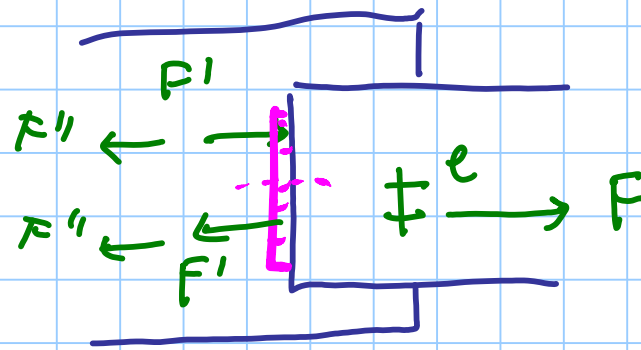
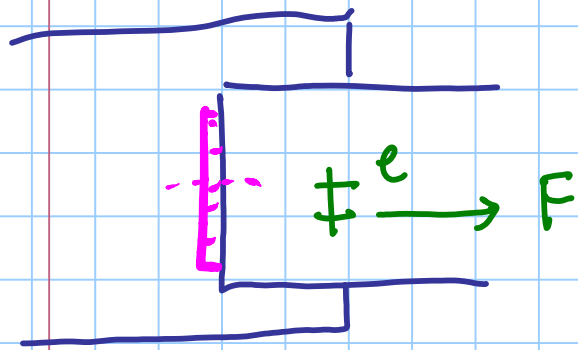


$$F' = \frac{M}{l/2}$$

$$F'' = \frac{V}{2}$$

dominio: $\sqrt{F'^2 + F''^2} \leq \frac{a l}{2} f_{v,wd}$



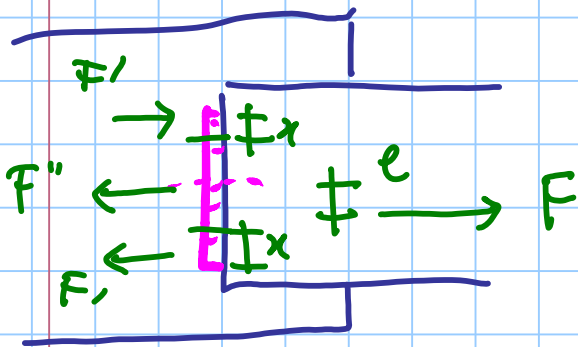
$$M = F l$$

$$N = F$$

rotation
non minimal

$$F' = \frac{M}{l/2}$$

$$F'' = \frac{N}{2}$$



$$F'' = N$$

$$\leq a(l-2x) f_{v,w}$$

$$F' = \frac{M}{l-x}$$

$$\leq a x f_{v,w}$$

$$F = a(l-2x) f_{v,wd}$$

2 equations

$$\frac{Fe}{l-x} = ax f_{v,wd}$$

2 unknowns F, x

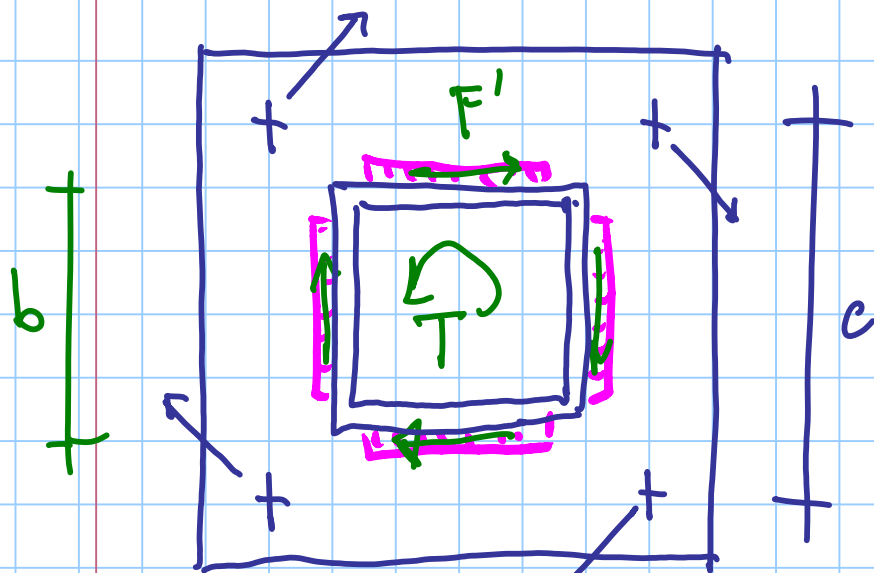
$$\frac{\cancel{a(l-2x)} \cancel{f_{v,wd}} e}{l-x} = \cancel{ax} \cancel{f_{v,wd}}$$



$$(l-2x)e = x(l-x)$$

$$le - 2xe = lx - x^2$$

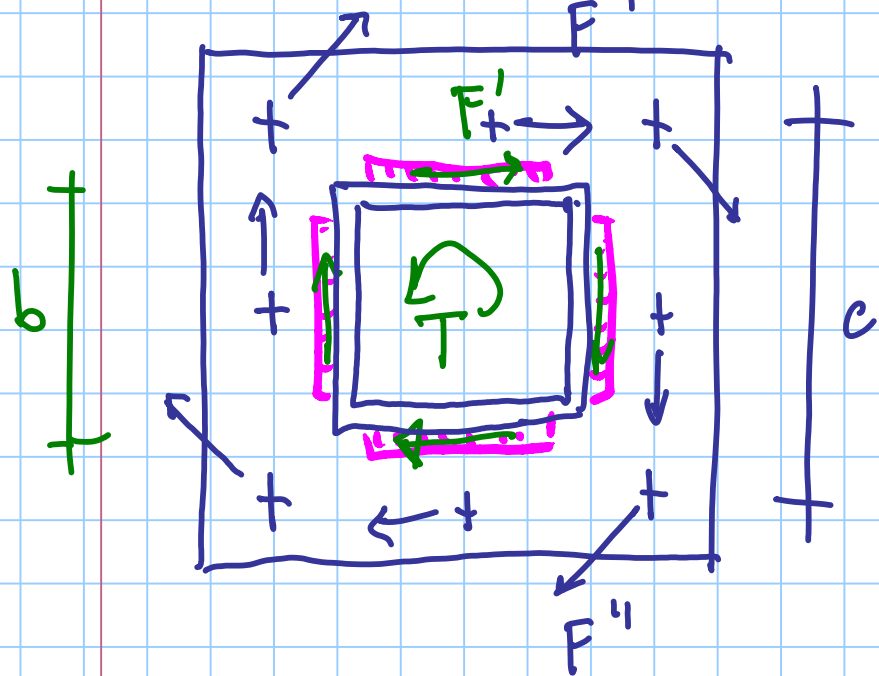
$$x^2 - (l+2e)x + le = 0$$



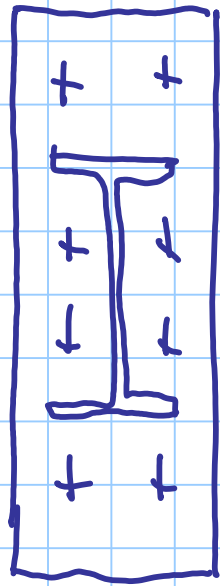
$$T = 2 F' b$$

$$T = 2 F'' c \sqrt{2}$$

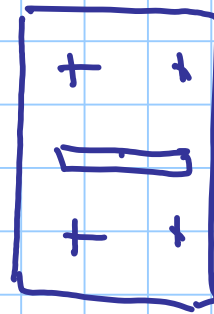
$$F'' \leq F_{v, R1}$$



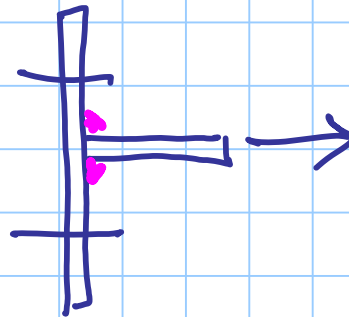
$$T = 2 F'' c \sqrt{2} + 2 F'' c$$



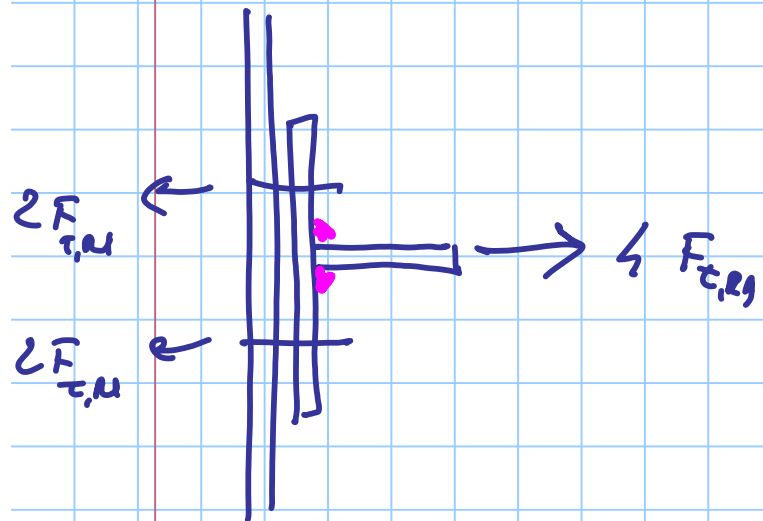
L_f



TRA.

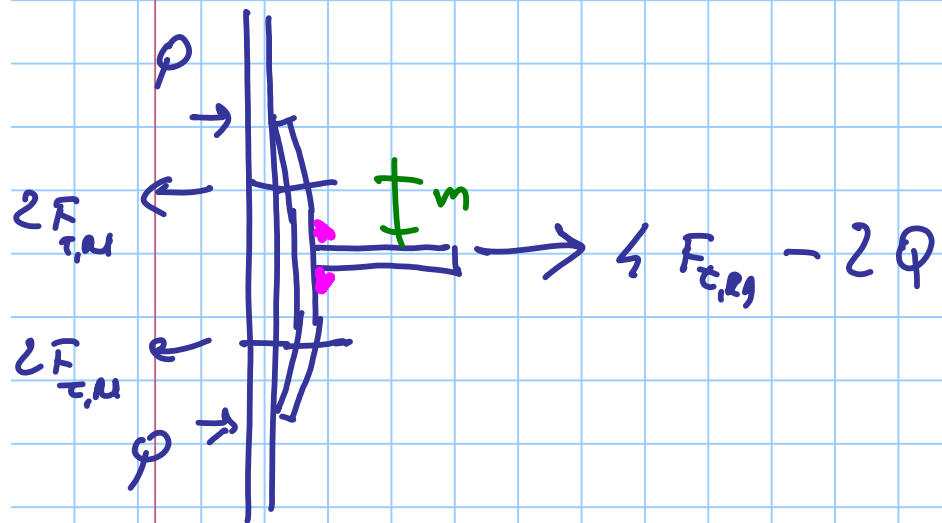


T_{sub}



$F_{t,r}$
 $B_{p,r}$

} il più piccolo
di due



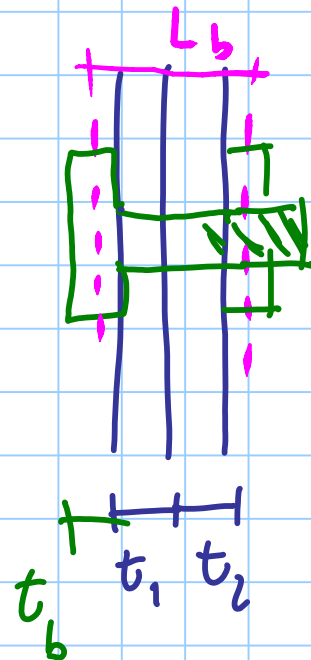
effett. leve

allungamento bullone $\longleftrightarrow \frac{F L_b}{EA}$ L_b lunghezza bullone

deformazione flessionale della flangia $\frac{2 F m^3}{3 EI}$

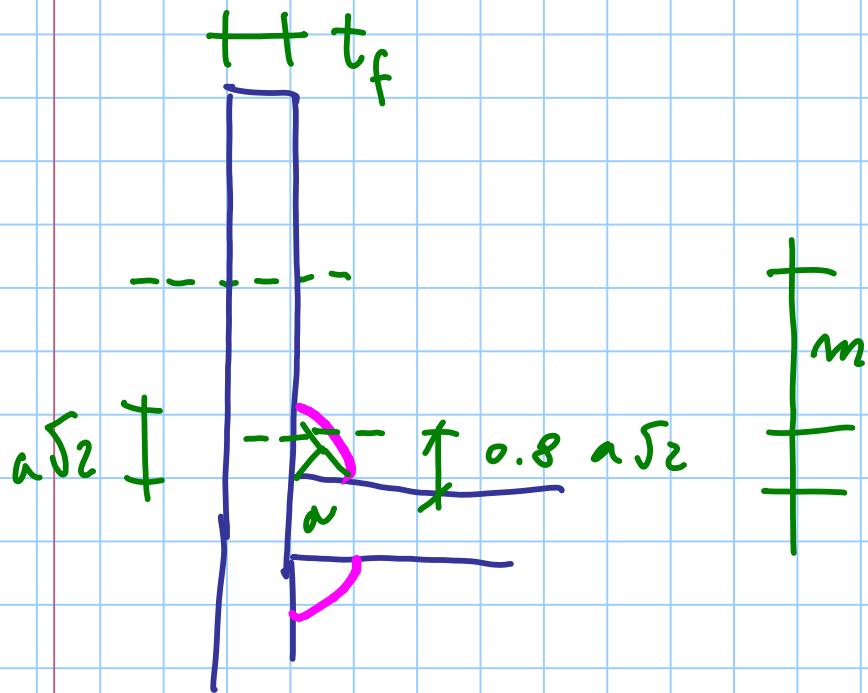


lunghezza bullone



$$t_b \approx 0.6 d$$

$$L_b = t_1 + t_2 + t_b$$



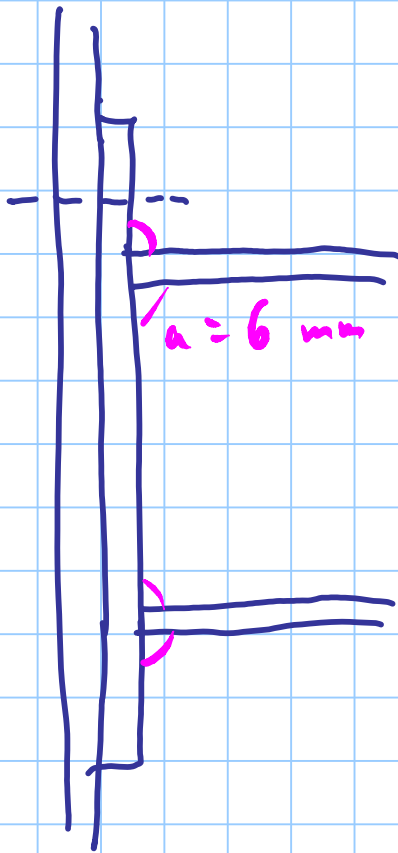
$$I = \frac{L_f t_f^3}{12}$$

$$\frac{F L_b}{E A_m}$$

$$> \frac{2 F m^3}{3 E L_f t_f^3}$$

$$L_b > \frac{8 m^3 A_m}{L_f t_f^3}$$

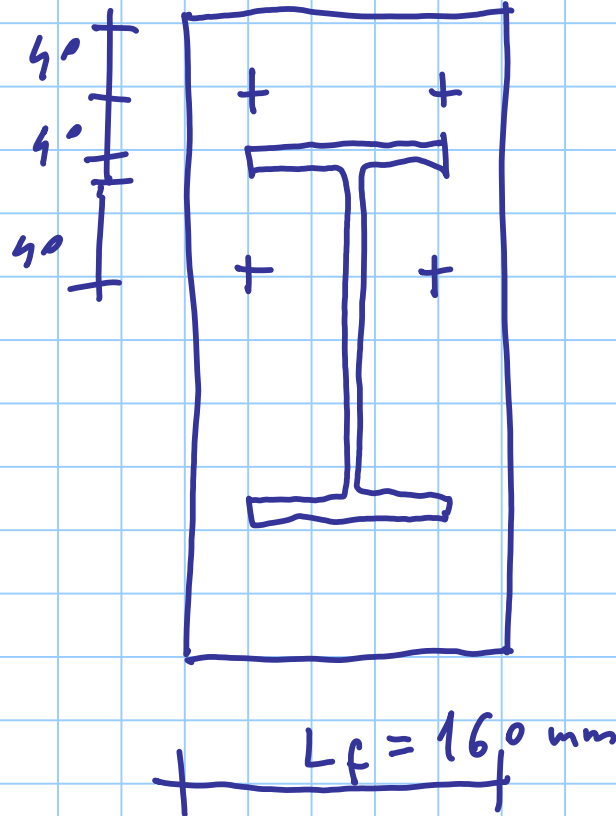
$$\frac{8.8 m^3 A_m}{L_f t_f^3}$$



column

HE 160 B

$t_f = 13 \text{ mm}$



pi-~~to~~ S275

IPE 160

$t_f = 7.4 \text{ mm}$

M16 8.8

$A_{us} = 157 \text{ mm}^2$

$$F_{t,RA} = 0.9 A_{us} \frac{f_{ub}}{\gamma_{M2}} = 90.4 \text{ kN}$$

$$B_{p.R} = 0.6 \pi d_m t \frac{f_u}{\gamma_{M2}} = 199.2 \text{ kN}$$

non ha
problem:

$$t = 12 \text{ mm}$$

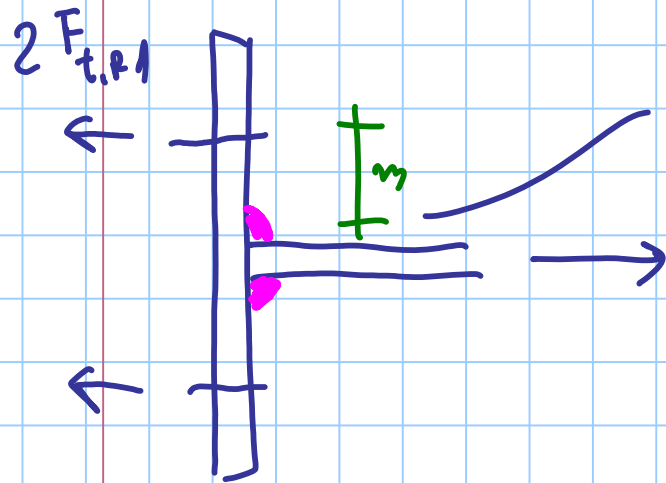
$$d_m \approx 1.6 d = 25.6 \text{ mm}$$

$$m = 40 - 0.8 \times 6 \times \sqrt{2} = 33.2 \text{ mm}$$

$$L_b = 13 + 12 + 0.6 \times 16 = 34.6 \text{ mm}$$

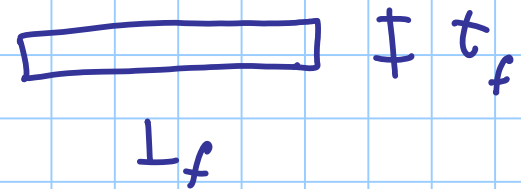
$$\frac{8.8 \text{ m}^3 A_{us}}{L_f t_f^3} = \frac{8.8 \times 33.2^3 \times 157}{160 \times 12^3} = 182.9 \text{ mm}$$

$$L_b < 182.9 \text{ mm} \quad \text{c'è effetto leva}$$



$$M = 2 F_{t, Rd} m$$

vérification de flexion
à flexion



$$M_{Rd} = W_{pl} \frac{f_y}{\gamma_m} = 1.51 \text{ kNm}$$

$$W_{pl} = \frac{L_f t_f^2}{4} = 5.76 \times 10^3 \text{ mm}^3$$

$$2 F_{t, Rd} = 180.8 \text{ kN}$$

$$m = 33.2 \text{ mm}$$

$$M_{Ed} = 5.99 \text{ kNm} > M_{Rd} \quad \text{non acceptable}$$

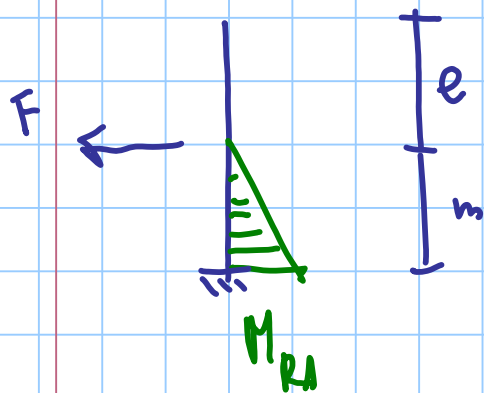
con questo M_{RA}

$$F_{max} = \frac{1.51}{0.0332} = 45.5 \text{ kN} \quad (1)$$

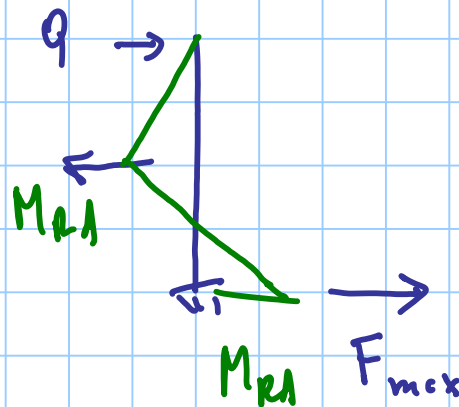
sintesi effetti leve

cosa comporta l'effetto leva?

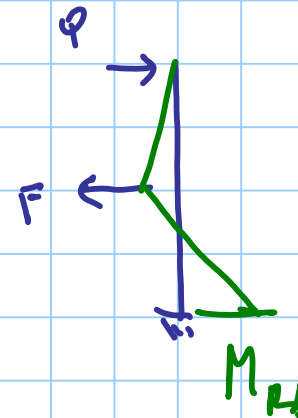
ogni bullone ha $F_{z,eq} = 22.8 \text{ kN}$



(1)



(2)



(3)

$$\textcircled{2} \quad F_{max} = \frac{2 M_{Rd}}{m} = 91 \text{ kN}$$

$$Q = \frac{M_{Rd}}{e} = \frac{1.51}{0.040} = 37.8 \text{ kN}$$

$$F_{t,Ed} = \frac{F_{max} + Q}{2} = \frac{91 + 37.8}{2} = 64.4 \text{ kN}$$

\nwarrow k_{bulb}

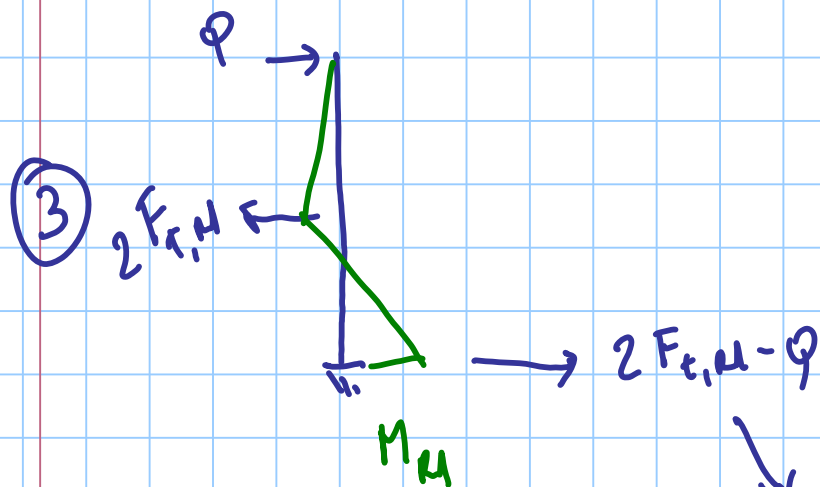
se $F_{t,Rd} > 64.4 \text{ kN}$ il collegamento porta 91 kN

nel nostro esempio è così

se invece avessi bulloni M16 classe 5.6

$$F_{t,Rd} = 0.9 \times 157 \times \frac{500}{1.25} = 56.5 \text{ kN}$$

in quest. cas. $F_{t,Rd} < 66.4 \text{ kN}$ non pos. avere
doppia plasticazione

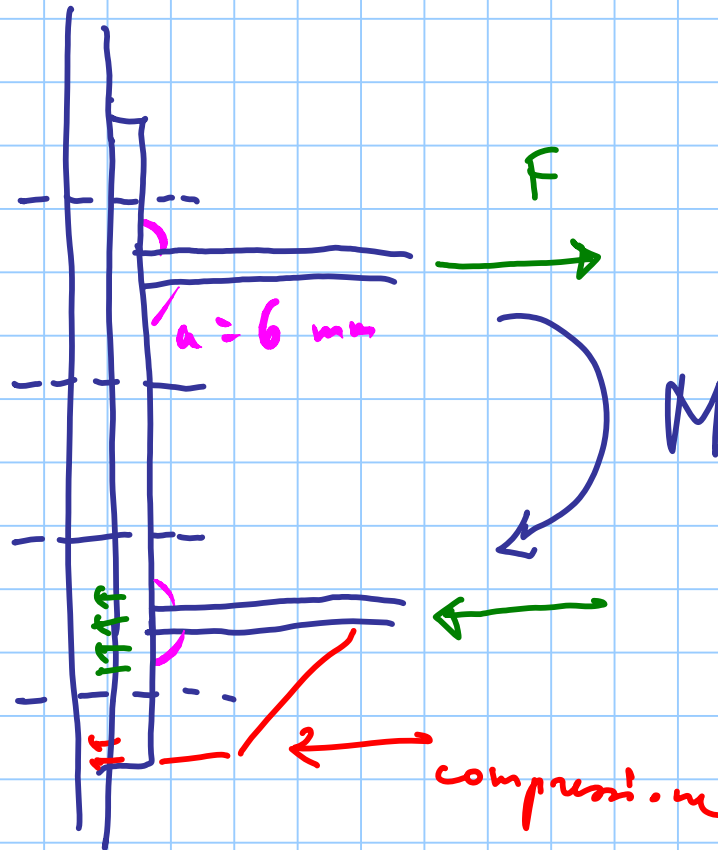


$$M_{Rd} = 2 F_{t,Rd} m - Q (l + m)$$

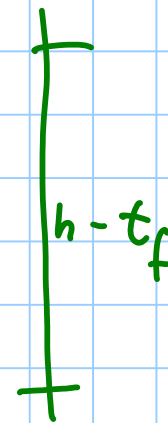
$$Q = \frac{2 F_{t,Rd} m - M_{Rd}}{l + m}$$

$$2 F_{t,Rd} - \frac{2 F_{t,Rd} m - M_{Rd}}{l + m} = \frac{2 F_{t,Rd} l + M_{Rd}}{l + m}$$

$$\frac{2 \times 56.5 \times 0.040 + 1.51}{0.0732} = 82.4 \text{ kN}$$



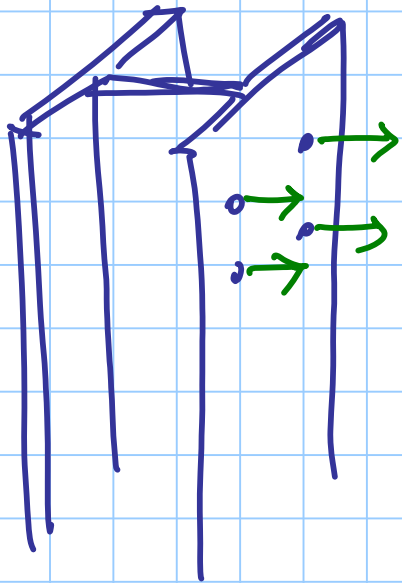
$$\bar{F} = \frac{M}{h - t_f}$$



compression qui se ci sono irrigidimenti,
o flange molto spesse

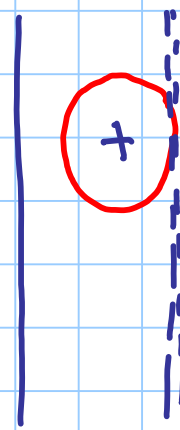
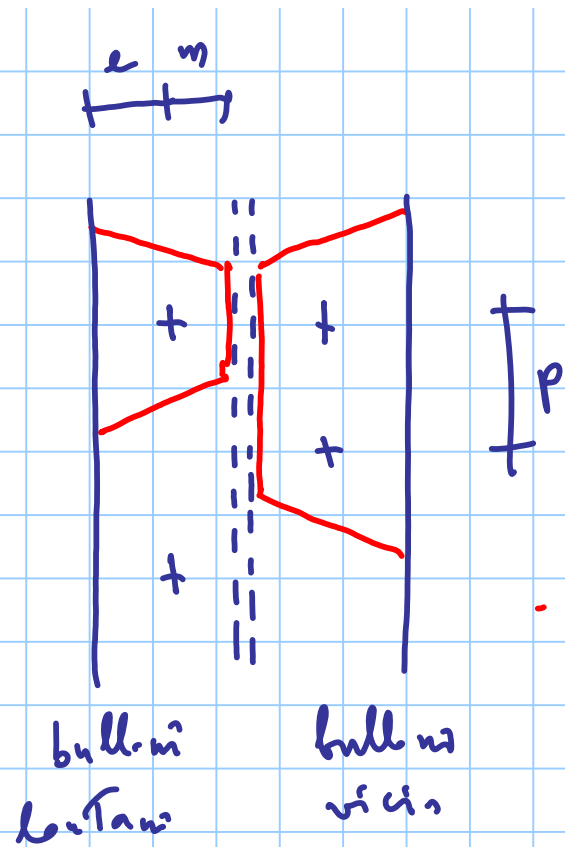
1) verifica della flangia (vedi sopra)

2) verifica dell'ala colonna



verificare ala a flessione

ma quale L_f

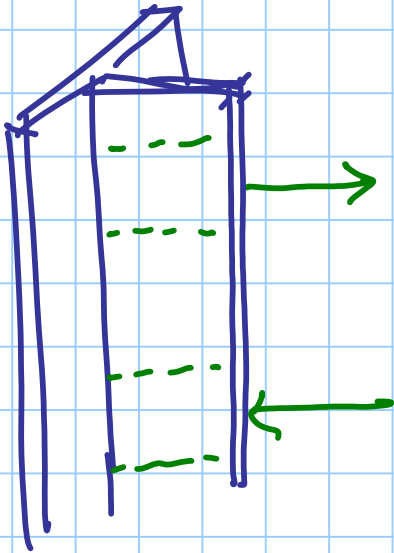


per il
multigress

$$L_f = 2\pi m$$

$$L_f = 2(2m + 0.625e) \quad \text{in 2-6 bulbini}$$

$$L_f = 2(2m + 0.625e) + p \quad \text{due bulbini}$$

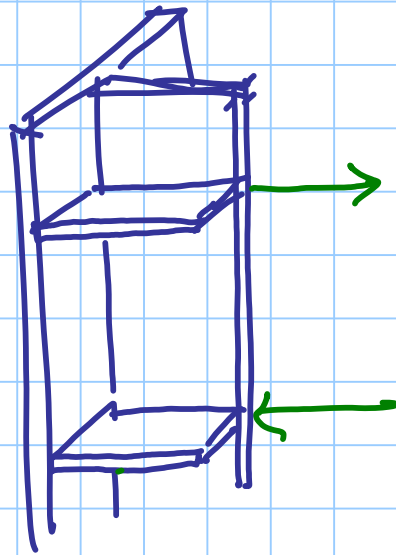


3) verifica a trazione dell'anima
della colonna

4) verifica a compressione dell'anima
della colonna

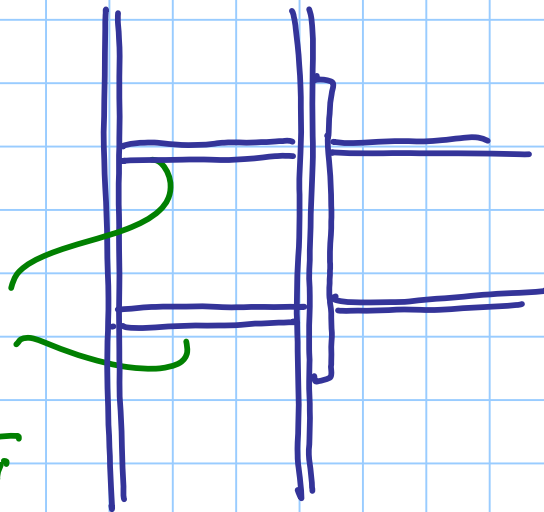
5) verifica a tagli. dell'anima
della colonna

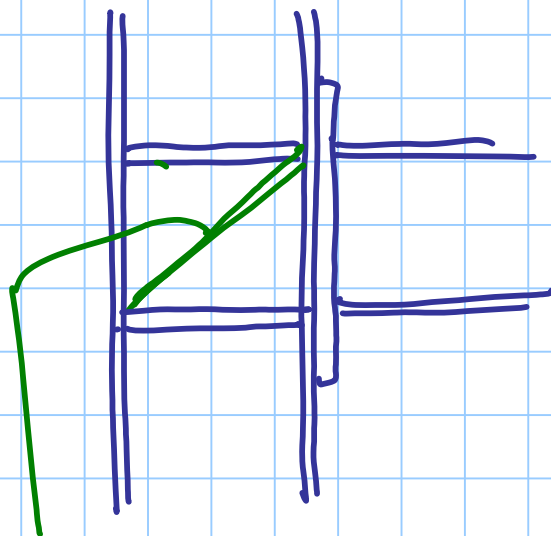
di solito si inserisce piatti saldati:



le verifiche 3 e 4 sono
sicuramente soddisfatte

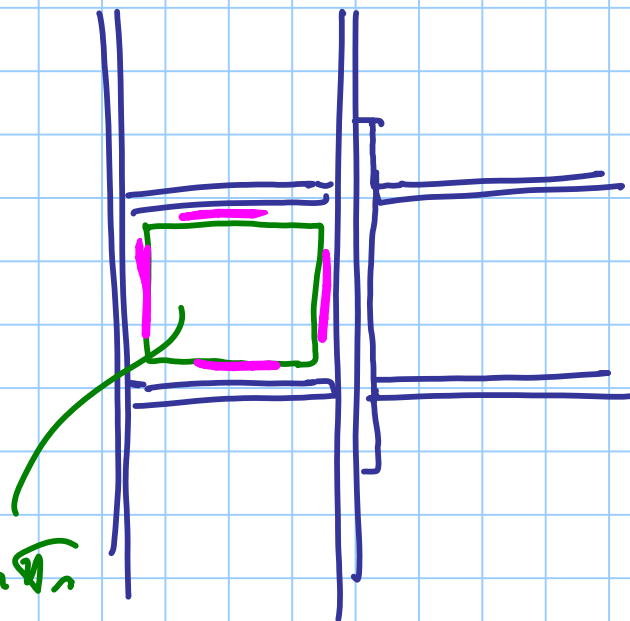
piatti
^
giunti





ultimare piatto e ci
sono problemi di Tagh.

oppure



piatto

