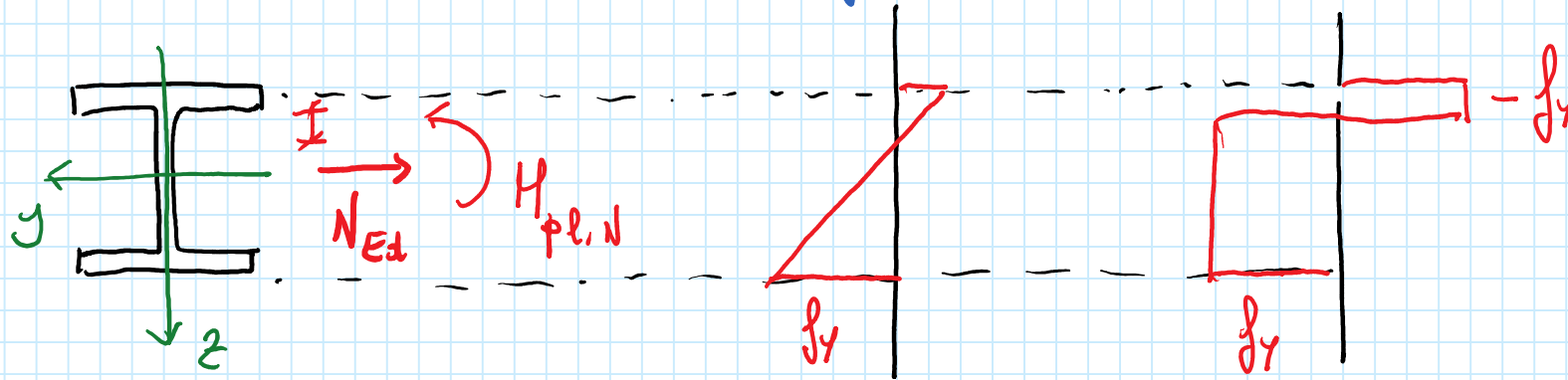


Tenso-flessione (puro-flessione delle sezioni)



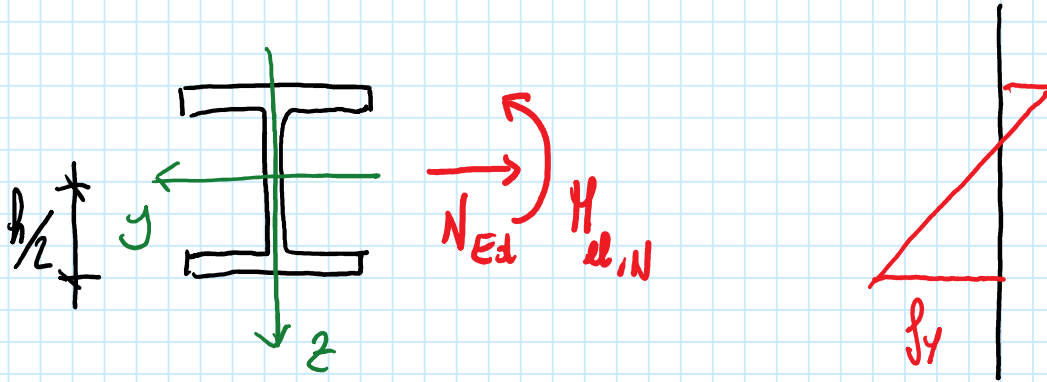
$$M_{Ed} \leq M_{N,Rd}$$

Quale resistenza usare per le verifiche?

Classe 1 e 2 uso $M_{pl,N}$

Classe 3 uso $M_{el,N}$

Sezioni di classe 3



Lo SLO si raggiunge
alle prime plasticizzazioni

$$f_y = \frac{N_{Ed}}{A} + \frac{M_{Ed,N}}{I} \left(\frac{h}{2} \right)$$

$$\frac{M_{Ed,N}}{I} \left(\frac{h}{2} \right) = f_y - \frac{N_{Ed}}{A}$$

$$M_{Ed,N} = \frac{I}{h/2} \left(f_y - \frac{N_{Ed}}{A} \right)$$

$$M_{Ed,N} = \frac{I}{h/2} f_y \left(1 - \frac{N_{Ed}}{A f_y} \right) = \underbrace{W_{el} f_y}_{M_{el}} \left(1 - \underbrace{\frac{N_{Ed}}{A f_y}}_{N_{pe}} \right)$$

Riassumendo...

Sezioni di classe 3

$$1. N_{Ed} \leq N_{pl,Rd}$$

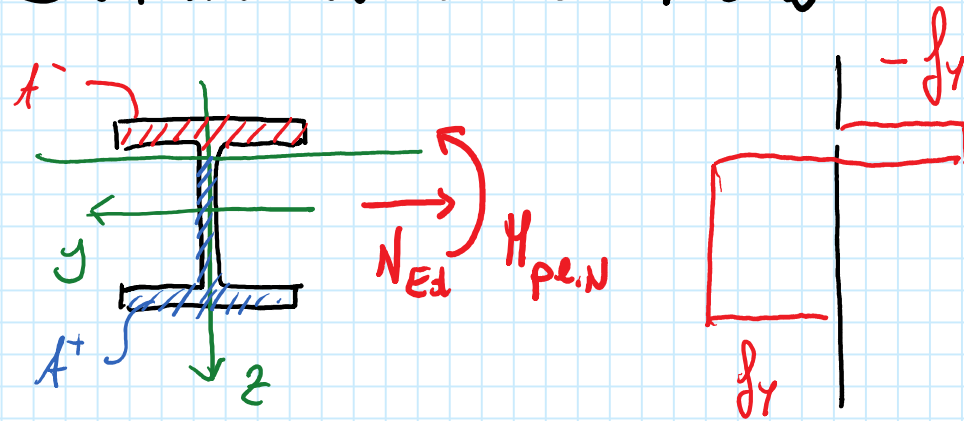
$$N_{pl,Rd} = A f_y / \gamma_{M0}$$

$$2. M_{el,N,Rd} = M_{el,Rd} \left(1 - \frac{N_{Ed}}{N_{pl,Rd}} \right)$$

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

$$3. M_{Ed} \leq M_{N,Rd} = M_{el,N,Rd}$$

Sezioni di classe 1 o 2



Lo SLU si raggiunge con la completa plasticizzazione delle sezioni.

$$M_{pl,N} = \int_A \sigma z dA = \int_{A^+} \sigma z dA + \int_{A^-} \sigma z dA = f_y \int_{A^+} z dA - f_y \int_{A^-} z dA$$

$$= \int_y S^+ - \int_y S^-$$

$$S^+ + S^- = S = 0 \Rightarrow S^- = -S^+$$

$$M_{pl,N} = 2 S^+ f_y = -2 S^- f_y$$

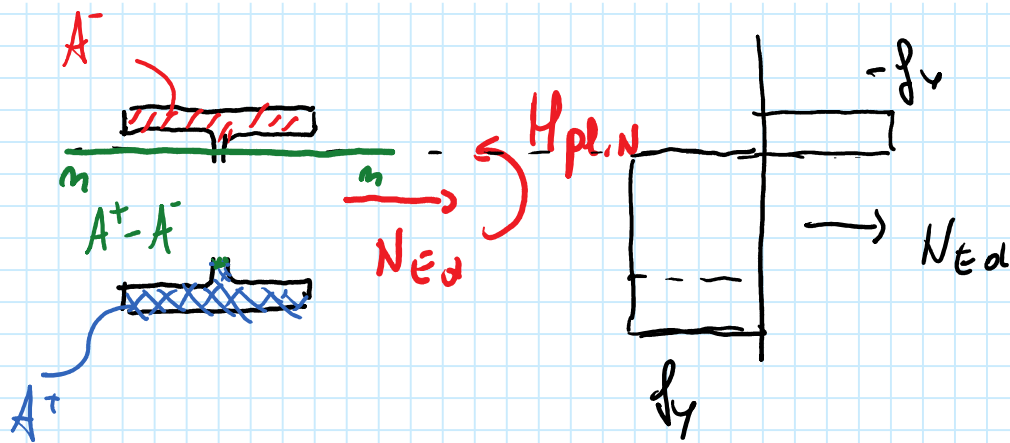
Ha due prime determinare le parti tese e compresse
della nazione

$$\underbrace{\int_A \sigma dA}_{N_{Ed}} = \int_{A^+} \sigma dA + \int_{A^-} \sigma dA = \oint \int_{A^+} dA - \oint \int_{A^-} dA = (A^+ - A^-) \oint$$

$$(A^+ - A^-) = \frac{N_{Ed}}{\oint}$$

$$A^+ + A^- = A$$

Sezioni di classe 1 o 2



$$N_{Ed} = \int_A \sigma dA = (A^+ - A^-) f_y$$

Le parti centrali delle sezioni portano lo sforzo normale

Solo le parti estreme possono portare il momento flettente.

Il momento plastico resistente in presenza di sforzo normale è minore di quello in assenza di sforzo normale.

Sezioni di eloni 1 o 2

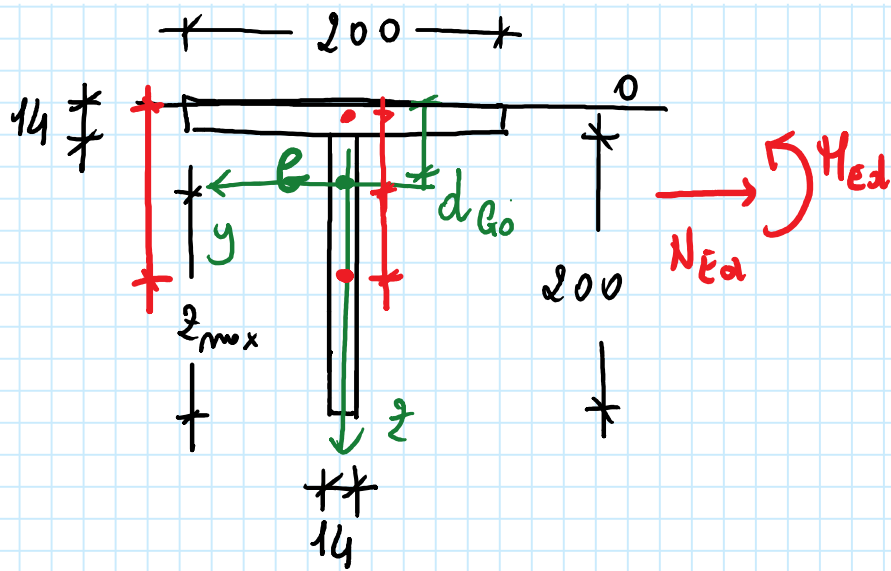
$$1. N_{Ed} \leq N_{pl,Rd}$$

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

$$2. A^+ - A^- = \frac{N_{Ed}}{\gamma_{M0}} \rightarrow A^+, A^-$$
$$A^+ + A^- = A$$

$$3. M_{pl,N,Rd} = 2 S^+ f_y / \gamma_{M0} = - 2 S^- f_y / \gamma_{M0}$$

$$4. M_{Ed} \leq M_{N,Rd} = M_{pl,N,Rd}$$



S235

$$N_{Ed} = 1000 \text{ kN}$$

$$M_{Ed} = 50 \text{ kNm}$$

Class 3

$$1. N_{Ed} \leq N_{pl,Rd}$$

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

$$2. M_{el,N,Rd} = M_{el,Rd} \left(1 - \frac{N_{Ed}}{N_{pl,Rd}} \right)$$

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

$$3. M_{Ed} \leq M_{el,N,Rd}$$

$$1. N_{Ed} \leq N_{pl,Rd}$$

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

$$A = 14 \times 200 \times 2 = 5600 \text{ mm}^2$$

$$N_{pl,Rd} = 5600 \times \frac{235}{1.05} \times \frac{1}{10^3} = 1253,3 \text{ kN}$$

$$N_{Ed} = 1000 \text{ kN} < N_{pl,Rd} = 1253,3 \text{ kN}$$

OK, continuo...

$$2. \text{ Calcule } W_{el,N,Rd}$$

$$S_o = 200 \times 14 \times \frac{14}{2} + 14 \times 200 \times \left(14 + \frac{200}{2} \right) = 338800 \text{ mm}^3$$

$$d_{e0} = \frac{S_o}{A} = \frac{338800}{5600} = 60,5 \text{ mm}$$

$$\begin{aligned}
 I &= 200 \times \frac{14^3}{12} + 200 \times 14 \times \left(60,5 - \frac{14}{2}\right)^2 + \\
 &\quad + 14 \times \frac{200^3}{12} + 14 \times 200 \times (100 - 60,5 + 14)^2 = \\
 &= 25407667 \text{ mm}^4
 \end{aligned}$$

$$z_{\max} = 200 + 14 - 60,5 = 153,5 \text{ mm}$$

$$W_u = \frac{25407667}{153,5} = 165522 \text{ mm}^3 = 165,5 \text{ cm}^3$$

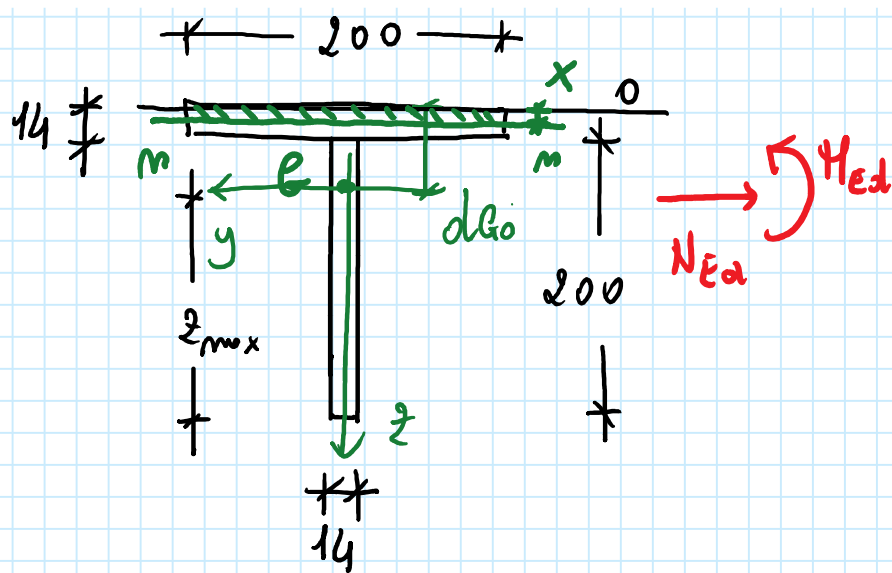
$$M_{el, Rd} = 165,5 \times \frac{235}{1,05} \times \frac{1}{10^3} = 37,0 \text{ kNm}$$

$$M_{ed,N,Rd} = 34,0 \times \left(1 - \frac{1000}{1253,3} \right) = 7,5 \text{ KNm}$$

3. Verfiice

$$M_{Ed} = 50 \text{ KNm} < M_{N,Rd} = M_{ed,N,Rd} = 7,5 \text{ KNm}$$

NO



S 235

$$N_{Ed} = 1000 \text{ kN}$$

$$M_{Ed} = 50 \text{ kNm}$$

Classe 1 o 2

$$1. N_{Ed} \leq N_{pl,Rd}$$

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

$$2. A^+ - A^- = \frac{N_{Ed}}{\gamma_{M0}} \rightarrow A^+, A^-$$

$$A^+ + A^- = A$$

$$3. M_{pl,N,Rd} = 2 S^+ \frac{f_y}{\gamma_{M0}} = - 2 S^- \frac{f_y}{\gamma_{M0}}$$

$$4. M_{Ed} \leq M_{Rd,N} = M_{pl,N,Rd}$$

$$1. N_{Ed} \leq N_{pl,Rd}$$

$$N_{Ed} = 1000 \text{ kN} < N_{pl,Rd} = 1253,3 \text{ kN}$$

$$2. \text{ Determinare } A^+ \text{ e } A^-$$

$$A^+ - A^- = \frac{1000 \times 1,05 \times 10^3}{235} = 4468 \text{ mm}^2$$

$$A^+ - A^- = 4468 \text{ mm}^2$$

$$\underline{A^+ + A^- = 5600 \text{ mm}^2}$$

$$2A^+ = 4468 + 5600 = 10068 \text{ mm}^2$$

$$A^+ = 10068/2 = 5034 \text{ mm}^2$$

$$A^- = A - A^+ = 5600 - 5034 = 566 \text{ mm}^2$$

$$200x = 566 \text{ mm}^2$$

$$x = \frac{566}{200} = 2.83 \text{ mm}$$

3. Calcule $M_{pl,N,Rd}$

$$S^- = -200 \times 2.83 \times \left(d_{go} - \frac{x}{2} \right) = -200 \times 2.83 \times \left(60.5 - \frac{2.83}{2} \right) :$$

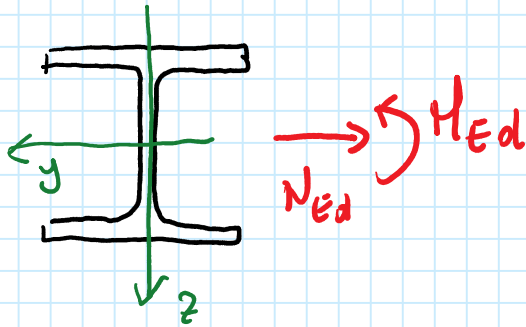
$$= -33442 \text{ mm}^3 = -33.4 \text{ cm}^3$$

$$M_{pl,N,Rd} = -2 S^- \frac{f_y}{\gamma_{M0}} = + 2 \times 33.4 \times \frac{235}{1.05} \times \frac{1}{10^3} = 15.0 \text{ kNm}$$

4. Verifiee

$$M_{Ed} = 50 \text{ kNm} < M_{Rd,N} = M_{pl,N,Rd} = 15.0 \text{ kNm} \quad \text{NO}$$

Domini di resistenza M-N di sezioni di classe 3

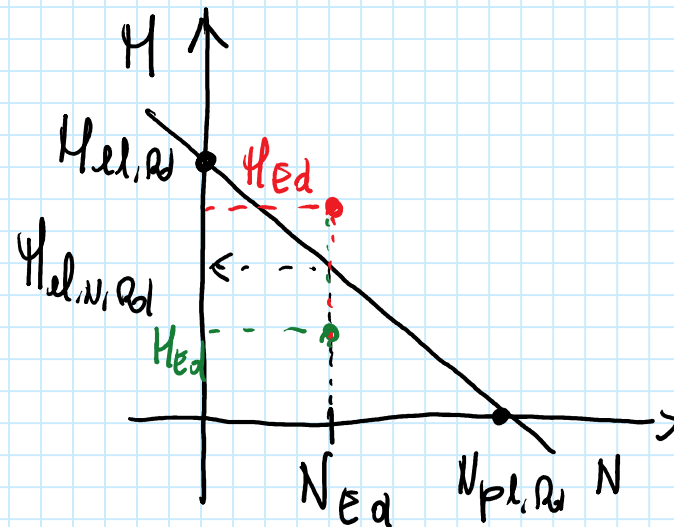


$$M_{Ed} \leq M_{el,N,Rd} = M_{el,Rd} \left(1 - \frac{N_{Ed}}{N_{pl,Rd}} \right)$$

Fino $N_{Ed} \rightarrow M_{el,N,Rd}$

1. $N_{Ed} = 0 \rightarrow M_{el,N,Rd} = M_{el,Rd}$

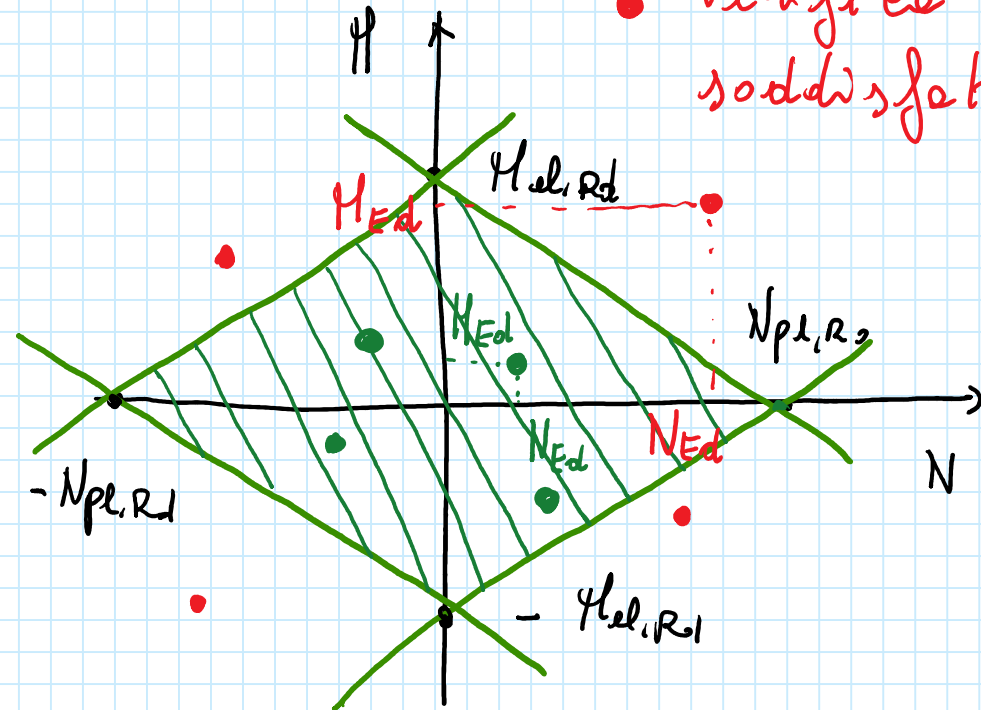
2. $N_{Ed} = N_{pl,Rd} \rightarrow M_{el,N,Rd} =$



$$M_{Ed} \leq M_{el,Rd} \left(1 - \frac{N_{Ed}}{N_{pl,Rd}} \right)$$

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

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



• Verificare
soddisfatta

• Verificare non
soddisfatta