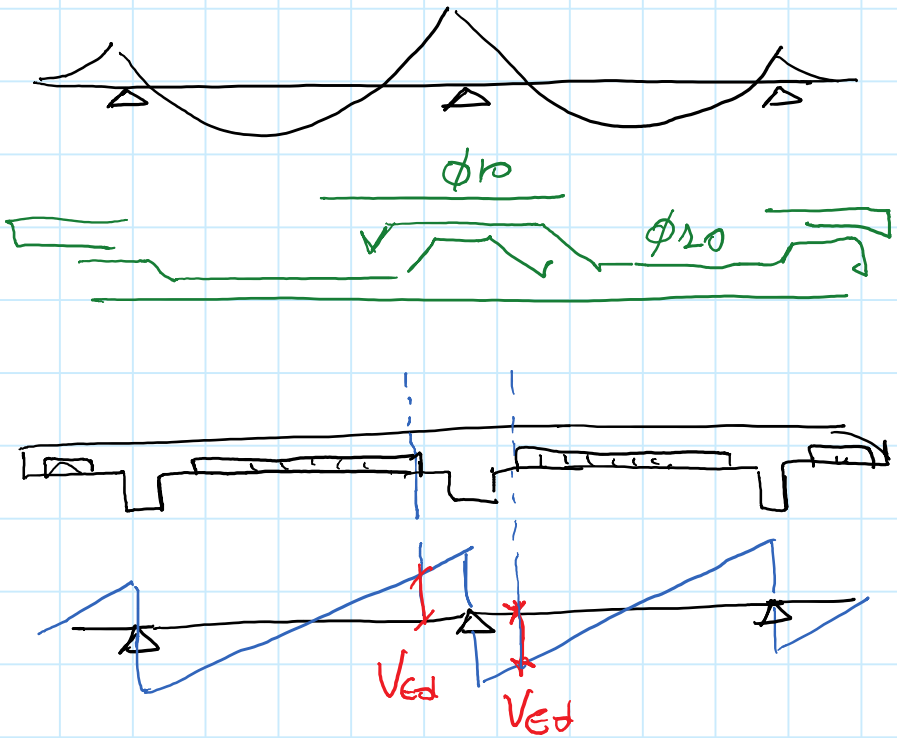
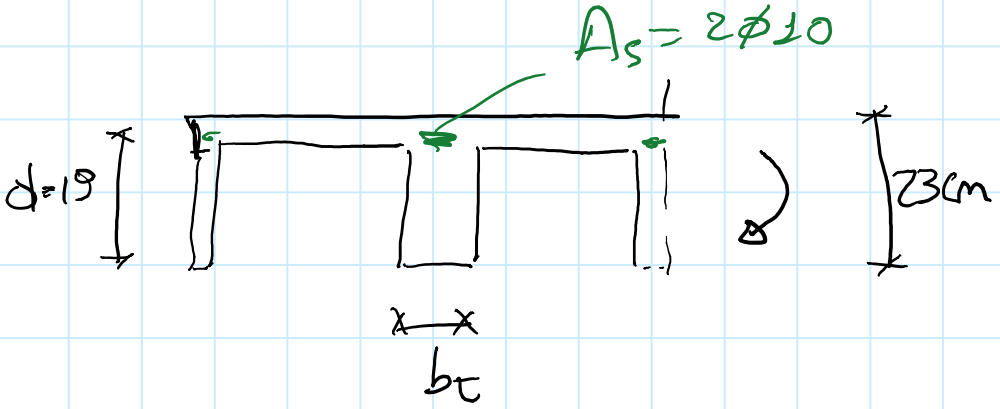
VERIFICA A TAGLIO SOLAIO





CONSIDERO IN As SOLO ARMATURA TESA BEN ANCORATA

$$V_{Rd,c} = \max\left\{ \frac{0.18}{\gamma_c} k \sqrt[3]{100 \rho_e f_{cm}} \cdot b_w d \;;\; 0.035 \sqrt{k^3 f_{ck}}\, b_w d \right\}$$

f_{cm} ↑ MPa f_{ck} ↑ MPa

$$k = 1 + \sqrt{\frac{200}{d}} \qquad d \text{ IN mm} \rightarrow k = 1 + \sqrt{\frac{200}{190}} = 2.02 \;\; 2$$

$$\rho_e = \frac{A_{se}}{b_w d} = \frac{N_{TR} \times A_s^{\text{TRAVETTO}}}{N_{TR} \times b_t \times d} = \frac{2 \times 2 \times 0.785\ cm^2}{2 \times 10 \times 19\ cm^2} = 8.26 \times 10^{-3}$$

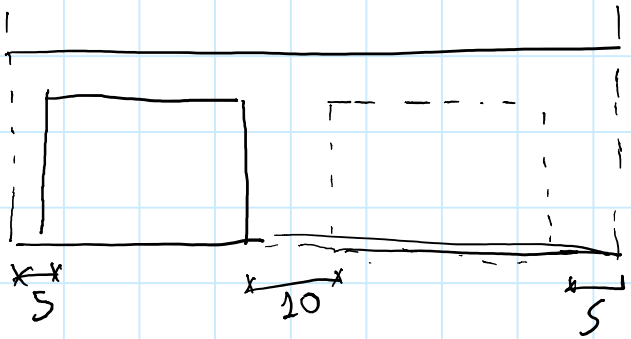
$$V_{Rdc,1} = \frac{0.18 \times 2 \times \sqrt[3]{100 \times 8.26 \times 10^{-3} \cdot 30}}{1.5} \times \underbrace{2 \times 10}_{N_{Te} \times b_t} \times \underbrace{19}_{d} \cdot \frac{1}{10} = 26.6 \text{ KN}$$

$$V_{Rdc,2} = 0.035 \times \sqrt{2^3 \times 30} \times \underbrace{2 \times 10 \times 19}_{bwd} = 20.60 \text{ KN}$$

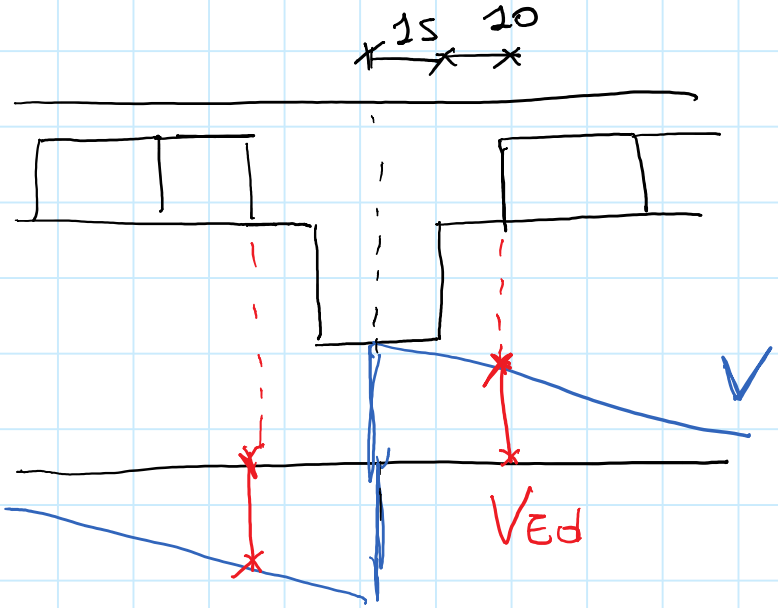
$V_{Rdc} = 26.6$ KN

SE $V_{Ed} > V_{Rdc} \Rightarrow$

FASCIA SEMIPIENA

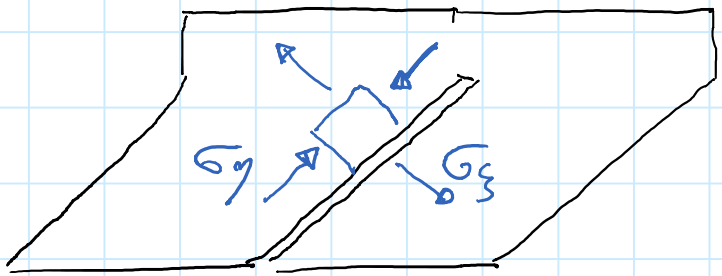


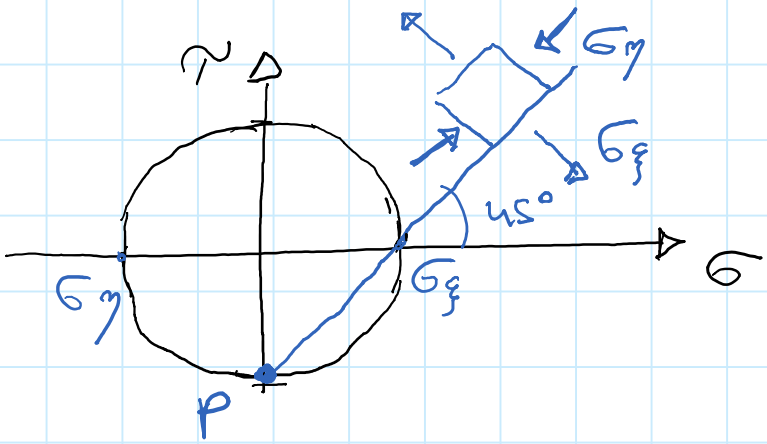
$\Rightarrow b_w = 60$ cm



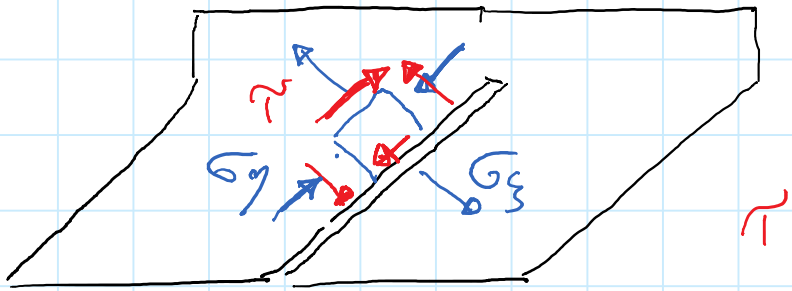
CONSIDERAZIONI SULLO STATO TENSIONALE

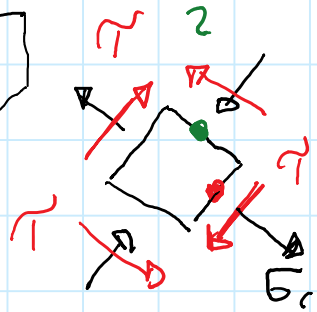
NEL MOMENTO IN CUI SI FORMANO LESIONE

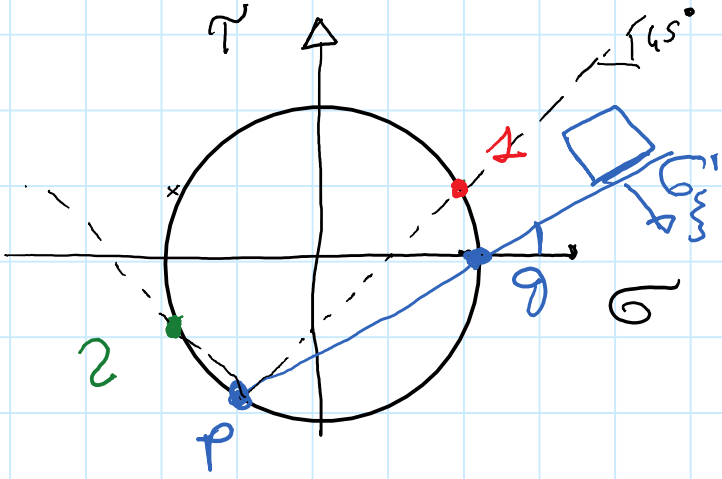




DOPO LO SCORRIMENTO TRA LE LESIONI

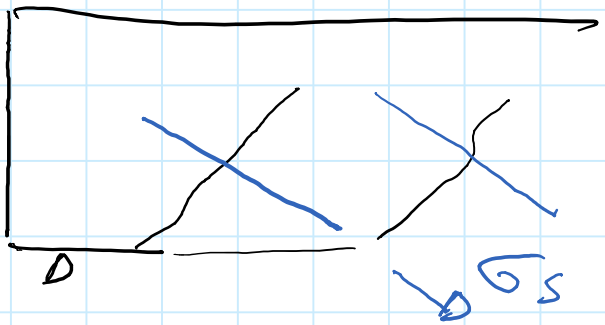




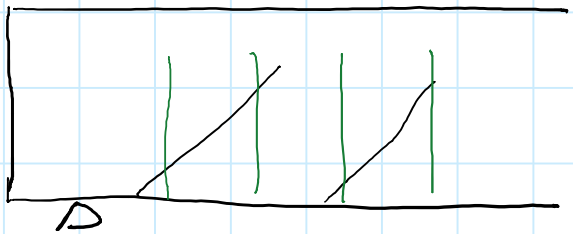


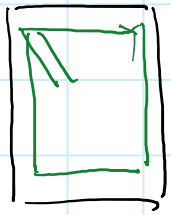
IL FLUSSO DI TENSIONI DI COMPRESSIONE SI INCLINA DI UN ANGOLO $\vartheta \leq 45°$

POSSIBILI DISPOSIZIONI DI ARMATURA A TAGLIO

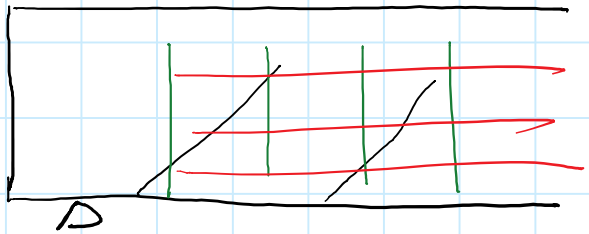


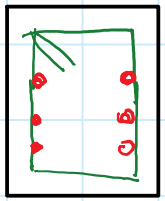
ARMATURA CON SAGOMATI
(MOLTO USATA IN PASSATO)





ARMATURA CON STAFFE
(USATA AL NORD)

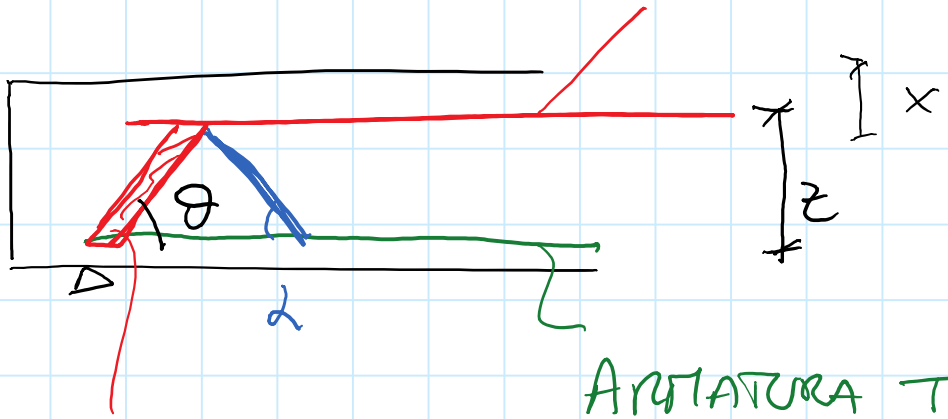




ARMATURA CON STAFFE
+ ARMATURA DI PARETE
(USATA AL SUD)

MODELLI PER LA VERIFICA ALLO SLU

1) TRALICCIO AD INCLINAZIONE VARIABILE DEL PUNTONE



CORRENTE COMPRESSO

= ARMATURA A TAGLIO

ARMATURA TESA

SE USO STAFFE $\alpha = 90°$

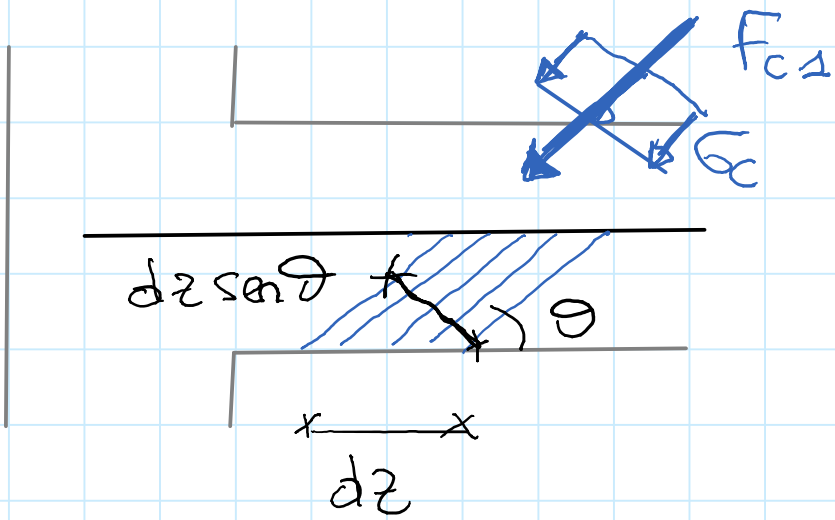
PUNTONI DI CLS

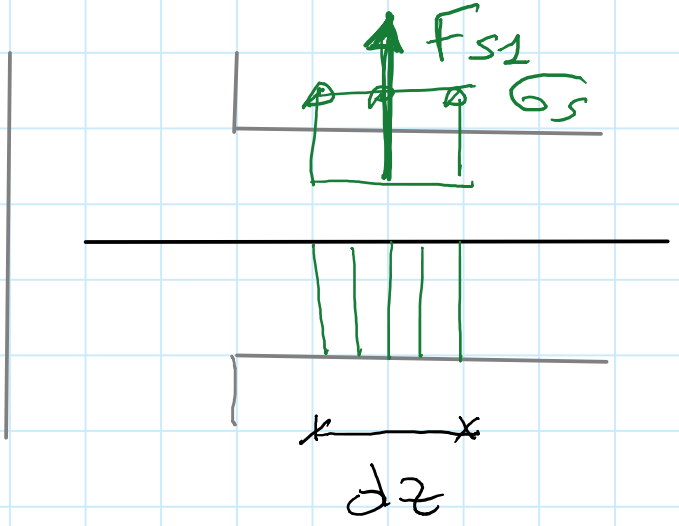
2) MODELLO CAMPI DI TENSIONE

CONSIDERO :

- FLUSSO σ_c INCLINATE SECONDO DIREZ. PRINCIPALI DI COMPRESSIONE
- σ_s INCLINATE SECONDO ARMATURA
- V, M

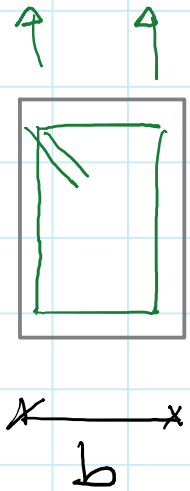
CAMPI DI TENSIONE : SEZIONE ORIZZONTALE



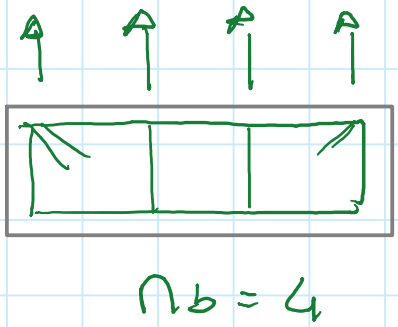


$$F_{c1} = b\, dz \sin\vartheta \cdot \sigma_c$$

$$F_{s1} = n_b \frac{A_s}{s} dz\, \sigma_s$$



$n_b = 2$

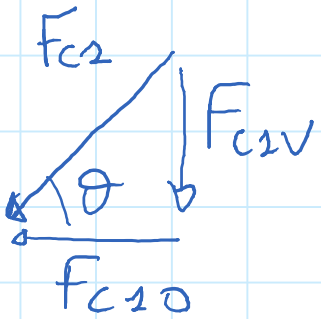


$n_b = 4$

s = PASSO STAFFE

$\frac{dz}{s}$ = NUM. STAFFE NEL TRATTO dz

EQUILIBRIO ALLA TRASLAZIONE VERTICALE



$F_{c1.o}$ = FORZA DI SCORRIMENTO

$$F_{c1v} = F_{s1}$$

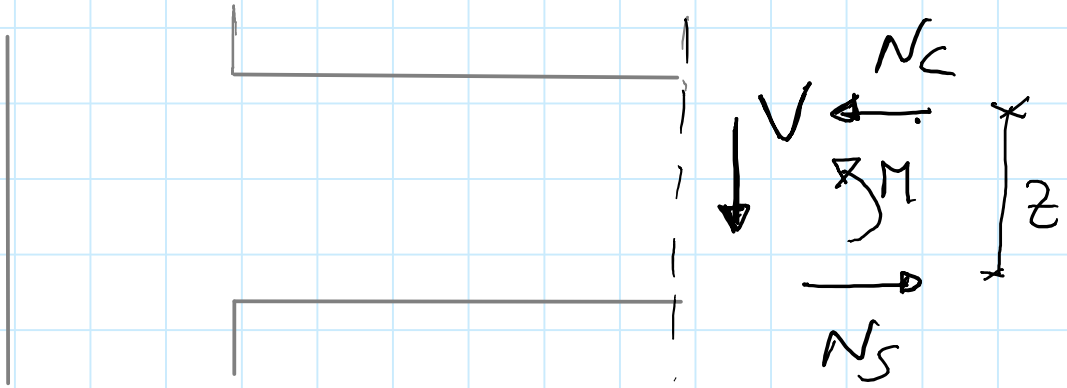
$$F_{c1} \operatorname{sen}\vartheta = F_{s1}$$

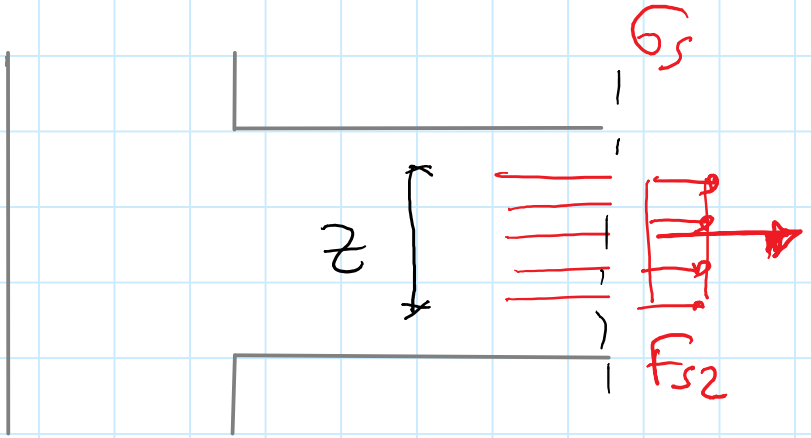
$$\sigma_c \cdot b \, dx \operatorname{sen}^2\vartheta = \sigma_s \cdot n_L \frac{A_{st}}{s} \cdot dx \quad \Rightarrow$$

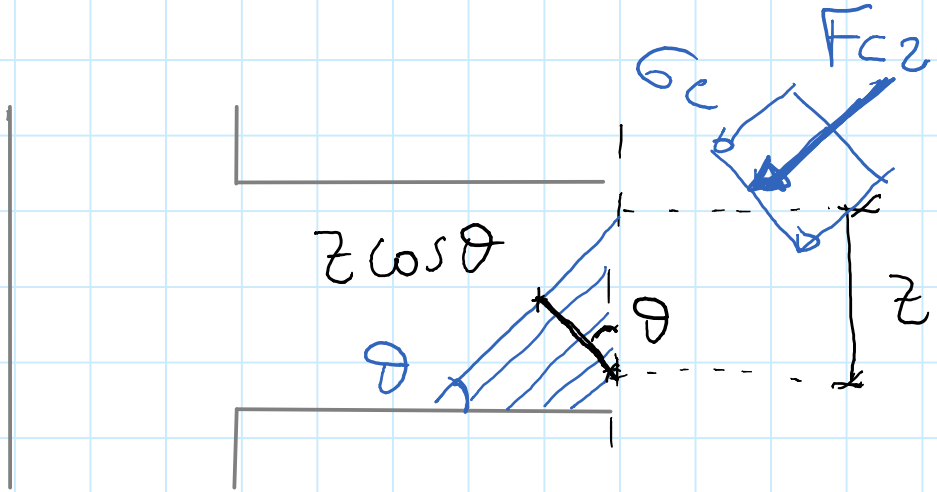
$$\boxed{\sigma_c = \sigma_s \frac{n_b A_{st}}{s_b} \frac{1}{\operatorname{sen}^2\vartheta}}$$

SEZIONE VERTICALE

AZIONI ESTERNE



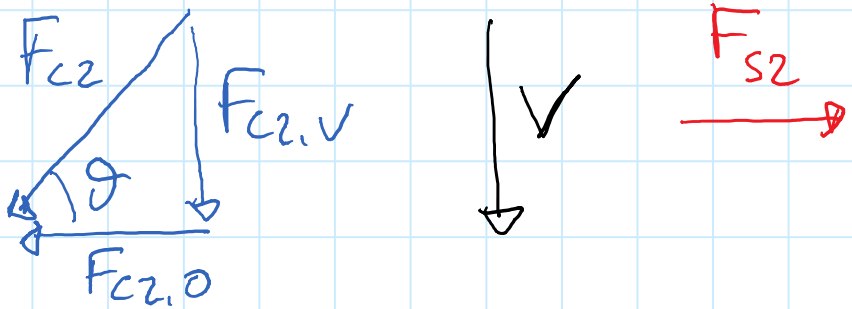




$$F_{c2} = b z \cos\vartheta \, \sigma_c$$

$$F_{s2} = A_{sp} \cdot \sigma_s$$

A_{sp} = ARMATURA DI PARETE



$$F_{c2,V} = V \Rightarrow$$

$$F_{c2} \cdot \operatorname{sen}\vartheta = V$$

$$\sigma_c \cdot b\, z \frac{\cos\vartheta}{\operatorname{sen}\vartheta} \cdot \operatorname{sen}^2\vartheta = V \longrightarrow$$

$$\boxed{V = \sigma_c\, b\, z \cot g\vartheta \cdot \operatorname{sen}^2\vartheta} \quad (2)$$

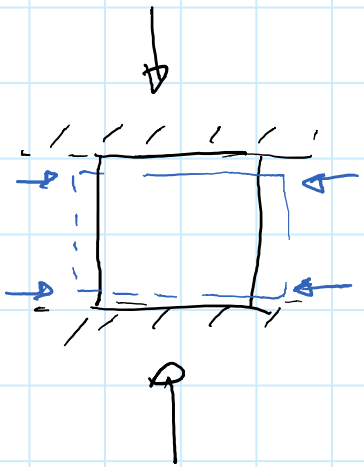
DA TRIGONOMETRIA $\operatorname{sen}^2\vartheta = \dfrac{1}{1+\cot g^2\vartheta} \Rightarrow$

$$V = \sigma_c\, b\, z \frac{\cot g\vartheta}{1+\cot g^2\vartheta}$$

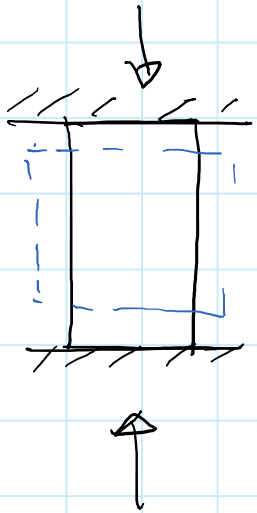
CRISI PER SCHIACCIAMENTO SE $\sigma_c = \nu f_{cd}$

$$V_{Rdc} = \nu f_{cd}\, b\, z \frac{\cot g\vartheta}{1+\cot g^2\vartheta}$$

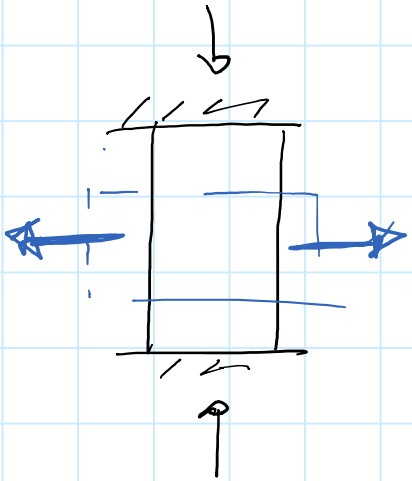
ν = COEFFICIENTE RIDUTTIVO DELLA RESISTENZA A COMPRESSIONE A CAUSA DI TRAZIONE ORTOGONALE



R_{ck}



f_{ck}



RESISTENZA INFERIORE A f_{ck}

$R_{ck} > f_{ck}$

RESISTENZA DELLE ARMATURE

SOSTITUENDO (1) IN (2) $\Rightarrow$

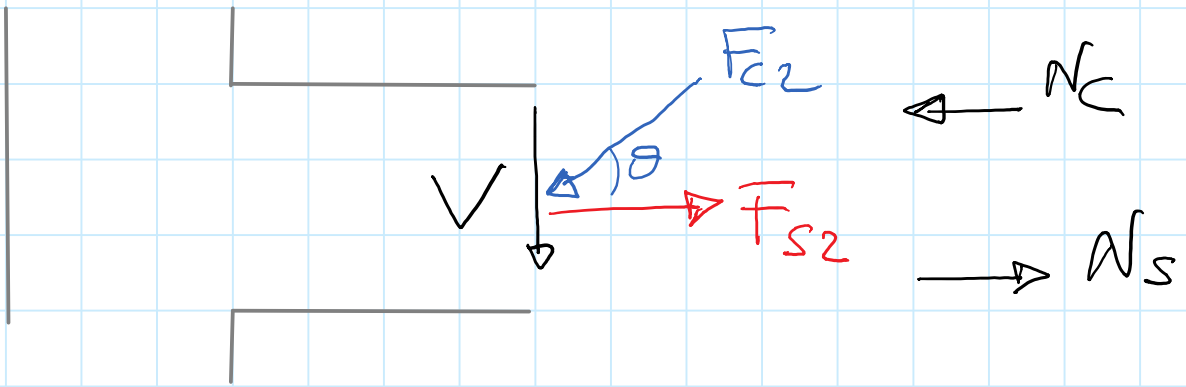
$$V = \underbrace{\sigma_s \frac{n_b A_{st}}{s b} \cdot \frac{1}{\operatorname{sen}^2\vartheta}}_{\sigma_c} \cdot b z \cot^2\vartheta \cdot \operatorname{sen}^2\vartheta \rightarrow$$

$$V = \sigma_s \frac{n_b A_{st}}{s} z \cot^2\vartheta$$

CRISI SE $\sigma_s = f_{yd}$ $\rightarrow$

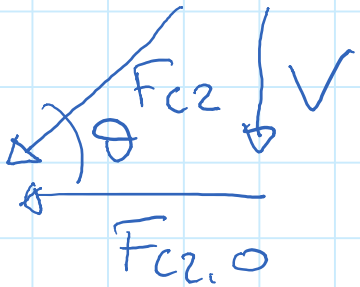
$$V_{Rds} = n_b \frac{A_{st}}{s} z f_{yd} \cot^2\vartheta$$

DIREZIONE ORIZZONTALE: ARMATURA DI PARETE



SE VOGLIO EVITARE TRASLAZIONE DEL DIAGRAMMA DEI MOMENTI $(N_c = N_s) \Rightarrow$

$$F_{c2,0} = F_{s2}$$

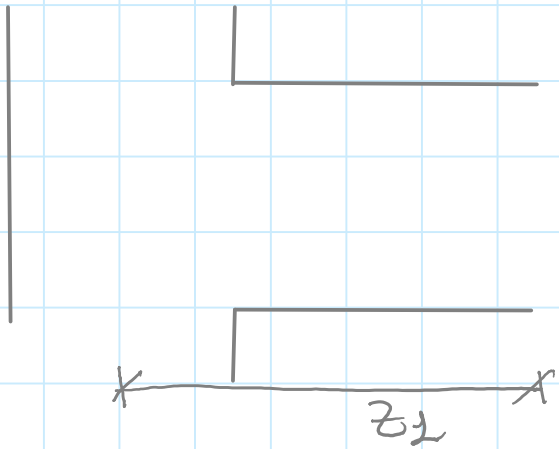


$$F_{c2,0} = V \cot\theta \Rightarrow F_{s2} = V \cot\theta$$

$$A_{sp} \cdot \sigma_s = V \cot\theta \Rightarrow$$

SE $\sigma_s = f_{yd} \rightarrow A_{sp} = \dfrac{V \cot\theta}{f_y}$ (ARMATURA DI PARETE)

SOLUZIONE SENZA ARMATURA DI PARETE



$\rightarrow F_s/2 \quad \leftarrow N_c$ (RIDUZIONE DI N_c CHE NON CREA PROBLEMI)

$\rightarrow F_s/2 \rightarrow N_s$ (AUMENTO DI N_s)

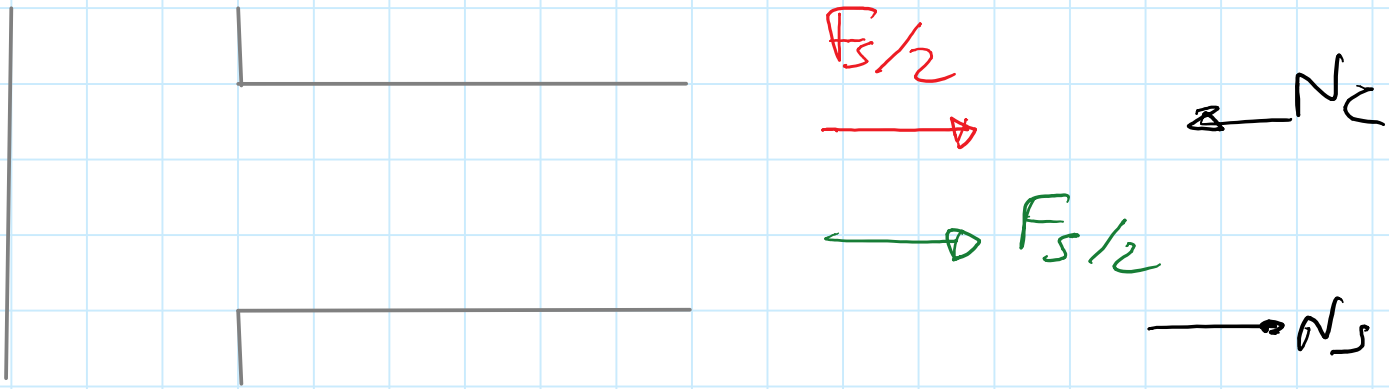
$$N_s' = N_s + F_{s/2} = \frac{M(z_1)}{z} + \frac{V}{2}\cot\vartheta \cdot \frac{z}{z}$$

$$= \frac{1}{z}\left[M(z_1) + V\frac{z}{2}\cot\vartheta\right] \Rightarrow$$

$$M\left(z_1 + \frac{z}{2}\cot\vartheta\right)$$

TRASLAZIONE DEL DIAGRAMMA DEI MOMENTI DI $\frac{z}{2}\cot\vartheta$

SOLUZIONE ALTERNATIVA CON ARMATURA DI PARETE



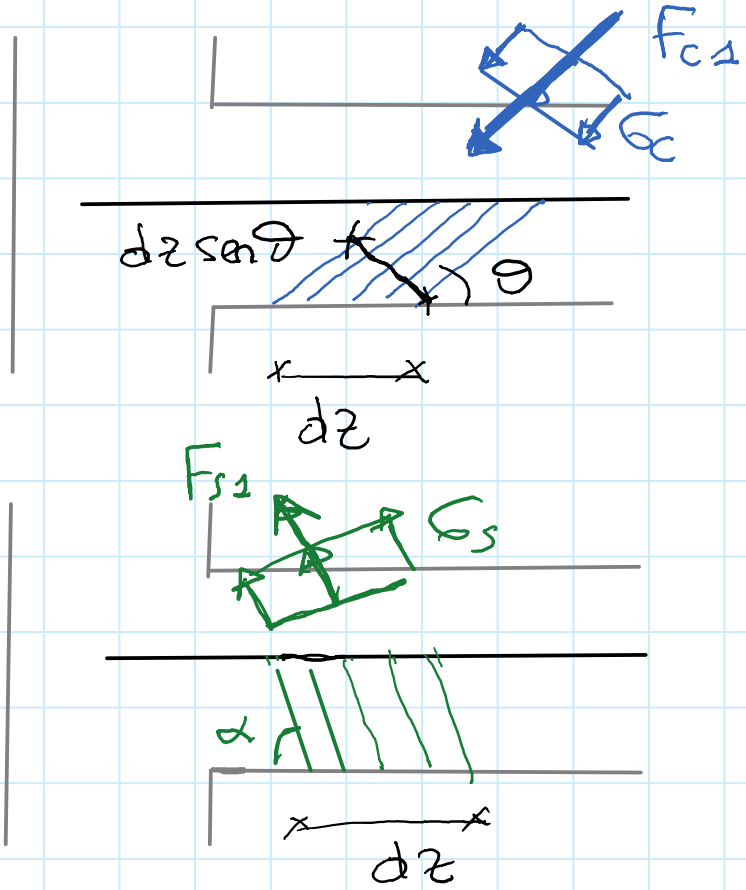
PROGETTO ARMATURA DI PARETE PER PORTARE

$F_{s/2} \Rightarrow$ $A_{sp} = \frac{F_{s/2}}{f_{yd}} = \frac{V}{2} \cot\vartheta$

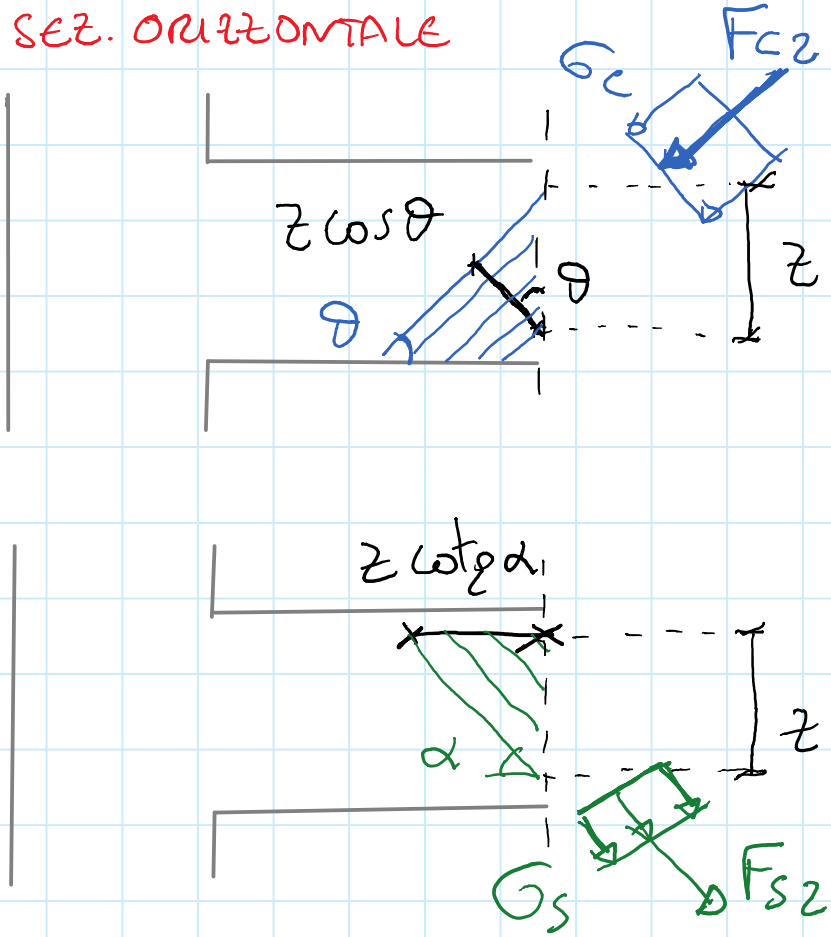
(IN QUESTO CASO NON È NECESSARIA TRASLAZIONE DEL DIAGRAMMA DEI MOMENTI)

ARMATURA CON SAGOMATI

SEZ. VERTICALE



SEZ. ORIZZONTALE



EQ. TRASLAZIONE VERTICALE : $F_{c2V} = F_{s1,V}$

$F_{c2V} + F_{s2V} = V$

INDICAZIONI DI NORMATIVA

RESISTENZA DEL CLS:

$$V_{Rd,max} = \alpha_{cw} \nu f_{cd} b z \frac{(\cot\vartheta + \cot\alpha)}{1+\cot g^2\vartheta}$$

RESISTENZA ARMATURA A TAGLIO

$$V_{Rd,s} = n_b \frac{A_{st}}{s} f_{yd} z \operatorname{sen}\alpha (\cot\vartheta + \cot\alpha)$$

DOVE $1 \le \cot\vartheta \le 2.5$ $\left(\cot\vartheta = 1 \rightarrow \vartheta = 45°\right)$

$$\alpha_{cw} = \begin{cases} 1 & \text{IN ASSENZA DI COMPRESSIONE} \\ 1 + \frac{\sigma_{cp}}{f_{cd}} & \frac{\sigma_{cp}}{f_{yd}} \le 0.25 \\ 1.25 & 0.25 \le \frac{\sigma_{cp}}{f_{cd}} \le 0.5 \\ 2.5\left(1 - \frac{\sigma_{cp}}{f_{cd}}\right) & 0.5 < \frac{\sigma_{cp}}{f_{cd}} \le 1 \end{cases}$$

$$\sigma_{cp} = \frac{N_{ed}}{A_c}$$

>0 SE DI COMPRESSIONE

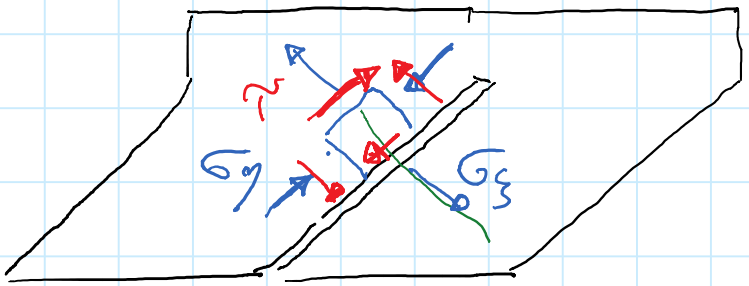
INFLUENZA DI $\cot\vartheta$

Se $V_{Rd,max}\ (\cot\vartheta = 1) < V_{Ed}$ ⟹

CRISI PER SCHIACCIAMENTO DEL CLS
(ROTTURA FRAGILE)

SE $V_{Rd\,max}\ (\cot\vartheta = 1) > V_{Ed}$

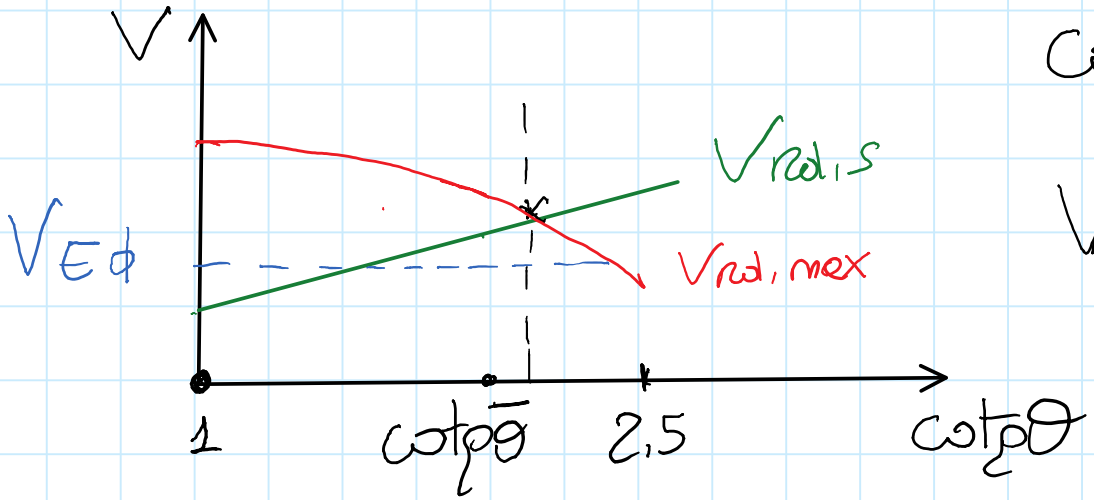
$V_{Rd,s}\ (\cot\vartheta = 1) < V_{Ed}$ ⟹ SI SNERVANO LE ARMATURE



⟹ NASCONO SCORRIMENTI LUNGO LE LESIONI ⟹ SI MODIFICA LO STATO TENSIONALE ⟶

DIREZ. DELLE TENSIONI DI COMPRESSIONE INCLINATE DI $\vartheta < 45°$

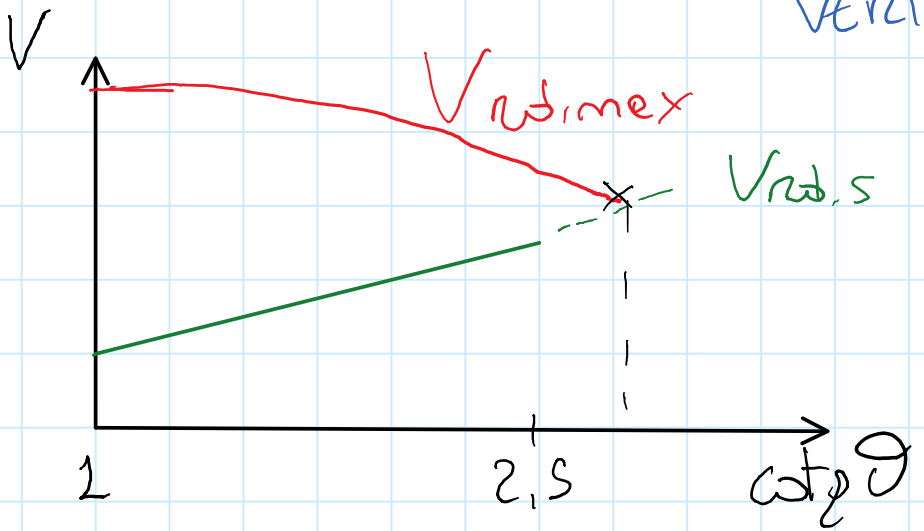
VERIFICA A TAGLIO



CONOSCO $b, z, A_{st}/s$

$$V_{Rd} = \min\{V_{Rd,s}, V_{Rd,max}\}$$

CERCO $\cot\bar{\theta}$ TALE CHE $V_{Rd,max} = V_{Rd,s}$



VERIFICA $V_{Ed} < V_{Rd}(\cot\bar{\theta})$

SE $\cot\bar{\theta} > 2.5$

$\Rightarrow$ CALCOLO

$V_{Rd,s}$ CON $\cot\bar{\theta} = 2.5$

$\cot\vartheta$ OTTIMALE

$$V_{Rd,max} = V_{Rsd,s} \rightarrow$$

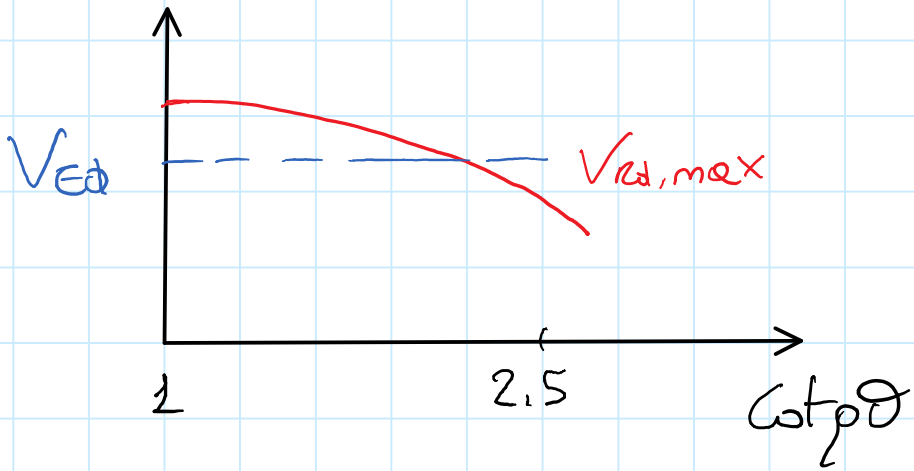
$$\frac{n_b A_{st}}{s} z f_{yd} \cot\vartheta = b z \nu f_{cd} \frac{\cot\vartheta}{1+\cot^2\vartheta}$$

$$1+\cot^2\vartheta = \frac{b\nu f_{cd}}{\frac{n_b A_{st}}{s} f_{yd}}$$

$$\cot\vartheta = \sqrt{\frac{b\nu f_{cd}}{\frac{n_b A_{st}}{s} f_{yd}} - 1}$$

PROGETTO

NOTI $b, z, V_{Ed} \Rightarrow$ DETERMINARE $n_b A_{st}/s$

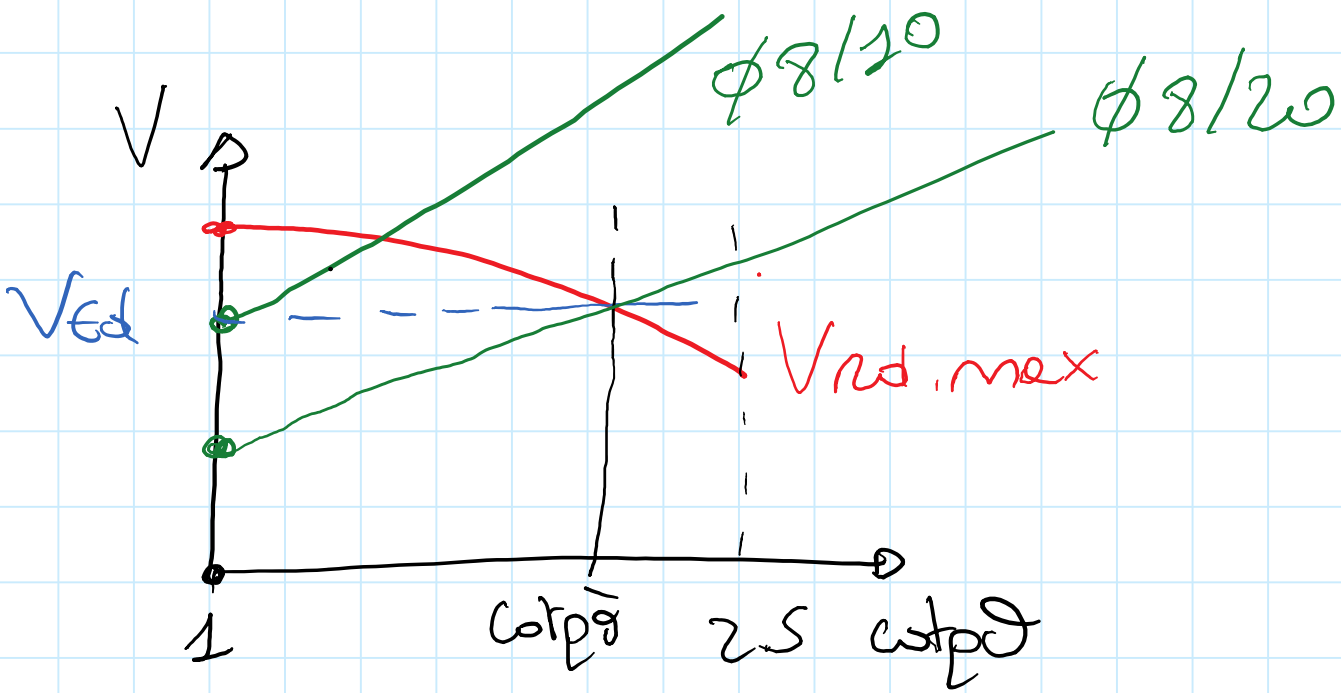


CERCO $\cot\vartheta$ TALE CHE $V_{Ed} = V_{Rd,max}$

$$V_{Ed} = \alpha_{cw} \nu f_{cd} b z \frac{\cot\vartheta}{1+\cot^2\vartheta} \Rightarrow \text{Eq } 2^\circ$$

$$\cot\vartheta = \frac{\alpha_{cw} \nu f_{cd} b z}{2 V_{Ed}} + \sqrt{\left(\frac{\alpha_{cw} \nu f_{cd} b z}{2 V_{Ed}}\right)^2 - 1}$$

PROGETTO STAFFE

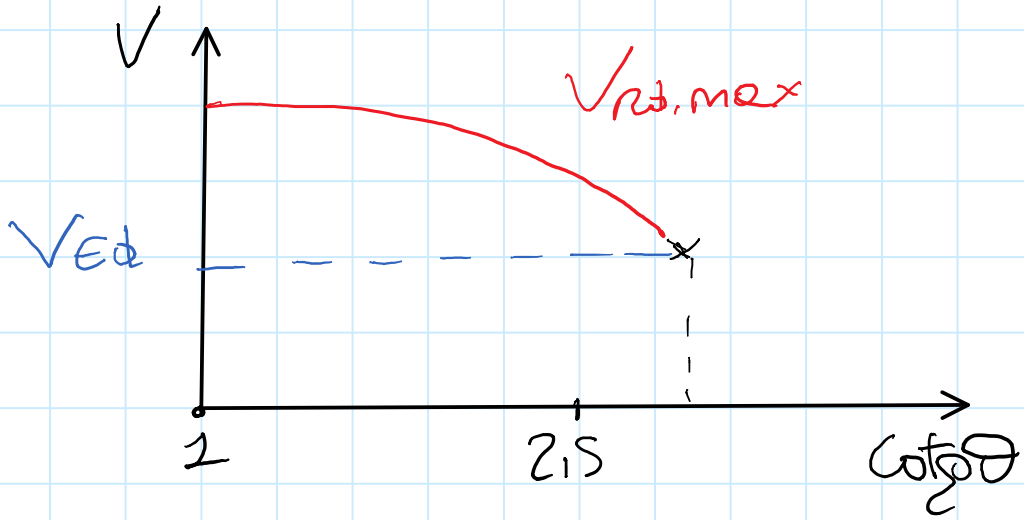


DA $V_{Rds} = \frac{n_b A_{st}}{s} z f_{yd} \cot g \vartheta$

POSTO $V_{Rds} = V_{Ed}$ ⇒

$$\frac{n_b A_{st}}{s} \geq \frac{V_{Ed}}{z f_{yd} \cot g \vartheta}$$

NEL CASO IN CUI



$V_{Rd,max} > V_{Ed} \quad \forall \cot\vartheta \leq 2.5$

CONSIGLIO: PROGETTO $\frac{A_{st}}{s}$ CON $\cot\vartheta = 2$

Se $\cot\vartheta \geq 2 \Rightarrow$ AUMENTA ARMATURA DI PARETE $A_p = \frac{V}{2} \cot\vartheta$

LIMITI ARMATURA A TAGLIO (NTC 18)

$$\frac{n_b A_{st}}{s} \geq 0.15\, b_w \ \frac{cm^2}{m}$$

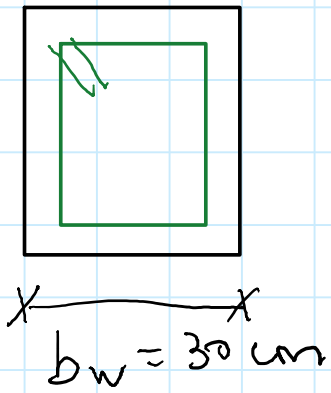
b_w IN cm

$$s \leq 0.8\, d$$

d = ALTEZZA UTILE

(VINCOLANTE SOLO PER TRAVI A SPESSORE)

ESEMPIO TRAVE EMERGENTE



$\phi 8 \rightarrow A_{\phi 8} = 0{,}5\ cm^2$

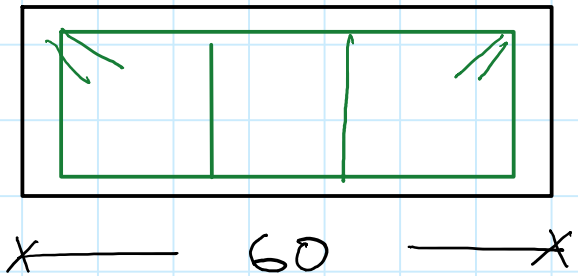
$n_b = 2$

$$\frac{2 \times A_{\phi 8}}{s} \geq 0.15 \times 30 \ \frac{cm^2}{m} \Rightarrow \frac{1\ cm^2}{s} \geq 4{,}5\ \frac{cm^2}{m}$$

$$s \leq \frac{1}{4{,}5}\, m = 0.22\, m \Rightarrow \phi 8/20$$

ESEMPIO TRAVE A SPESSORE

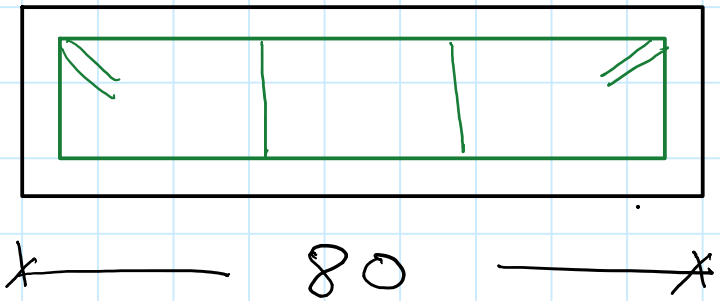
$$\frac{4 \times 0.5}{s} \geq 0.15 \times 60$$



$n_b = 4$

$\rightarrow s \leq 0{,}22\ m$ $\quad \phi 8/20$ (4 BRACCI)

$$\frac{4 \times 0.5}{s} \geq 0.15 \times 80 \ \frac{cm^2}{m}$$



$$\rightarrow s \leq \frac{2\ cm^2}{0{,}15 \times 80\ cm^2}\ m = 0.16 \rightarrow \phi 8/15$$

INFLUENZA DEL SECONDO LIMITE

$s \leq 0.8\,d$ $\quad$ d ALTEZZA UTILE

CONDIZIONA SOLO PER TRAVI A SPESSORE BASSE

SE $d = 15\,cm \longrightarrow s = 15.2 \longrightarrow \phi 8/15$

ALTRE INDICAZIONI DI NORMATIVA

ALMENO IL 50% DEL TAGLIO DEVE ESSERE PORTATO DALLE STAFFE