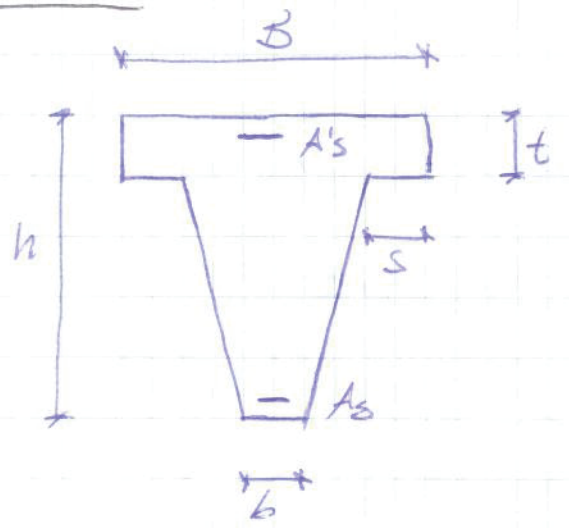
Es. n. 3




$b = 30\ cm$
$B = 46\ cm$
$h = 60\ cm$
$d' = 3\ cm$
$t = 20\ cm$
$s = 5\ cm$
$A_s = 18{,}84\ cm^2$
$A'_s = 6{,}03\ cm^2$
$M = 120\ kNm$

$C\ 20/25 \rightarrow f_{ck} = 20{,}75\ MPa \qquad f_{cd} = \frac{20{,}75 \cdot 0{,}85}{1{,}5} = 11{,}75\ MPa$

$B450C \rightarrow f_{sd} = 391{,}3\ MPa$

Verifica a flessione:

- Calcolo asse neutro

Hp → armature entrambe snervate e $y_c < t$

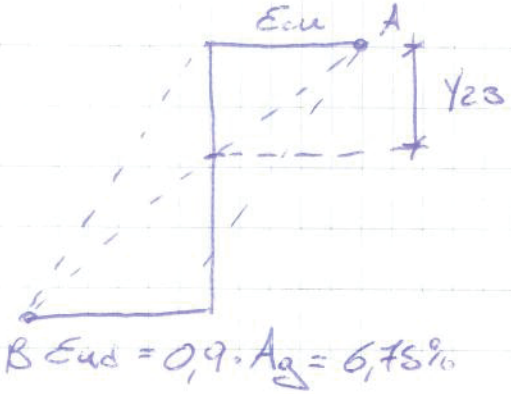
$$\psi B f_{cd} y_c + A'_s f_{sd} - A_s f_{sd} = 0$$

$$y_c = \frac{(A_s - A'_s) f_{sd}}{\psi B f_{cd}} = \frac{1281 \cdot 391{,}3}{0{,}8 \cdot 460 \cdot 11{,}75} = 115{,}9\ mm$$

$$y_c = 11{,}59\ cm < t \quad (\text{verificato } y_c < t)$$

- Si vanno a determinare le $\varepsilon_s$ per verificare se sono snervate.

Si determina il polo di rotazione della sezione



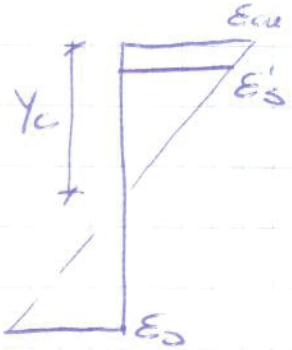

se $y_c < y_{2,3}$ polo B

se $y_c > y_{2,3}$ polo A

$$\varepsilon_{cu} : y_c = (\varepsilon_{cu} + \varepsilon_{ud}) : d$$

$$y_{2,3} = \frac{\varepsilon_{cu}}{\varepsilon_{cu}+\varepsilon_{ud}} \cdot d = \frac{0{,}0035}{0{,}0035+0{,}0675} \cdot 57 = 2{,}81\ cm$$

il polo di rotazione è A




$$\varepsilon_{cu} : y_c = \varepsilon'_s (y_c - d')$$

$$\varepsilon'_s = \frac{\varepsilon_{cu}}{y_c} \cdot (y_c - d') = 0{,}0026$$

$$\varepsilon_s = \frac{\varepsilon_{cu}}{y_c} (y_c - d) = -0{,}0137$$

$$\left[ \varepsilon_{sy} = \frac{f_{sd}}{E_s} = \frac{391{,}3}{210\,000} = 0{,}0019 \right]$$

$|\varepsilon'_s| > \varepsilon_{sy}$ snervata

$|\varepsilon_s| > \varepsilon_{sy}$ snervata

Le Hp. fatte sono soddisfatte → $y_c = 11,59$ cm.

~~$M_{u,0} = \varphi B f'_{cd} y_c \left(\frac{h}{2} - \lambda y_c\right) + A'_s f_{sd}\left(\frac{h}{2} - d'\right) + A_s f_{sd}\left(\frac{h}{2} - d'\right) =$~~

~~$= 0,8 \cdot 460 \cdot 11,75 \cdot 115,9 \left(300 - 0,4 \cdot 115,9\right) + 603 \cdot 391,3 \left(300 - 30\right) +$~~

~~$+ 1884 \cdot 391,3 \left(300 - 30\right) =$~~

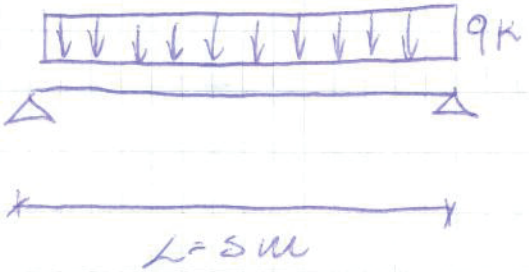
Si determina $M_u$ rispetto all'armatura tesa per evitare di determinare la posizione del baricentro geometrico

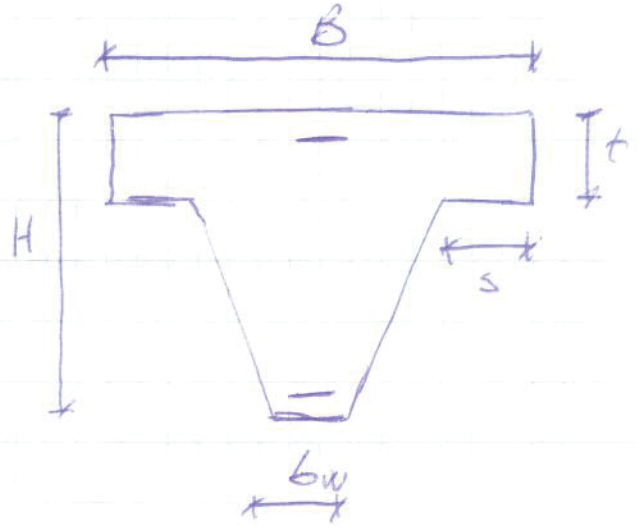
$$M_u = \varphi B f'_{cd} y_c \left(h - d' - \lambda y_c\right) + A'_s f_{sd}\left(h - 2d'\right) =$$

$$= 0,8 \cdot 460 \cdot 11,75 \cdot 115,9 \left(600 - 30 - 0,4 \cdot 115,9\right) + 603 \cdot 391,3 \left(600 - 60\right) =$$

$$= 389,84 \text{ kNm} > M_{sd} \quad \text{Verificata.}$$

Esercizio n 4



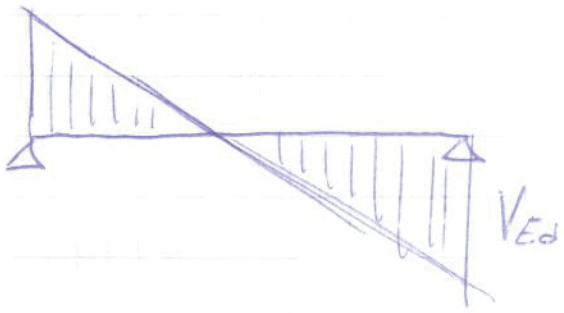




$q_k = 18\ kN/m$

$$g_k = \left\{ (B \cdot t) + \frac{[b_w + (B - 2s)]}{2} \cdot (H - t) \right\} \cdot 25\ kN/m^3 = 5,6\ kN/m$$

$$q_d = 1,3\, g_k + 1,5\, q_k = 34,28\ kN/m$$

$$T = \frac{q_d L}{2} = 85,7\ kN$$




Trave non Armata a taglio:

$$V_{Rd} = \left[ \frac{0,18 \cdot k \left(100\, \rho_l\, f_{ck}\right)^{1/3}}{\gamma_c} \right] b_w \cdot d \geq v_{min}\, b_w\, d$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1,592$$

$$v_{min} = 0,035\, k^{3/2}\, f_{ck}^{1/2} = 0,035 \cdot 1,592^{3/2} \cdot 20,75^{1/2} = 0,32$$

$$\rho_L = \frac{A_s}{b_w d} = \frac{1884}{300 \cdot 570} = 0{,}011$$

($A_s$ = armatura inferiore perché essendo app-app. è sempre l'armatura tesa)

$$V_{Rd} = \frac{0{,}18 \cdot 1{,}592 \left(100 \cdot 0{,}011 \cdot 20{,}75\right)^{1/3}}{1{,}5} \cdot 300 \cdot 570 \geq 0{,}32 \cdot 300 \cdot 570$$

$$V_{Rd} = 92{,}67 \text{ kN} \geq 57{,}75 \text{ kN} \Rightarrow V_{Rd} = 92{,}67 \text{ kN}$$

$V_{Rd} > V_{Ed}$ (85,7 kN) No Armatura a taglio

⇓

minimi normativi

~~[illegible]~~

in campata $\phi 8/20$ cm ⇓ $A_{st} = 5 \text{ cm}^2/\text{m}$

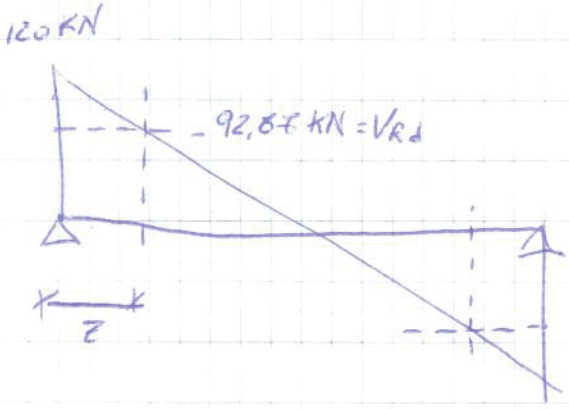
- $A_{st} \geq 1{,}5\, b = 1{,}5 \cdot 300 = 4{,}5 \text{ cm}^2/\text{m}$
- $p_{st} \leq 0{,}8\, d = 0{,}8 \cdot 570 = 45$ cm
- 3 staffe/m $\Rightarrow p_{st} \leq 30$ cm

agli appoggi $\phi 8/10$ cm

- $p_{st} \leq \frac{d}{4} = \frac{570}{4} = 14{,}25$ cm
- 17,5 cm in CA "A" e 22,5 cm in CA "B"
- $6\phi_L$ e $8\phi_L$ in CA "A" e CA "B"
- $24\phi_{st} = 24 \cdot 0{,}8 = 19{,}2$ cm

Per esercizio di progettazione ipotizziamo

$V_{Ed} = 120 \text{ kN} > V_{Rd} \Rightarrow$ Progettare a taglio




$$120 : \frac{L}{2} = 92{,}67 : x$$

$$x = \frac{92{,}67}{120} \cdot \frac{L}{2}$$

$$V_{Cd} = 0{,}9\, b_w \cdot d \cdot f'_{cd} \frac{(\cot g\, \theta)}{1+\cot g^2 \theta} = V_{Ed}$$

$$0{,}9 \cdot 300 \cdot 570 \cdot 11{,}75 \frac{\cot g\, \theta}{1+\cot g^2 \theta} = 120{,}00 \text{ kN}$$

$$\cot g\, \theta = 15{,}00$$

$$1 \leq \cot g\, \theta \leq 2{,}5 \Rightarrow \cot g\, \theta = 2{,}5$$

$$\theta = 21{,}8°$$

$$V_{Rsd} = 0{,}9\, d \frac{A_{st}}{s} f_{sd} (\cot g\, \theta) = V_{Ed}$$

$$A_{st} = \phi 8 \text{ 2 br} \Rightarrow 1{,}00 \text{ cm}^2$$

$$s = \frac{0{,}9\, d\, A_{st}\, f_{sd} \cot g\, \theta}{V_{Rsd}} = 41{,}82 \text{ cm}$$

Si armerà tenendo conto dei minimi normativi.