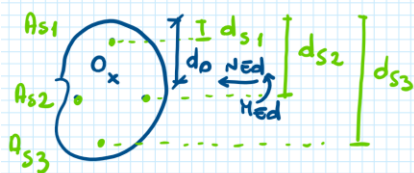


# VERIFICA DI SEZ. DI FORMA GENERICA



3) SEZ. PARZ. O TUTTA COMPR.?

1) DET.  $\epsilon_{LIM}$

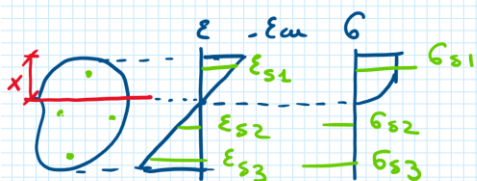
2)  $M_{Rd}(N_{Ed})$

SEZ. PARZIALIZZATA

SEZ. TUTTA COMPRESSA

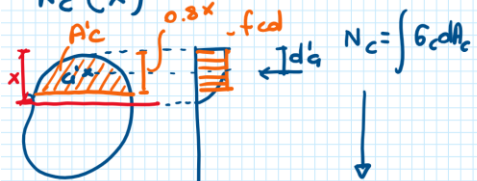
1) DETERMINARE  $\epsilon_{LIM}$

⇒ TROVARE  $x$



$$N_c(x) + \sum_{i=1}^3 N_{si}(x) = N_{Ed}$$

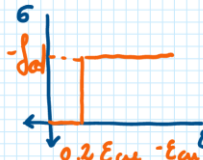
•  $N_c(x)$



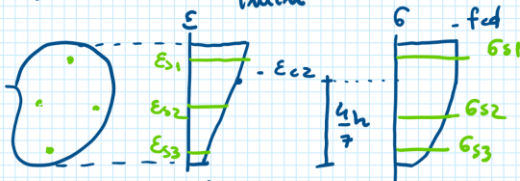
STRESS BLOCK

$$N_c = -A'_c f_{cd}$$

APPLICATO IN  $G'$



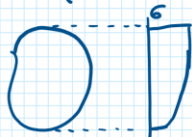
⇒ TROVARE  $\eta_{min}$



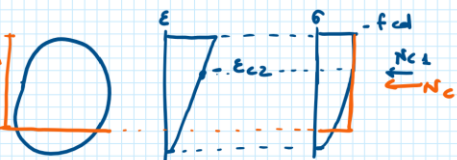
$\epsilon_{cmin} \Rightarrow \eta_{min}$

$$N_c(\eta_{min}) + \sum_{i=1}^3 N_{si}(\eta_{min}) = N_{Ed}$$

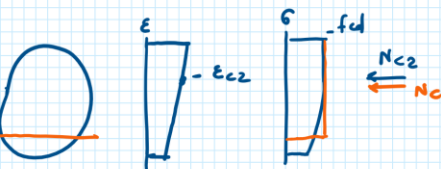
•  $N_c(\eta_{min})$



STRESS BLOCK? NO, SOLO PER SEZ. PARZIALIZZATA!

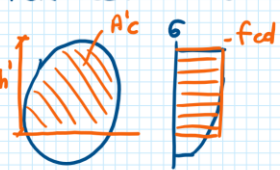


NON POSSO USARE LO STRESS BLOCK



STESSO RISULTANTE PER DIAGR. E DIVERSI, NON PUO' ESSERE!

PER SEZ. NON RETTANGOLARE TUTTA COMPRESSA:



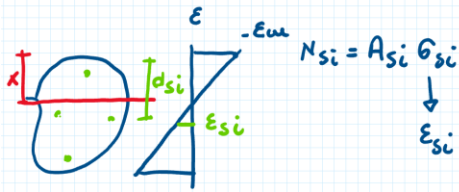
$$N_c = -A'_c f_{cd}$$

$$A'_c = f(h')$$

$$h' = h [1 - 0.2(1 - \eta_{min})^2]$$

### SEZ. PARZIALIZZATA

•  $N_{Si}$



$$N_{Si} = A_{Si} \sigma_{Si} \downarrow \epsilon_{Si}$$

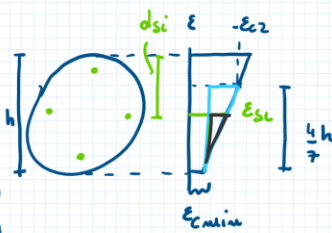
$$\frac{\epsilon_{Si}}{d_{Si} - x} = \frac{\epsilon_{cu}}{x}$$

$$\epsilon_{Si} = \frac{d_{Si} - x}{x} \epsilon_{cu}$$

$$\hookrightarrow \sigma_{Si}$$

### SEZ. TUTTA COMPRESSA

•  $N_{Si}$



$$N_{Si} = A_{Si} \cdot \sigma_{Si} \downarrow \epsilon_{Si}$$

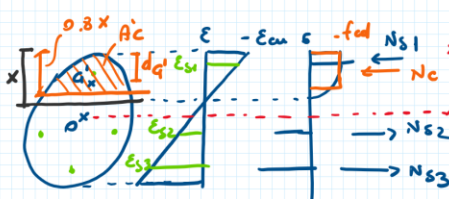
$$\frac{\epsilon_{Si} - \epsilon_{cmin}}{h - d_{Si}} = \frac{-\epsilon_{c2} - \epsilon_{cmin}}{\frac{4}{7}h}$$

$$\epsilon_{Si} = \left[ \frac{h - d_{Si}}{\frac{4}{7}h} (-\epsilon_{c2} - \epsilon_{cmin}) + \epsilon_{cmin} \right]$$

$$\epsilon_{Si} = -\epsilon_{c2} \left[ \frac{h - d_{Si}}{\frac{4}{7}h} (1 - \eta_{min}) + \eta_{min} \right]$$

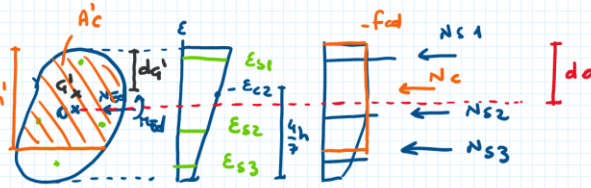
$$\hookrightarrow \sigma_{Si}$$

### DETERMINARE $M_{Rd}$



$$M_{Rd}(N_{Ed}) = -N_c (d_o - d_{g1})$$

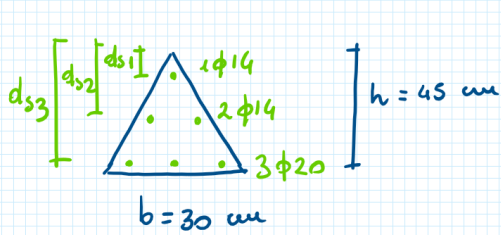
$$N_{Si} (d_{Si} - d_o) \left\{ \begin{array}{l} -N_{S1} (d_o - d_{S1}) \\ + \\ + N_{S2} (d_{S2} - d_o) \\ + \\ + N_{S3} (d_{S3} - d_o) \end{array} \right.$$



$$M_{Rd}(N_{Ed}) = -N_c (d_o - d_{g1})$$

$$\left. \begin{array}{l} -N_{S1} (d_o - d_{S1}) \\ + \\ + N_{S2} (d_{S2} - d_o) \\ + \\ + N_{S3} (d_{S3} - d_o) \end{array} \right\} N_{Si} (d_{Si} - d_o)$$

## ESEMPIO 1



$$d_{s1} = 5 \text{ cm}$$

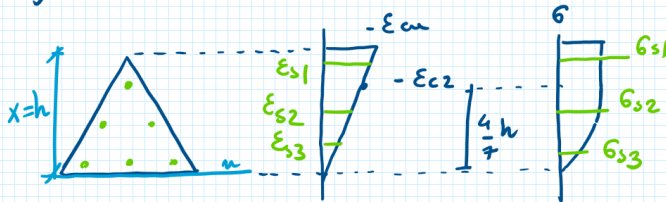
$$N_{Ed} = -400 \text{ kN}$$

$$d_{s2} = 22.5 \text{ cm}$$

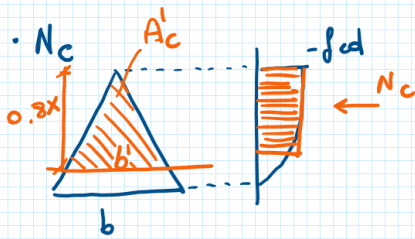
$$M_{Ed} = 100 \text{ kNm}$$

$$d_{s3} = 40 \text{ cm}$$

0) SEZ. PARZIALEZZATA O TUTTA COMPRESSA?



$$|N_c + N_{s1} + N_{s2} + N_{s3}| \quad V_s \quad |N_{Ed}|$$

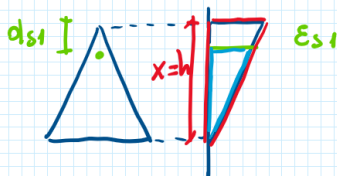


$$N_c = -A'_c f_{cd} = -432 \cdot \frac{16.17}{10} = -612.1 \text{ kN}$$

$$A'_c = b' \frac{(0.8x)}{2} = 24 \cdot \frac{(0.8 \cdot 45)}{2} = 432.0 \text{ cm}^2$$

$$b' = \frac{b}{h} \cdot 0.8x = \frac{30}{45} \cdot 0.8 \cdot 45 = 24 \text{ cm}$$

$$N_{s1} = A_{s1} \sigma_{s1}$$



$$\frac{\epsilon_{s1}}{h - d_{s1}} = \frac{-\epsilon_{cu}}{h} \Rightarrow \epsilon_{s1} = -\frac{h - d_{s1}}{h} \epsilon_{cu}$$

$$\text{PER IL GENERICO STRATO: } \epsilon_{si} = -\frac{h - d_{si}}{h} \epsilon_{cu}$$

$$\epsilon_{s1} = -\frac{45 - 5}{45} \cdot 0.0035 = -0.0031 \Rightarrow \sigma_{s1} = -391.3 \text{ MPa}$$

$$\varepsilon_{s2} = - \frac{45 - 22.5}{45} \cdot 0.0035 = -0.0017 \Rightarrow \sigma_{s2} = - \frac{0.0017}{0.00197} 391.3 = -337.7 \text{ MPa}$$

$$\varepsilon_{s3} = - \frac{45 - 40}{45} \cdot 0.0035 = -0.00038 \Rightarrow \sigma_{s3} = - \frac{0.00038}{0.00197} 391.3 = -75.41 \text{ MPa}$$

$$N_{s1} = -1.54 \cdot \frac{391.3}{10} = -60.26 \text{ kN}$$

$$N_{s2} = -2 \cdot 1.54 \cdot \frac{337.7}{10} = -104.0 \text{ kN}$$

$$N_{s3} = -3 \cdot 3.14 \cdot \frac{75.41}{10} = -71.0 \text{ kN}$$

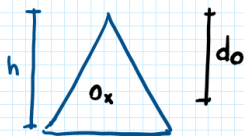
$$N_c + N_{s1} + N_{s2} + N_{s3} = -612.1 - 60.26 - 104.0 - 71 = -847.4 \text{ kN}$$

$$|847| > |N_{ed}| \Rightarrow \text{sez. PARZIALIZZATA}$$

1) DIAGR.  $\varepsilon_{L,H} \Rightarrow \times$

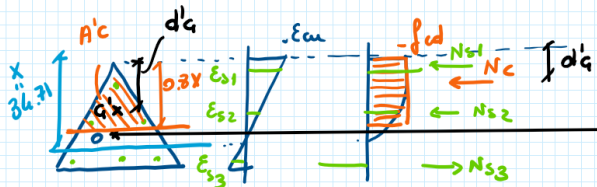
X	34.71 cm			
0.8X	27.77134 cm			
b'	18.51423 cm			
A'c	257.0825 cm <sup>2</sup>			
			Nc	-364.29 kN
es1	-0.002996 $\sigma_{s1}$	-391.3 MPa	Ns1	-60.3 kN
es2	-0.001231 $\sigma_{s2}$	-246.3 MPa	Ns2	-75.9 kN
es3	0.000533 $\sigma_{s3}$	106.59 MPa	Ns3	100.4 kN
			Somma N	-400.00 kN

2)  $M_{rd}(N_{ed})$



$$d_0 = \frac{2}{3} h = 30 \text{ cm}$$

$$d'_a = \frac{2}{3} (0.8x) = 17.51 \text{ cm}$$



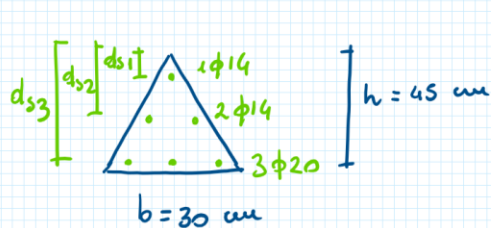
$$M_{rd} = N_c \left[ -(d_0 - d'_a) \right] + \sum_{i=1}^3 N_{si} (d_{si} - d_0)$$

$$M_{Rd} = N_c \left[ -(d_o - d'_a) \right] + \sum_{i=1}^3 N_{si} (d_{si} - d_o)$$

X	34.71 cm								
0.8X	27.77 cm								
b'	18.51 cm								
A'c	257.08 cm2								
d <sub>o</sub>	30 cm								
d'G	18.51 cm								
				Nc	-364.29 kN	bc	-0.115 m	Mc	41.84 kNm
εs1	-0.002996	σs1	-391.3 MPa	Ns1	-60.3 kN	bs1	-0.25 m	Ms1	15.07 kNm
εs2	-0.001231	σs2	-246.3 MPa	Ns2	-75.9 kN	bs2	-0.075 m	Ms2	5.69 kNm
εs3	0.000533	σs3	106.59 MPa	Ns3	100.4 kN	bs3	0.1 m	Ms3	10.04 kNm
				Somma N	-400.00 kN			MRd (Ned)	72.64 kNm

POI CHE'  $72.64 < 100 \text{ kNm}$  NO

## ESEMPIO 2



$$d_{s1} = 5 \text{ cm}$$

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

$$d_{s2} = 22.5 \text{ cm}$$

$$M_{Ed} = 100 \text{ kNm}$$

$$d_{s3} = 40 \text{ cm}$$

0) SEZ. PARZIALIZZATA O TUTTA COMPRESSA

$$\text{VEDI ESEMPIO 1} \Rightarrow x = h \quad |N_c + N_{s1} + N_{s2} + N_{s3}| = 847 \text{ kN}$$

$$|847| < |N_{Ed}| \Rightarrow \text{SEZ. TUTTA COMPRESSA}$$

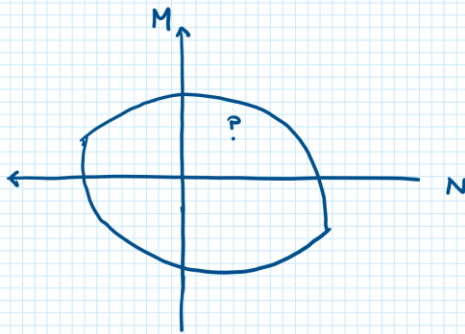
1) DIAGR  $\epsilon_{lim} \Rightarrow \eta_{min}$

η <sub>min</sub>	0.16 cm							
h'	38.69 cm							
b'	25.79 cm							
A'c	498.86 cm <sup>2</sup>							
d <sub>o</sub>	30 cm							
d'G	25.79 cm							
				Nc	-706.88 kN			
εs1	-0.002931	σs1	-391.3 MPa	Ns1	-60.3 kN			
εs2	-0.001791	σs2	-358.1 MPa	Ns2	-110.3 kN			
εs3	-0.000651	σs3	-130.10 MPa	Ns3	-122.6 kN			
				Somma N	-1000.00 kN			

2)  $M_{Rd} (N_{Ed}) \Rightarrow$  POLO RISPETTO "O"

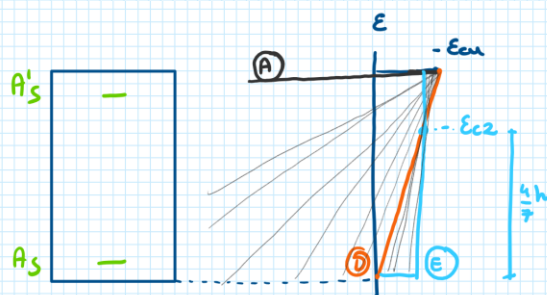
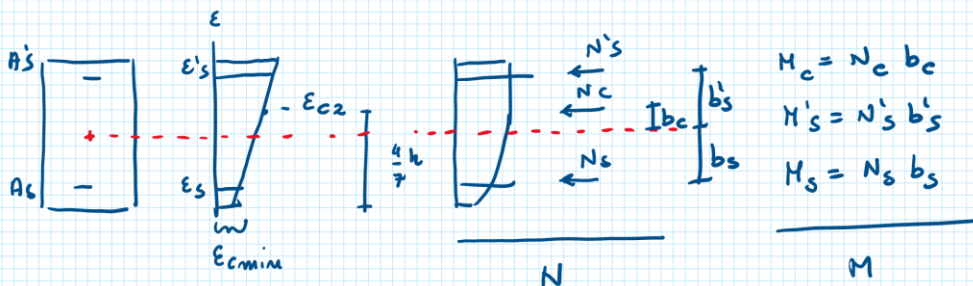
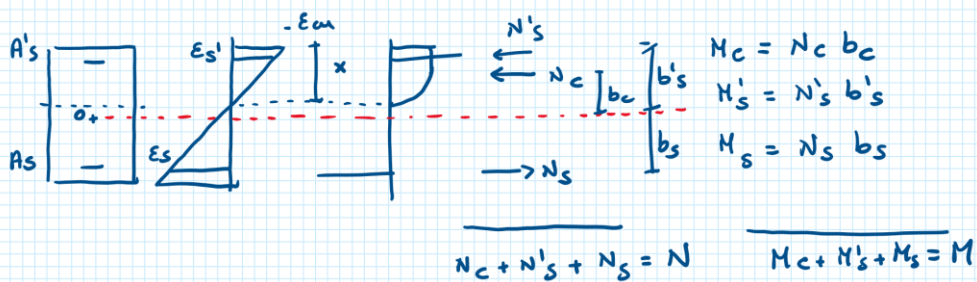
η <sub>min</sub>	0.16 cm								
h'	38.69 cm								
b'	25.79 cm								
A'c	498.86 cm <sup>2</sup>								
d <sub>o</sub>	30 cm								
d'G	25.79 cm								
			Nc	-706.88 kN	bc	-0.042 m	Mc		29.76 kNm
ε <sub>s1</sub>	-0.002931 σ <sub>S1</sub>	-391.3 MPa	Ns1	-60.3 kN	bs1	-0.25 m	Ms1		15.07 kNm
ε <sub>s2</sub>	-0.001791 σ <sub>S2</sub>	-358.1 MPa	Ns2	-110.3 kN	bs2	-0.075 m	Ms2		8.27 kNm
ε <sub>s3</sub>	-0.000651 σ <sub>S3</sub>	-130.10 MPa	Ns3	-122.6 kN	bs3	0.1 m	Ms3		-12.26 kNm
			<b>Somma N</b>	<b>-1000.00 kN</b>			<b>MRd (Ned)</b>		<b>40.84 kNm</b>

POI CHE'  $40.84 < M_{Ed} \Rightarrow$  NO!



$$P(N, M)$$

PER COSTRUIRE UN PUNTO DEL DOMINIO:  $P\left(\begin{matrix} x \\ N \end{matrix}, \begin{matrix} y \\ M \end{matrix}\right)$



SEZ. PARZIALMENTE COMPRESSA

CAMPO 1

$\left\{ \begin{matrix} A \\ D \end{matrix} \right.$

SEZ. TUTTA COMPRESSA

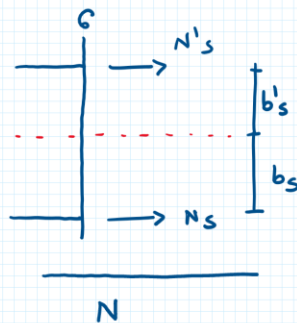
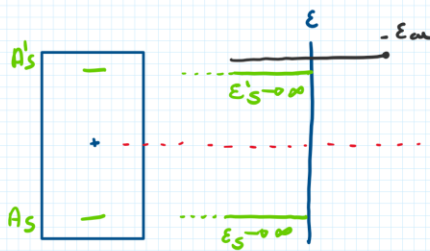
CAMPO 2

$\left\{ \begin{matrix} D \\ E \end{matrix} \right.$

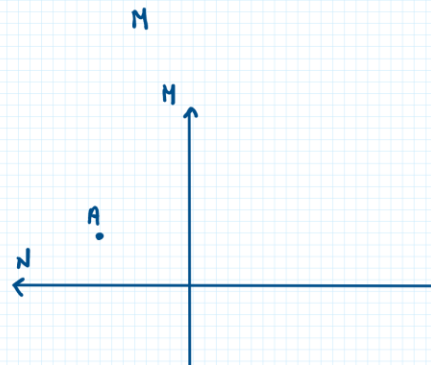


COSTRUIAMO IL DOCHINO M-N PER PUNTI:

DIAGRAMMA A

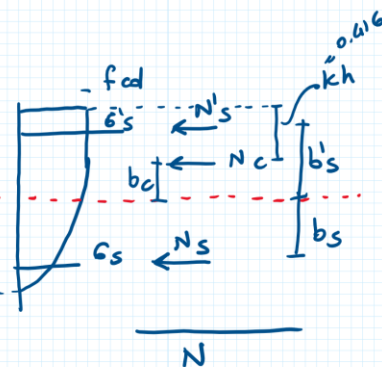
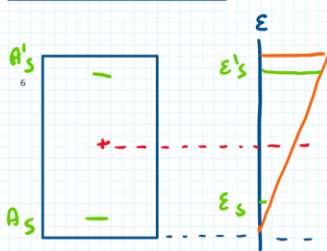


$$\begin{aligned} M'_s &= -N'_s \left( \frac{h}{2} - c \right) \\ M_s &= N_s \left( \frac{h}{2} - c \right) \\ M_c &= 0 \end{aligned}$$



$$\begin{aligned} \epsilon'_s &= \epsilon_s \rightarrow \infty \\ \sigma'_s &= \sigma_s = f_{yd} \\ N'_s &= A'_s f_{yd} \\ N_s &= A_s f_{yd} \\ N_c &= 0 \end{aligned}$$

DIAGRAMMA D



$$\begin{aligned} M'_s &= -N'_s \left( \frac{h}{2} - c \right) \\ M_s &= N_s \left( \frac{h}{2} - c \right) \\ M_c &= -N_c \left( \frac{h}{2} - kh \right) \end{aligned}$$

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

$$N'_s = A'_s \sigma'_s$$

$$\hookrightarrow \frac{\epsilon'_s}{d} = \frac{-\epsilon_m}{h} \Rightarrow \epsilon'_s = -\frac{d}{h} \epsilon_m$$

$$\hookrightarrow \epsilon'_s \leq -\epsilon_{yd} \Rightarrow \sigma'_s = -f_{yd}$$

$$\sigma'_s = \frac{\epsilon'_s}{\epsilon_{yd}} f_{yd}$$

$$N_s = A_s \sigma_s$$

$$\hookrightarrow \frac{\epsilon_s}{c} = \frac{-\epsilon_m}{h} \Rightarrow \epsilon_s = -\frac{c}{h} \epsilon_m$$

$$\hookrightarrow \epsilon_s \leq -\epsilon_{yd} \Rightarrow \sigma_s = -f_{yd}$$

$$\sigma_s = \frac{\epsilon_s}{\epsilon_{yd}} f_{yd}$$

