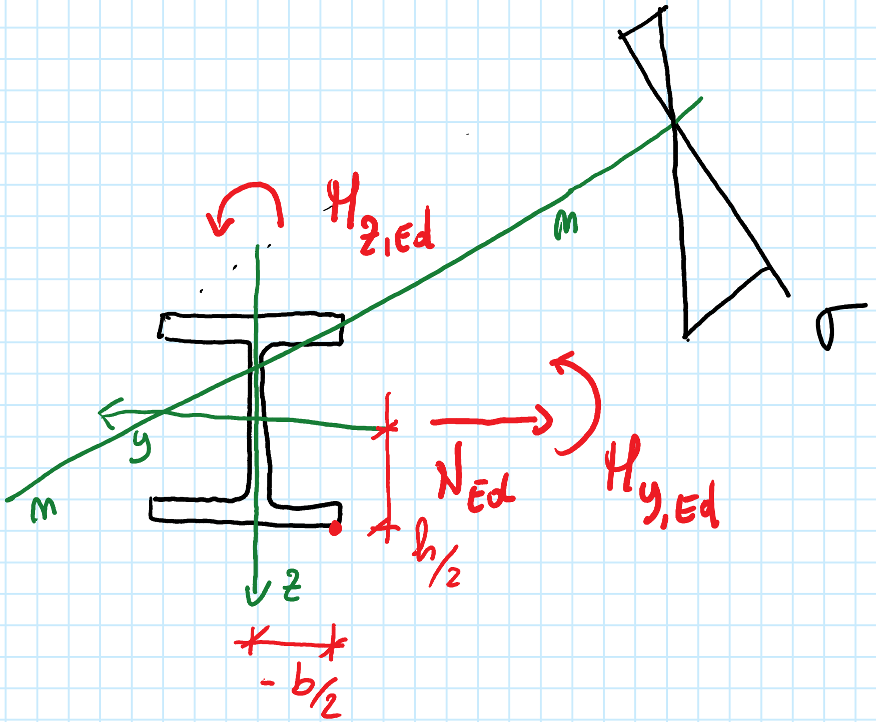
Flessione composta deviata

Sezioni di classe 3



Verifica in termini di tensione

$$\sigma = \frac{N_{Ed}}{A} + \frac{M_{y,Ed}}{I_y} z - \frac{M_{z,Ed}}{I_z} y$$

$$\sigma_{max} = \frac{N_{Ed}}{A} + \underbrace{\frac{M_{y,Ed}}{I_y}\left(h/2\right)}_{1/W_{el,y}} + \underbrace{\frac{M_{z,Ed}}{I_z}\left(b/2\right)}_{1/W_{el,z}} \leq f_y/\gamma_{M0}$$

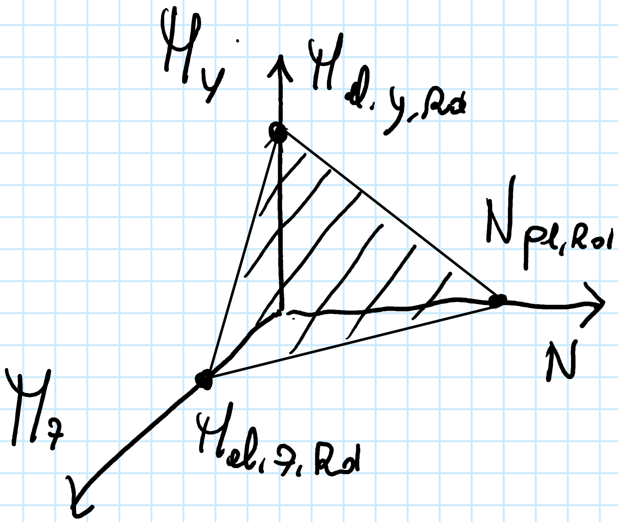
$$\sigma_{max} = \frac{|N_{Ed}|}{A} + \frac{|M_{y,Ed}|}{W_{el,y}} + \frac{|M_{z,Ed}|}{W_{el,z}} \leq f_y / \gamma_{M0}$$

Dominio M_y - M_z - N

$$\frac{|N_{Ed}|}{A} + \frac{|M_{y,Ed}|}{W_{el,y}} + \frac{|M_{z,Ed}|}{W_{el,z}} \leq f_y / \gamma_{M0}$$

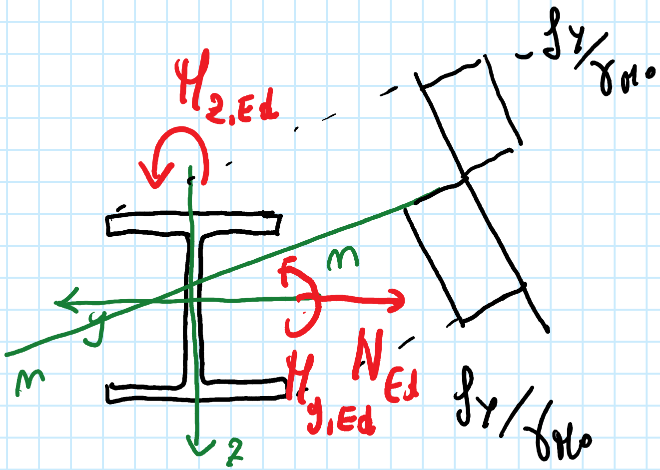
$$\frac{|N_{Ed}|}{\underbrace{A\, f_y/\gamma_{M0}}_{N_{pl,Rd}}} + \frac{|M_{y,Ed}|}{\underbrace{W_{el,y}\, f_y/\gamma_{M0}}_{M_{el,y,Rd}}} + \frac{|M_{z,Ed}|}{\underbrace{W_{el,z}\, f_y/\gamma_{M0}}_{M_{el,z,Rd}}} \leq 1$$

$$\frac{|N_{Ed}|}{N_{pl,Rd}} + \frac{|M_{Ed,y}|}{M_{el,y,Rd}} + \frac{|M_{Ed,z}|}{M_{el,z,Rd}} \leq 1$$



Sezioni di classe 1 e 2

Si può costruire un dominio ma non è pieno... 3 punti non bastano



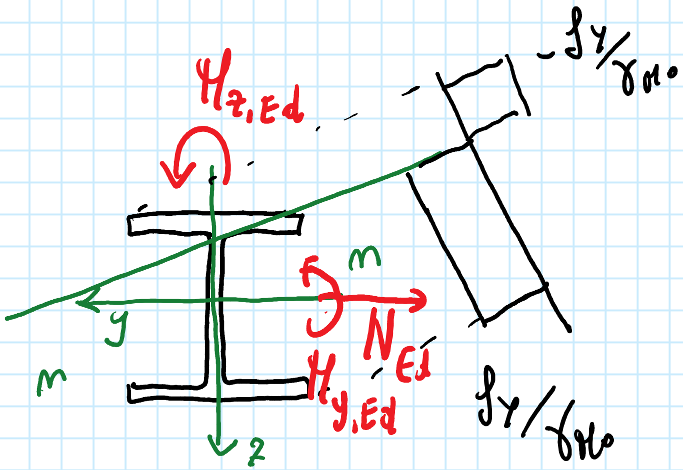
$$N_{Ed} = \int_A \sigma \, dA$$

$$M_{y,Ed} = \int_A \sigma z \, dA$$

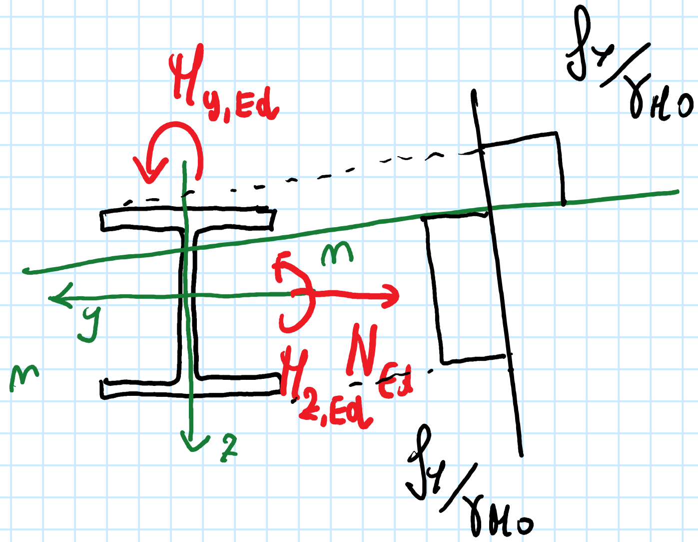
$$M_{z,Ed} = -\int_A \sigma y \, dA$$

$\Rightarrow$ Ottengo un punto del dominio.

$(N_{Ed}, M_{y,Ed}, M_{z,Ed})$

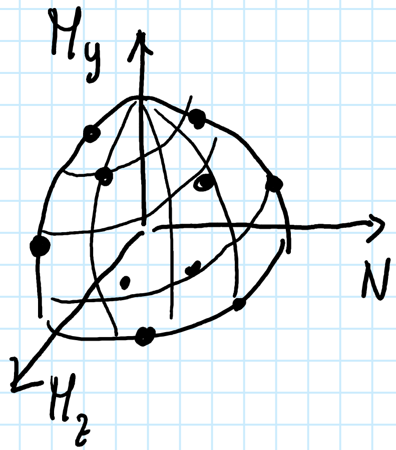


Faccio variare la posizione dell'asse neutro e ottengo altri punti.



Cambio l'inclinazione dell'asse neutro e ripeto il procedimento determinando una nuova serie di punti facendo variare le posizioni dell'asse neutro.

Infine, collego i punti ottenuti ottenendo una superficie che definisce il dominio M_y - M_z - N.



Le NTC18 e l'EC3 forniscono domini approssimati ma in forma analitica

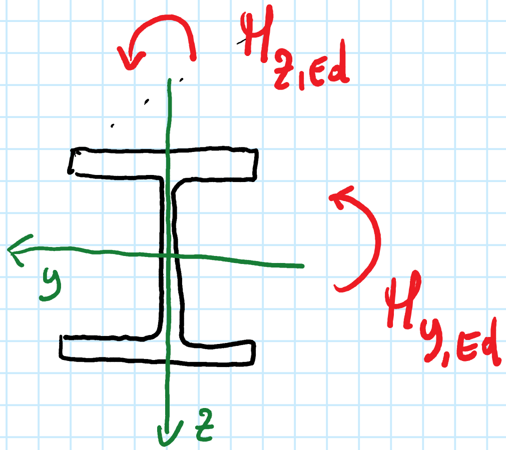
Dominio (analitico) delle NTC18 per sezioni a doppio T di classe 1 e 2

$$\left(\frac{|M_{y,Ed}|}{M_{pl,N,y,Rd}}\right)^2 + \left(\frac{|M_{z,Ed}|}{M_{pl,N,z,Rd}}\right)^{5n} \leq 1 \qquad n \geq 0{,}2$$

$$\frac{|M_{y,Ed}|}{M_{pl,N,y,Rd}} + \frac{|M_{z,Ed}|}{M_{pl,N,z,Rd}} \leq 1 \qquad n < 0{,}2$$

$$n = \frac{N_{Ed}}{N_{pl,Rd}}$$

Flessione semplice deviata

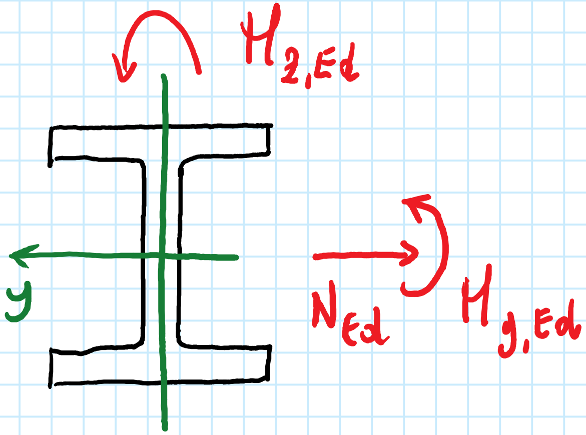


E' un caso particolare della flessione composta...

...per qualunque forma della sezione.

$$\frac{|M_{y,Ed}|}{M_{pl,y,Rd}} + \frac{|M_{z,Ed}|}{M_{pl,z,Rd}} \leq 1 \qquad \text{Classe 1 e 2}$$

$$\frac{|M_{y,Ed}|}{M_{el,y,Rd}} + \frac{|M_{z,Ed}|}{M_{el,z,Rd}} \leq 1 \qquad \text{Classe 3}$$



HEB 260

S 235

Classe 3

$$N_{Ed} = 500 \text{ KN}$$

$$M_{y,Ed} = M_{z,Ed} = 50 \text{ KN m}$$

$$\frac{|N_{Ed}|}{N_{pl,Rd}} + \frac{|M_{y,Ed}|}{M_{el,y,Rd}} + \frac{|M_{z,Ed}|}{M_{el,z,Rd}} \leq 1$$

$$N_{pl,Rd} = A \frac{f_y}{\gamma_{M0}} = 118{,}4 \times \frac{235}{1{,}05} \times \frac{1}{10} = 2649{,}9 \text{ KN}$$

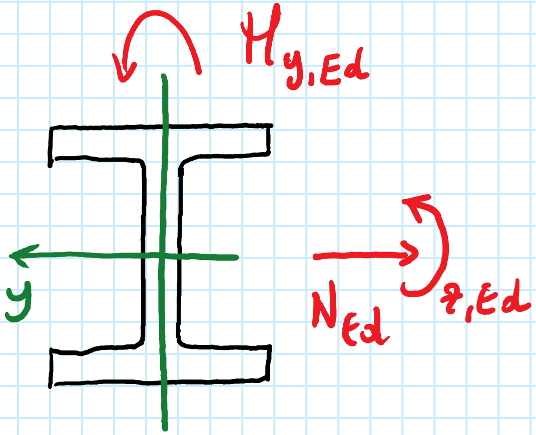
$$M_{el,y,Rd} = W_{el,y} \frac{f_y}{\gamma_{M0}} = 1148 \times \frac{235}{1{,}05} \times \frac{1}{10^3} = 256{,}9 \text{ KN m}$$

$$M_{el,z,Rd} = W_{el,z} \frac{f_y}{\gamma_{M0}} = 395 \times \frac{235}{1{,}05} \times \frac{1}{10^3} = 88{,}4 \text{ KN m}$$

$$\frac{500}{2649,9} + \frac{50}{256,9} + \frac{50}{88,4} \leq 1$$

$$0,1887 + 0,1946 + 0,5656 = 0,9489 < 1$$

OK!



HEB 260

S 235

Classe 1 o 2

$N_{Ed} = 500$ KN

$M_{y,Ed} = M_{z,Ed} = 50$ KNm

1. Individuo le formule di verifica

$$n = \frac{500}{2649,9} = 0,1887 < 0,2$$

$$N_{pl,Rd} = \frac{A f_y}{\gamma_{M0}} = 118,4 \times \frac{235}{1,05} \times \frac{1}{10} = 2649,9 \text{ KN}$$

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

2. Calcolo $M_{pl,N,y,Rd}$

$$M_{pl,N,y,Rd} = M_{pl,y,Rd} \quad \text{se} \quad n \leq 0{,}5\,a \quad (1)$$

$$M_{pl,N,y,Rd} = M_{pl,y,Rd} \frac{1-n}{1-0{,}5a} \quad n > 0{,}5\,a \quad (2)$$

$$a = \frac{118{,}4 - 2 \times 260 \times 17{,}5/100}{118{,}4} = 0{,}2314$$

$n = 0{,}1887 < 0{,}5 \times 0{,}2314 = 0{,}1157$ NO => uso la (2)

$$M_{pl,y,Rd} = W_{pl,y} \frac{f_y}{\gamma_{M0}} = 1283 \times \frac{235}{1{,}05} \times \frac{1}{10^3} = 287{,}2 \text{ KNm}$$

$$M_{pl,N,y,Rd} = M_{pl,y,Rd} \frac{1-n}{1-0{,}5a} = 287{,}2 \times \frac{1-0{,}1887}{1-0{,}1157} \times \frac{1}{10^3}$$

$$= 263{,}5 \text{ KNm}$$

3. Calcolo $M_{pl,N,z,Rd}$

$$M_{pl,N,z,Rd} = M_{pl,z,Rd} \quad \text{se} \quad n \leq a \qquad (1)$$

$$M_{pl,N,z,Rd} = M_{pl,z,Rd}\left[1 - \left(\frac{n-a}{1-a}\right)^2\right] \quad n > a \qquad (2)$$

$$n = 0{,}1887 \leq a = 0{,}2314$$ SI $\Rightarrow$ uso la (1)

$$M_{pl,N,z,Rd} = M_{pl,z,Rd} = W_{pl,z}\frac{f_y}{\gamma_{M0}} = 602.2 \times \frac{235}{1{,}05} \times \frac{1}{10^3} = 134{,}8 \text{ KNm}$$

4. Eseguo le verifiche

$$\frac{|M_{y,Ed}|}{M_{pl,N,y,Rd}} + \frac{|M_{z,Ed}|}{M_{pl,N,z,Rd}} = \frac{50}{263,5} + \frac{50}{134,8} = 0,5600 < 1$$

$0,1897$ $\quad$ $0,3710$

OK!