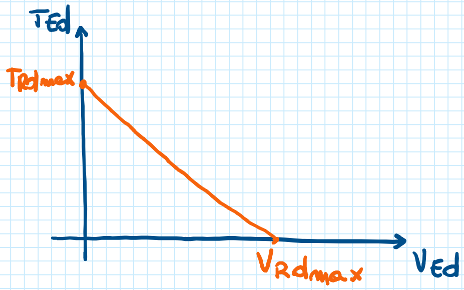
$$\left.\begin{matrix} V \\ T \end{matrix}\right\} \tau$$

## VERIFICARE LA SEZ. IN CLS:

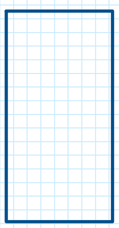



$$\underbrace{\frac{V_{Ed}}{V_{Rd\,max}} + \frac{T_{Ed}}{T_{Rd\,max}}}_{\text{STESSO } \cot\theta} \leq 1$$

## ARMATURE

$$\left.\begin{matrix} \left(\dfrac{A_{s,st}}{s}\right)_V \\ \left(\dfrac{A_{s,st}}{s}\right)_T \end{matrix}\right\} \qquad \left.\begin{matrix} (A_{par})_V \\ (A_{s\,LON})_T \end{matrix}\right\}$$

## ESEMPIO



30x60 $\quad c = 5$ cm

$M_{Ed} = 130$ kNm

$V_{Ed} = 100$ kN

$T_{Ed} = 30$ kNm

1) VERIFICO LA SEZ. IN CLS

$$M_{Rd} = \frac{b d^2}{r^2} = \frac{0.3 \cdot 0.55^2}{0.0197^2} = 233.8 \text{ kNm}$$

$r = 0.0197$ (C 25/30) PER SEZ A SEMPLICE ARMATURA

$d = 60 - 5 = 55$ cm

$$V_{Rd_{max}} = 0.9\, d\, b\, f'_{cd} \frac{\cot\theta}{1+\cot^2\theta} = 0.9 \cdot 55 \cdot 30 \cdot \frac{0.5}{10} \cdot 14.17 \frac{\cot\theta}{1+\cot^2\theta}$$

$\cot\theta = 1 \Rightarrow 526.1$ kN

$\cot\theta = 2.5 \Rightarrow 362.8$ kN

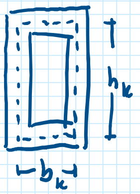
$\cot\theta = 1 \Rightarrow 70.85$ kNm

$$T_{Rd\,max} = 2\,A_k\,t\,f'_{cd}\,\frac{\cot\theta}{1+\cot^2\theta} = 2\cdot 1000\cdot 10\cdot \frac{0.5\cdot 14.17}{10^3}\,\frac{\cot\theta}{1+\cot^2\theta}$$

$\cot\theta = 1 \Rightarrow 70.85\ kNm$

$\cot\theta = 2.5 \Rightarrow 48.9\ kNm$

$$t = MAX \begin{cases} 2c = 2\cdot 5 = 10\ cm \\ \frac{A}{u} = \frac{30\times 60}{2\,(30+60)} = \frac{1800}{180} = 10\ cm \end{cases} \Rightarrow t = 10\ cm$$




$b_k = 30 - \frac{10}{2} - \frac{10}{2} = 20\ cm$

$h_k = 60 - \frac{10}{2} - \frac{10}{2} = 50\ cm$

$u_k = 2\,(20+50) = 140\ cm$

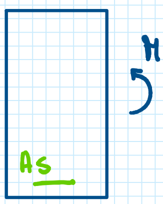
$A_k = 50\times 20 = 1000\ cm^2$

PER VERIFICARE A V + T: $\frac{V_{Ed}}{V_{Rd\,max}} + \frac{T_{Ed}}{T_{Rd\,max}} \leq 1$

$\frac{100}{362.8} + \frac{30}{48.9} = 0.889 < 1 \Rightarrow$ PER LE ARMATURE POSSO USARE $\forall \cot\theta$

2) PROG. LE ARMATURE

- $M_{Ed} = 130\ kNm$




$M_{Ed}$ $A_s = \frac{M_{Ed}}{0.9\,d\,f_{yd}} = \frac{130\cdot 10^3}{0.9\cdot 55\cdot 391.3} = 6.71\ cm^2$

- STAFFE

$$\left(\frac{A_{s,st}}{s}\right)_{V,\,1m} = \frac{V_{Ed}}{0.9\,d\,f_{yd}\,\cot\theta} = \frac{100\times 10^3}{0.9\cdot 55\cdot 391.3\cdot\cot\theta} = \frac{5.16}{\cot\theta}\ \frac{cm^2}{1m}$$

$$\left(\frac{A_{s,st}}{s}\right)_{T,\,1m} = \frac{T_{Ed}}{2\,A_k\,f_{yd}\,\cot\theta} = \frac{30\cdot 10^5}{2\cdot 1000\cdot 391.3\,\cot\theta} = \frac{3.33}{\cot\theta}\ \frac{cm^2}{1m}$$

FISSO $\phi 8 \Rightarrow A_{st} = 0.5\ cm^2$

FISSO $\phi 8 \Rightarrow A_{1\phi 8} = 0.5\ cm^2$

PER $V_{Ed} \Rightarrow$ STAFFA A 2 BRACCI $\Rightarrow \left(\dfrac{A_{s,st}}{s}\right)_V = \dfrac{5.16}{\cot\theta} \cdot \dfrac{1}{2} = \dfrac{2.6}{\cot\theta} \dfrac{cm^2}{1m}$

$$\left(\frac{A_{s,st}}{s}\right)_{T+V} = \frac{2.6}{\cot\theta} + \frac{3.33}{\cot\theta} = \frac{6.43}{\cot\theta} \frac{cm^2}{1m}$$

STABILISCO $\phi 8/10 \Rightarrow$ 1 m METRO – $N_{STAFFE} = 10$

$0.5\ cm^2 \times 10 = 5\ \dfrac{cm^2}{1m}$

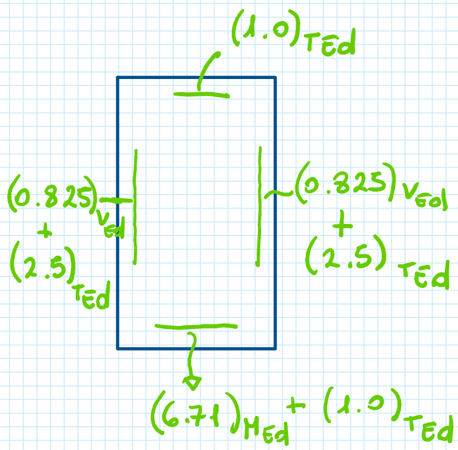
$$\frac{6.43}{\cot\theta} = 5 \Rightarrow \cot\theta = \frac{6.43}{5} = 1.29$$

ARMATURA DI PARETE E LONGITUDINALE

$$A_{par} = \frac{V_{Ed}\cot\theta}{2\, f_{yd}} = \frac{100 \times 10 \times 1.29}{2 \cdot 391.3} = 1.65\ cm^2$$

$$A_{sLON} = \frac{T_{Ed}\, u_k \cot\theta}{2 A_k\, f_{yd}} = \frac{30 \times 140 \times 1.29 \times 10^3}{2 \cdot 1000 \times 391.3} = 6.92\ cm^2$$

QUINDI :




STAFFE $\phi 8/10$

$M_{Ed} \Rightarrow A_s = 6.71\ cm^2$

$V_{Ed} \Rightarrow A_{par} = 1.65\ cm^2$

$\hookrightarrow$ SU CIASCUN LATO $\dfrac{1.65}{2}$

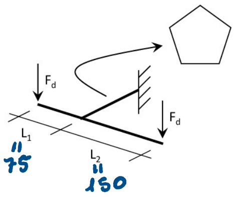
$T_{Ed} \Rightarrow A_{sLON} = 6.92\ cm^2$

$$\frac{6.92}{u_k} = \frac{x}{b_k} \Rightarrow x = \frac{6.92}{u_k} b_k = \frac{6.92}{140} \times 20 = 1.0\ cm^2$$

$$\frac{6.92}{u_k} = \frac{x}{h_k} \Rightarrow x = \frac{6.92}{u_k} h_k = \frac{6.92}{140} \times 50 = 2.5\ cm^2$$

2024

Considera la struttura disegnata a lato costituita da tre aste orizzontali. Le lunghezze $L_1$ ed $L_2$ sono 75 e 150 cm, rispettivamente. Il carico è costituito da due forze verticali uguali pari a $F_d$ applicate sui due estremi liberi. Per effetto delle due forze nell'asta centrale nasce momento flettente, taglio e momento torcente. Quest'asta ha sezione pentagonale regolare in c.a. di lato 35 cm armata con 10 barre $\phi$12. Il copriferro $c$ è 4 cm. L'armatura trasversale è costituita da staffe $\phi$8 con passo 20 cm. Il calcestruzzo è di classe C25/30 e le armature di acciaio B450C.



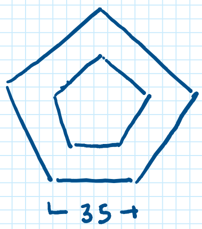

(7) Determina il momento torcente resistente $T_{Rd}$ della sezione pentagonale considerando tutti i possibili modi di rottura (rottura del calcestruzzo, snervamento delle staffe, snervamento delle barre longitudinali (punti 4)

43.18 kNm

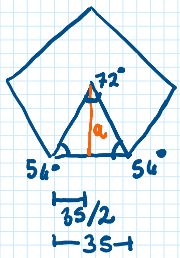
(8) Assumi che il taglio resistente $V_{RdMax}$ della sezione sia 200 kN, non considerare il momento flettente e determina il valore della forza $F_d$ che provoca il collasso della sezione pentagonale per schiacciamento del calcestruzzo. (punti 3)

53.0 kN

7) $$\cot^*\vartheta = \sqrt{\frac{A_{s\,LON}}{u_k}\,\frac{s}{A_{s,st}}}$$




$$t = \max\begin{cases} 2\times 4 = 8 \text{ cm} \\ \dfrac{A}{u} = \dfrac{2108.8}{175} = 12.05 \text{ cm} \end{cases}$$

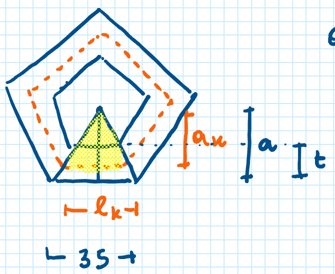



$$\frac{a}{\ell/2} = \text{tg}\,54^\circ$$

$$a = \frac{\ell}{2}\,\text{tg}\,54^\circ = \frac{35}{2}\,\text{tg}\,54^\circ = 24.1 \text{ cm}$$

$$A = 5\times\left(\frac{35\times 24.1}{2}\right) = 2108.8 \text{ cm}^2$$

$$u = 35\times 5 = 175 \text{ cm}$$




$$a_k = a - \frac{t}{2} = 24.1 - \frac{12.05}{2} = 17.85 \text{ cm}$$

$$\frac{a}{\ell} = \frac{a_k}{\ell_k} \Rightarrow \ell_k = \frac{a_k}{a}\,\ell$$

$$\ell_k = \frac{17.85}{24.1}\times 35 = 25.92$$

$$u_k = 5\cdot \ell_k = 5\times 25.92 = 129.6$$

$$A_k = 5\times\left(\frac{25.92\times 17.85}{2}\right) = 1156.7 \text{ cm}^2$$

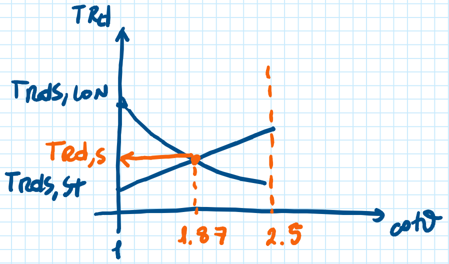
$$\cot^*\vartheta = \sqrt{\frac{A_{s\,LON}}{u_k}\,\frac{s}{A_{s,st}}} = \sqrt{\frac{10\times 1.13}{129.6}\,\frac{20}{0.5}} = 1.87$$

$$A_{\phi 12} = \pi\frac{1.2^2}{4} = 1.13 \text{ cm}^2$$

$$A_{\phi 12} = \pi \frac{1.2^2}{4} = 1.13 \ cm^2$$

POICHÉ $\cot^* \vartheta < 2.5 \Rightarrow \cot^* \vartheta = 1.87$

$$T_{Rd_S} = T_{Rds,st}(\cot \vartheta^*) = T_{Rds,lon}(\cot^* \vartheta)$$

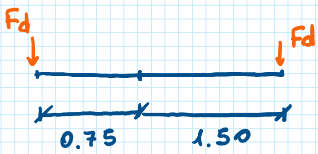



$$T_{Rds} = 2 A_k \frac{A_{s,st}}{s} f_{yd} \cot \vartheta = 2 \times 1156.7 \cdot \frac{0.5}{20} \cdot \frac{391.3 \cdot 1.87}{10^3} = 42.32 \ kNm$$

$$T_{Rd\,max} = 2 A_k t f'_{cd} \frac{\cot \vartheta}{1 + \cot^2 \vartheta} = 2 \times 1156.7 \times 12.05 \cdot \frac{0.5 \times 14.17}{10^3} \times \frac{1.87}{1 + 1.87^2} = 82.13 \ kNm$$

$$T_{Rd} = MIN(82.13; 42.32) = 42.32 \ kNm$$

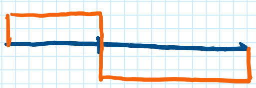
8) $$\frac{V_{Ed}}{V_{Rd\,max}} + \frac{T_{Ed}}{T_{Rd\,max}} = 1$$




$$T_{Ed} = F_d \times 1.50 - F_d \times 0.75$$

$$T_{Ed} = F_d (1.50 - 0.75)$$

$$T_{Ed} = 0.75 \ F_d$$



$$V_{Ed} = 2 \ F_d$$

$$\frac{2 \ F_d}{200} + \frac{0.75 \ F_d}{82.13} = 1$$

$$F_d = \frac{1}{\frac{2}{200} + \frac{0.75}{82.13}} = 52.26 \ kN$$