MATERIALI UTILIZZATI E COPRIFERRO

C 30/37

RICOPRIMENTO $r =$ 25 mm (AMBIENTE ORDINARIO)

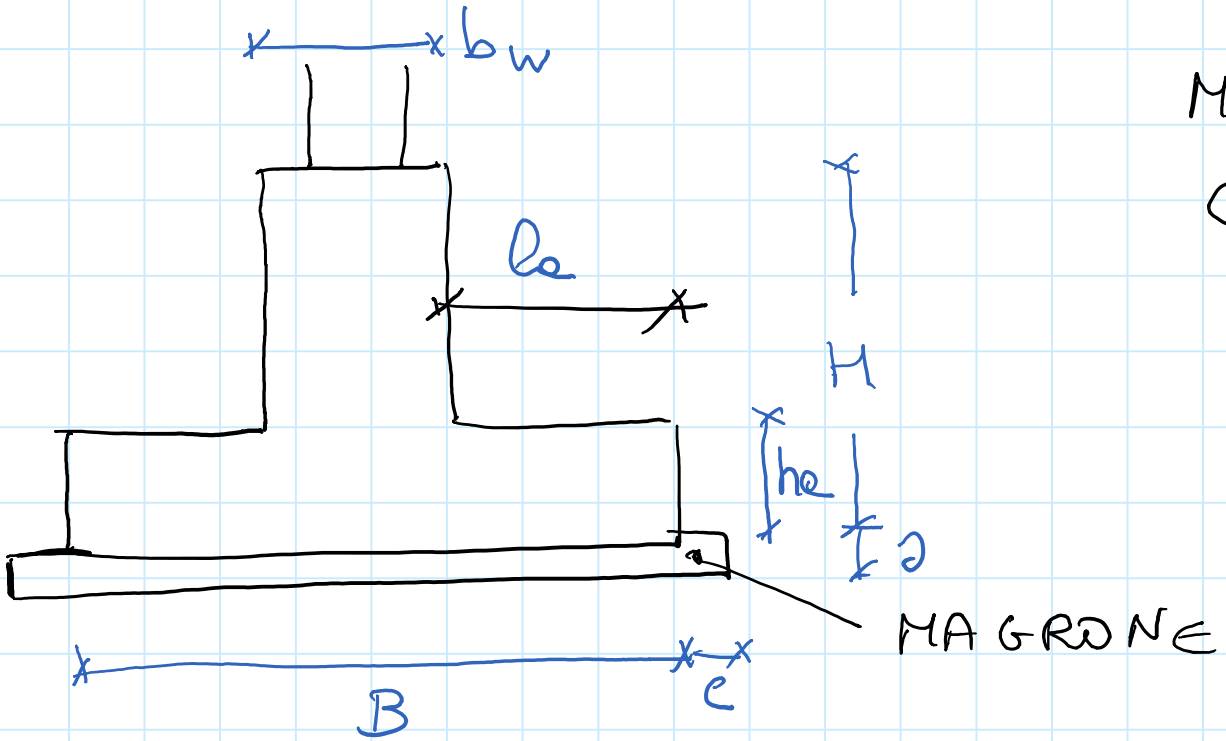
35 mm (AMBIENTE AGGRESSIVO)

$$c = r + \Delta r + \phi_{STAFFA} + \frac{\phi_{LONG}}{2}.$$

$$= 25 + 5 + 10 + 10 = 50 \text{ mm}$$

(60 mm PER AMBIENTE AGGRESSIVO)

PREDIMENSIONAMENTO



MAGRONE:

$C \leq S$ (PER AVERE ELEMENTO TOZZO)

$C = 10\ cm$

$S = 15\ cm$

PER POTER REALIZZARA LA CASSAFORMA DEL PILASTRO

$$b_w \geq 10\ cm + MAX\left\{L_{MIN,\ PIL}\right\} = 10 + 30 = 40\ cm$$

DEFINIZIONE ALTEZZA SEZIONE

H < RIGIDEZZA (1)
H < RESISTENZA (2)

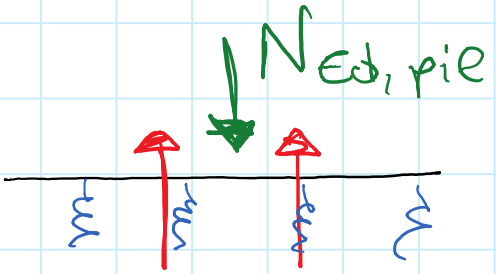
(1) RIGIDEZZA

PER AVERE FONDAZIONE RIGIDA $I_{fond} \geq 4 \sum_{i=1}^{n_p} I_{TRAVI\ ELEV}$

$$\Rightarrow \quad \underbrace{1.7\ \frac{b_w H^3}{12}}_{\text{CONTRIBUTO ALI}} \geq \underbrace{4}_{\text{6 PIANI}} \cdot 6 \cdot \frac{30 \cdot 60^3}{12} \quad \Rightarrow$$

$$H \geq \sqrt[3]{\frac{4 \times 6 \times 30 \times 60^3}{1.7 \times 40}} = 131.7 \text{ cm}$$

RESISTENZA



$$V_{Rd,max} \geq V_{Ed}$$

$$V_{Ed} \simeq 0.6\, N_{max,pile} = 0.6 \times 2554\ kN = 1532.4\ kN$$

$$V_{Rd\,max} = b_w\, 0{,}9\, d \cdot \nu f_{cd} \frac{\cot g\,\theta}{1+\cot g^2\theta} \geq 1532.4\ kN$$

Assumo $\cot g\,\theta = 2$

$f_{cd} = 17\ MPa$ $\Longrightarrow$

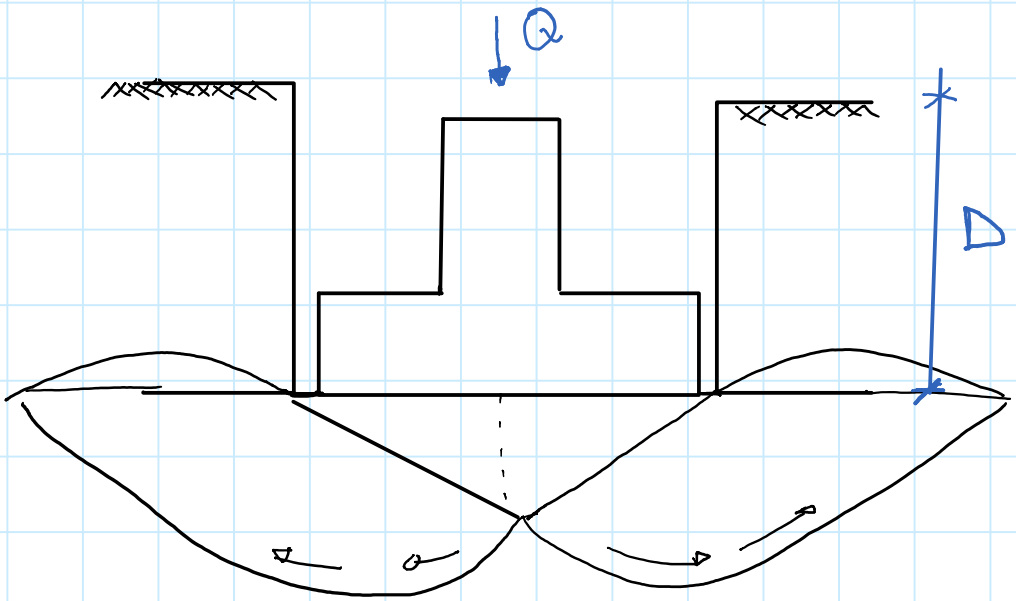
$\nu = 0.5$

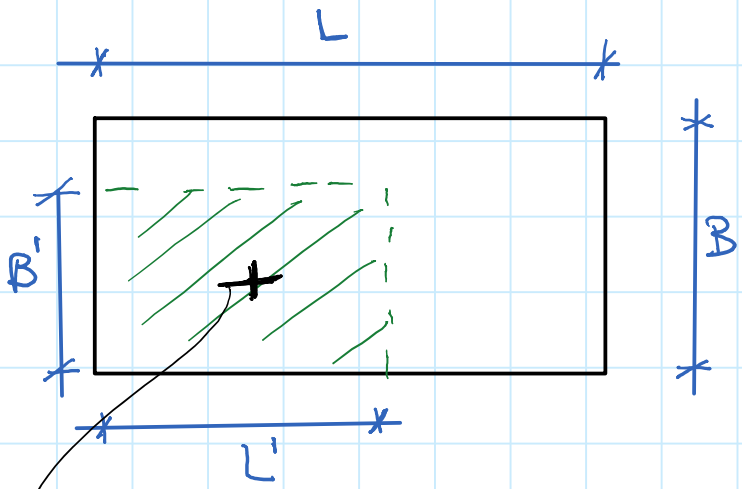
$$d \geq \frac{1532.4\ kN \cdot (1+2^2)}{40\,cm \times 0{,}9 \times 0{,}5 \times 17\ MPa \cdot 2} \cdot \frac{1}{10} = 125.2\ cm$$

FISSO $H = 135\ cm$

$H = d + c = 130{,}2\ cm$ $\Longrightarrow$

CAPACITA' PORTANTE TERRENO





PUNTO APPLICAZIONE RISULTANTE CARICHI

$$Q_{lim} = \frac{B'L'}{\gamma_R}\left[\frac{1}{2}\gamma B N_\gamma \alpha_\gamma + c N_c \alpha_c + \gamma D N_q \alpha_q\right]$$

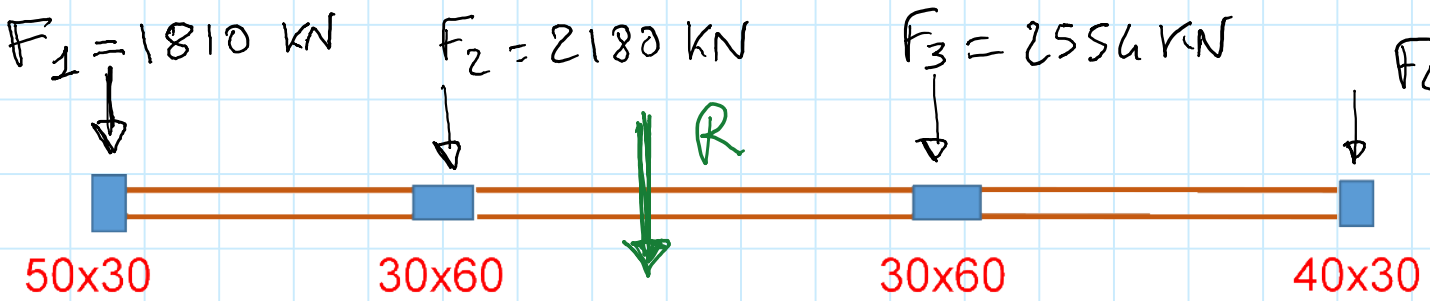
c = COESIONE

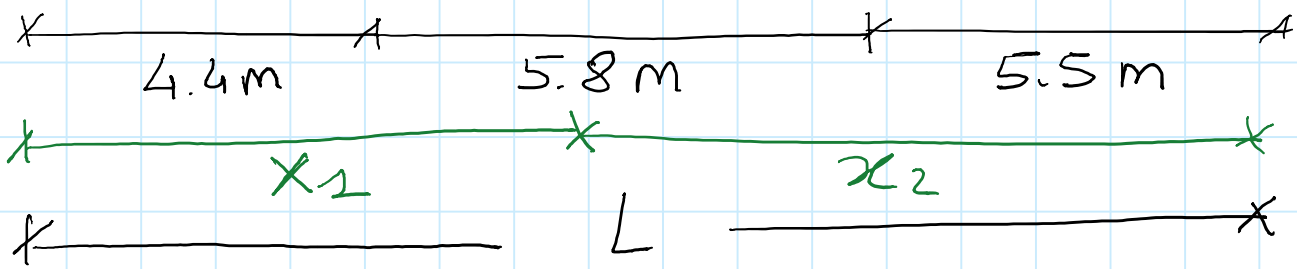
φ = ANGOLO D'ATTRITO TERRENO

γ = PESO PER UNITÀ DI VOLUME

D = AFFONDAMENTO

CALCOLO PUNTO DI APPLICAZIONE RISULTANTE





$L = 15.7\ m$

IPOTIZZO TRAVE IN ASSENZA DI SBALZI
(SCELTA NON OPPORTUNA)

$$R = F_1 + F_2 + F_3 + F_4 = 8000\ kN$$

$$x R = F_2\, 4.4 + F_3 (4.4 + 5.8) + F_4 (4.4 + 5.8 + 5.5)$$

$$\Rightarrow x_2 = 7.31\ m$$

$$x_2 = L - x_1 = 8.39\ m$$

$$\Rightarrow L' = 2 \times MIN(x_1, x_2) \Rightarrow$$

$$L' = 14.62\ m$$

FATTORI DI CAPACITÀ PORTANTE

PER L'EDIFICIO IN ESAME SI ASSUME

$c = 0$; $\varphi = 28° = \frac{28}{180}\pi = 0.156\pi$; $\gamma = 21\ kN/m^3$

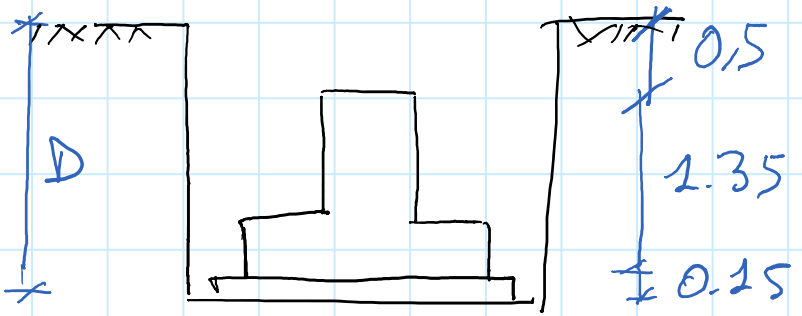
$$N_q = e^{\pi \operatorname{tg} 0.156\pi} \operatorname{tg}^2\left(\frac{\pi}{4} + \frac{0.156\pi}{2}\right) = 14.72$$

$$N_\gamma = 2(N_q + 1) \operatorname{tg} 0.156\pi = 16.77$$

$$N_c = (N_q - 1) \cot g\, \pi$$

NON NECESSARIO PERCHÈ $c = 0$

AFFONDAMENTO



$\Rightarrow D = 2.0\ m$

CALCOLO DELLA BASE

$$Q_{lim} = \frac{BL'}{\gamma_R} \cdot \left[\frac{1}{2} \gamma B N_\gamma \alpha_\gamma + c N_c \alpha_c + \gamma D N_q \alpha_q \right]$$

$\gamma_R = 2.3$

α_γ, α_q DIPENDONO DA INCLINAZIONE CARICO, PIANO DI CAMPAGNA, B/L

(ASSUMO VALORE UNITARIO)

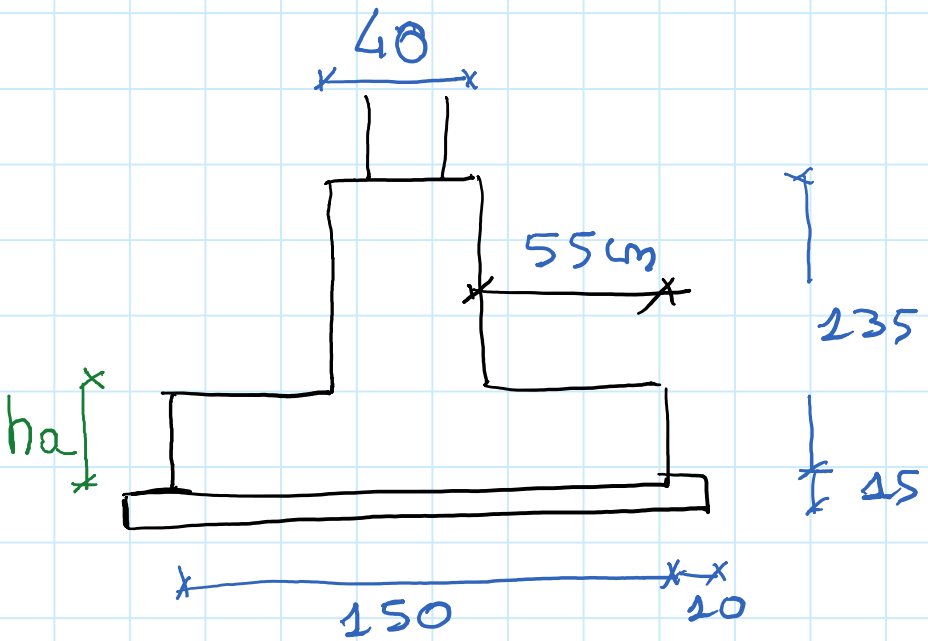
PONGO $Q_{lim} = 8000\,KN \Rightarrow B$

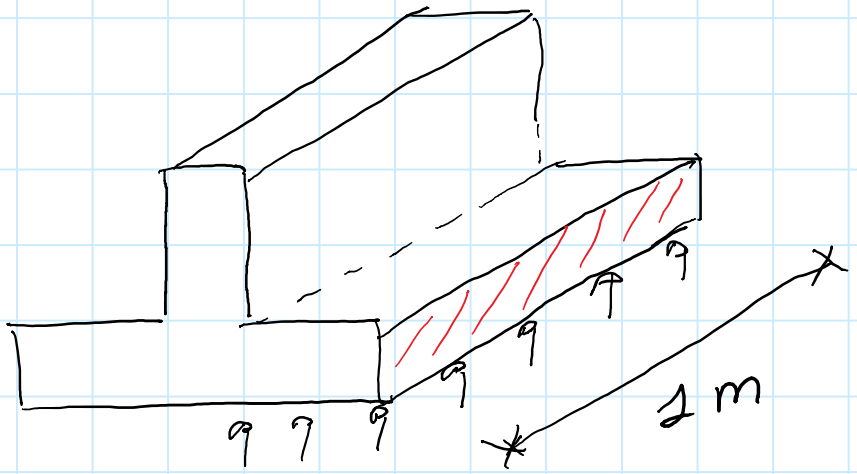
$$8000\,KN = \frac{14,62\,m\,B}{2,3} \left[\frac{B}{2} \cdot 21\frac{KN}{m^3} \cdot 16,77 + 21\frac{KN}{m^3} \cdot 2m \times 14,72 \right]$$

EQUAZIONE SECONDO GRADO $\Rightarrow B \geq 1.44\,m$

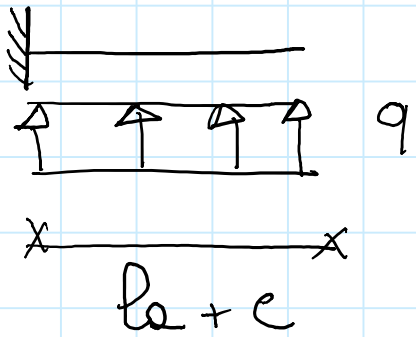
FISSO $B = 1.50\,m$

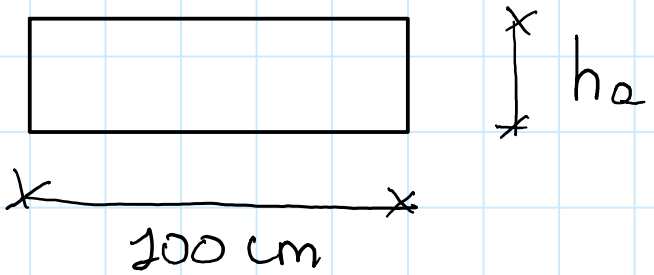
DEFINIZIONE ALTEZZA ALA





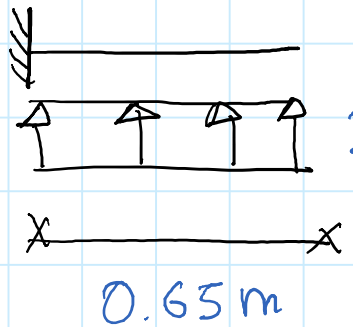
SEZIONE TRASVERSALE





CARICO TRASMESSO DAL TERRENO

$$q = \frac{Q_{TOT}}{BL'} \times 1m = \frac{8000\ kN}{1,5 \times 14,62 m^2} \times 1 = 365\ \frac{kN}{m}$$



N.B. CAUTELATIVAMENTE HO TRASCURATO C NEL CALCOLO DI 9, CONSIDERO C NEL DEFINIRE LA LUNGHEZZA DELLA MENSOLA

$$M_{max} = \frac{9(l_e + c)^2}{2} = 365 \times \frac{0,65^2}{2} = 77.1 \text{ kNm}$$

$$V_{max} = 9(l_e + c) = 365 \times 0.65 = 237.2 \text{ kN}$$

PER LA VERIFICA A FLESSIONE $M_{max} \leq \frac{bd^2}{\Sigma^2} \Rightarrow$

$$d \geq 0.018 \sqrt{\frac{77.1}{1.0}} = 0.16 \text{m}$$

PER NON DISPORRE ARMATURA A TAGLIO $\Rightarrow$

$$V_{Ed} \leq V_{Rd,c} = \max \begin{cases} 0.18\, k \sqrt[3]{\frac{100\, \rho_e f_{ck}}{\gamma_c}}\, bd \\ 0.035\, k^{3/2} f_{ck}^{1/2}\, bd \end{cases}$$

VERIFICA A TAGLIO

NON CONOSCO ρ_e ⇒ CONSIDERO LA SECONDA CONDIZIONE

$$K = 1 + \sqrt{\frac{200}{d}} \leq 2$$

SE $h_e = 50\,cm \Rightarrow d = 450\,mm \rightarrow K = 1.7$

$$V_{Rdc} = \underbrace{0.035 \cdot 1.7^{3/2} \cdot 30^{1/2}}_{N/mm^2} \cdot \underbrace{100}_{cm} \cdot d \Rightarrow$$

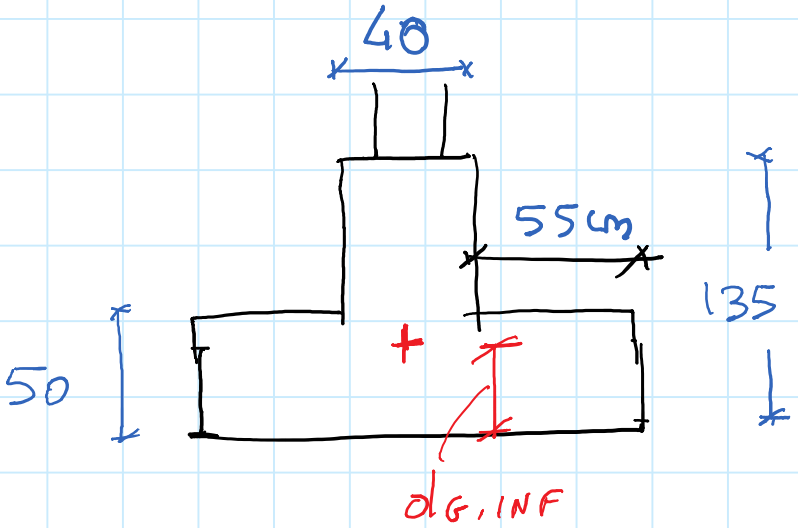
$V_{Rdc} = 237.2\,KN$

$$d = \frac{237.2\ KN}{0.035 \cdot 1.7^{3/2} \cdot 30^{1/2} \cdot 100} \times 10 = 55.8\ cm$$

DOVREI AVERE $h = 60\,cm$.

DISPONGO ARMATURA A TAGLIO E FISSO $h_e = 50\,cm$

VERIFICA ADEGUATEZZA I_{fond}



$$d_{G,INF} = S_{INF} / A$$

$$A = 0.4 \times 1.35 + 2 \times 0.55 \times 0.5 = 1.09\ m^2$$

$$S = \frac{0.4 \times 1.35^2}{2} + 2 \times 0.55 \times \frac{0.5^2}{2} = 0.502\ m^3$$

$$d_{G,INF} = 0.502 / 1.09 = 0.46\ m$$

$$I_{base} = \frac{0.4 \times 1.35^3}{3} + 2 \times 0.55 \times \frac{0.50^3}{3} = 0.37\ m^4$$

$$I_G = I_{base} - A \cdot d_{GINF}^2 = 0.37 - 1.09 \times 0.46^2 = 0.143\ m^4$$

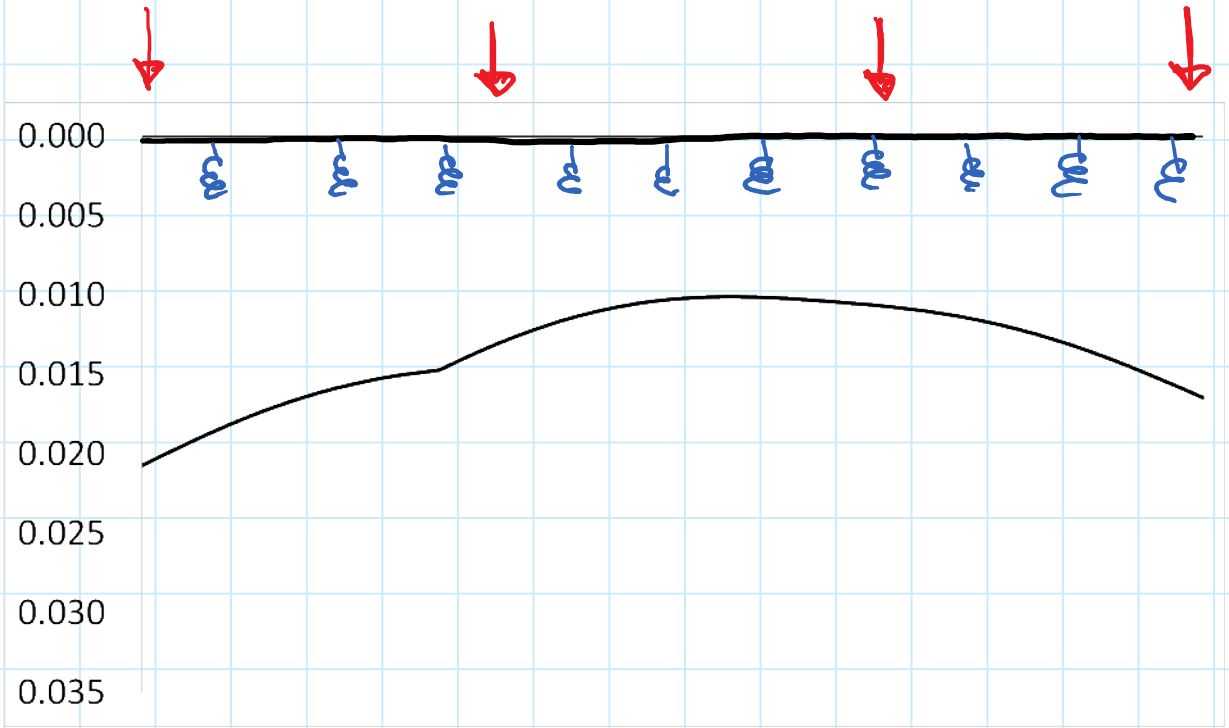
N.B. DA $1.7 \times \frac{bH^3}{12}$ TROVO $= 1.7 \times \frac{0.4 \times 1.35^3}{12} = 0.14\ m^4$

⟹ STIMA AFFIDABILE

SOLUZIONE TRAVE SU SUOLO ELASTICO

DA PROVA SU PIASTRA $K_s = 74\ N/cm^3$ ⇒

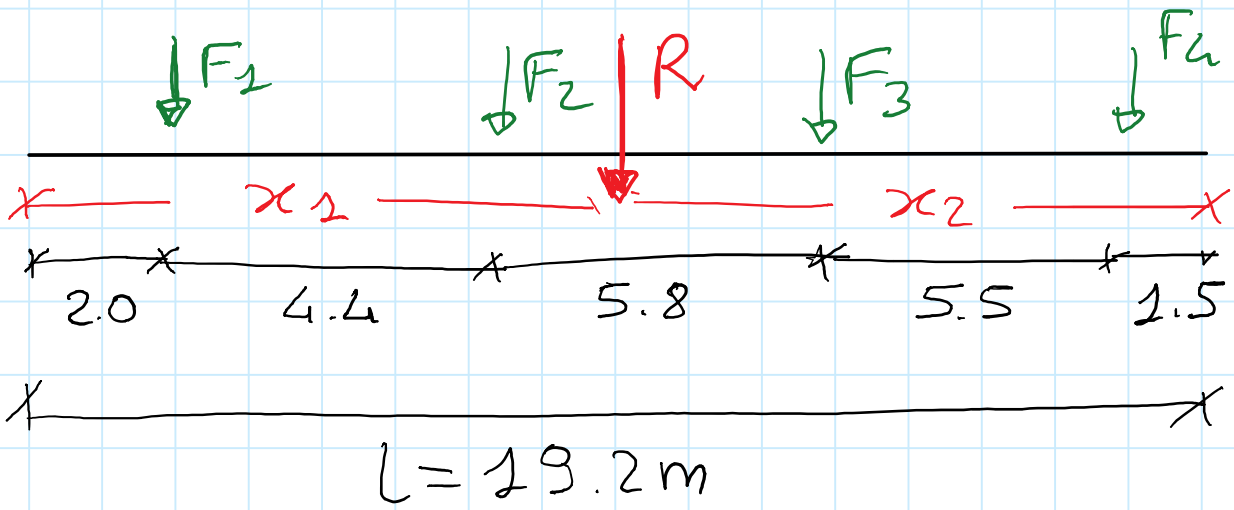
$$K = 74\ N/cm^3 \cdot \left(\frac{150+3}{2\times 150}\right)^2 = 26.64\ N/cm^3$$



⇒ CEDIMENTI NON UNIFORMI ⇒

OPPORTUNO INSERIRE SBALZI PER DISTRIBUIRE MEGLIO IL CARICO DEI PILASTRI D'ESTREMITÀ

CONFIGURAZIONE FINALE



$R = 8000\ kN$

$x_1 = 9.313\ m$

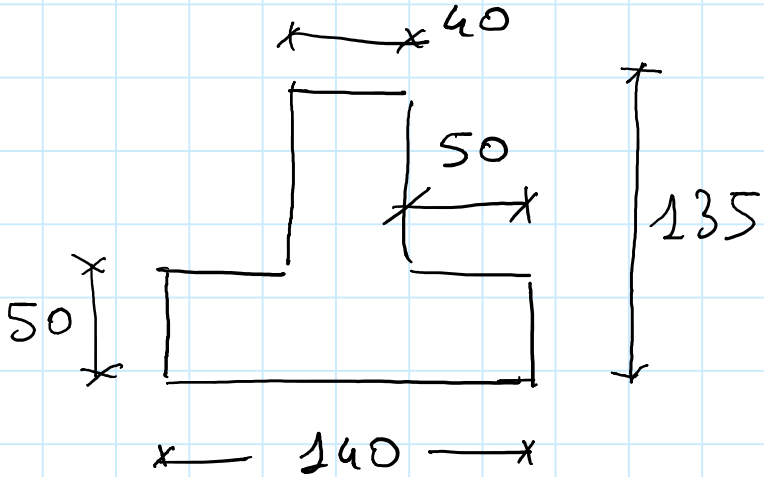
$L' = 18.63\ m$

DAL CALCOLO DELLA CAPACITA' PORTANTE → $B = 1{,}20\ m$

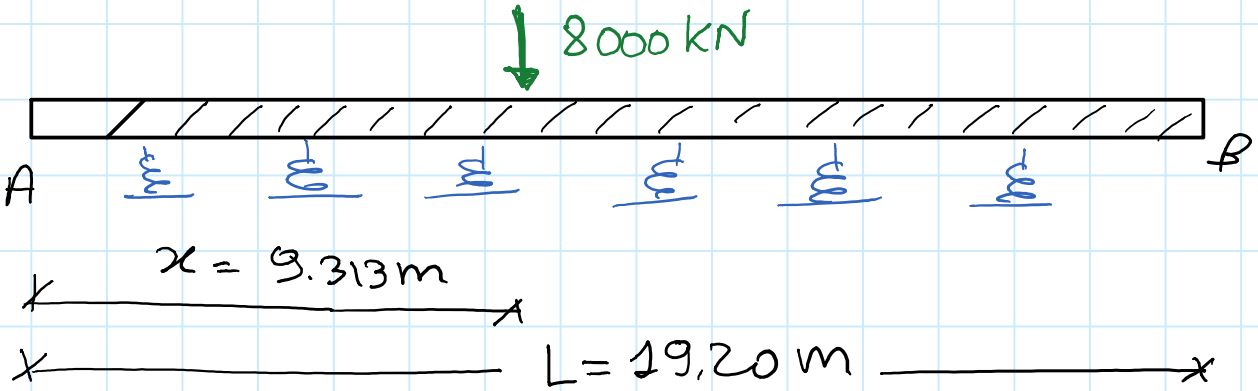
FISSO $B = 1{,}40\ m$

$I_{fond} = 0.139\ m^4$

$K = 27.28\ N/cm^3$



PREVISIONE SPOSTAMENTI (TRAVE RIGIDA SU SUOLO ELASTICO)



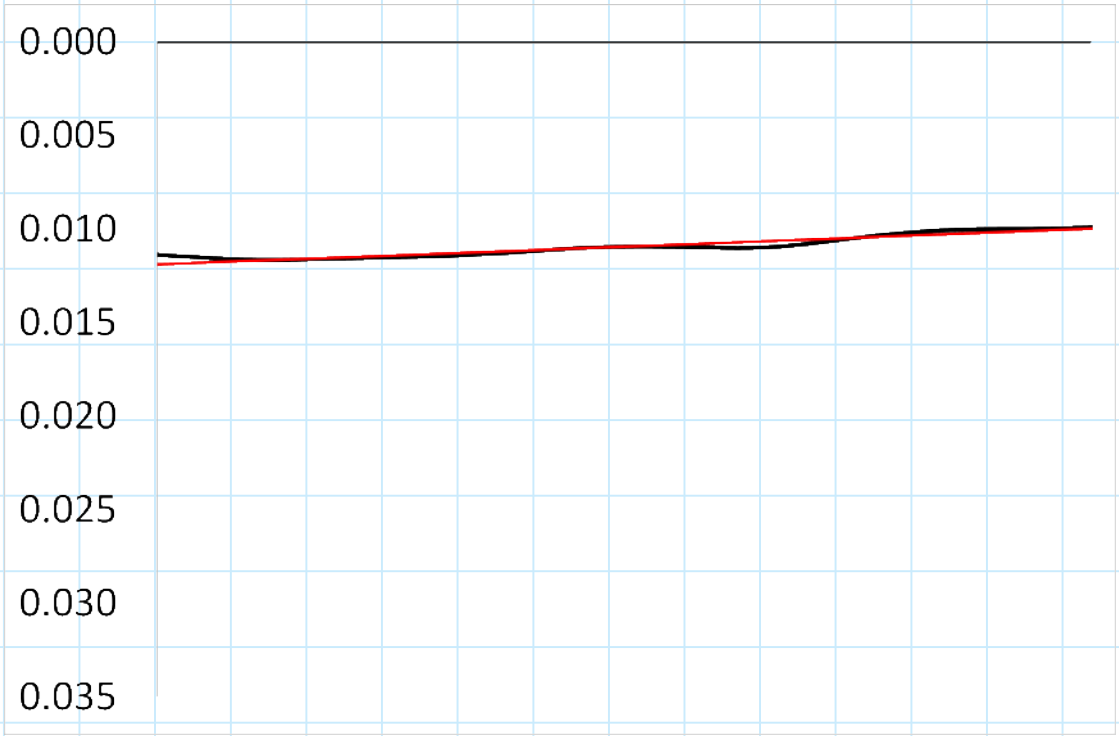
$$v_A = \frac{6F}{kbl^2}\left(\frac{2}{3}l - l_1\right) = \frac{6 \times 8000\ kN}{27.28 \times 10^3 \times 1{,}40\ m \times 19{,}2}\left(\frac{2}{3} - \frac{9{,}313}{19{,}2}\right)$$

$$= 0{,}012\ m$$

$$v_B = \frac{2F}{kbl^2}\left(-l + 3l_1\right) = \frac{2 \times 8000}{27{,}28 \cdot 10^3 \times 1{,}40 \times 19{,}2}\left(-1 + \frac{3 \times 9{,}313}{19{,}2}\right) =$$

$$= 0.010\ m$$

CONFRONTO CON SOLUZIONE DI TRAVE SU SUOLO ELASTICO



/ = TRAVE RIGIDA SU SUOLO ELASTICO

~ = TRAVE ELASTICA SU SUOLO ELASTICO

PROGETTO ARMATURA A FLESSIONE

ARMATURA MINIMA IN ZONA TESA $A_s = 0.2\% \, b_w d \Rightarrow$

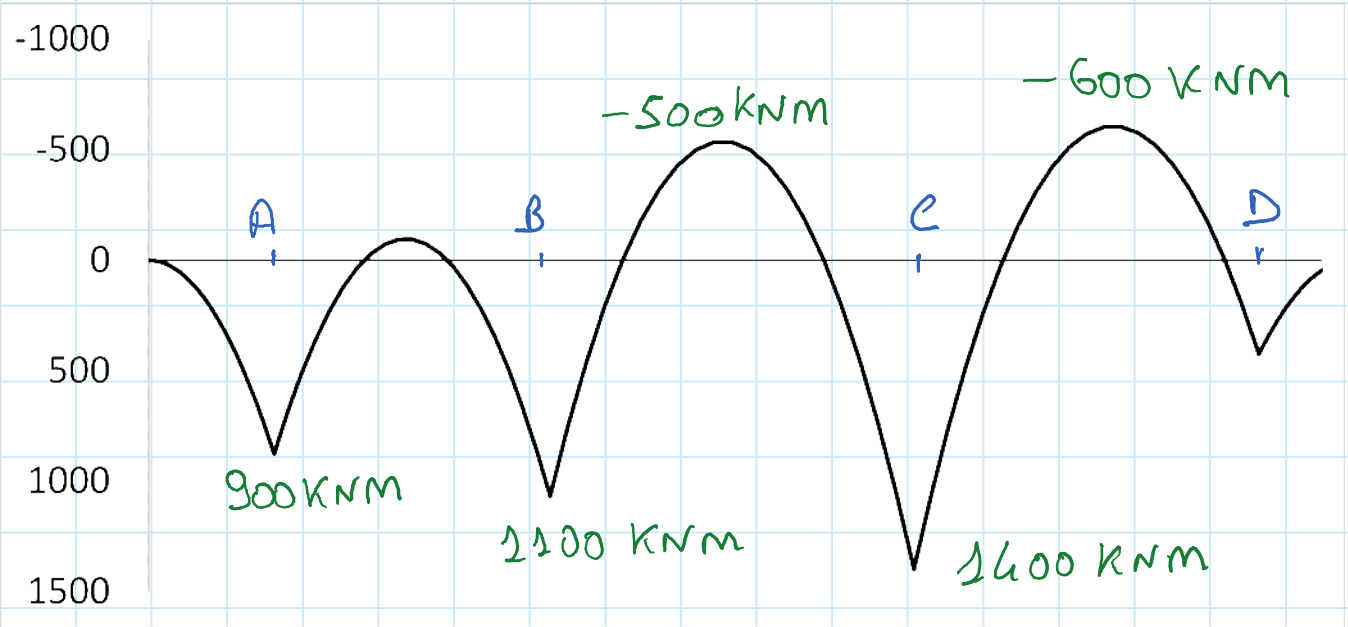
$$A_{s,MIN} = \frac{0.2}{100} \times 40\,cm \times (135-5)\,cm = 10.4\,cm^2$$

$\Rightarrow 4\phi 20$

CRITERIO DI FASCIA

DETERMINARE DIAGRAMMI M_{Ed}, V_{Ed} CONSIDERANDO VALORI DI K MOLTO DIVERSI (PROGETTARE ARMATURE PER INVILUPPO DIAGRAMMI)

PROGETTO ARMATURA A FLESSIONE



CAMPATA CD → $A_s = \dfrac{600\ \text{KNM}}{0{,}9 \times 1{,}30\ \text{m} \times 391.3\ \text{N/mm}^2} \times 10 = 13.11\ \text{cm}^2$

$A\phi 20 = 3.14\ \text{cm}^2 \Rightarrow 5\phi 20$

CAMPATA BC → $A_s = \dfrac{500 \times 10}{0{,}9 \times 1.30 \times 391.3} = 10.9\ \text{cm}^2 \rightarrow 4\phi 20$

MOMENTO RESISTENTE Ø20

$$M_{Rd\,\phi 20} = 3.14\,cm^2 \times 0{,}9 \times 1.30\,m \times 391.3\,\frac{N}{mm^2}\,\frac{1}{20} =$$

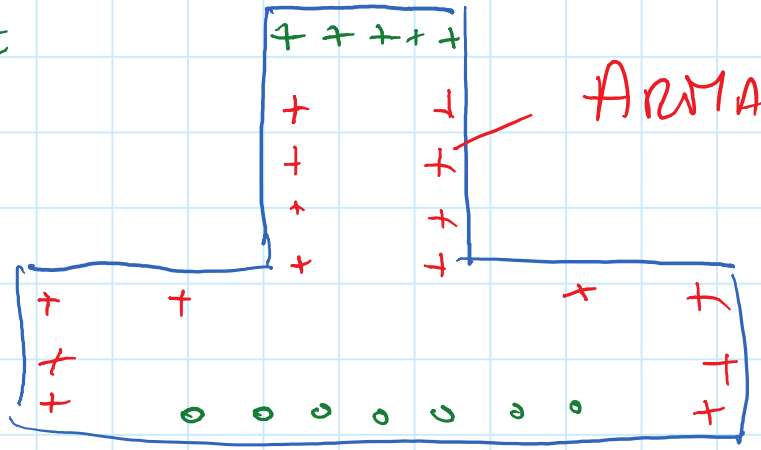
$$= 143.8\ KNm$$

APPOGGIO A $\Rightarrow$ $n_{\phi 20} = \dfrac{900\,KNm}{143.8\,KNm} \rightarrow 7\phi 20$

APPOGGIO B $\rightarrow$ $n_{\phi 20} = \dfrac{1100\,KNm}{143.8\,KNm} = 8\phi 20$

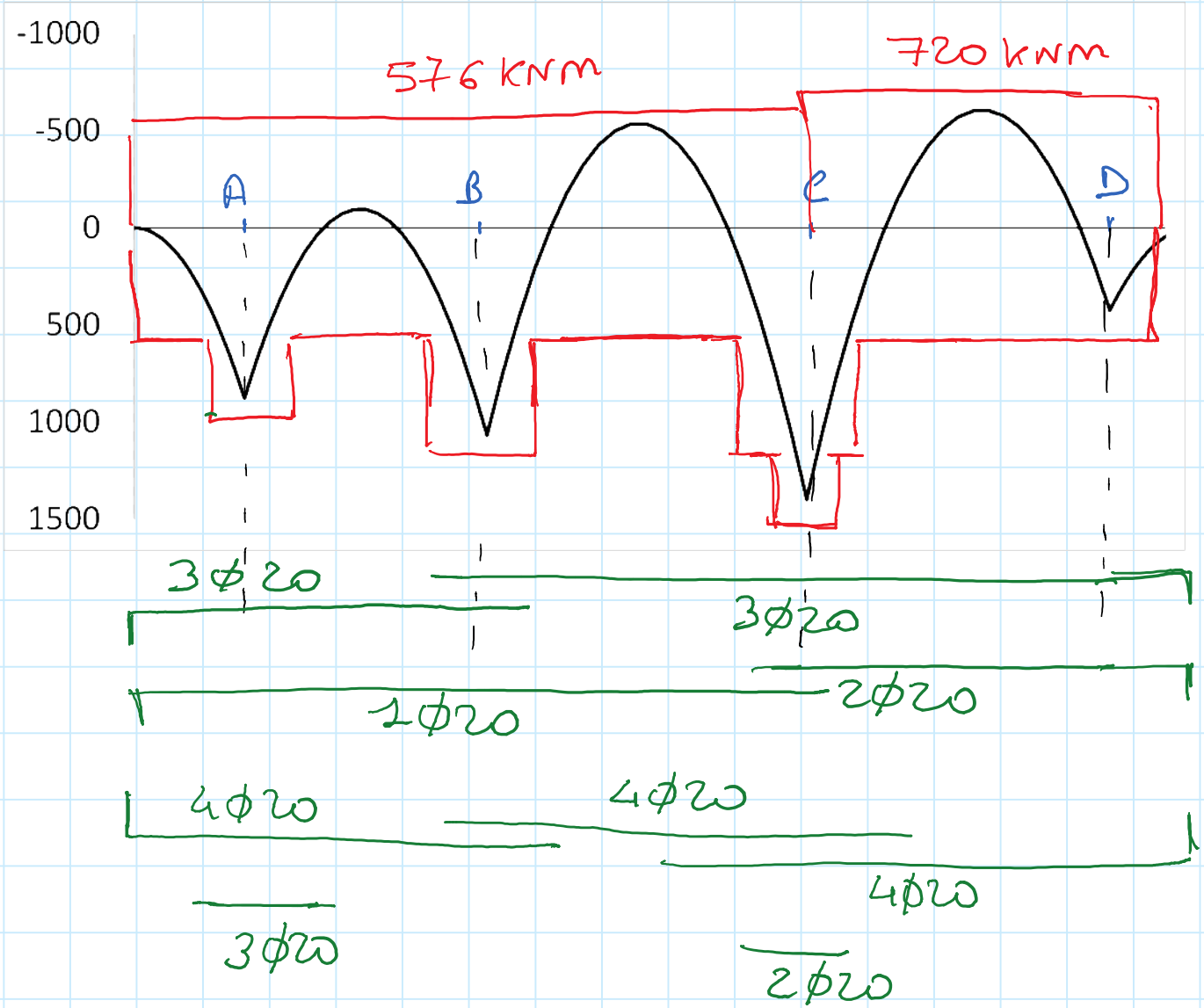
APPOGGIO C $\rightarrow$ $n_{\phi 20} = \dfrac{1400\,KNm}{143.8\,KNm} = 10\phi 20$

DISPOSIZIONE ARMATURE



ARMATURA DI PARETE (PER EVITARE TRASLAZIONE DIAGRAMMA M)

DISTINTA ARMATURE



PROGETTO STAFFE

ARMATURA MINIMA STAFFE $\quad \frac{n_b A_{st}}{s} \geq 1.5 \frac{b_w}{4} \left[\frac{mm^2}{m}\right]$

IN mm

UTILIZZO STAFFE $\phi 10 \quad n_b = 2$

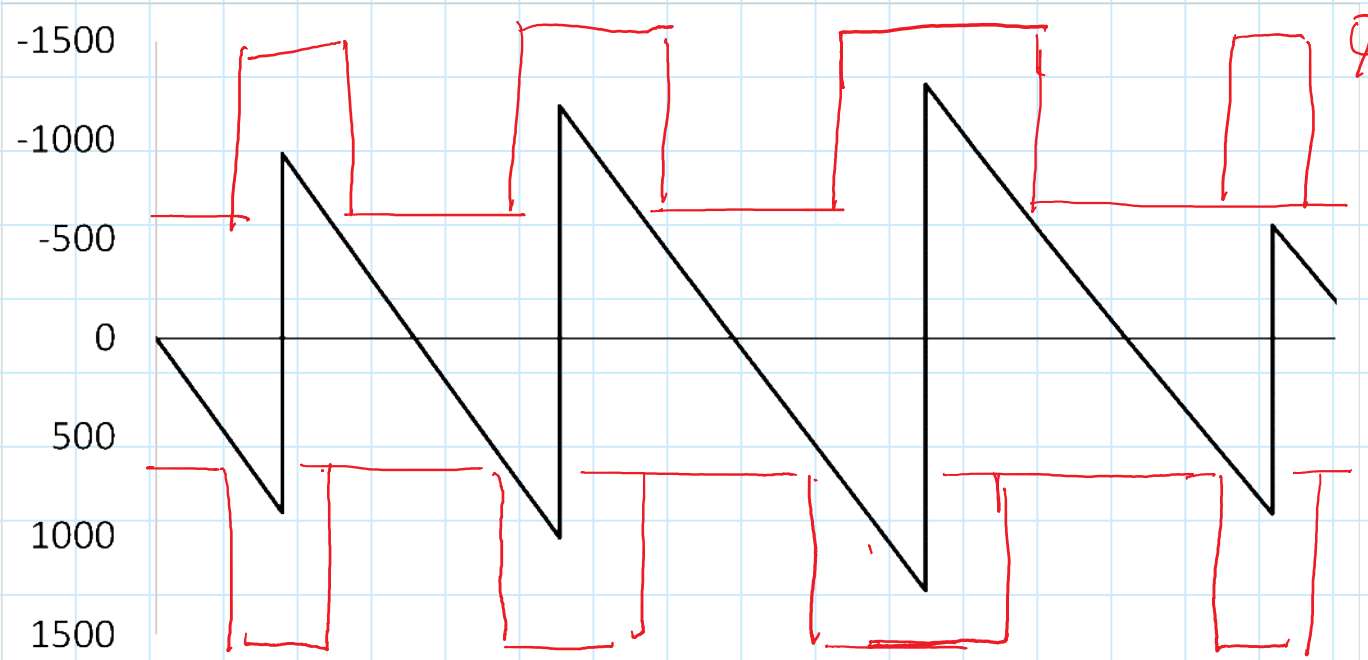
$$\Rightarrow \quad s \leq \frac{2 \times 78,5\ mm^2}{1,5 \times 400\ mm} = 0.26\ m \Rightarrow \phi 10/25$$

PER $\phi 10/25 \rightarrow V_{Rd,s} = n_b \cdot \frac{A_{st}}{s} \cdot z f_{yd} \cdot \cot\theta \Rightarrow$

$$V_{Rd,s} = 2 \times \frac{0,785\ cm^2}{25\ cm} \times 0,9 \times 130\ cm \times 391.3 \frac{N}{mm^2} \times 2 \frac{1}{10} = 575\ kN$$

PER $\phi 10/10 \rightarrow V_{Rd,s} = 1437.5\ kN$

DISPOSIZIONE STAFFE



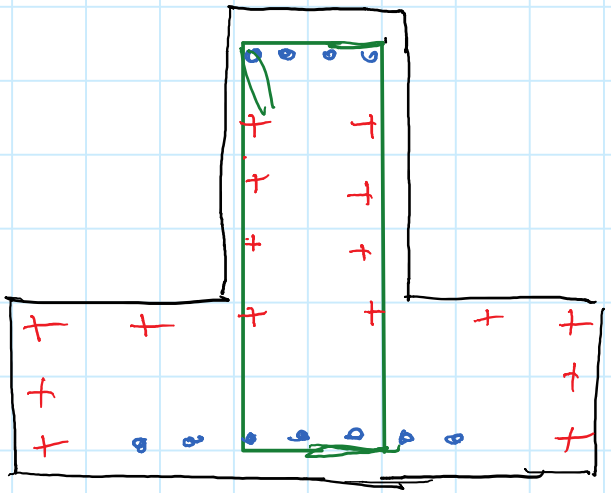
N.B. POTREI DISPORRE ϕ10/20 PER EVITARE BRUSCA VARIAZIONE DI PASSO

ARMATURA DI PARETE NECESSARIA

$$A_s = \frac{V}{2} \frac{\cot\vartheta}{f_{yol}}$$

SE $V = 1.300\ KN \rightarrow$

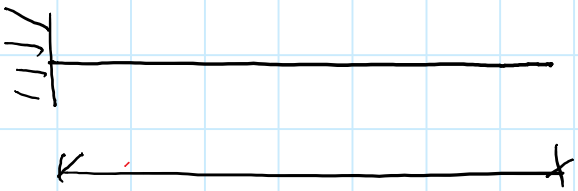
$$A_s = \frac{1300\ KN \times 2}{2 \times 391{,}3\ N/mm^2} \times 10 = 33.2\ cm^2$$



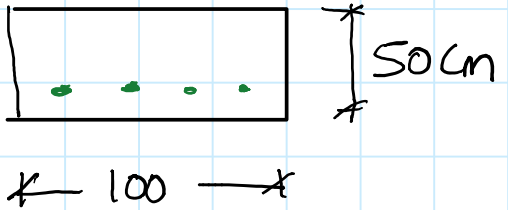
PROGETTO ARMATURA ALA

DALLA RISOLUZIONE DI TRAVE SU SUOLO ELASTICO $\Rightarrow \sigma$

$\Rightarrow q = K \cdot B \cdot \sigma$



SEZIONE TRASVERSALE

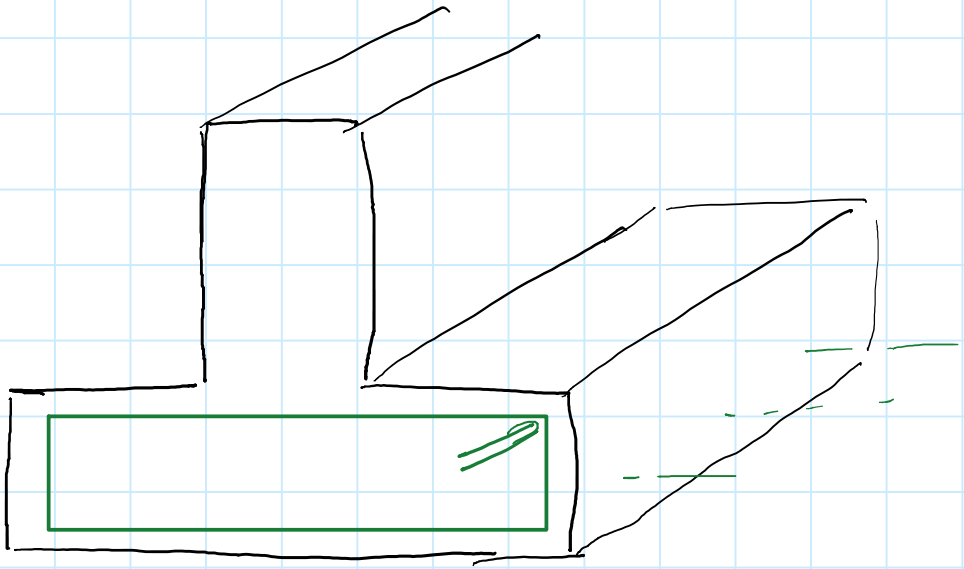


$$M_{Ed} = 450 \frac{kN}{m} \times \frac{0.60^2}{2} = 81\ kNm$$

$$V_{Ed} = 450 \frac{kN}{m} \times 0.60 = 270\ kN$$

$$A_s = \frac{81\ kNm \times 10}{0,9 \times 0,45m \times 391.3 \frac{N}{mm^2}} = 5.11\ cm^2/m$$

DISPOSIZIONE ARMATURA LONGITUDINALE ALA



$$A_{\phi 10} = 0.785\ cm^2 \rightarrow$$

$$n_{\phi 10} = \frac{5.11\ cm^2}{0.785\ cm^2} = 6,51\ \frac{BARRE}{m}$$

$$\Rightarrow \phi 10/14$$

(DISPONGO $\phi 10/10$ NEL TRATTO CON $q = 450\ kN/m$

$\phi 10/15$ NEI TRATTI CON $q <$)

RESISTENZA A TAGLIO ALA (IN ASSENZA DI ARMATURA)

$$V_{Rdc} < \begin{cases} 0.18\, k \sqrt[3]{\dfrac{100\,\rho_e f_{ck}}{\gamma_c}}\, b_w d & (1) \\ 0{,}035 \cdot k^{3/2} f_{ck}^{1/2}\, b_w d & (2) \end{cases}$$

$$\rho_e = \frac{A_{se}}{bd} = \frac{10 \times 0{,}785\ cm^2}{100 \times 45\ cm^2} = 0{,}0017 \leq 0.02 \rightarrow$$

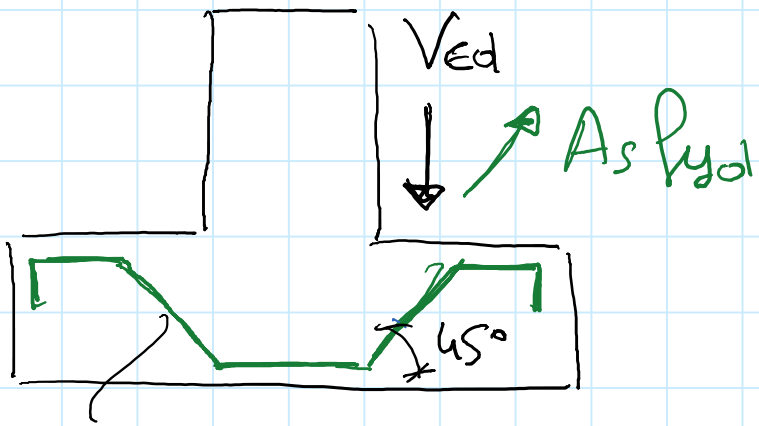
DA (1) $\rightarrow$ $V_{Rd.c} = 0{,}18 \times 1.7 \times \dfrac{\sqrt[3]{100 * 0.0017 \times 30}}{1.5} \times 100 \times \dfrac{45}{10}$

$= 207\ KN$

DA (2) $\rightarrow$ $V_{Rdc} = 185.6\ KN$ $\Rightarrow$

$V_{Rd.c} = 207\ KN < 270\ KN \Rightarrow$ DISPONGO ARMATURA A TAGLIO

CALCOLO ARMATURA A TAGLIO



CAVALLOTTI

$$A_s f_{yd} \frac{\sqrt{2}}{2} = V_{ed}$$

$$A_s = \frac{2 \times 270\,KN}{391{,}3\,\frac{N}{mm^2} \times \sqrt{2}} \times 10 = 9.76\,cm^2$$

SE USO $\phi 14$ → $A_s = 1.54\,cm^2$

→ 6.27 $\phi 14$

CIOÈ $\phi 14 / 15$

N.B. NEL TRATTO ORIZZONTALE POSSO USARE QUESTA ARMATURA COME ARMATURA TESA