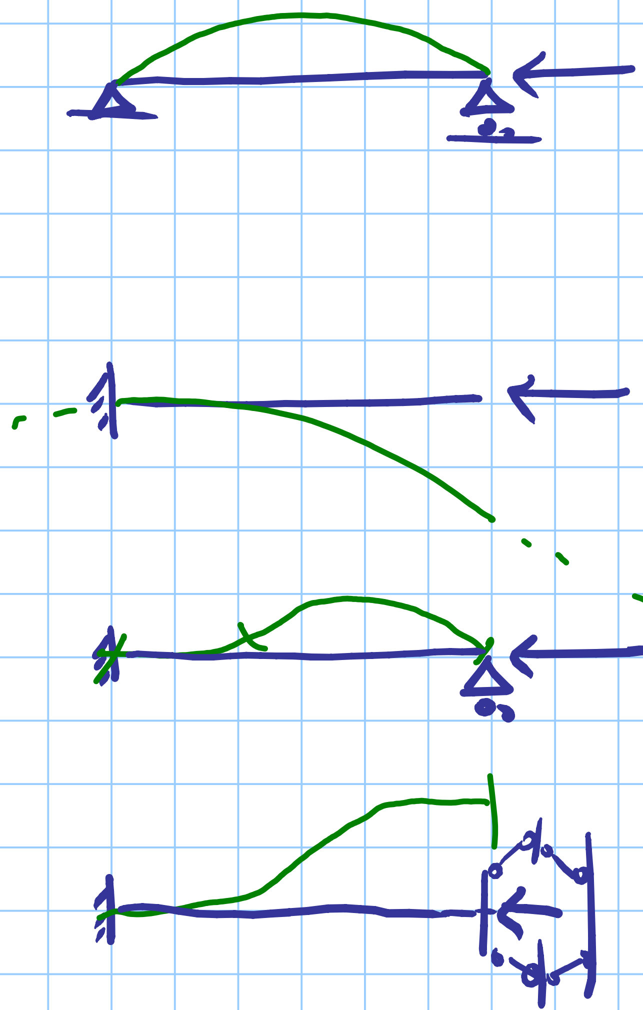
Hp. piccoli spostamenti

$$N_{cr} = \frac{\pi^2 E I}{l_0^2}$$

l_0 = lunghezza libera di inflessione → distanza tra flessi







$l_0 = l$

$l_0 = 2l$

$l_0 = \frac{l}{\sqrt{2}}$

$l_0 = l$