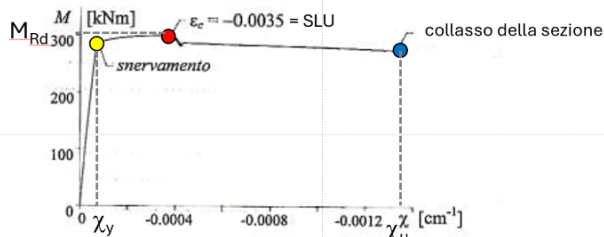


1) REQUISITO DI RESISTENZA

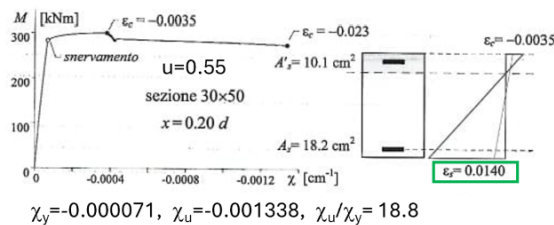
$$M_{Rd} = M_{Ed}$$

2) REQUISITO DI DUTTILITA'

Diagramma Momento – curvatura di una sezione in c.a.

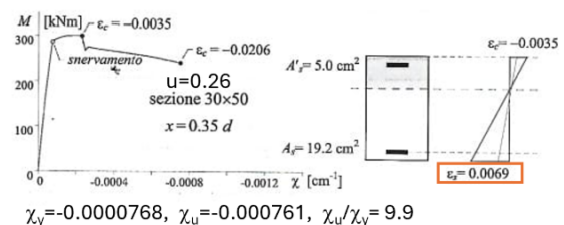


1) Sezione molto duttile



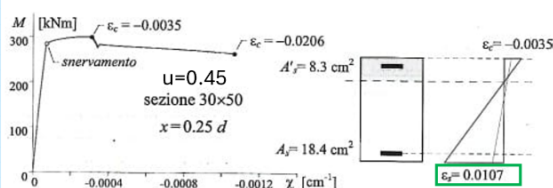
$$\chi_y = -0.000071, \chi_u = -0.001338, \chi_u/\chi_y = 18.8$$

3) Sezione mediamente duttile



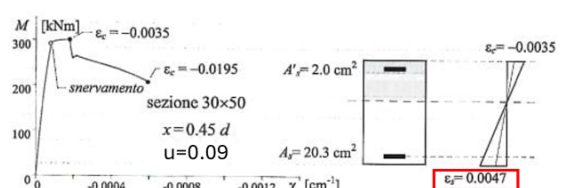
$$\chi_y = -0.0000768, \chi_u = -0.000761, \chi_u/\chi_y = 9.9$$

2) Sezione duttile

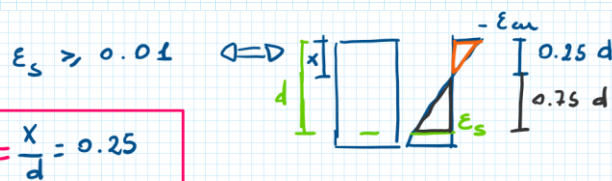


$$\chi_y = -0.000073, \chi_u = -0.001070, \chi_u/\chi_y = 14.7$$

4) Sezione mediamente (quasi poco) duttile



$$\chi_y = -0.0000848, \chi_u = -0.000594, \chi_u/\chi_y = 7.0$$



$$\xi = \frac{x}{d} = 0.25$$

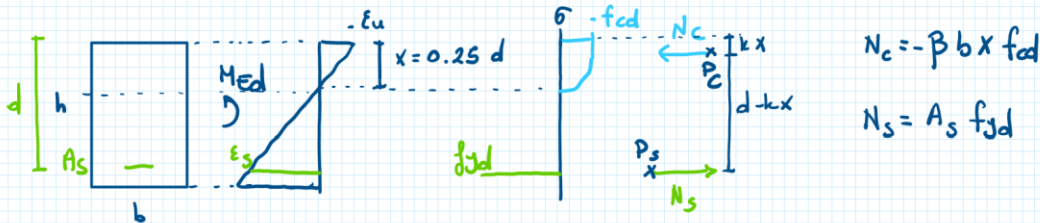
$$\frac{\epsilon_s}{0.75d} = \frac{1/\epsilon_{cu}}{1/0.25d} \Rightarrow \epsilon_s = \frac{0.75}{0.25} \epsilon_{cu}$$

$$\epsilon_s = \frac{0.75}{0.25} 0.0035 = 0.0105$$

FORMULE DI PROGETTO
SEZIONI RETTANGOLARI

- ① SEZIONI A SEMPLICE ARMATURA
($A'_s = 0$)
- ② SEZIONI A DOPPIA ARMATURA

① SEZIONI A SEMPLICE ARMATURA



PROG. LA SEZ. IN CLS :

POLO P_s : $M = -N_c (d - kx)$

$$M = +\beta b \xi d f_{cd} d \left(1 - k \frac{\xi}{d}\right) \quad \xi = \frac{x}{d} \Rightarrow x = \xi d$$

$$M = +\beta b \xi d f_{cd} d (1 - k \xi)$$

$$M = b d^2 \underbrace{\beta \xi f_{cd}}_{\frac{1}{z^2}} (1 - k \xi) \quad z = \frac{1}{\sqrt{\beta \xi f_{cd} (1 - k \xi)}} = \frac{1}{\sqrt{0.81 \times 0.25 \times 14.17 \times 10^3 (1 - 0.416 \times 0.25)}} = 0.0197$$

$$M = \frac{b d^2}{z^2}$$

$$M = M_{Ed} = \frac{b d^2}{z^2}$$

$$C 25/30 \quad f_{cd} = 14.17 \text{ MPa}$$

$$M \rightarrow [kNm] \quad f_{cd} \rightarrow \left[\frac{kN}{m^2}\right] \rightarrow 10^3$$

$$b, d \rightarrow [m]$$

PROG. TRAVI EMERGENTI : fisso $b \Rightarrow d = \sqrt{\frac{M_{Ed}}{b}} z^2 = z \sqrt{\frac{M_{Ed}}{b}}$

PROG. TRAVE SPESSORE : fisso $d \Rightarrow b = M_{Ed} \frac{z^2}{d^2}$
(da solaio)

PROG. ARM. TESA A_s :

POLO P_c : $N_s (d - kx) = M$

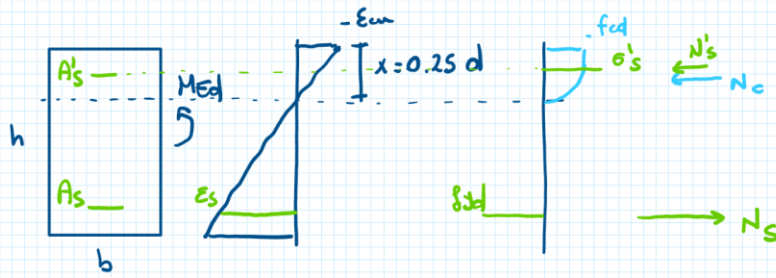
$$M = M_{Ed} \Rightarrow$$

$$A_s f_{sd} d (1 - k \xi) = M$$

$$1 - 0.416 \cdot 0.25 = 0.896$$

$$A_s = \frac{M_{Ed}}{0.9 d f_{sd}}$$

2) SEZIONE A DOPPIA ARMATURA



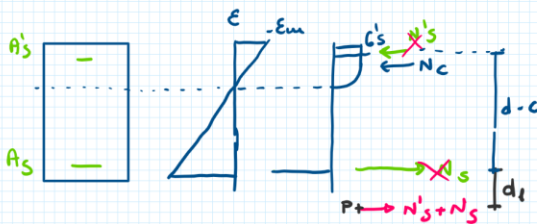
$$N_c = -\beta x f_{cd}$$

$$N_s = A_s f_{yd}$$

$$N_s' = A_s' \sigma_s' = -u A_s s' f_{yd}$$

$$\begin{cases} A_s' = u A_s \\ \sigma_s' = -s' f_{yd} \quad (s' \leq 1) \end{cases}$$

MI RICONDUCO A $N_s' + N_s$:



$$(N_s' + N_s) = N_s' + N_s$$

$$|N_s' + N_s| < |N_s|$$

$$M_{N_s' + N_s} = M_{N_s'} + M_{N_s}$$

Ricordo d_1 :

$$-N_s' (d_1 + d - c) - N_s d_1 = 0$$

$$+ u A_s s' f_{yd} (d_1 + d - c) - A_s f_{yd} d_1 = 0$$

$$u A_s s' f_{yd} d_1 + u A_s s' f_{yd} (d - c) - A_s f_{yd} d_1 = 0$$

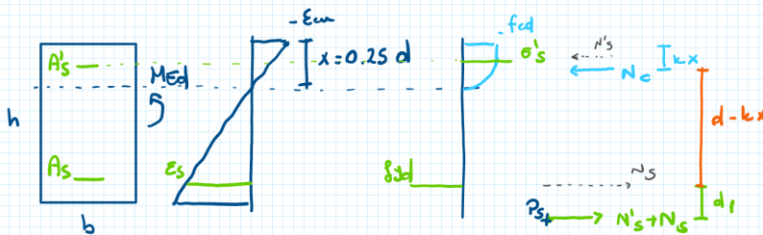
$$A_s f_{yd} d_1 (u s' - 1) + u A_s s' f_{yd} (d - c) = 0$$

$$d_1 (u s' - 1) = -u s' d \left(1 - \frac{c}{d}\right)$$

$$\gamma = \frac{c}{d}$$

$$d_1 = \frac{u s' d (1 - \gamma)}{1 - u s'}$$

MI RICONDUCO A UN SISTEMA DI DUE FORZE:



PROG. LA SED. IN CLS:

POLO P_s :

$$M = -N_c (d_1 + d - kx)$$

$$M = + \beta b \xi d f_{cd} (d_1 + d - kx)$$

$$M = \beta b \xi d f_{cd} d \left(\frac{d_1}{d} + 1 - k \frac{x}{d} \right)$$

$$M = b d^2 \beta \xi f_{cd} (1 - k \xi) \left[\frac{d l}{d (1 - k \xi)} + 1 \right]$$

$$M = b d^2 \beta \xi f_{cd} (1 - k \xi) \left[\frac{\mu s' d (1 - \gamma)}{1 - \mu s'} \frac{1}{d (1 - k \xi)} + 1 \right]$$

$$M = b d^2 \beta \xi f_{cd} (1 - k \xi) \left[\frac{\mu s'}{1 - \mu s'} \frac{(1 - \gamma)}{(1 - k \xi)} + 1 \right]$$

$\frac{1}{z^2}$ $\frac{1}{k^2}$
 $\frac{1}{z^2} \cdot \frac{1}{k^2} = \frac{1}{z'^2}$

$$M = \frac{b d^2}{z'^2}$$

PROG. TRAVI EMERGENTI : fisso $b \Rightarrow d = \sqrt{\frac{M_{Ed}}{b}} z'^2 = z' \sqrt{\frac{M_{Ed}}{b}}$

PROG. TRAVE SPESSORE : fisso $d \Rightarrow b = \frac{M_{Ed}}{d^2} z'^2$
(da soloio)

OSSERVO z' :

$$z' = z K$$

↳ STUDIO K

$$\frac{1}{k^2} = \frac{\mu s'}{1 - \mu s'} \left(\frac{1 - \gamma}{1 - k \xi} \right) + 1$$

$$\gamma = \frac{c}{d} \approx 0.1 \quad \text{TRAVI EMERGENTI}$$

$$1 - k \xi = 0.396^{0.9}$$

$$\frac{1}{k^2} = \frac{\mu s'}{1 - \mu s'} + 1 \Rightarrow \frac{1}{k^2} = \frac{\mu s' + 1 - \mu s'}{1 - \mu s'}$$

$$\frac{1}{k^2} = \frac{1}{1 - \mu s'}$$

$$k = \sqrt{1 - \mu s'} < 1$$



$$\Sigma' = 2K < 2$$

Calcestruzzo:	$f_{ck} =$	25.0	MPa	$f_{cd} =$	14.17	MPa
Acciaio:	$f_{yk} =$	450.0	MPa	$f_{yd} =$	391.3	MPa
				$\xi = x/d =$	0.2500	
<div>TR. EMER. TR. SPESS.</div>						
$\gamma =$		0.05	0.10	0.15	0.20	0.25
$s' =$		1.0000	1.0000	0.7156	0.3578	0.0000
$u = 0.00$	$r =$			0.0197		
$u = 0.10$	$r' =$	0.0187	0.0187	0.0190	0.0194	0.0197
$u = 0.20$	$r' =$	0.0175	0.0176	0.0183	0.0191	0.0197
$u = 0.30$	$r' =$	0.0164	0.0165	0.0176	0.0187	0.0197
$u = 0.40$	$r' =$	0.0151	0.0153	0.0168	0.0184	0.0197
$u = 0.50$	$r' =$	0.0137	0.0139	0.0160	0.0181	0.0197

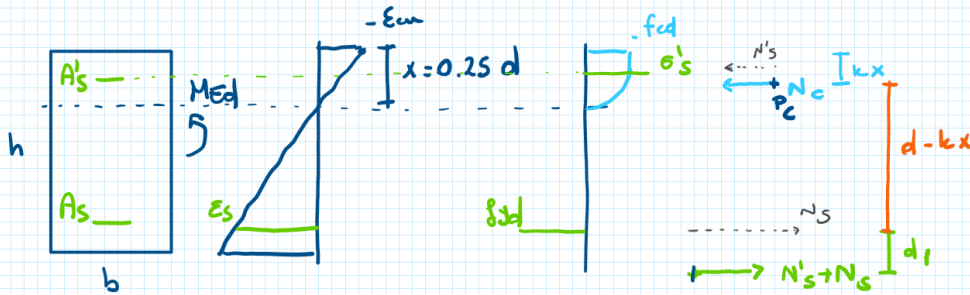
$$s' \Rightarrow \sigma'_s = -s f_{yd}$$

$$s' = \frac{\varepsilon'_s}{-\varepsilon_{yd}} = -\frac{x-c}{x} \frac{\varepsilon_{cu}}{(\pm \varepsilon_{yd})} \Rightarrow s' = \frac{\xi - \gamma}{\xi} \frac{\varepsilon_{cu}}{\varepsilon_{yd}}$$

TRAVE EMERG.: $\gamma = \frac{c}{d} \approx 0.1$ $s' = \frac{0.25 - 0.1}{0.25} \frac{0.0035}{0.00196} = 1.04$

TRAVE A SPESS.: $\gamma = \frac{c}{d} \approx 0.2$ $s' = \frac{0.25 - 0.2}{0.25} \frac{0.0035}{0.00196} = 0.36$

PROG. L'ARMATURA TESA A_s :



Po lo su P_c : $(N'_s + N_s) (d_1 + d - kx) = M$

$$(-\mu A_s \sigma'_s f_{yd} + A_s f_{yd}) (d_1 + d - kx) = M$$

$$A_s f_{yd} (1 - \mu s') d \left(\frac{d_1}{d} + 1 - k \frac{x}{d} \right) = M$$

$$A_s f_{yd} d (1 - \mu s') \underbrace{(1 - k\xi)}_{\approx 0.9} \left[\frac{d_1}{d (1 - k\xi)} + 1 \right] = M$$

$$A_s f_{yd} d 0.9 (1 - \mu s') \left[\frac{\mu s' d (1 - \xi)}{(1 - \mu s') d (1 - k\xi)} + 1 \right] = M$$

$$0.9 d A_s f_{yd} (1 - \mu s') \left[\frac{\mu s'}{1 - \mu s'} + 1 \right] = M$$

$$0.9 d A_s f_{yd} \cancel{(1 - \mu s')} \left[\frac{\mu s' + 1 - \mu s'}{1 - \mu s'} \right] = M$$

$$M = 0.9 d A_s f_{yd}$$

$$M = M_{Ed} \Rightarrow$$

$$A_s = \frac{M_{Ed}}{0.9 d f_{yd}}$$