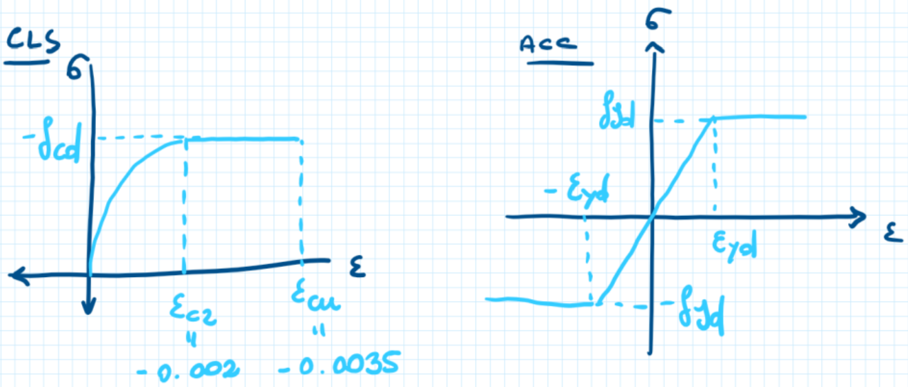
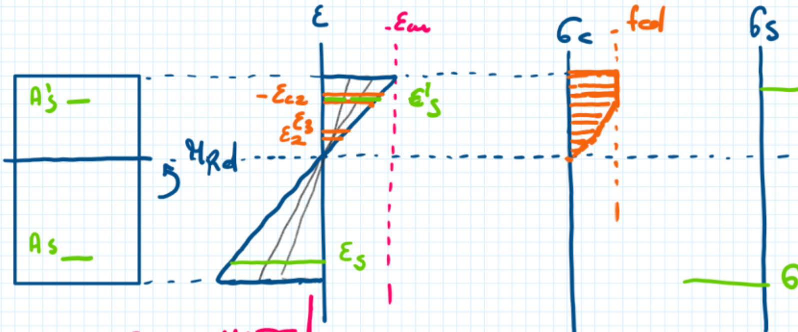
III STADIO

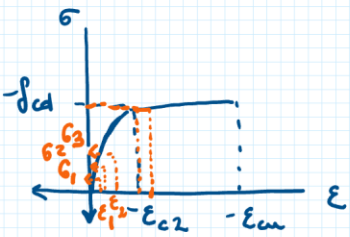
VERIFICA ALLO SLU $\Longrightarrow$ $M_{Rd} \geq M_{Ed}$

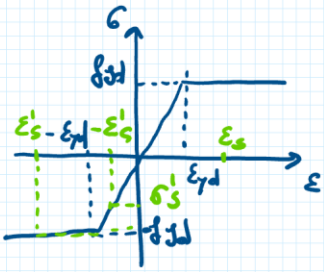




$\Longrightarrow M_{Rd} = \int \sigma \, y \, dA$

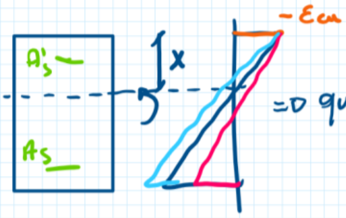
DIAGR. LIMITE DELLE DEF. ε_{LIM}





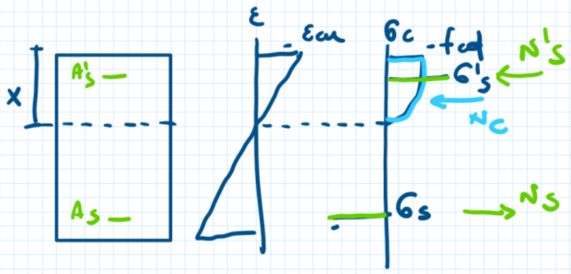
PROCEDIMENTO

1) DIAGR. LIMITE DI ε_{LIM} $\rightarrow$ a) $-\varepsilon_{cu}$ sul bordo più compresso



$\Longrightarrow$ quale ?

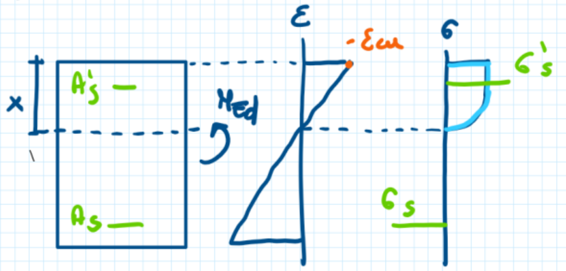
b) x



$$N_c(x) + N'_s(x) + N_s(x) = 0$$

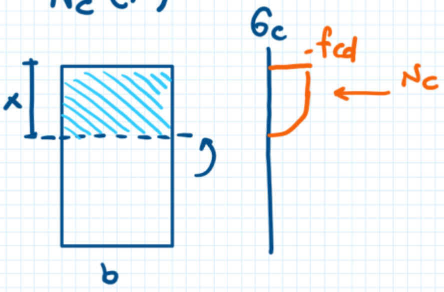
2) M_{Rd}

1) DETERMINO $\varepsilon_{LIM} \Rightarrow x$



$$N_c(x) + N'_s(x) + N_s(x) = 0$$

• $N_c(x)$

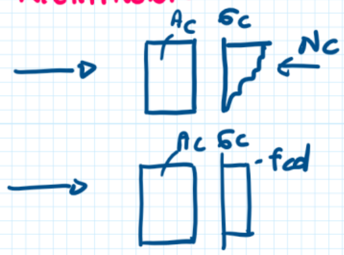


$$N_c = \int \sigma_c \, dA_c$$

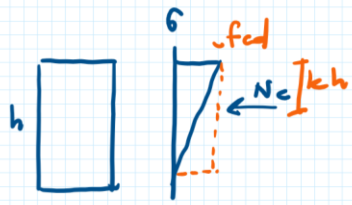
$$N_c = -\beta\, b\, x\, f_{cd}$$

COEFF. DI RIEMPIMENTO

$$\beta = \frac{\int \sigma_c \, dA}{A_c f_{cd}}$$



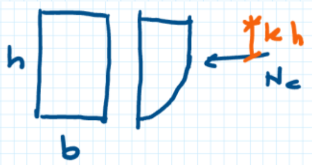
ES.



$$N_c = -\beta A_c f_{cd}$$

$\beta \rightarrow 0.5$ $\quad k = \frac{1}{3}$

NEL CASO DI SEZ. RETT. $\Rightarrow$

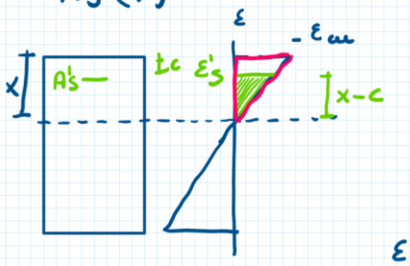


$$N_c = -\beta\, b\, h\, f_{cd}$$

$\beta = 0.81$

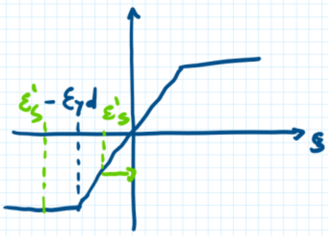
$k = 0.416$

- $N'_s(x)$



$$N'_s = A'_s\,\sigma'_s(x)$$
$$\downarrow$$
$$\varepsilon'_s$$

$$\frac{\varepsilon'_s}{-(x-c)} = \frac{\cancel{-}\varepsilon_{cu}}{\cancel{-}x} \Rightarrow \varepsilon'_s = -\frac{x-c}{x}\,\varepsilon_{cu}$$

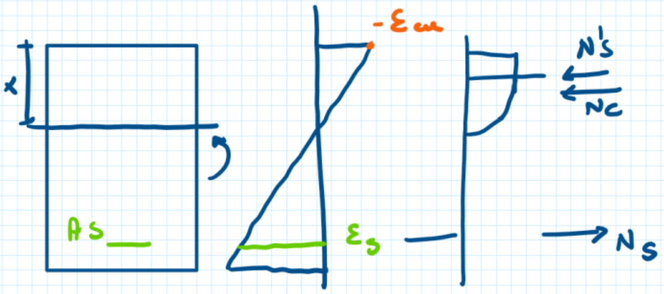


se $\varepsilon'_s \leq -\varepsilon_{yd} \Rightarrow \sigma'_s = -f_{yd}$

se $0 \geq \varepsilon'_s \geq -\varepsilon_{yd} \Rightarrow \sigma'_s = \dfrac{\varepsilon'_s}{\varepsilon_{yd}}\,f_{yd}$

$\varepsilon_{yd} = 0.00196$

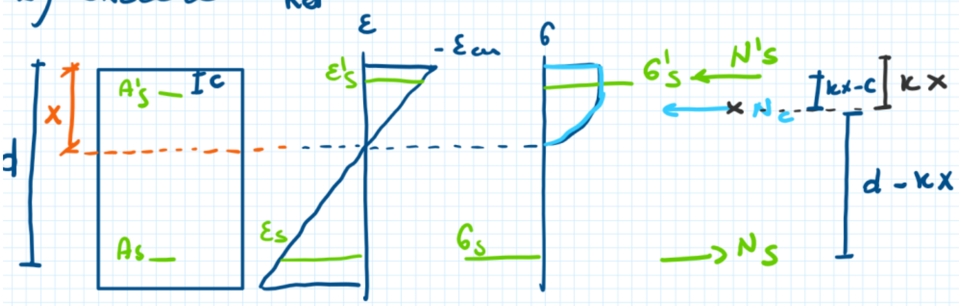
- N_s



$$N_s = A_s f_{yd}$$

EQUAZIONE PER TROVARE x : $\boxed{-\beta b x f_{cd} + A'_s\,\tilde{\sigma}'_s(x) + A_s f_{yd} = 0}$

2) CALCOLO M_{Rd}

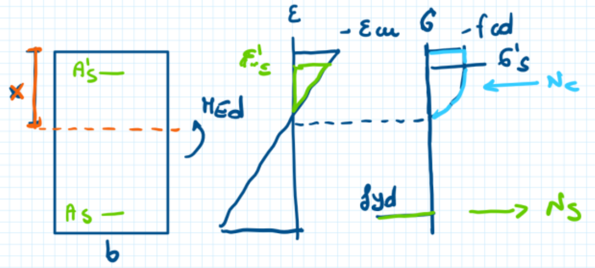


$$M_{Rd} = \underbrace{\underbrace{N'_s}_{(-)}\,\underbrace{[(kx-c)]}_{(-)}}_{M^+} + \underbrace{\underbrace{N_s}_{(+)}\,\underbrace{(d-kx)}_{(+)}}_{M^+}$$

SEZ. RETTANGOLARE

- A SEMPLICE ARMATURA $A'_s = 0$
- A **DOPPIA ARMATURA** A'_s, A_s
  - $\varepsilon'_s \le -\varepsilon_{yd}$ = ARM. COMPR. SNERVATA (1)
  - $\varepsilon'_s \ge -\varepsilon_{yd}$ = ARM. COMPR. ELASTICA (2)

(1) SEZ. RETTANGOLARE, A'_s PLASTICIZZATA



1) DETERMINO x

$$N_c + N'_s + N_s = 0$$

$$-\beta\, b\, x\, f_{cd} - A'_s f_{yd} + A_s f_{yd} = 0$$

$$\Downarrow$$

$$\varepsilon'_s \le -\varepsilon_{yd} \implies \sigma'_s = -f_{yd}$$

$$+\beta\, b\, x\, f_{cd} = -A'_s f_{yd} + A_s f_{yd}$$

$$\boxed{x = \frac{(A_s - A'_s)\, f_{yd}}{\beta\, b\, f_{cd}}}$$

VERIFICO CHE A'_s SIA SNERVATA $\implies$ $\varepsilon'_s \le -\varepsilon_{yd}$

$$\frac{\varepsilon'_s}{-(x-c)} = \frac{-\varepsilon_{cu}}{-x} \implies \varepsilon'_s = -\frac{x-c}{x}\varepsilon_{cu}$$

$$-\frac{x-c}{x}\varepsilon_{cu} \le -\varepsilon_{yd}$$

$$-(x-c)\,\varepsilon_{cu} \le -x\,\varepsilon_{yd}$$

$$-x\,\varepsilon_{cu} + c\,\varepsilon_{cu} + x\,\varepsilon_{yd} \le 0$$

$$-x\,\varepsilon_{cu} + c\,\varepsilon_{cu} + x\,\varepsilon_{yd} \le 0$$

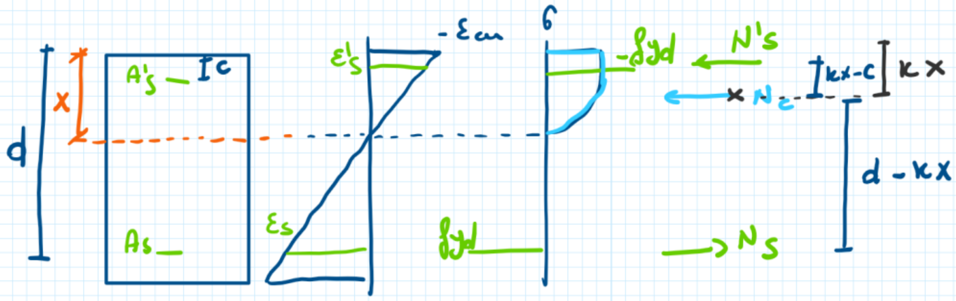
$$(-\varepsilon_{cu} + \varepsilon_{yd})\,x \le -c\,\varepsilon_{cu}$$

$$(\varepsilon_{cu} - \varepsilon_{yd})\,x \ge c\,\varepsilon_{cu}$$

$$x \ge c\,\frac{\overset{0.0035}{\varepsilon_{cu}}}{\varepsilon_{cu} - \underset{0.00196}{\varepsilon_{yd}}}$$

$$\boxed{x \ge 2.27\,c}$$

2) M_{Rd}

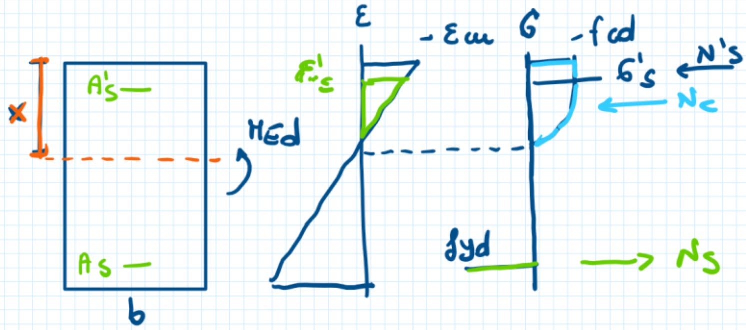


$$M_{Rd} = -N'_s\,(kx - c) + N_s\,(d - kx)$$

$$M_{Rd} = -(-A'_s f_{yd})(kx - c) + A_s f_{yd}\,(d - kx)$$

$$M_{Rd} = A'_s f_{yd}\,(kx - c) + A_s f_{yd}\,(d - kx)$$

2 SEZ. RETTANGOLARE, A'_s ELASTICA



1) DETERMINARE x

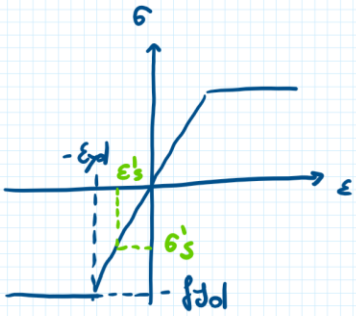
$$N_c + N'_s + N_s = 0$$

$$-\beta b x f_{cd} + A'_s \sigma'_s \qquad + A_s f_{yd} = 0$$

$$\downarrow$$

$$\varepsilon'_s = -\frac{x-c}{x}\varepsilon_{cu}$$

$$\sigma'_s = \frac{\varepsilon'_s}{\varepsilon_{yd}} f_{yd}$$



$$-\beta b x f_{cd} + A'_s\left(-\frac{x-c}{x}\varepsilon_{cu}\right)\frac{f_{yd}}{\varepsilon_{yd}} + A_s f_{yd} = 0$$

$$-\beta b x f_{cd} - \frac{x-c}{x}\frac{\varepsilon_{cu}}{\varepsilon_{yd}} f_{yd} A'_s + A_s f_{yd} = 0$$

$$-\beta b x^2 f_{cd} - (x-c)\frac{\varepsilon_{cu}}{\varepsilon_{yd}} f_{yd} A'_s + A_s f_{yd}\, x = 0 \qquad \mu = \frac{A'_s}{A_s} \Rightarrow A'_s = \mu A_s$$

$$-\beta b x^2 f_{cd} - (x-c)\overbrace{\frac{\varepsilon_{cu}}{\varepsilon_{yd}} f_{yd}\,\mu}^{\mu_1} A_s + A_s f_{yd}\, x = 0 \qquad \mu_1 = \mu\frac{\varepsilon_{cu}}{\varepsilon_{yd}}$$

$$-\beta b x^2 f_{cd} - (x-c)\mu_1 A_s f_{yd} + A_s f_{yd}\, x = 0$$

$$\frac{-\beta \cancel{b} x^2 \cancel{f_{cd}}}{\cancel{b}\, d\, \cancel{f_{cd}}} - (x-c)\mu_1 \overbrace{\frac{A_s f_{yd}}{b\, d\, f_{cd}}}^{\omega} + \overbrace{\frac{A_s f_{yd}\, x}{b\, d\, f_{cd}}}^{\omega} = 0 \qquad \omega = \frac{A_s f_{yd}}{b\, d\, f_{cd}}$$

$$-\frac{\beta}{d}x^2 - (x-c)\mu_1\omega + \omega x = 0$$

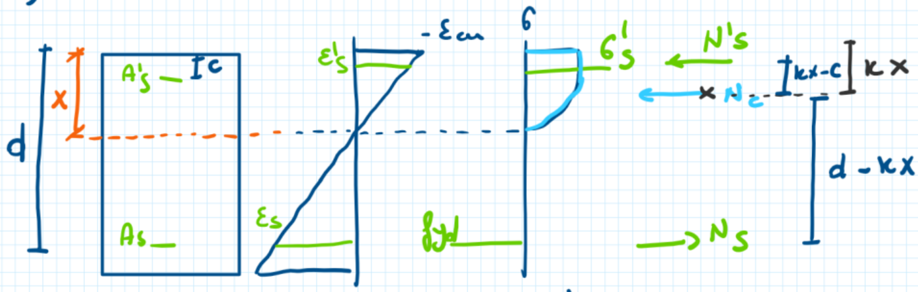
$$-\frac{\beta}{d}x^2 - \mu_1\omega x + \mu_1\omega c + \omega x = 0$$

$$-\frac{\beta}{d}x^2 + \omega(1-\mu_1)x + \mu_1\omega c = 0$$

$$\frac{\beta}{d}x^2 + \omega(\mu_1-1)x - \mu_1\omega c = 0$$

$$\boxed{\beta x^2 + \omega d(\mu_1 - 1)x - \mu_1\omega c d = 0} \Rightarrow x$$

2) M_{Rd}



$$M_{Rd} = -N'_s\,(kx - c) + \underbrace{N_s}_{=A_s f_{yd}}(d - kx)$$