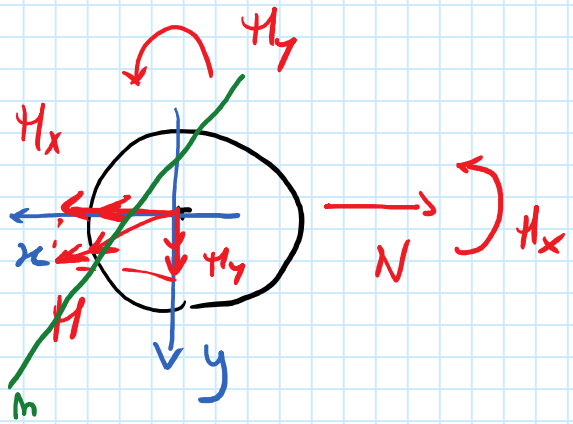
FLESSIONE COMPOSTA

... deviata

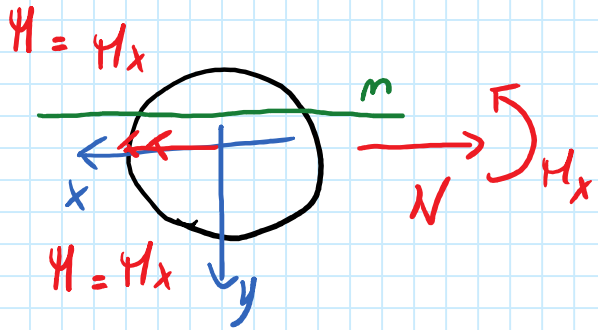


$$\sigma = \frac{N}{A} + \frac{M_x}{I_x} y - \frac{M_y}{I_y} x$$

$$\varepsilon = \frac{\sigma}{E}$$

$$\frac{N}{A} + \frac{M_x}{I_x} y - \frac{M_y}{I_y} x = 0$$

... retta

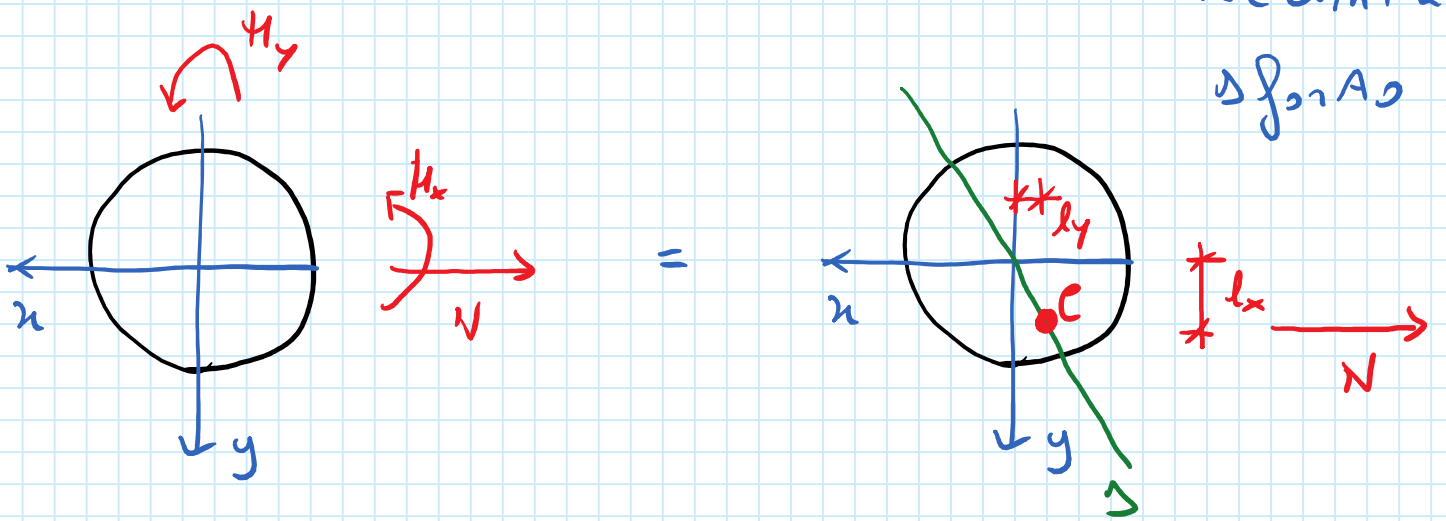


$$\sigma = \frac{N}{A} + \frac{M_x}{I_x} y$$

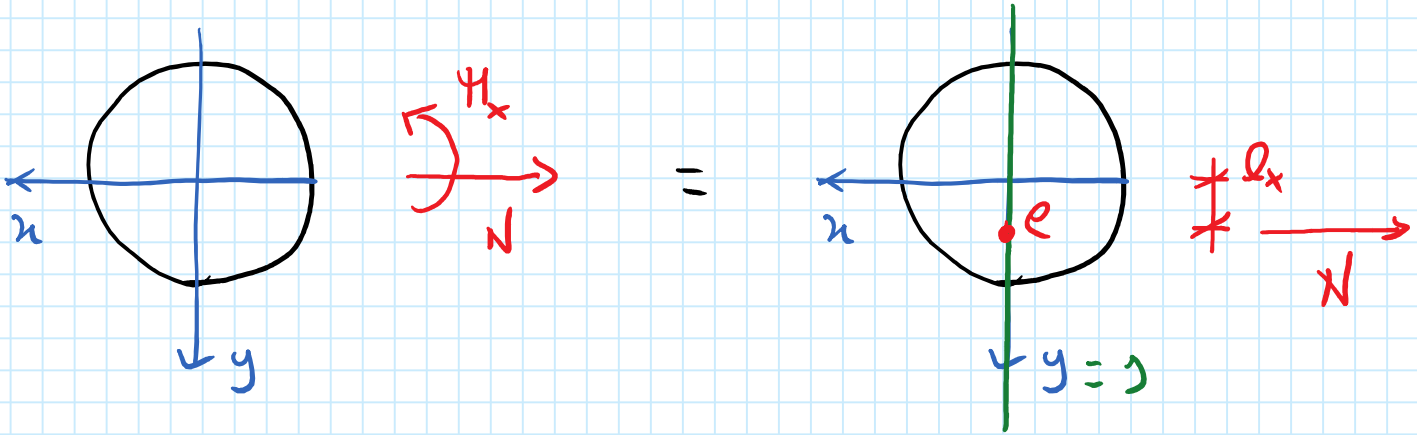
$$\varepsilon = \frac{\sigma}{E}$$

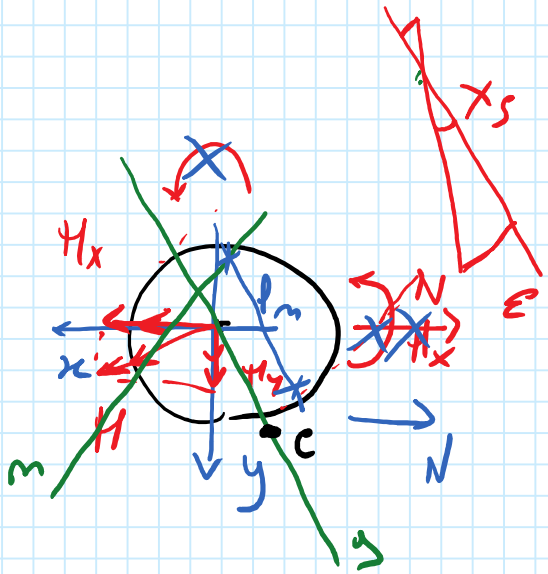
$$\frac{N}{A} + \frac{M_x}{I_x} y = 0$$ asse neutro

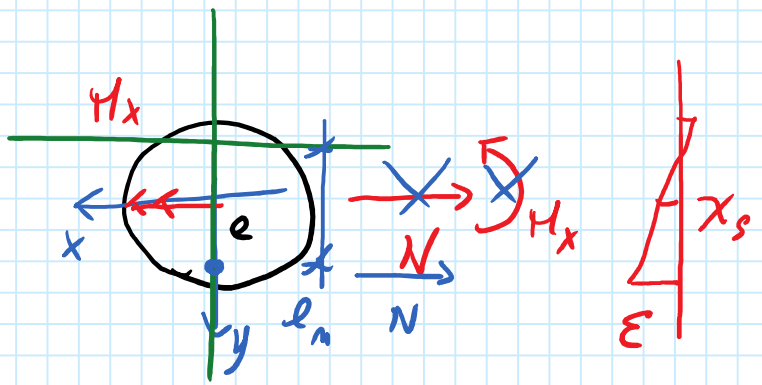
Eccentricità della sezione normale



$$e_x : \frac{M_x}{N} \qquad e_y : -\frac{M_y}{N}$$







$$\varepsilon = \chi_s S$$

$$\sigma = E \chi_s S \qquad E\chi_s = \frac{\sigma}{S}$$

$$N = \int_A \sigma \, dA = \int_A E\chi_s S \, dA = E\chi_s \int_A S \, dA = E\chi_s S_n$$

$$M_n = \int_A \sigma S \, dA = \int_A E\chi_s S^2 \, dA = E\chi_s I_n$$

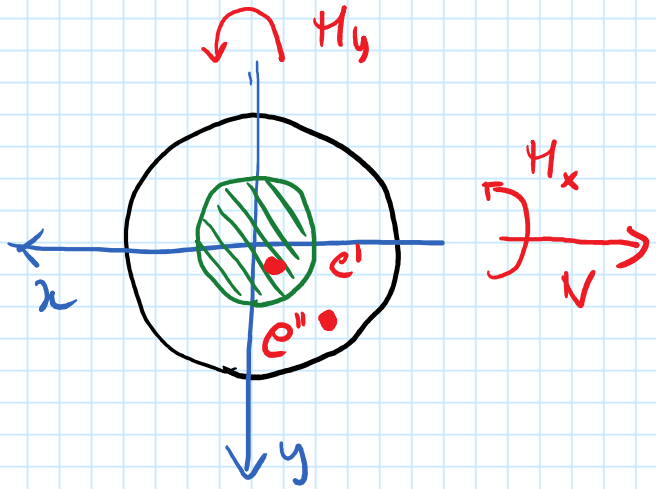
$$\frac{M_n}{N} = \frac{E\chi_s I_n}{E\chi_s S_n} \Rightarrow \frac{M_n}{N} = \frac{I_n}{S_n} \Rightarrow \boxed{l_n = \frac{I_n}{S_n}}$$

Formule momomie

$$N = E\chi_s S_m \quad \Rightarrow \quad N = \frac{\sigma}{S} S_m \quad \Rightarrow \quad \boxed{\sigma = \frac{N}{S_m} s}$$

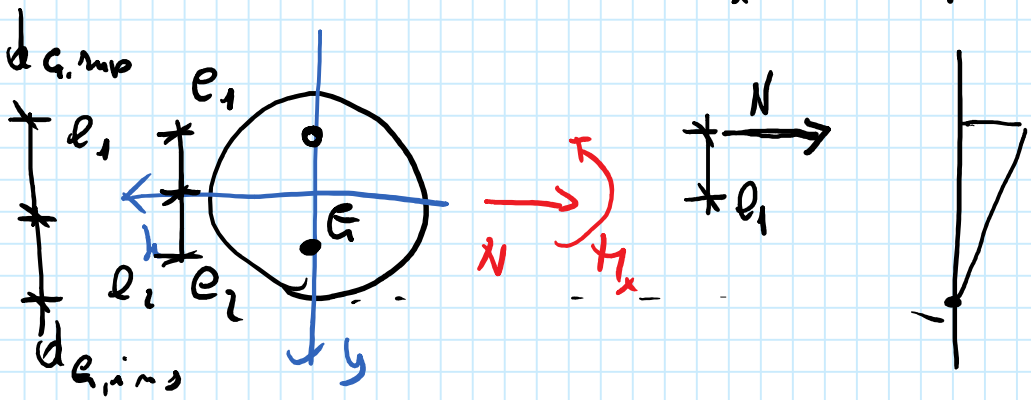
$$M_m = E\chi_s I_m \quad \Rightarrow \quad M_m = \frac{\sigma}{S} I_m \quad \Rightarrow \quad \boxed{\sigma = \frac{M_m}{I_m} s}$$

Nocciolo centrale d'inerzia



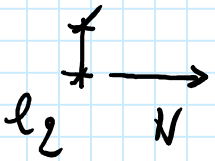
e' interno, asse neutro esterno alla sezione

e'' esterno, asse neutro interno alla sezione



$M_x = -N e_1$

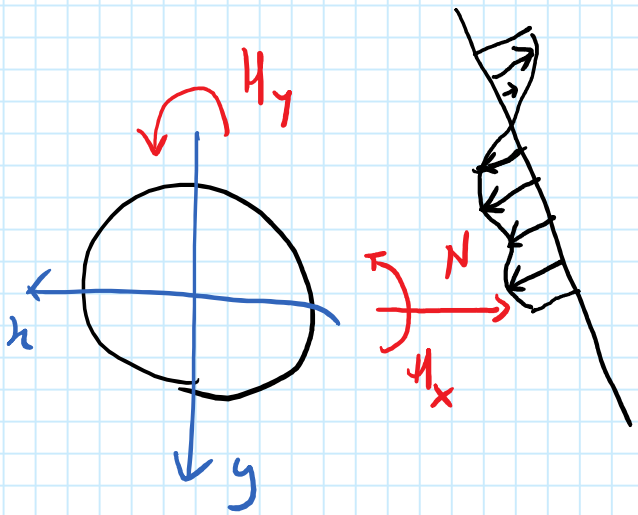
$M_x = N e_2$



$$\sigma = \frac{N}{A} + \frac{M_x}{I_x} y \Rightarrow 0 = \frac{N}{A} + \frac{M_x}{I_x} d_{G,inf}$$

$$\frac{N}{A} - \frac{N e_1}{I_x} d_{G,inf} = 0$$

$$\boxed{e_1 = \frac{I_x}{A\, d_{G,inf}}} \qquad \boxed{e_2 = \frac{I_x}{A\, d_{G,sup}}}$$



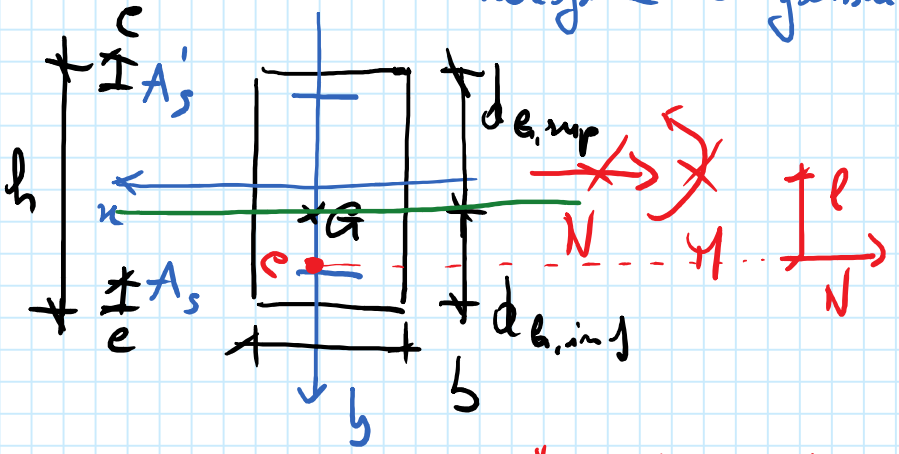
σ con distribuzione non lineare

Formule generali per il calcolo di N, M_x ed M_y

$$N = \int_A \sigma \, dA \qquad M_x = \int_A \sigma y \, dA \qquad M_y = -\int_A \sigma x \, dA$$

Valgono anche per σ con distribuzione lineare

Verifica a fessurazione — I stadio



$$e^* = \frac{M}{N} - \left(d_{G,sup} - \frac{h}{2}\right)$$

1) Sez. I sez. omogeneizzata

2) $\sigma = \frac{N}{A} + \frac{M}{I}\, y$

3) $\sigma_{max,t} \leq f_{ctk}$

4) $n = \frac{E_s}{E_c}$

$$A = A_c + n\left(A_s + A'_s\right)$$

$$S_0 = \frac{b h^2}{2} + n A'_s c + n A_s d$$

$$d_{G,sup} = \frac{S_0}{A} \qquad d_{G,inf} = h - d_{G,sup}$$

$$I = \frac{b\, d_{G,inf}^{3}}{3} + \frac{b\, d_{G,sup}^{3}}{3} + n A_s' \left(d_{G,sup} - e\right)^2 + n A_s \left(d_{G,inf} - e\right)^2$$

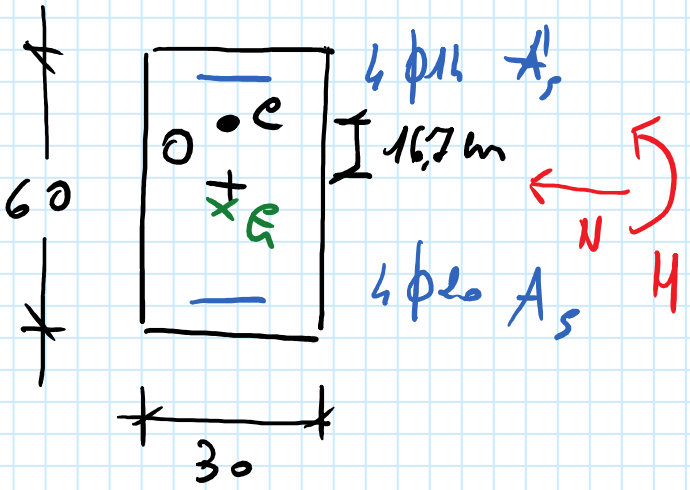
2)

$$\sigma = \frac{N}{A} + \frac{M^*}{I} y = \frac{N}{A} + \frac{N e^*}{I} y$$

$$M^* = N e^*$$

$$e^* = \frac{M}{N} - \left(d_{G,sup} - \frac{h}{2}\right)$$

3) $$\sigma_{max,t} = \frac{N}{A} + \frac{M+N}{I} d_{G,inf} \leq f_{ctk}$$



C30/37 BH30C

N : -300 kN

M : 50 kNm

c : 5 cm

1) $A = 30 \times 60 + 6{,}35 \times (4 \times 1{,}54 + 4 \times 3{,}14) = 1919{,}0 \text{ cm}^2$

$$S_0 = 30 \times \frac{60^2}{2} + 6{,}35 \times 4 \times 1{,}54 \times 5 + 6{,}35 \times 4 \times 3{,}14 \times 55 =$$

$$= 58582{,}2 \text{ cm}^3$$

$$d_{G,inf} = \frac{58582{,}2}{1919} = 30{,}53 \text{ cm} \qquad d_{G,inf} = 29{,}47 \text{ cm}$$

$$I = 30 \times \frac{29,47^3}{3} + 30 \times \frac{30,53^3}{3} + 6,35 \times 4 \times 3,14 \times (29,47 - 5)^2 +$$

$$+ 6,35 \times 4 \times 1,54 \times (30,53 - 5)^2 = 613757 \ cm^4$$

2) $$\sigma = \frac{N}{A} + \frac{M^*}{I} y$$

$$e = \frac{M}{N} = \frac{50}{-300} = -0,167 \ m$$

$$e^* = \frac{M}{N} - \left(d_{G,sup} - \frac{h}{2}\right) = -0,167 - \left(0,3053 - 0,3\right) = 0,1723 \ m$$

$$M^* = N e^* = -300 \times (-0,1723) = 51,69 \ kN\,m$$

3)

$$\sigma_{max,t} = -\frac{300}{1919} \times 10 + \frac{51,69}{613757} \times 29,42 \times \frac{10^3 \times 10^3}{10^3}$$

$$= 0,92 \text{ MPa} < 2,43 \text{ MPa}$$ ok!

$$f_{cfk} = 2,43 \text{ MPa}$$

Verifica allo stato limite di fessurazione in esercizio — II stadio

$\sigma_c \leq 0{,}6\, f_{ck}$ $\qquad$ $\sigma_c \leq 0{,}45\, f_{ck}$

$\sigma_s \leq 0{,}8\, f_{yk}$

comb. rara $\qquad$ comb. quasi perm.

interno nocciolo → piccola eccentricità → 1 C $\qquad$ 1 T

compressione $\qquad$ trazione

esterno al nocciolo → grande eccentricità