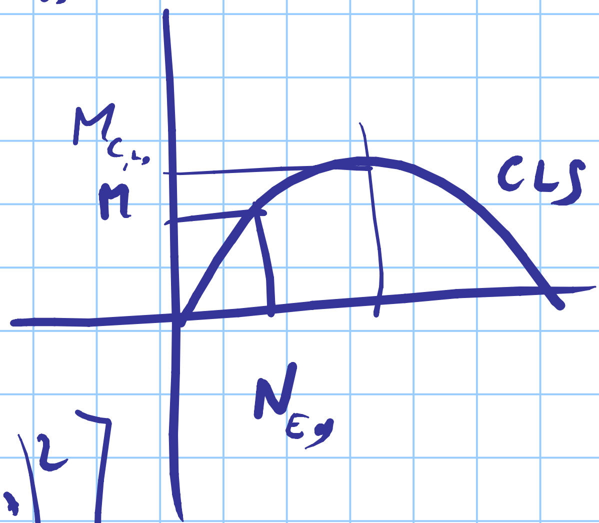
Titolo nota 01/12/2012

40x70 $M_{Ed} = 550$ kNm

$N = 1500$ kN (compr.)



$$M_c = M_{c,max}\left[1-\left(\frac{N_{Ed}+\nu_m N_{c,max}}{\nu_m N_{c,max}}\right)^2\right] =$$

$$= 338.4\left[1-\left(\frac{-1500+1932}{1932}\right)^2\right] = 321.5 \text{ kNm}$$

$$M_{s,max} = A_s (h-2c) f_{yd}$$

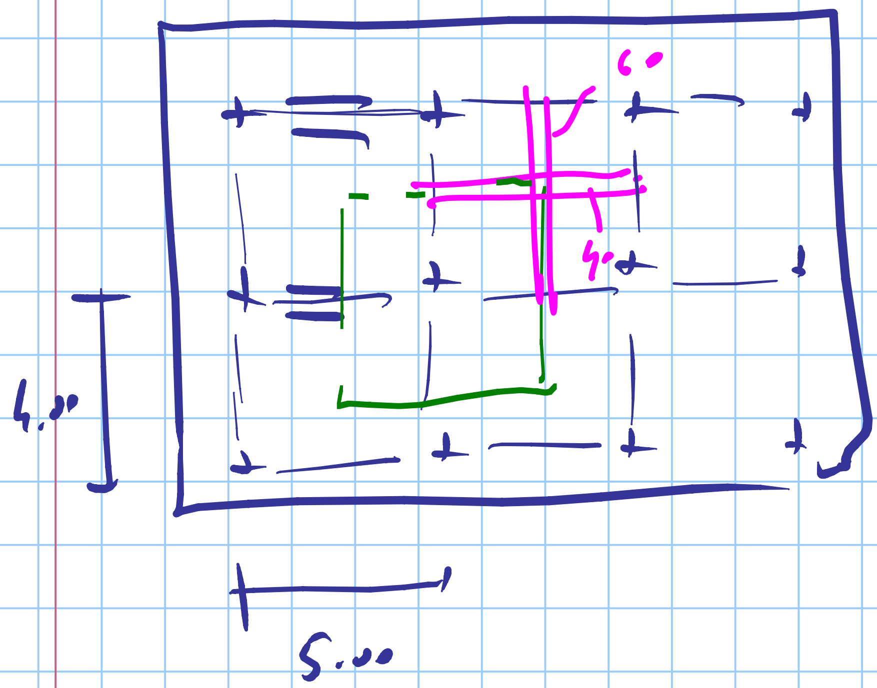
$$A_s = \frac{(M_{Ed} - M_c)}{(h-2c)\, f_{yd}} = \frac{(550 - 321.5) \times 10}{0.62 \times 391.3} = 9.4\ m^2$$

se $N_{Ed} = 400$ kN compr

$$M_c = M_{c,max}\left[1 - \left(\frac{N_{Ed} + \nu_m N_{c,max}}{\nu_m N_{c,max}}\right)^2\right] = 338.4\left[1 - \left(\frac{-400 + 1932}{1932}\right)^2\right] =$$

$$= 125.6\ \text{kNm}$$

$$A_s = \frac{(550 - 125.6) \times 10}{0.62 \times 391.3} = 17.5 \text{ cm}^2$$



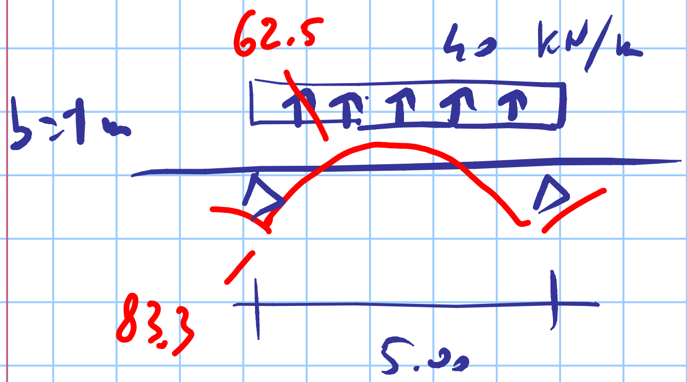
$N_{el} = 2000$ kN

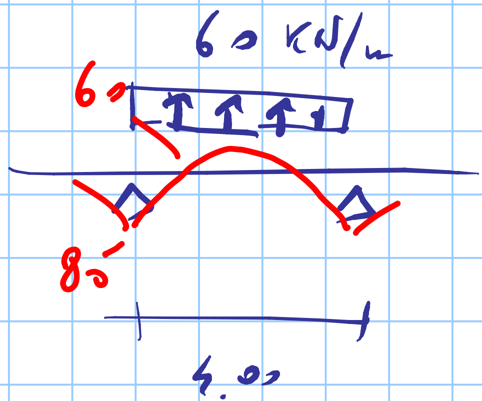
$t = ?$

$$\sigma_t = \frac{2000 \times 10^3}{4 \times 5 \times 10^6} = 0.1 \text{ MPa};$$

$= 100$ kPa

kN/m²





$\frac{ql^2}{16}$

$\frac{ql^2}{12}$

$$d = r'\sqrt{\frac{M}{b}} = 0.019\sqrt{\frac{83.3}{1.00}} = 0.17\ m$$

basti 22 cm

prendo $t = 30$ cm

$c = 5$ cm

$$A_s = \frac{M}{0.9\,d\,f_{yd}} = \frac{83.3 \times 10}{0.9 \times 0.25 \times 391.3} = 9.5\ cm^2$$

serve in armatura in compressione ?

$$M_{Rd} = \frac{b\,d^2}{r^2} = 161\ kNm > 83.3\ kNm$$

$r^2 \rightarrow 0.0197$

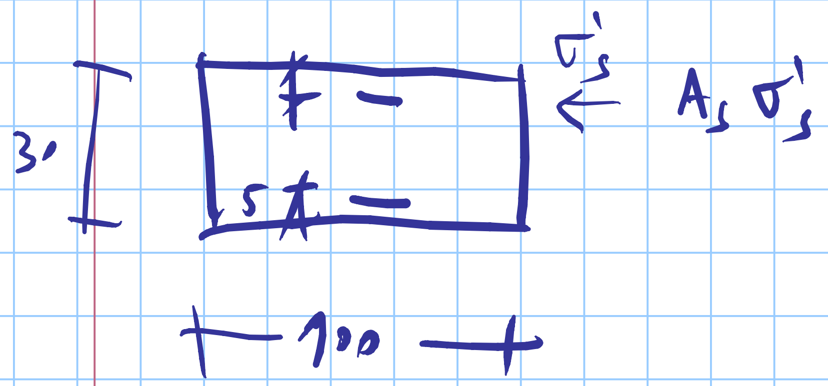
NON SERVE

Esempio (cont. A.)

$$M_{Ed} = 220 \text{ kNm}$$

$$A_s = \frac{220 \times 10}{0.9 \times 0.25 \times 391.3} = 25.0 \text{ cm}^2$$

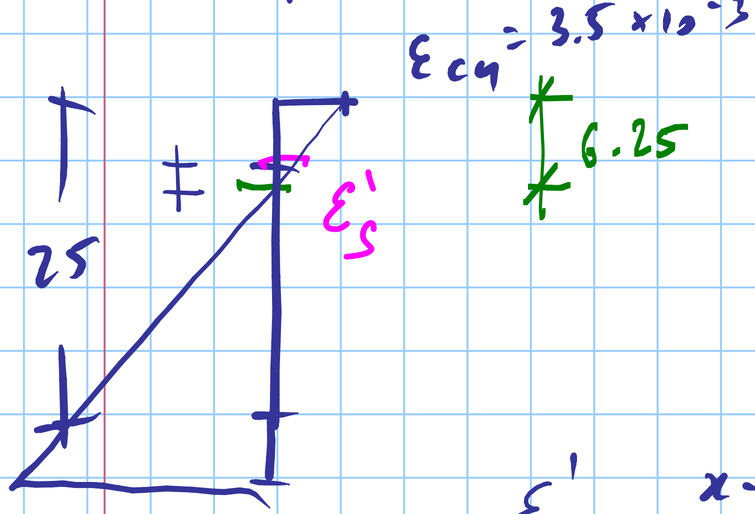
$$M_{Rd}(n=0) = 161 \text{ kNm}$$



$$\Delta M = 220 - 161 = 59 \text{ kNm}$$

$$A'_s = \frac{\Delta M}{(h - 2c)\, \sigma'_s}$$

a quanto lavora l'armatura compressa ?



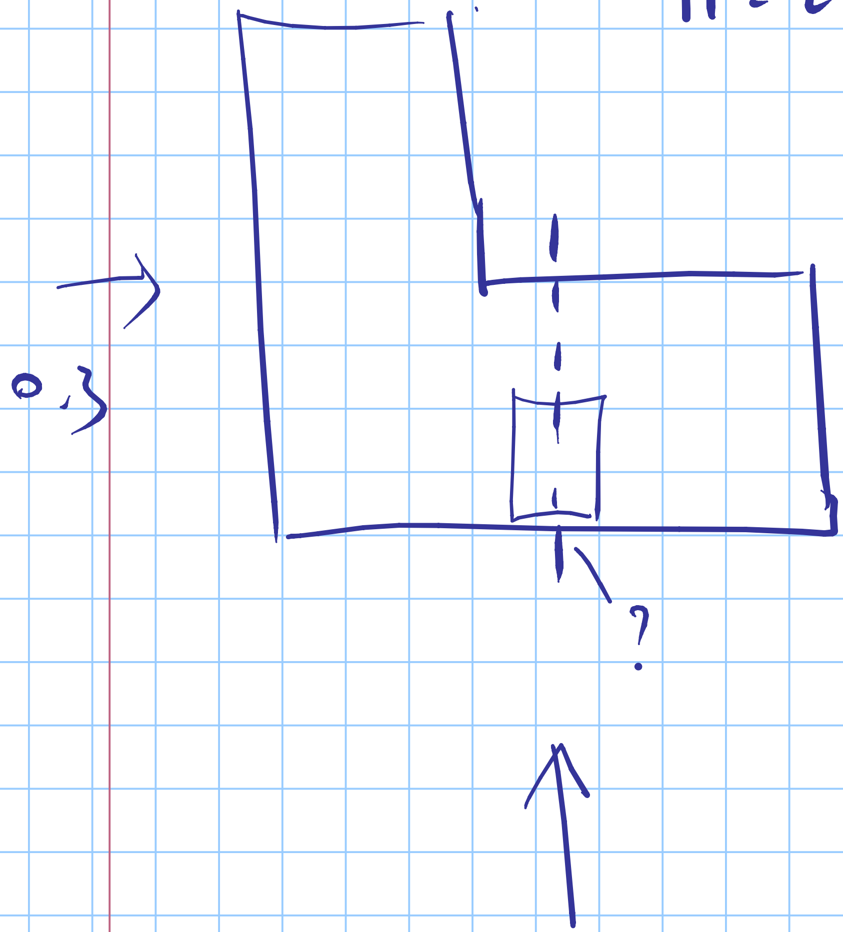
$$x = 0.25\, d = 6.25 \text{ cm}$$

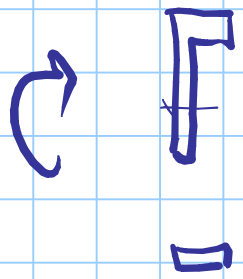
$$\varepsilon'_s = \frac{x - c}{x}\, \varepsilon_{cu} = \frac{6.25 - 5}{6.25}\, \varepsilon_{cu} = 0.2\, \varepsilon_{cu} = 0.7 \times 10^{-3}$$

$$\sigma'_s = 0.7 \times 10^{-3} \times 200\,000 = 140 \text{ MPa}$$

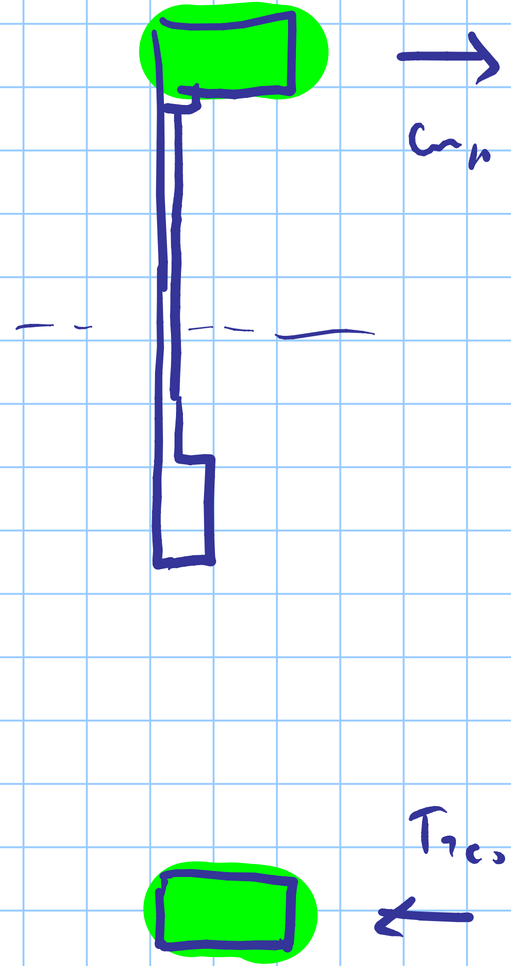
$$A'_s = \frac{\Delta M}{(h - 2c)\, \sigma'_s} = \frac{59 \times 10}{0.20 \times 140} = 21.0 \text{ cm}^2$$

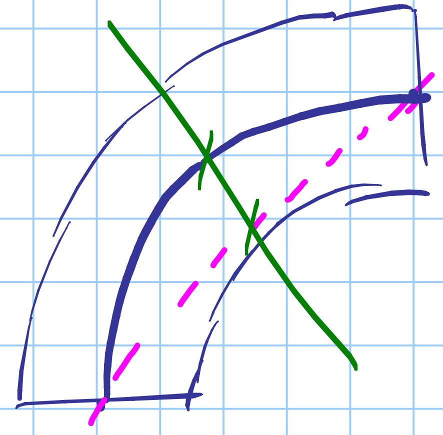
M = 2360 kNm



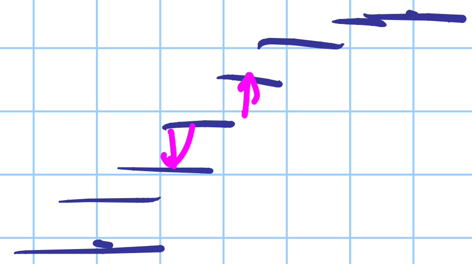


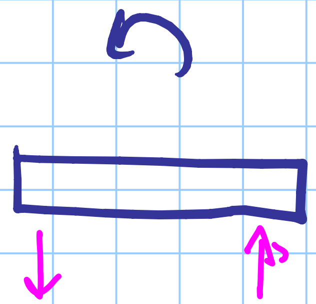
SEZIONE

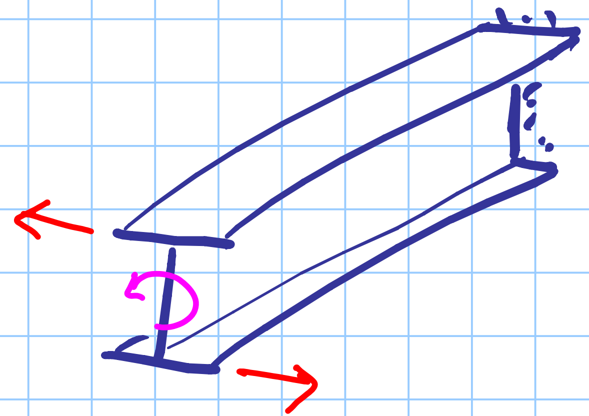




planar







$V_{Ed} = 300\ kN$ $\quad 30 \times 50 \quad c = 4\ cm$

$1 \leq \cot\theta \leq 2.5$ (opt. 2)

$V_{Rd,max} = \underbrace{\dfrac{\cot\theta}{1+\cot^2\theta}}_{0.4}\ b\, z\, f'_{cd} =$

$f'_{cd} = \frac{1}{2} f_{cd} = 7.1\ MPa$

$z = 0.9 \times 46 = 41.4\ cm$

$= 0.4 \times \underbrace{30 \times 41.4}_{10} \times 7.1 = 352.7\ kN > V_{Ed}$

posso usare $\cot\theta = 2$

$$A_{st} = \frac{V \quad s}{z \, f_{yd} \, \underbrace{\cot\theta}_{2}} = \frac{300 \times 100}{41.4 \times 391.3 \times 2} \times 10 = 9.3 \ cm^2/m$$

staffe $\phi 8$ 2 br $\qquad\qquad\qquad\qquad$ $\phi 8/10$ cm

$\Downarrow$

$0.5 \ cm^2 \times 2 = 1 \ cm^2$

staffe $\phi 8/20$ $\quad \dfrac{5\ cm^2}{m}$ $\quad$ 30 x 50 $\quad c = 4\ cm$

2 br

$V_{Rd,max}^{(\cot\theta = 2)} = 352.7\ kN$

$$V_{Rd,s} = \underbrace{\frac{A_{st}}{s}} f_y\ z \cot\theta =$$

$$= \frac{5}{100}\ 391.3 \times \frac{41.4}{10} \times 2 = 162\ kN$$

staffe $\phi 8/15$ $\quad 6.67\ cm^2/m$ $\quad V_{Rd,s} = 216\ kN$

staffe $\phi 8/10$ $\quad 10\ cm^2/m$ $\quad V_{Rd,s} = 324\ kN$

staffe $\phi 8 / 7.5$ $\quad 1.333\ cm^2$

$V_{Rd,s} = 379\ kN$

$\cot\theta = 2 \qquad V_{Rd,s} = 432\ kN$

NON PUÒ ESSERE

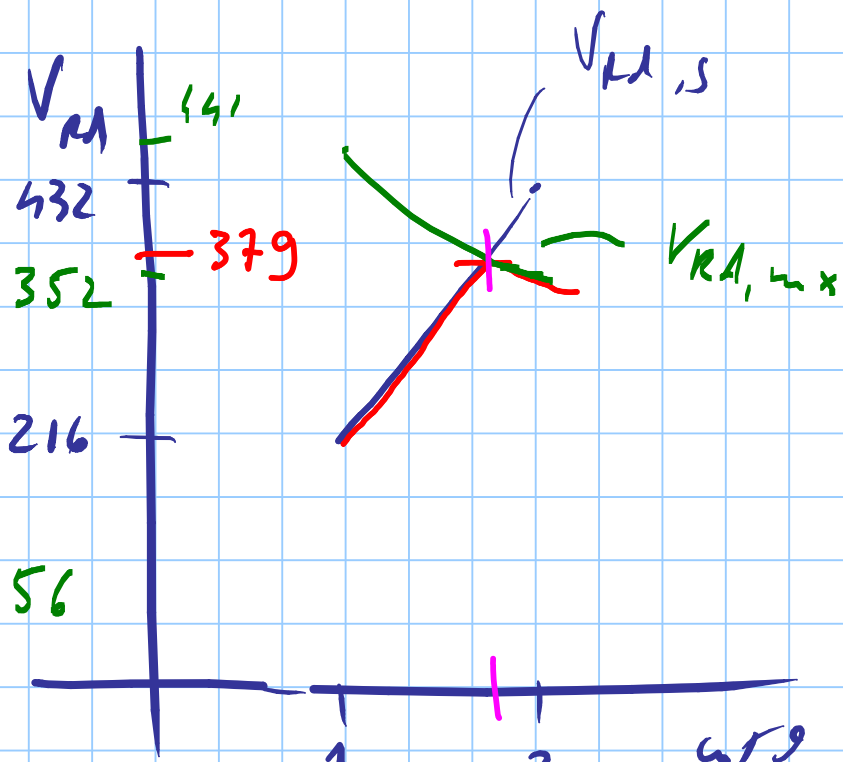
$V_{Rd,max} = 352.7\ kN$

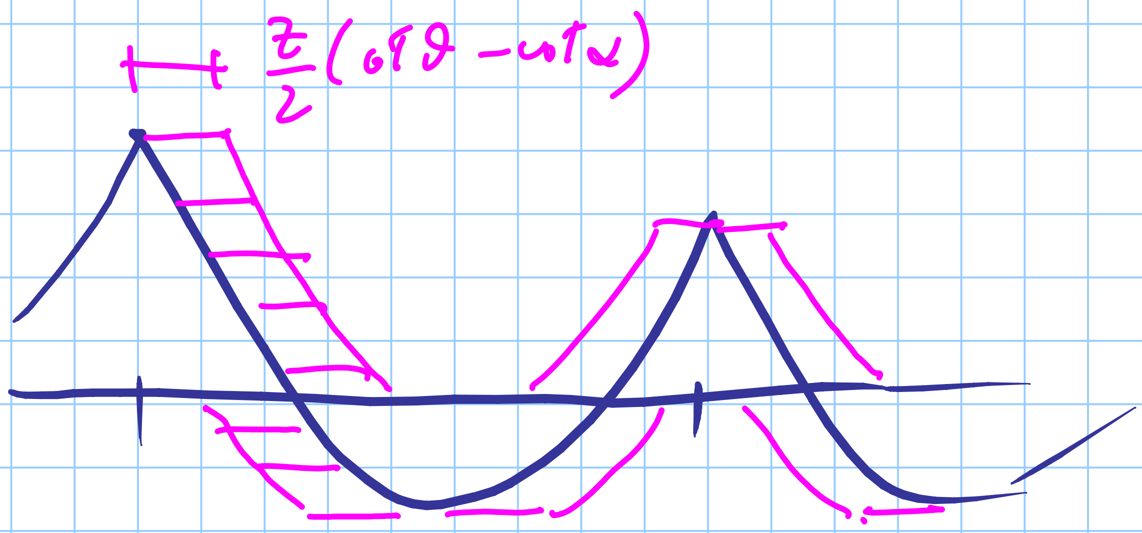
ricavo $\cot\theta$

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

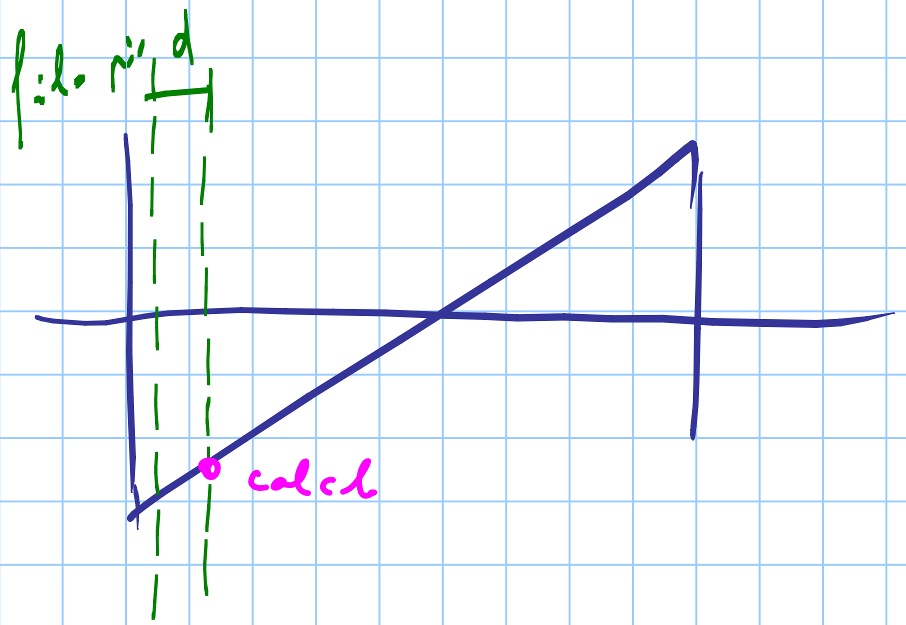
$$\frac{A_{st}}{s} f_{yd}\, \cancel{z}\, \cancel{\cot\theta} = \frac{\cancel{\cot\theta}}{1+\cot^2\theta}\, b\, \cancel{z}\, f'_{cd}$$

$$\cot\theta = \sqrt{\frac{b \quad f'_{cd}}{\frac{A_{st}}{s} \quad f_{yd}} - 1} = 1.756$$





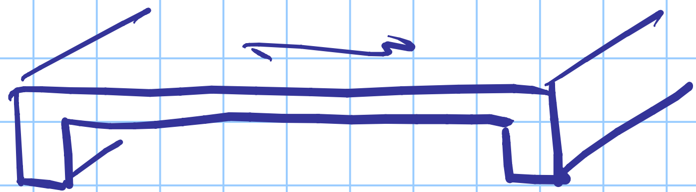
$\frac{z}{2}(\cot\theta - \cot\alpha)$

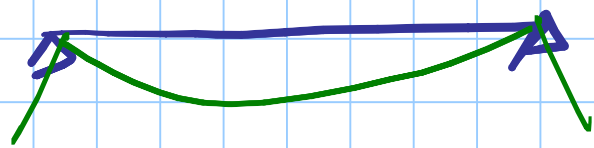


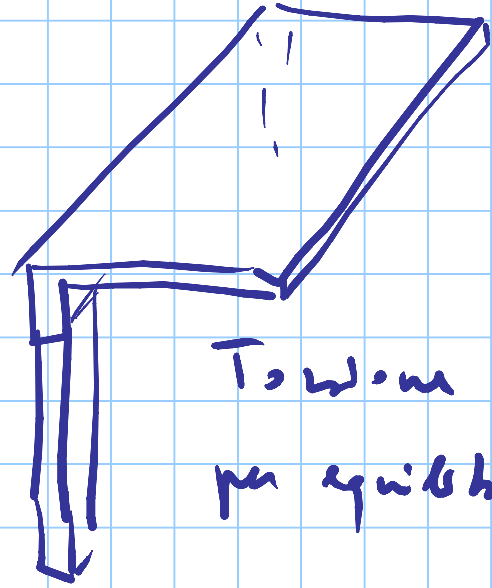
d
calcul

TORSIONE

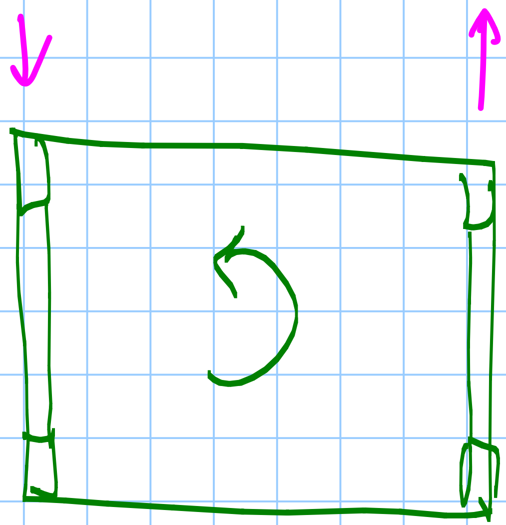
- per equilibrio
- per congruenza



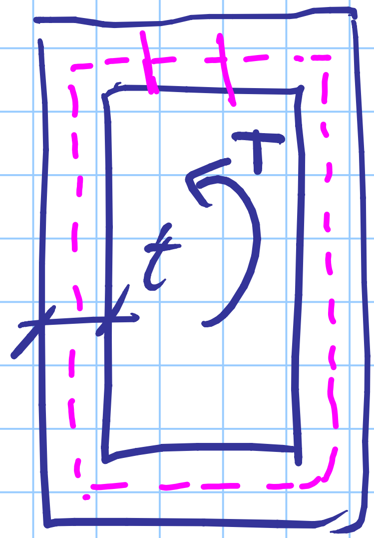




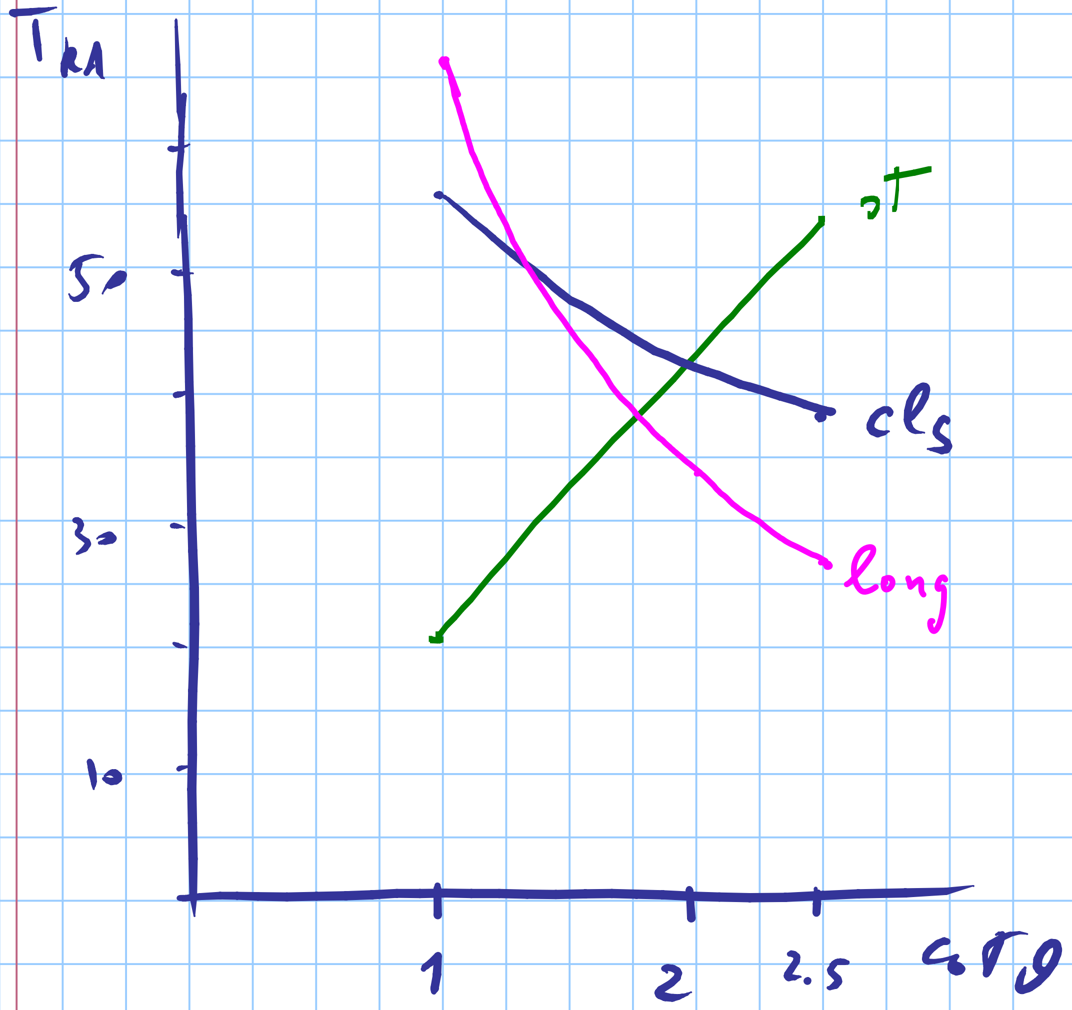
Torsione
per equilibrio



Bredt



$$\tau = \frac{T}{2 A_k t}$$



T_{RA}
50
30
10
1
2
2.5
ST
cls
long

$T_{Ed} = 120 \text{ KNm}$ $\qquad \cot\theta = 2 \qquad c = 4 \text{ cm}$

$t = 10 \text{ cm}$ $\qquad$ 1° Ta T. $\qquad t \geq 2c \qquad f'_{cd} = 7.1 \text{ MPa}$

$$A_k = \frac{T_{Ed}}{2t\, f'_{cd}\, \frac{\cot\theta}{1+\cot^2\theta}} = \frac{120 \times 10^3}{2 \times 10 \times 7.1 \times 0.4} = 2113 \text{ cm}^2$$

$b_k = 40 \qquad h_k = 60$

$+10 \qquad +10$

50×70

$$t = \frac{50 \times 70}{2(50+70)} = 14.6 \text{ cm}$$

$$A_k = \frac{T_{Ed}}{2t\, f'_{cd} \frac{\cot\theta}{1+\cot^2\theta}} = 1447 \text{ cm}^2$$

35×45

$14.6 \quad 14.6$

50×60

$$t = \frac{50 \times 60}{2(50+60)} = 13.64$$

$b_k = 50 - 13.64 = 36.36$ cm

$h_k = 60 - 13.64 = 46.36$ cm

$A_k = 1549$ cm^2

$A_k = 1686$ cm^2

$u_k = 165.4$ cm

$$\cot\theta = \frac{A_k\, t\, f'_{cd}}{T_{Ed}} + \sqrt{\left(\frac{A_k\, t\, f'_{cd}}{T_{Ed}}\right)^2 - 1} = 1.36 + \sqrt{1.36^2 - 1} = 2.28$$

$$\frac{A_k\, t\, f'_{cd}}{T_{Ed}} = \frac{1686 \times 13.66 \times 7.1}{120 \times 10^3} = 1.36$$

$$\frac{A_{st}}{\cancel{s}} = \frac{T_{Ed}\, s}{2 A_k\, f_{yd} \cot\theta} = \frac{120 \times 100 \times 10^3}{2 \times 1686 \times 391.3 \times 2} = 4.55\ cm^2$$

$$\Downarrow$$

$$\phi 8/10$$

$$\cot\theta = \frac{T_{Ed}\, s}{A_{st}\, 2 A_k\, f_{yd}} = \frac{120 \times 100 \times 10^3}{5 \times 2 \times 1686 \times 391.3} = 1.82$$

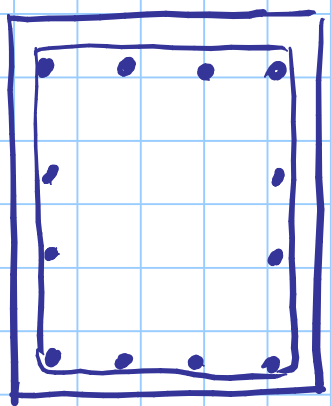
$$A_{s,lon} = \frac{T_{Ed}\, u_k \cot\theta}{2 A_k f_{yd}} = \frac{120 \times 165.4 \times 2 \times 10^3}{2 \times 1686 \times 391.3} = 30.1\ cm^2$$

1.82

$27.4\ cm^2$

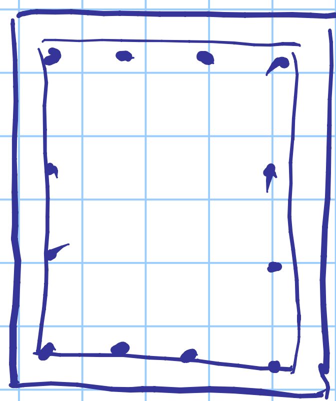
alternative $\quad \phi 10/10 \quad \cot\vartheta = 1.15$

$A_{sl} = 17.3\ cm^2$



$\phi 10/10$

$12\phi 14 \rightarrow 18\ cm^2$



$\phi 8/10$

$12\phi 18$

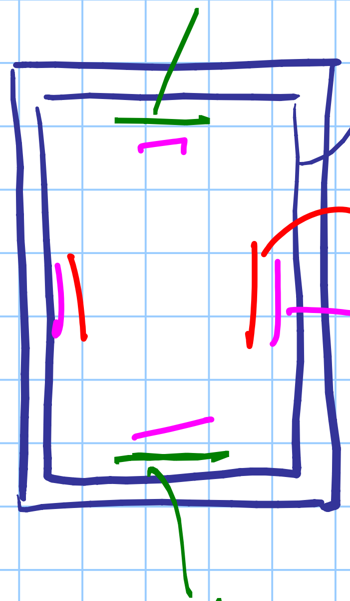
A_s per M^-

τ_{eff}

Taglio + Torsione

τ_{eff} conf. ×2

×1



A_s parete a Taglio

A_{sl} a Torsione

A_s per M^+

$T_{Ed} = 90 \text{ kNm}$

$M_{Ed} = 320 \text{ kNm}$

$V_{Ed} = 210 \text{ kN}$

50×60

$\cot\theta = 2$

$M_{Rd} = \dfrac{b\,d^2}{2.2} = 484 \text{ kNm}$

OK

$$T_{Rcd} = 2 A_k\, t\, f'_{cd} \frac{\cot\theta}{1+\cot^2\theta} = \frac{2 \times 1686 \times 13.64 \times 7.1 \times 0.4}{10^3} =$$

$$= 130.6 \text{ kNm}$$

$$V_{Rd,max} = \frac{\cot\theta}{1+\cot^2\theta}\,\alpha_c\, f'_{cd}\, b\, z = 0.4 \times 7.1 \times \frac{50 \times 50.4}{10} = 715.7 \text{ kN}$$

$$\frac{210}{715.7} + \frac{90}{130.6} = 0.293 + 0.689 = 0.982 < 1$$

OK

se avessi avuto $V_{Ed} = 250\ kN$ e $T_{Ed} = 100\ kNm$

avrei dovuto usare $\cot\theta \simeq 1.6$

$V_{Rd\,max} = 802\ kN$ $T_{Rd} = 146\ kNm$

Decido di usare $\cot\theta = 2$ [ott. $\cot\theta = 1.6$]

Torsione $A_{st} = 3.41\ cm^2/m$

$$V_{Rd,s} = \frac{A_{sw}}{s} f_{yd}\, z \cot\theta$$

$$A_{st} = \frac{V\ s}{f_{yd}\, z \cot\theta} = \frac{210 \times 100 \quad \times 10}{391.3 \times 50.4 \times 2} = 5.3\ cm^2/m$$

$\downarrow$

bracci 2 b.

$$A_{st} = 3.41 + \frac{5.3}{2} = 6.0\ cm^2/m$$

12 staffe $\phi 8$ / metro