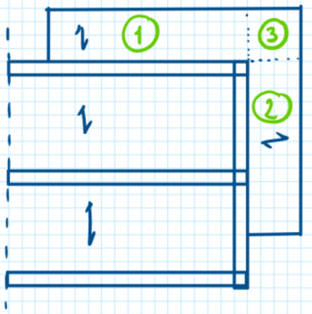
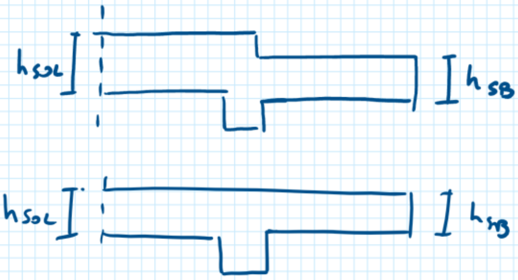
Complementi TC - Sbalzi e fori

venerdì 8 novembre 2019 08:36

SBALZI



SOLUZIONI TECNOLOGICHE

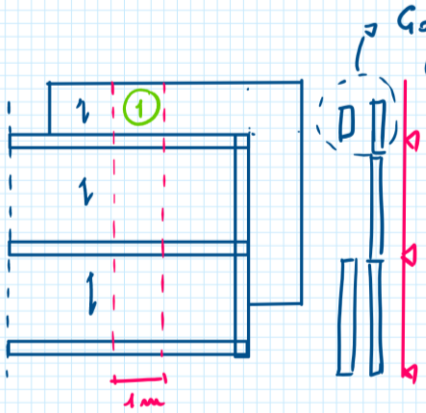


$h_s > h_{SB}$

$h_s = h_{SB}$

1. SBALZO IN PROSECUZIONE
2. SBALZO LATERALE
3. SBALZO D'ANGOLO

1) SBALZO IN PROSECUZIONE

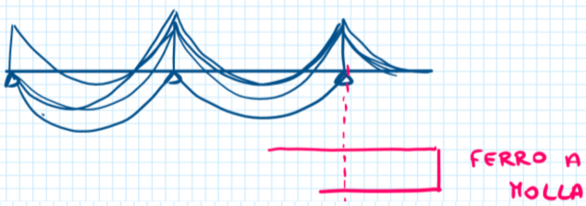


$\to Gd_{SBALZO}$

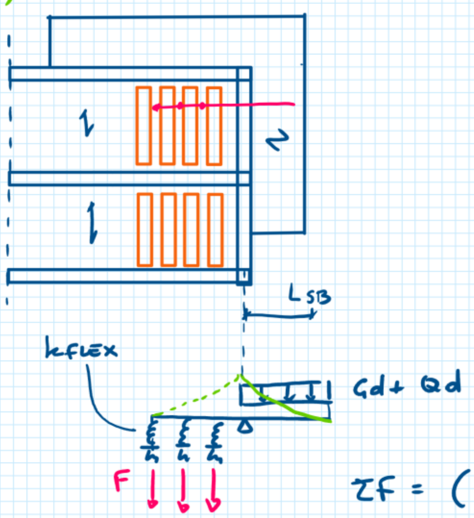
Qd_{SBALZO}

$\Rightarrow A_S$ CAMPATA

A_S APPOGGI

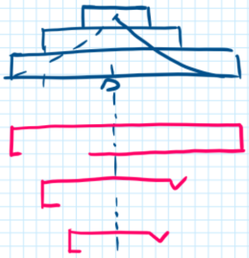


2) SBALZI LATERALI



$\Sigma F = (Gd + Qd)\, L_{SB}$

$\Rightarrow A_s$

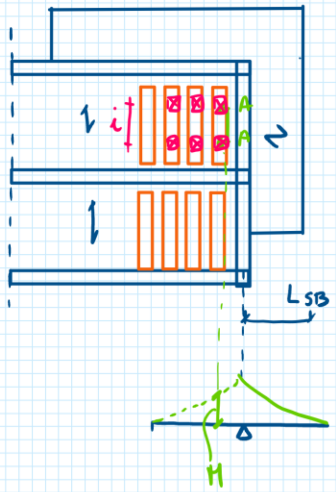


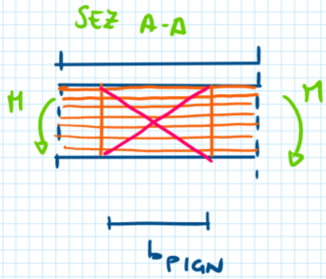
$$M_{Ed} = \frac{q\,L_{SB}^2}{2} \Rightarrow A_{s_{1m}} = \frac{M_{Ed}}{0.9\ d\ f_{yd}}$$

$$\downarrow$$

$$A_{s_{1TR}} = \frac{A_{s1m}}{n_{trav.}}$$

$\Rightarrow$ OSSERVO IL SOLAIO INTERNO





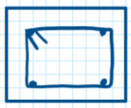
$h = h_{SOL}$

$b = b_{PIGN}$

$\Rightarrow$ TRAVETTONE

$4\phi 12$

$\phi 8/20$

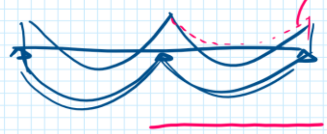


interasse i dei travettoni ?

$$M_{Ed} = M_{Rd,c} = \frac{b^* d^2}{z'^2} \Rightarrow b^*$$

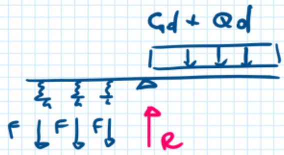
$$\frac{b^*}{1\,m} = \frac{b_{PIGN}}{i} \rightarrow i = \frac{b_{PIGN}}{b^*} \Rightarrow i = 1.5 \div 2.0\ m$$

NOTE

- 

$\Rightarrow$ M RIDOTTO NEL SOLAIO PER EFFETTO DELLO SBALZO

$\hookrightarrow$ armatura filante

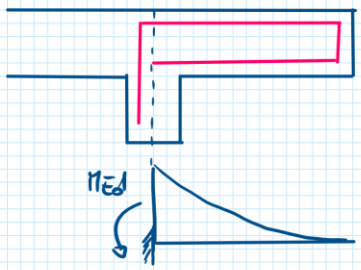
- 

$$R = (G_d + Q_d)\,L_{SB} + \Sigma F =$$

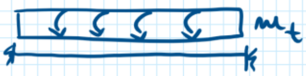
$$= 2\,(G_d + Q_d)\,L_{SB}$$

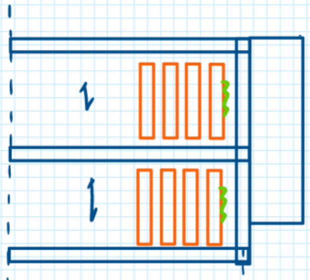
$\Rightarrow$ TRAVE DI BORDO PORTA UN CARICO DOPPIO RISPETTO IL SOLO SBALZO

SOLUZIONE ALTERNATIVA: TRAVE DI BORDO SOGGETTA A T.



$\Rightarrow M_{Ed} \Rightarrow m_t$ per la trave di bordo





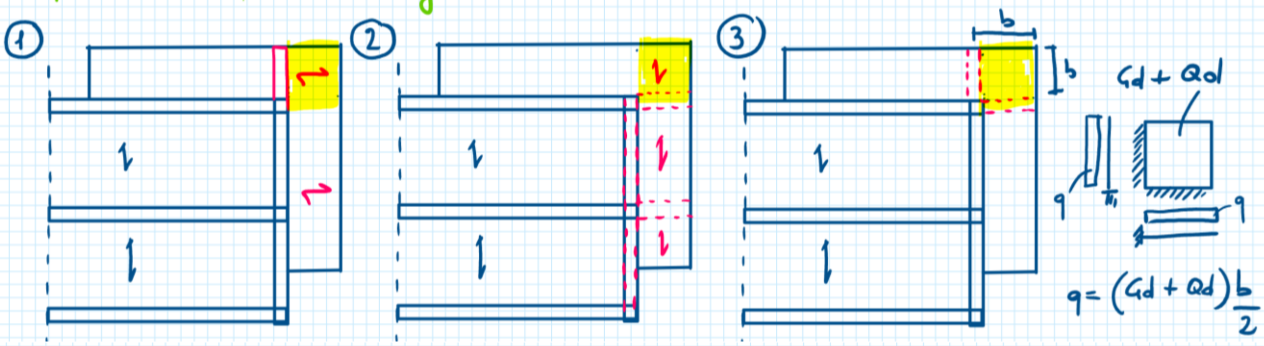
$k_{FLEX\ SOL} > k_{TORS\ T}$

$\Downarrow$

LESIONE $\Rightarrow$ SCONSIGLIATO!

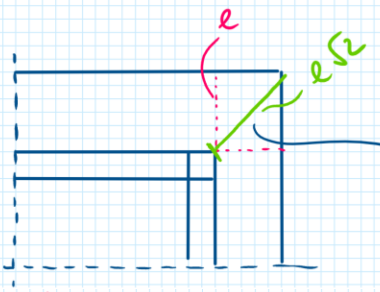
3) SBALZO D'ANGOLO

* Alternative "non rigorose"



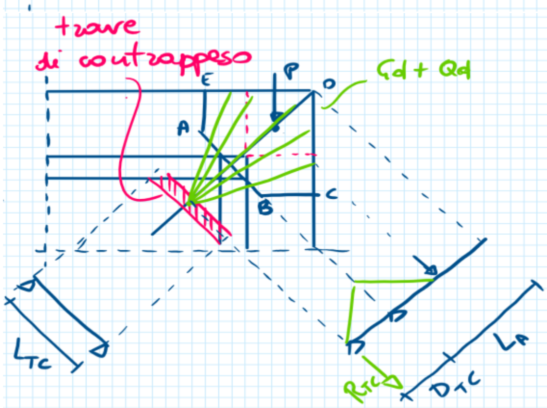
$q = (G_d + Q_d)\dfrac{b}{2}$

* SOLUZIONE RIGOROSA



FENOMENO FISICO $\Rightarrow$ MENSOLA

$\Rightarrow$ NON QUESTO SCHEMA! PERCHÉ INCASTRO = PUNTO!



$P = (G_d + Q_d) A_{ANG}$, $A_{ANG} = A_{ABCDE}$

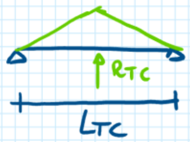
1) ARMATURA DELL'ANGOLO $\Rightarrow$ RAGGIERA

$\Rightarrow M_{Ed} = P \dfrac{L_A}{2}$

$\Downarrow$

$A_s = \dfrac{M_{Ed}}{0.9\, d\, f_{yd}}$

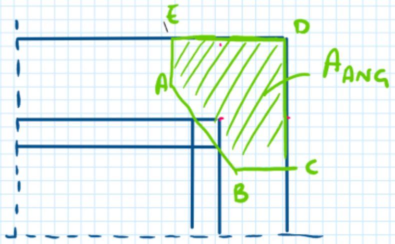
2) TRAVE DI CONTRAPPESO



$$M_{Ed} = M_{Rd_c} = \frac{b d^2}{r'^2} \Rightarrow b_{TC}$$

$$M_{Ed} \Rightarrow A_S$$

OSSERVAZIONE SEZ. D' INCASTRO $\Rightarrow$ PROCEDURA ITERATIVA



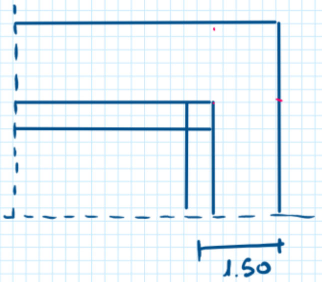
$$M_{Ed} < M_{Rd_c} = \frac{\overset{AB}{b} d^2}{r'^2}$$

Fisso $\overline{AB} \Rightarrow M_{Rd_c}$

$$M_{Ed} = P \cdot \frac{L_A}{2}$$

$$P = (G_d + Q_d) A_{ANG}$$

ESEMPIO SBALZO



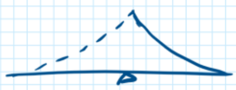
$G_d + Q_d = 12 \ \frac{kN}{m^2}$

C 25/30 $\qquad h = 21$ cm

B 450 C $\qquad$ PIGNATTE 33 × 40

$L_B = 1.50$ m

1) ARMATURE



$$M_{Ed} = (G_d + Q_d) \frac{L_B^2}{2} =$$

$$= 12 \cdot \frac{1.5^2}{2} = 13.5 \ kNm$$

$d = 21 - 3 = 18$ cm
$= 0.18$ m

$$A_{S_{1m}} = \frac{13.5 \times 10}{0.9 \ 0.18 \cdot 391.3} = 2.13 \ cm^2$$

$$A_{S_{1TR}} = \frac{2.13}{3} = 0.71 \ cm^2$$

$3\phi 10$

2) TRAVETTONI

$M_{Ed} = 13.5\ kNm \Rightarrow M_{Rd_c} = \dfrac{b^* d^2}{r'^2} = M_{Ed}$

$$b^* = \frac{M_{Ed}\ r'^2}{d^2} = \frac{13.5 \cdot 0.0185^2}{0.18^2} = 0.14\ m$$

$d = 0.18\ m$

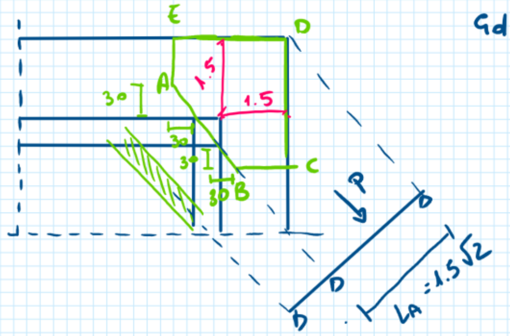
r' C25/30

$\left.\begin{array}{l} \dfrac{c}{d} = \dfrac{3}{18} = 0.167 \\ \mu = 20\% \end{array}\right\} r' = 0.0185$

Ma: $b = 40\ cm$ $i = \dfrac{40}{14} = 2.\cancel{8}6\ m$ $i = 1.5 \div 2.0$

TRAVETTONE: $4\phi 12 + \phi 8/20$

ESEMPIO: SBALZO D'ANGOLO



$G_d + Q_d = 14\ \dfrac{kN}{m^2}$

1) ARMATURE + SEZ IN CLS DELL'ANGOLO

$P = 14 \cdot A_{ABCDE} = 14 \cdot 3.4 = 47.6\ kN$

$AB = (30 \cdot \sqrt{2}) \times 3 = 127\ cm$

$\left.\begin{array}{l} A_{EFCD} = (1.5 + 0.15 + 0.3)^2 = 3.8\ m^2 \\ A_{AFB} = 0.9 \cdot \dfrac{0.9}{2} = 0.4\ m^2 \end{array}\right\} A_{ABCDE} = 3.4\ m^2$

$M_{Ed} = P \cdot \dfrac{L}{2} = 47.6 \cdot \dfrac{1.5\sqrt{2}}{2} = 50.5\ kNm$

$M_{Rd_c} = \dfrac{b^{AB} d^2}{r'^2} = \dfrac{1.27 \cdot 0.18^2}{0.019^2} = 114\ kNm > M_{Ed}$

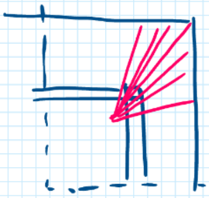
ok!

$$A_s = \frac{50.5 \times 10}{0.9 \cdot 0.18 \cdot 391.3} = \cancel{7.95}\ \mathrm{cm}^2 \Rightarrow$$

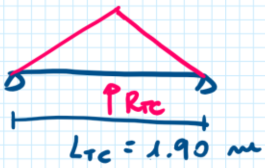
7 ϕ14

$5\phi 14 = 7.7 < 7.95$ NO

$6\phi 14 = 9.24 > 7.9 \Rightarrow$ PARI $\Rightarrow$ NO



2) TRAVE DI CONTRAPPESO



$$D_{TC} \approx \frac{1}{2} L_A$$

$$R_{TC} = P = 47.6\ \mathrm{kN}$$

$$M_{Ed} = R_{TC} \frac{L_{TC}}{4} = 47.6 \frac{1.90}{4} = 22.6\ \mathrm{kNm}$$

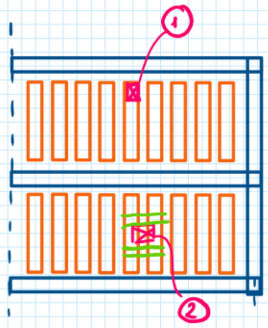
$$d = 0.18\ \mathrm{m} \Rightarrow b = M_{Ed} \cdot \frac{r'^2}{d^2} = \frac{22.6 \cdot 0.019^2}{0.18^2} = \cancel{0.25}\ \mathrm{m}$$

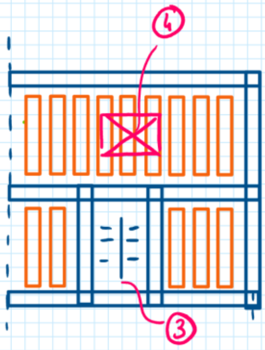
30 cm

$$A_s = \frac{22.6 \times 10}{0.9 \cdot 0.18 \cdot 391.3} = 3.6\ \mathrm{cm}^2 \Rightarrow 4\phi 14 + \phi 8/20$$

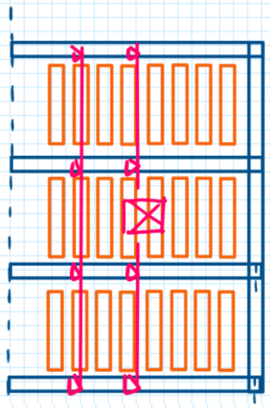
FORI DI SOLAIO

FORI
- PICCOLI ① ②
- GRANDI ③ ④



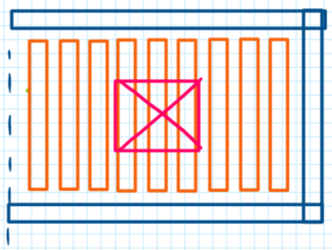


POSSONO ESSERCI SOLUZIONI NON RIGOROSE

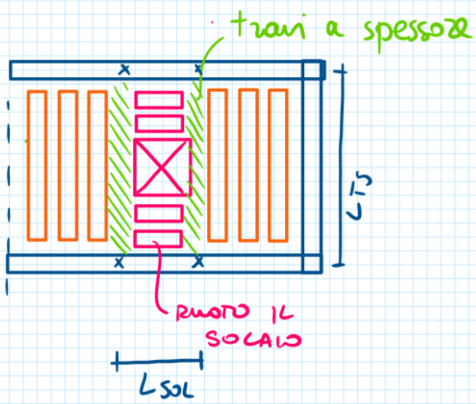


PROG. FORO
- ALTERA SCHEMA STRUTTURALE ①'
- NON ALTERA SCHEMA STRUTTURALE ②'

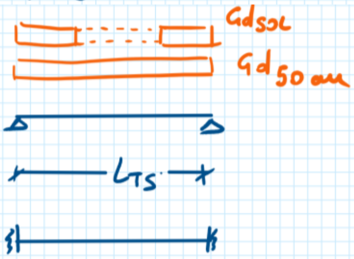
① SOLUZIONE CHE ALTERA LO SCHEMA STRUTTURALE



$\Rightarrow$



1) TRAVE A SPESSORE



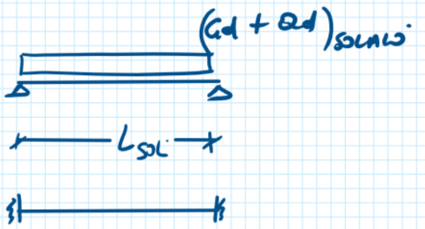
$$\Rightarrow \left.\begin{matrix} M_{Ed} \\ V_{Ed} \end{matrix}\right\} \quad \text{SEZ. IN CLS} + A_s,\ \frac{A_{s,st}}{s}$$

$\Rightarrow$ OSSERVO LE TRAVI DI BORDO: F CONCENTRATE ?

$M_{(1)} \rightarrow T_{(bordo)}$ (?)

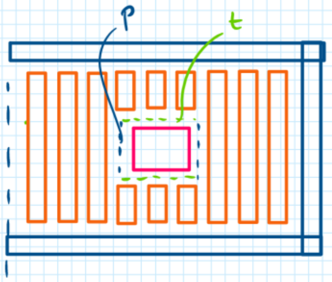
$\hookrightarrow A_{pont}$

2) SOLAIETTO RUOTATO



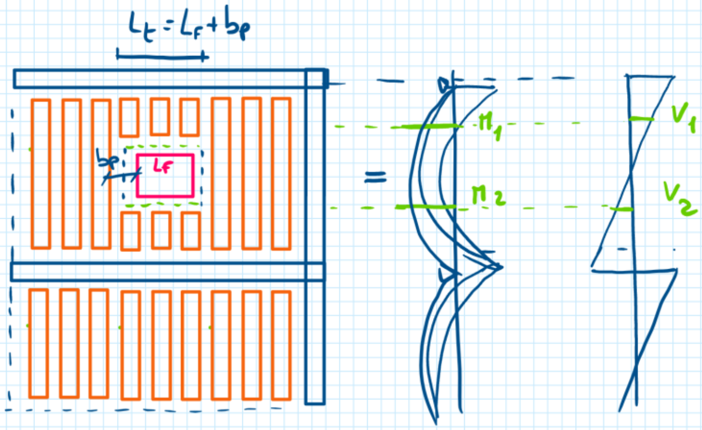
$\Rightarrow M_{Ed} \Rightarrow A_s$

② SOLUZIONE CHE NON ALTERA LO SCHEMA STRUTTURALE



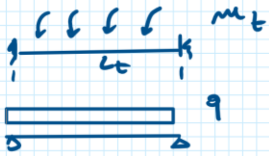
$= \Rightarrow$ ANALOGIA IDRAULICA

1) PROG. TRAVI T

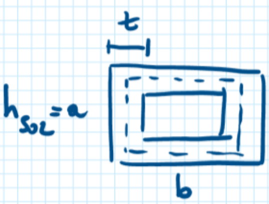


$M_{sol} \rightarrow m_t \quad \Rightarrow$

$V_{sol} \rightarrow q \quad \Rightarrow$



PROG. SEZ:

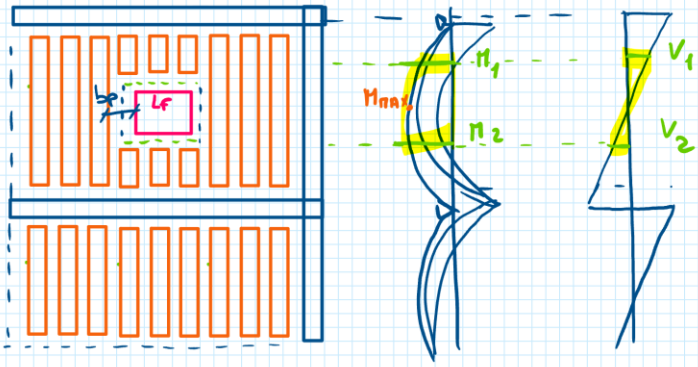


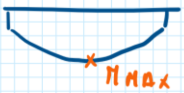
$T_{Ed} = m_t \dfrac{L_t}{2} \Rightarrow$

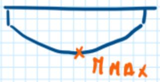
$T_{Ed} = T_{Rd,max} \Rightarrow A_k \Rightarrow a_k, b_k \Rightarrow a, b$

PROG. ARMATURE : $T_{Ed} < \begin{matrix} A_{s,lon} \\ \frac{A_{s,st}}{s} \end{matrix}$ $\quad M_{Ed} \to A_s \quad V_{Ed} \to \frac{A_{s,st}}{s}$

2) PROG. TRAVI P

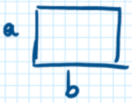


Travi p =>  dal solaio

Travi p => dal solaio 

$M_{Ed} = M_{MAX} \cdot \frac{L_{fl}}{2} \to L_{fl} = L_F + b_p + b_p + \frac{b_{PIGN}}{2} + \frac{b_{PIGN}}{2}$

$V_{Ed} = V_{MAX} \times \frac{L_{fl}}{2}$

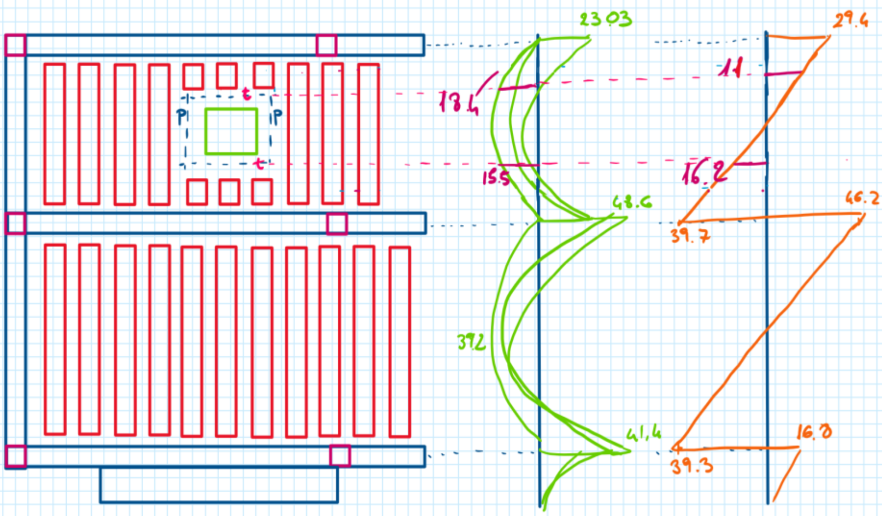


$a = h_{sol}$
$b = n_{trav.}\frac{int}{2} \times L_{TR}$

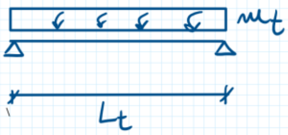
$M_{Rd,c} > M_{Ed}$ => Prog. A_s per M_{Ed}

Prog. $\frac{A_{s,st}}{s}$ per V_{Ed}

ESEMPIO C 25/30 B450 C PROG. FORO $L_F = 1.60$ m



1) PROGETTO LE TRAVI t



$M_{SOLAIO} \to m_t = MAX\,(18.4\,;\,15.5) = 18.4\ kNm$

$L_t = L_g + b_p = 1.60 + 0.30 = 1.90\ m$

n Trav. interrotti $= 5$

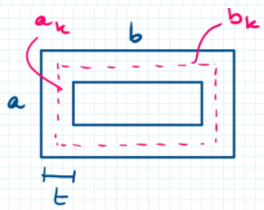
$b_{TR} = 10\ cm$

$b_p = \dfrac{5 \times 10}{2} = \cancel{25}\ 30\ cm$

$$T_{Ed} = m_t \cdot \frac{L_t}{2} = \frac{18.4 \cdot 1.9}{2} = 17,5\ kNm$$

$\Rightarrow$ Dimensiono la sezione trasversale della trave t

$$T_{Rd\,max} = 2\,A_k\,f'_{cd}\,t\,\frac{\cot\vartheta}{1+\cot^2\vartheta} = T_{Ed} \qquad f'_{cd} = 0.5 \times 14.2 = 7.1\ MPa$$



$t = 2c = 2 \cdot 4 = 8\ cm$

$$A_k = \frac{T_{Ed}}{2 \cdot 7.1 \cdot 8}\ \frac{(1+\cot^2\vartheta)}{\cot\vartheta} =$$

$\cot\vartheta = 2$

$$A_k = \frac{17 \times 10^3}{2 \cdot 7.1 \cdot 8}\ \frac{5}{2} = 384.6\ cm^2$$

$$\frac{kN\cancel{m} \times 10^3}{\frac{\cancel{N}}{mm^2} \cdot \cancel{cm}} \times \frac{\cancel{10^2}}{\cancel{10^2}}$$

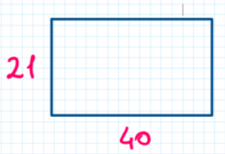
$A_k = a_k \cdot b_k$

$h_{SOLAIO} = 21\ cm \Rightarrow a_k = h - t = 21 - 8 = 13\ cm$

$b_k = \dfrac{384.6}{13} = 29.6\ cm$

$\hookrightarrow b = 29.6 + 8 = \cancel{37.8}\ 40$

SEZ. TRASV. t

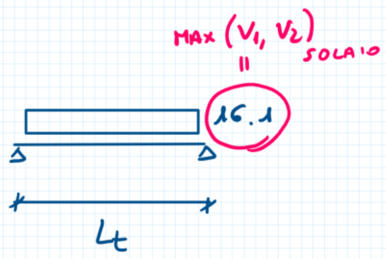


$\Rightarrow$ Dimensiono le armature

$(T_{Ed} = 17.5\ kNm)$

$$M_{Ed} = q\,\frac{L_t^2}{8} = 16.1 \cdot \frac{1.9^2}{8} = 7.3\ kNm$$

$$V_{Ed} = q\,\frac{L_t}{2} = 16.1 \cdot \frac{1.9}{2} = 15.3\ kN$$



- M_{Ed}

$$A_{s_M} = \frac{7.3 \times 10}{0.9 \cdot 0.17 \cdot 391.3} = 1.21 \text{ cm}^2$$

- T_{Ed}

$$\left(\frac{A_{s,st}}{s}\right)_T = \frac{T_{Ed}}{2 A_k f_{yd} \cdot \cot\vartheta} = \frac{17.5 \times 10 \cdot 10^4}{2 \cdot 416 \cdot 391.3 \cdot 2} = 2.7 \ \frac{\text{cm}^2}{\text{m}}$$

$$A_k = (21-8)\cdot(40-8) = 416 \text{ cm}^2$$

$$\frac{\cancel{kN}\text{m} \times \cancel{10^3}}{\cancel{\text{cm}^2} \cdot \frac{\cancel{N}}{\cancel{\text{mm}^2}} \times \cancel{10^2}} \quad \frac{\text{m}}{\text{m}} \times 10^4 \rightarrow \frac{\text{cm}^2}{\text{m}}$$

$$A_{s,lon} = \frac{T_{Ed} \ u_k \cdot \cot\vartheta}{2 A_k f_{yd}} = \frac{17.5 \ 90 \cdot \ \cdot 2 \ 10^3}{2 \cdot 416 \cdot 391.3} = 9.7 \text{ cm}^2$$

$$u_k = (13+32)\times 2 = 90 \text{ cm}$$

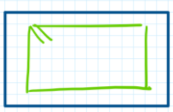
$$\frac{\cancel{kN}\text{m} \cdot \text{cm} \times 10^3}{\cancel{\text{cm}^2} \cdot \frac{\cancel{N}}{\cancel{\text{mm}^2}} \cdot \cancel{10^2}} \times \cancel{10} \quad 2$$

- V_{Ed}

$$\left(\frac{A_{s,st}}{s}\right) = \frac{V_{Ed}}{0.9 \cdot d \cdot f_{yd} \cdot \cot\vartheta} = \frac{15.3 \times 10}{0.9 \cdot 0.17 \cdot 391.3 \cdot 2} = 1.28 \ \frac{\text{cm}^2}{\text{m}}$$

$$\frac{\cancel{kN} \times \cancel{10^3}}{\cancel{\text{m}} \cdot \frac{\cancel{N}}{\text{mm}^2} \times \cancel{10^3}} \times \frac{\text{mm}}{\text{mm}} \quad \frac{\cancel{10^3}}{\cancel{10^2}}$$

DISPONGO LE ARMATURE



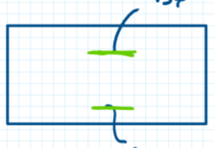
$$\frac{A_{s,st}}{s} = \left(\frac{A_{s,st}}{s}\right)_T + \left(\frac{A_{s,st}}{s}\right)_V =$$

$$= 2.7 \ \frac{\text{cm}^2}{\text{m}} + \frac{1.28}{2 \text{ bracci}} \ \frac{\text{cm}^2}{\text{m}} =$$

$$= 3.32 \ \frac{\text{cm}^2}{\text{m}}$$

SCELGO $\phi 8 \Rightarrow A = 0.5 \text{ cm}^2$ $\quad \boxed{\phi 8/10} \Rightarrow 5 \ \frac{\text{cm}^2}{\text{m}}$

$A_{s_T} = \frac{9.7}{2}$



$A_{s_M} = 1.21\ cm^2$

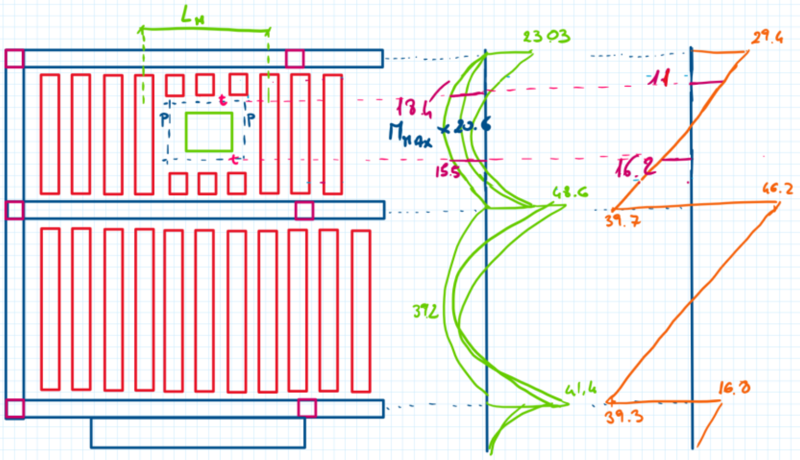
$A_{s_T} = \frac{9.7}{2}$

$n_{b\,sup} = \frac{9.7}{2} \cdot \frac{1}{1.54} = 3.\cancel{15}$ → $4\phi 14$

$\Rightarrow\ n\ \phi 14 \qquad A_{1\phi 14} = 1.54\ cm^2$

$n_{b.inf} = \left(\frac{9.7}{2} + 1.21\right) \frac{1}{1.54} = 3.\cancel{9}$ → $4\phi 14$

2) PROGETTO LA TRAVE P



$$M_{Ed} = M_{MAX} \frac{L_M}{2} = 20.6 \times \frac{2.6}{2} = 26.8\ kNm$$

$$V_{Ed} = V_{MAX} \cdot \frac{L_M}{2} = 16.2 \times \frac{2.6}{2} = 21.1\ kN$$

$$L_M = L_f + 2\, b_p + \frac{b_{PIGN}}{2} \times 2 = 1.60 + 2 \cdot 0.3 + \frac{0.40}{2} \times 2 = 2.60\ m$$

VERIFICO LA SEZ. TRASVERSALE

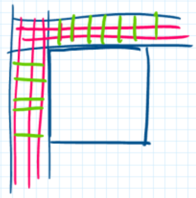
$$\left(M_{Rd_c} = \frac{0.25 \cdot 0.17^2}{0.0185^2} = 21.11\ kNm < 25.8\ kNm \right)$$

$$\Rightarrow M_{Rd_c} = \frac{0.30 \cdot 0.17^2}{0.0185^2} = 25.33 < 26.8\ kNm \quad \text{NO!}$$

Aumento $\mu = 30\%$ $\Rightarrow$ $r' = 0.0175$

$$M_{Rd_c} = \frac{0.30 \cdot 0.17^2}{0.0175} = 28.3 > M_{Ed} = 26.8\ kNm \quad \text{OK}$$

Progetto le armature



$$A_s = \frac{25.8 \times 10}{0.9 \cdot 0.17 \cdot 391.3} = \cancel{4.3} \; cm^2 \rightarrow 4\phi 14$$

$$\frac{A_{s,st}}{s} = \frac{20.3 \times 10}{0.9 \cdot 0.17 \cdot 391.3 \cdot 2} = \cancel{1.7} \; \frac{cm^2}{m} \rightarrow \phi 8/20$$

$\Downarrow$

OPPURE $\phi 8/10$ COME PER TRAVE t