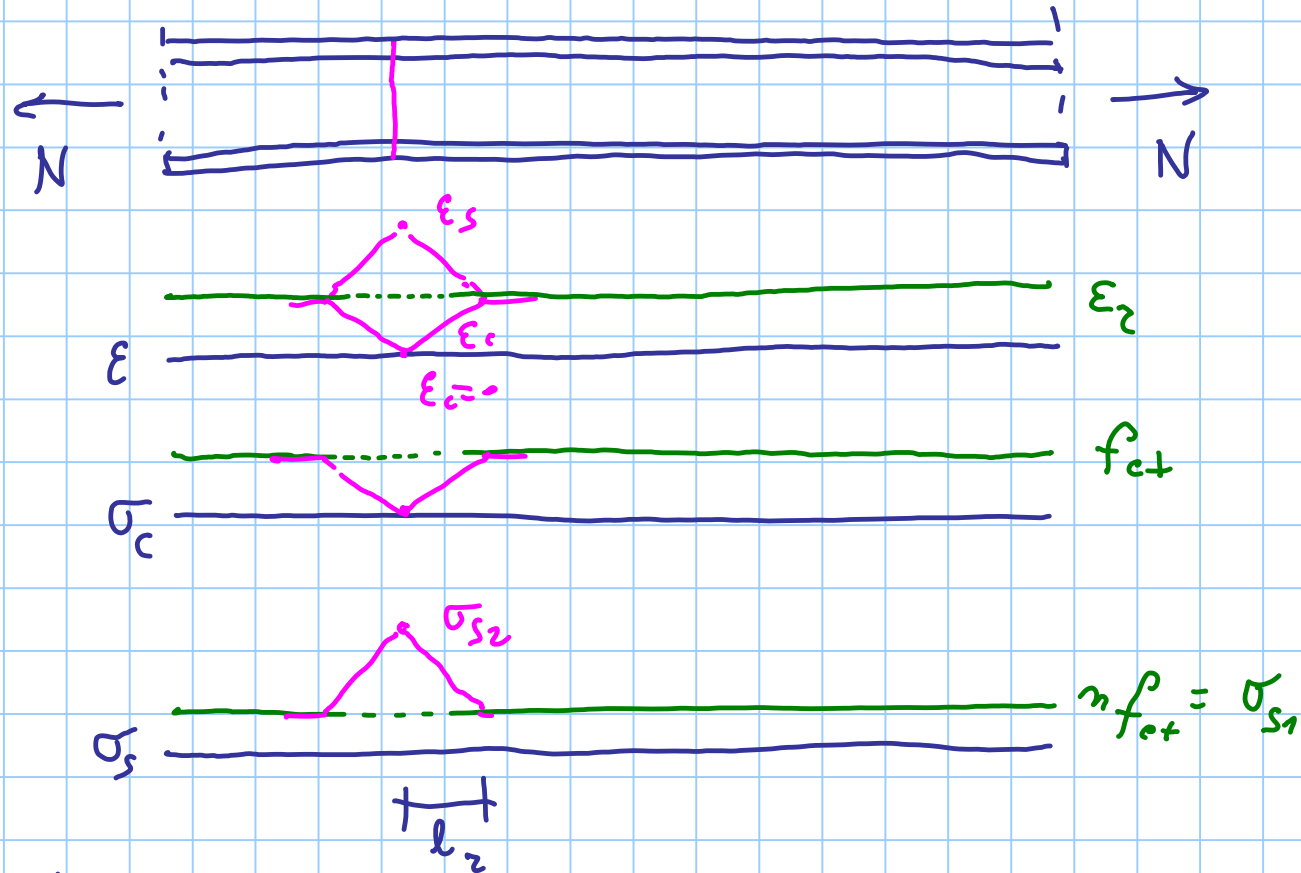


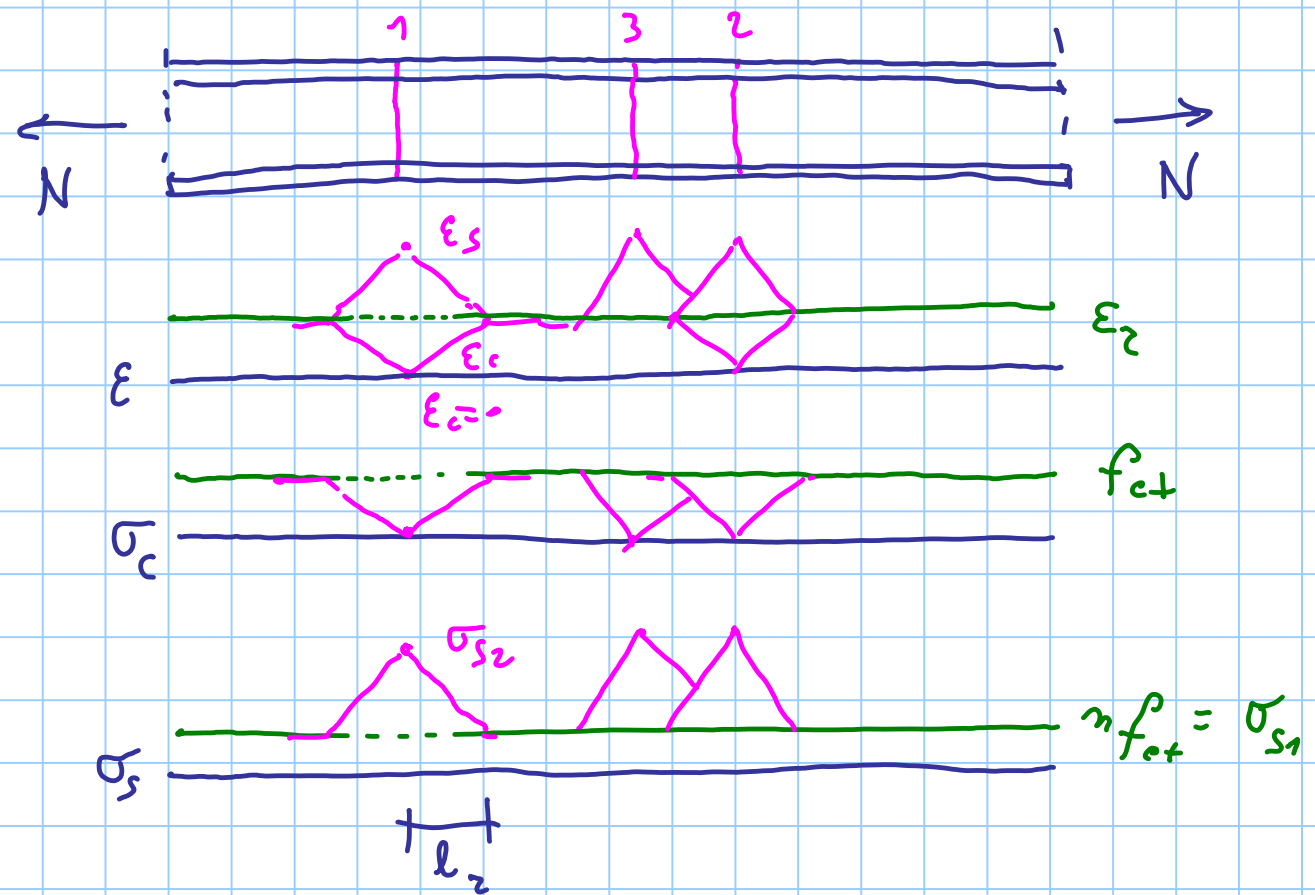
$$\rho_H = \frac{A_s}{A_{ct}}$$



$$l_z = \frac{A_{ct} f_{ct}}{\pi d f_b} \frac{d/4}{d/4}$$

$$= \frac{1}{4} \frac{A_{ct}}{A_s} \frac{f_{ct}}{f_b} d$$

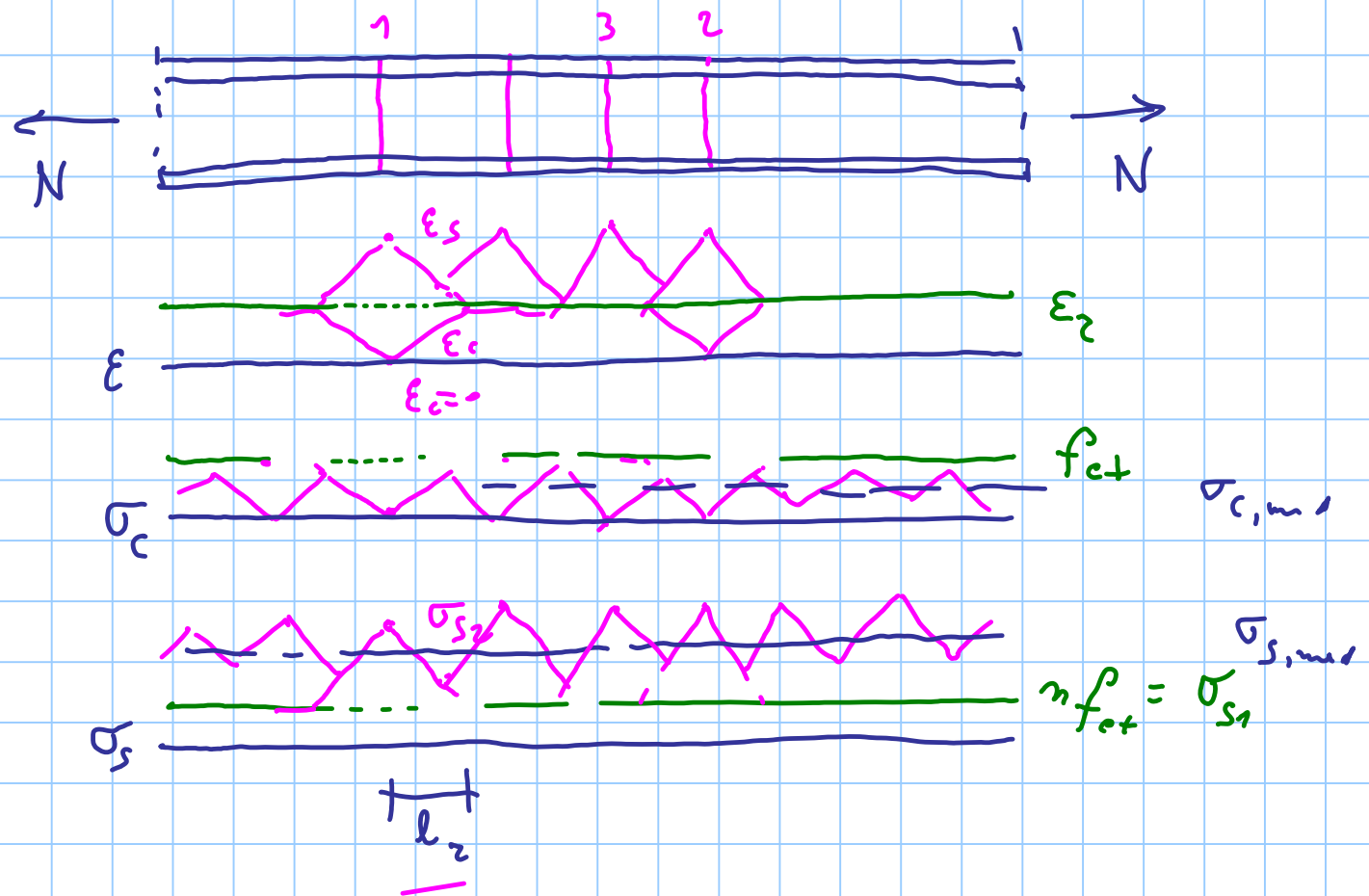
$$l_z = \frac{1}{4} \frac{f_{ct} \kappa}{f_{br}} \frac{\phi}{\rho_H}$$



alla fine, Tante lesioni a distanza s_2 $l_2 \leq s_2 < 2 l_2$

$$0 \leq \sigma_{\epsilon, \max} \leq f_{ct}$$

$$\sigma_{s1} \leq \sigma_{s, \max} \leq \sigma_{s2}$$



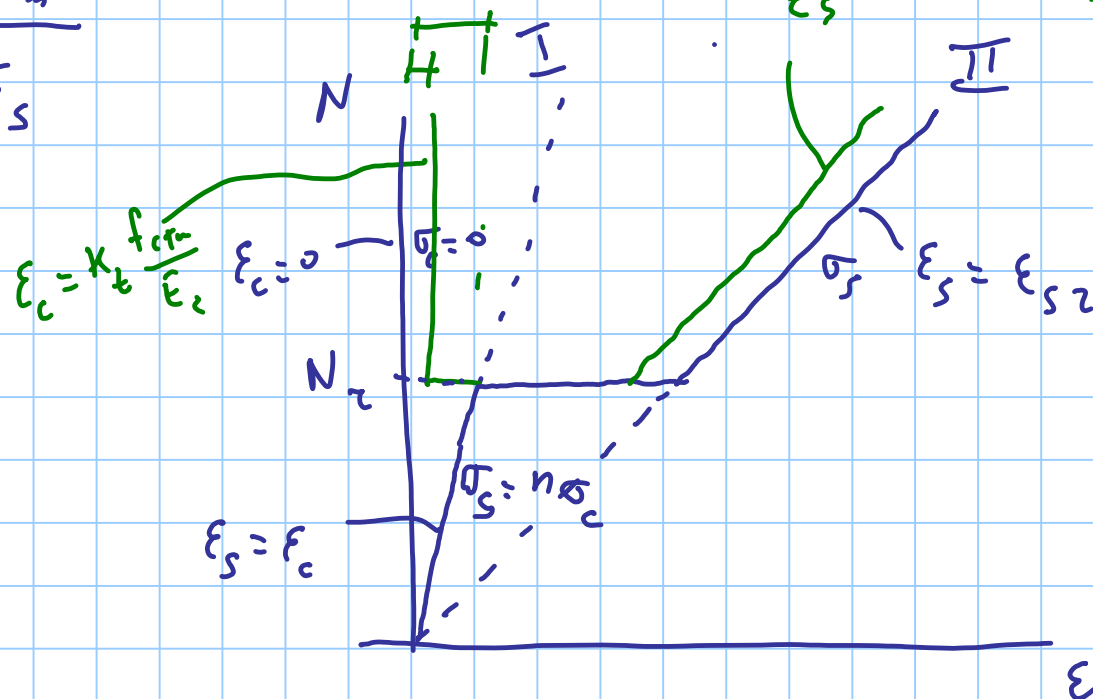
$$\sigma_{cm} = K_t f_{ctm}$$

$$\epsilon_{cm} = \frac{K_t f_{ctm}}{E_c}$$

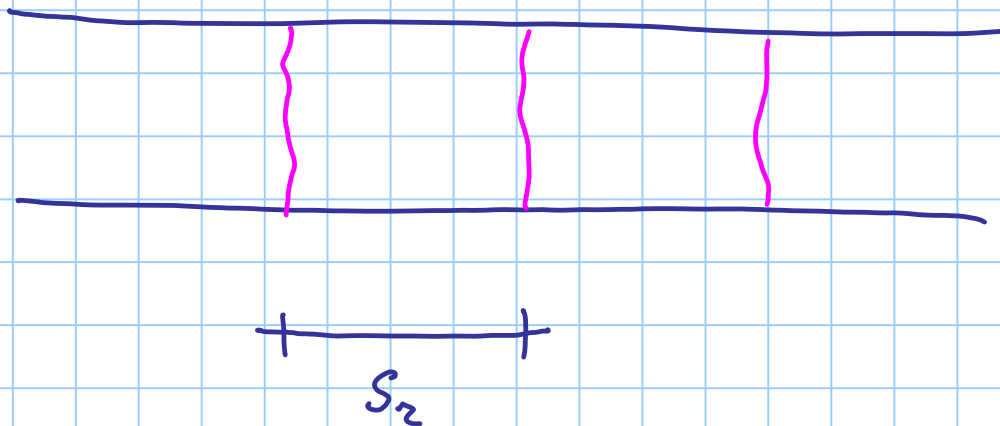
$$\sigma_{cm} A_{CT, \text{II}} + \sigma_{sm} A_s = N$$

$$\sigma_{s_1} = \frac{N - \sigma_{c_1} A_{ct, 1}}{A_s} = \sigma_{s_2} - \frac{k_z f_{ctm}}{f_{eff}}$$

$$\epsilon_{sm} = \epsilon_{s2} - \frac{K_t P_{ctm}}{P_{eff} E_s}$$



AMPIEZZA DELLE FESSURE



$S_{2,m}$ valore medio

$S_{2,max}$ massimo (f.c.w.h. 95%)

modello "tradizionale" $I - II$ \rightarrow σ o ϵ

Tra una fessura e l'altra

$$\sigma_c = 0$$

$$\sigma_{s2} = \frac{N}{A}$$

$$\epsilon_c = 0$$

$$\epsilon_{s2} = \frac{\sigma_{s2}}{E_s}$$

inerte

si allunga

in un tratto S_2 l'armatura si allunga di $\Delta l = S_2 \cdot \epsilon_{S2}$

il calcestruzzo non si allunga

l'ampiezza delle lesioni è $S_2 \epsilon_{S2}$

col ragionament. fatto, invece

calcestruzzo $\epsilon_{cm} = \frac{k_t f_{ctm}}{E_c} > 0$

si allunga un po'

acciaio $\epsilon_{sm} = \epsilon_{S2} - \frac{k_t f_{tm}}{\rho_{eff} E_s}$

si allunga

deformazione minore grazie a c/s ten.

TENSION
STIFFENING

l'ampiezza della flessione è $S_z (\epsilon_{sm} - \epsilon_{cm})$

$$l_2 \leq S_z \leq 2 l_2 \quad l_2 = \frac{1}{4} \frac{f_{ctm}}{f_{ty}} \frac{\phi}{f_{ty}}$$

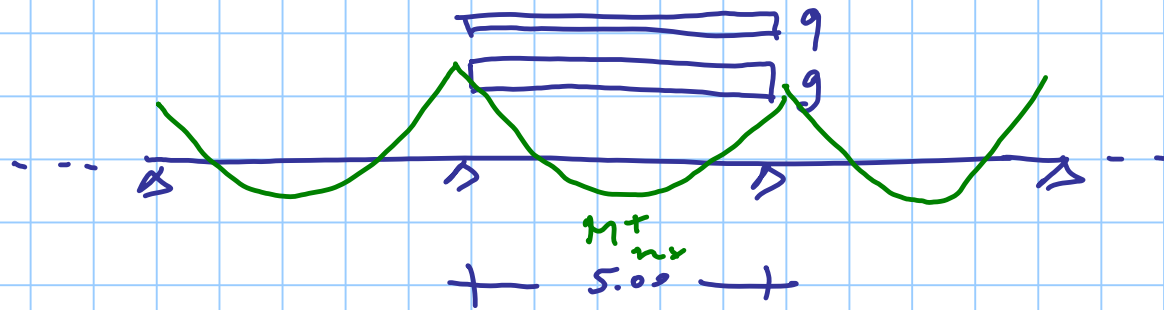
$$S_{z, max} = K_3 c + K_1 K_2 K_4 \frac{\phi}{f_{ty}}$$

\nearrow 3,4
 \uparrow ricoprimento
 \uparrow $K_1 = 0.8$ barre ad aderenza migliorata
 \uparrow $K_2 = 1$ per trazione
 \uparrow 0.5 per flessione
 \uparrow $K_4 = \frac{1}{4} \times 1.7 = 0.425$
 1.6 barre lisce

$$\varepsilon_{sm} - \varepsilon_{cm} = \varepsilon_{s2} - \frac{\kappa_t f_{ctm}}{\rho_{st} E_s} - \frac{\kappa_t f_{ctm}}{E_c} =$$

$$= \varepsilon_{s2} - \frac{\kappa_t f_{ctm}}{\rho_{st} E_s} \left(1 + \frac{E_s}{E_c} \rho_{st} \right)$$

Esempio



sezione
30 x 50

$$g_k = 40 \text{ KN/m}$$

$$q_k = 12 \text{ KN/m}$$

M_{max}^+

per SLU $g_d + q_d = 40 \times 1.3 + 12 \times 1.5 = 70 \text{ KN/m}$

70 KN/m

per SLE max $g_k + q_k = 52 \text{ KN/m}$

80 KN/m

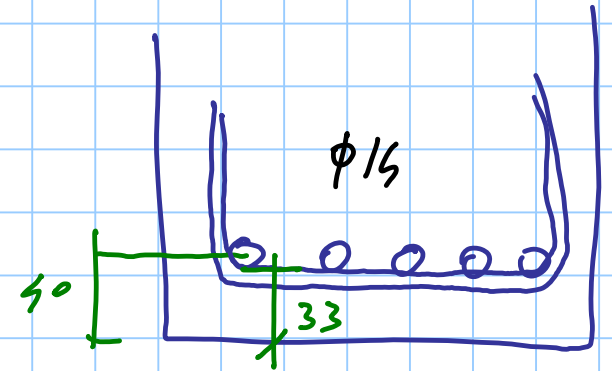
per SLE quasi permanente $g_k + \psi_2 q_k = 40 + 0.3 \times 12 = 43.6 \text{ KN/m}$ 70 KN/m

$$A_{s,inf} \text{ per SLU} = \frac{M}{0.9 d f_{yd}} = 6.8 \text{ cm}^2$$

E.g. 5 $\phi 14$ oppure 3 $\phi 18$
oppure 2 $\phi 20 + 1 \phi 14$

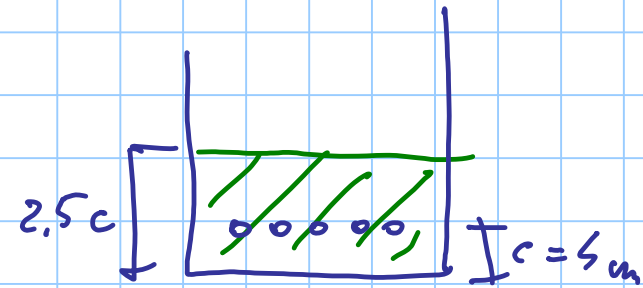
$$S_{\tau, \max} = K_3 c + K_1 K_2 K_4 \frac{\phi}{\rho_{st}}$$

$\begin{array}{ccccccc} & | & & | & & | & \\ 3.4 & & 33 \text{ mm} & & 0.8 & & 0.5 & & 0.425 \end{array}$



$$5 \phi 14 \rightarrow \phi = 14 \text{ mm} \quad A_s = 7.7 \text{ cm}^2$$

$$A_{cT, st} = 30 \times (2.5 \times 4) = 300 \text{ cm}^2$$



$$\rho_{st} = \frac{7.7}{300} = 0.0257$$

$$S_{\tau, \max} = \underbrace{3.4 \times 33}_{112.2} + \underbrace{0.8 \times 0.5 \times 0.425 \times \frac{14}{0.0257}}_{92.6} = 204.8 \text{ mm}$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \varepsilon_{s2} - \frac{k_t f_{ctm}}{\rho_{eff} E_s} \left(1 + \frac{E_s}{E_c} \rho_{eff} \right)$$

$k_t = 0.6$ carichi di breve durata
 0.4 carichi di lunga durata

$$\varepsilon_{s2} = \frac{\sigma_{s2}}{E_s} \quad - \text{calcolo con verifica a flessione} \quad 2^{\circ} \text{ s.d.}$$

$$- \text{stimare} \quad A_s = \frac{M}{0.9 \lambda \sigma_s} \quad \rightarrow \quad \sigma_s = \frac{M}{0.9 \lambda A_s}$$

E_c c.c. quasi permanente $M = 70 \text{ kNm}$

$$\sigma_s = \frac{70 \times 10}{0.9 \times 0.46 \times 7.7} = 219.6 \text{ MPa}$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \varepsilon_{sz} - \frac{\kappa_t f_{ctm}}{\rho_{eff} E_s} \left(1 + \frac{E_s}{E_c} \rho_{eff} \right) =$$

$$= \frac{219.1}{200000} - \frac{0.4 \times 2.56}{0.0257 \times 200000} \left(1 + \frac{200000}{31500} \times 0.0257 \right) =$$

$$10.98 \times 10^{-5}$$

$$1.163$$

$$2.32 \times 10^{-5}$$

$$= 8.66 \times 10^{-5}$$

$$w_n = 204.8 \times 8.66 \times 10^{-5} = 0.177 \text{ mm}$$

VERIFICA DI DEFORMABILITA'

limiti di freccia
/
abbassamenti

δ_{max}

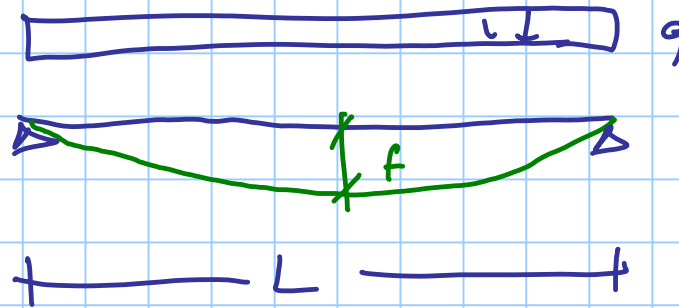
carichi totali

δ_2

carichi variabili



Esmpa



$$f = \frac{5}{384} \frac{q L^4}{E I}$$

Tab. 5. Valori limite del rapporto l/h (calcestruzzo C25/30, acciaio B450C)

Sistema strutturale	k	ρ 0.5%	ρ 1.0%	ρ 1.5%
Travi semplicemente appoggiate, piastre semplicemente appoggiate mono o bidirezionali	1.0	20.6	16.4	15.0
Campata terminale di trave continua o piastre continue monodirezionali o piastre bidirezionali continue su un lato lungo	1.3	26.7	21.3	19.5
Campata intermedia di travi o di piastre mono o bidirezionali	1.5	30.8	24.6	22.5
Piastre sorrette da pilastri senza travi (con riferimento alla luce maggiore)	1.2	24.7	19.7	18.0
Mensole	0.4	8.2	6.6	6.0

$$\rho = \frac{A_s}{b d}$$