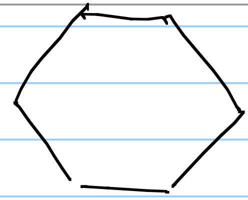
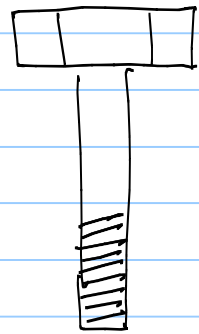
BULLONI

- a taglio
- a trazione



diametri d M12 → d = 12 mm
14
16
18
M20



testa

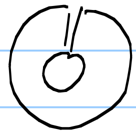
gambo

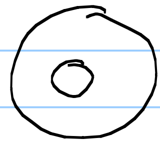
filettato all'estremità

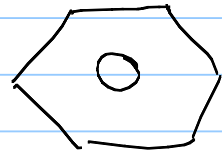
tutto filettato

SERRAGGIO

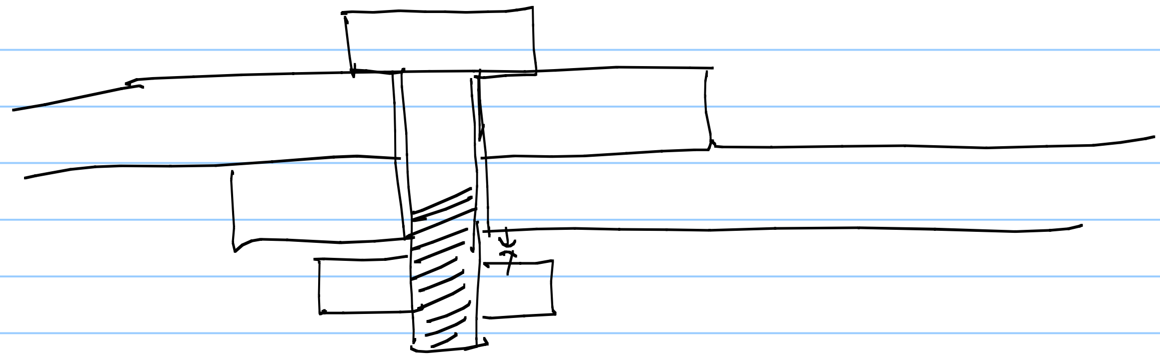
rondelle

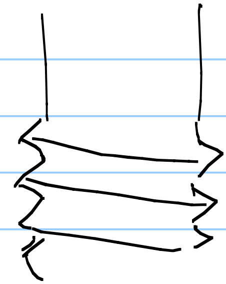






dado





azione di TRAZIONE nel bullone

COMPRESSIONE tra testa, piatti, dado

classi di acciaio 4.6 5.6 6.8

8.8 10.9

↑ tensione di rottura (4)

↑ snervamento (6)

(8.8, 10.9) bulloni ad alta resistenza

4.6

↓ ↖ $f_{yb} = 0.6\, f_{ub} = 240$ MPa

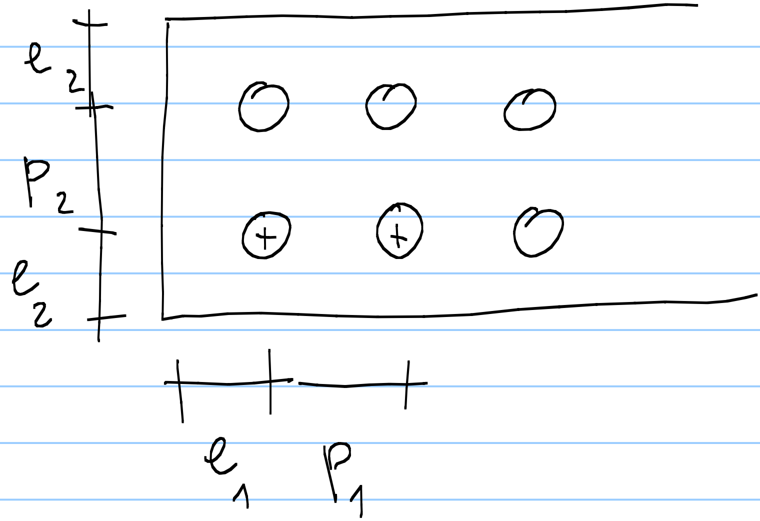
$f_{ub} = 400$ MPa

6.8

↙ ↘ $f_{yb} = 480$ MPa

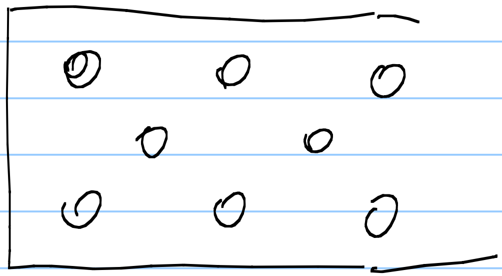
$f_{ub} = 600$ MPa

Nel disporre i bulloni



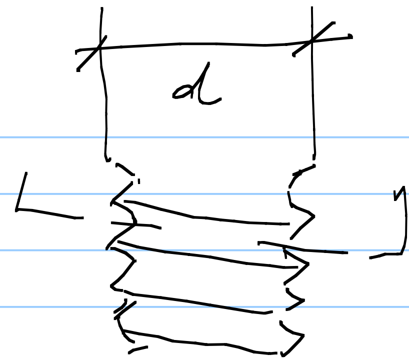
→ d_0 = diametro del foro

$d_0 = d + 1$ mm (fino a M20)



distanze minime	distanze max
$e_1 \geq 1,2\ d_0$	$e_1 \leq 4t + 40$ mm
$e_2 \geq 1,2\ d_0$	e_2 idem
$p_1 \geq 2,2\ d_0$	$p_1 \leq \min \begin{pmatrix} 14\ t \\ 200\ \text{mm} \end{pmatrix}$
$p_2 \geq 2,4\ d_0$	p_2 idem

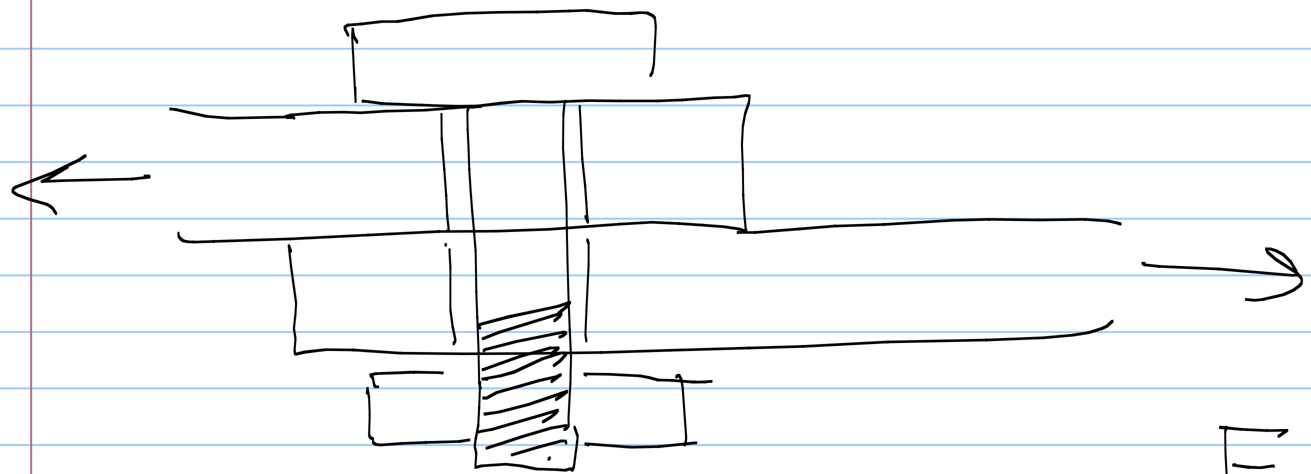
Area del bullone



area nominale
(zona non filettata) $A = \frac{\pi d^2}{4}$

area resistente
(zona filettata) $A_{res} = 0,75\ A$

BULLONI che lavorano a taglio

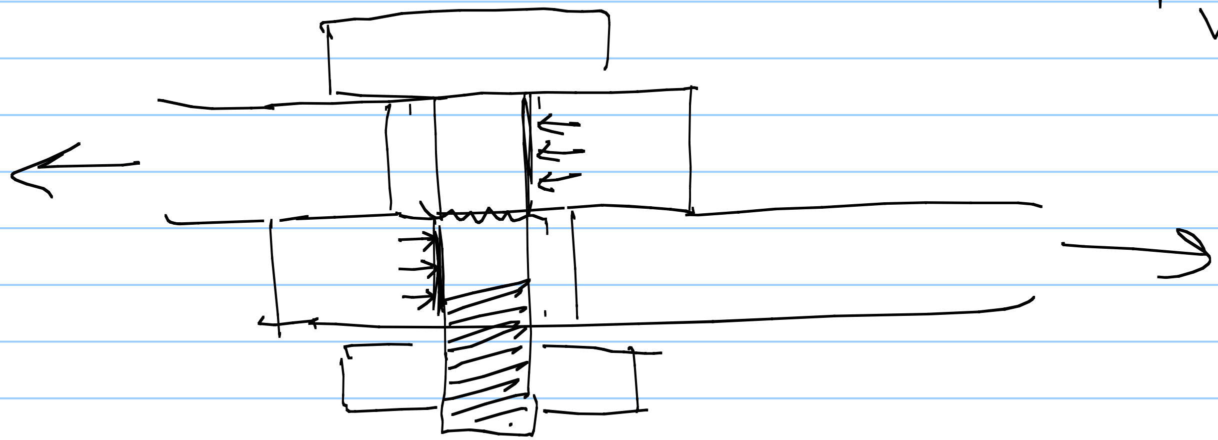


taglio $f/\sqrt{3}$

$$\frac{1}{\sqrt{3}} \cong 0.58$$

SINGOLA SEZIONE

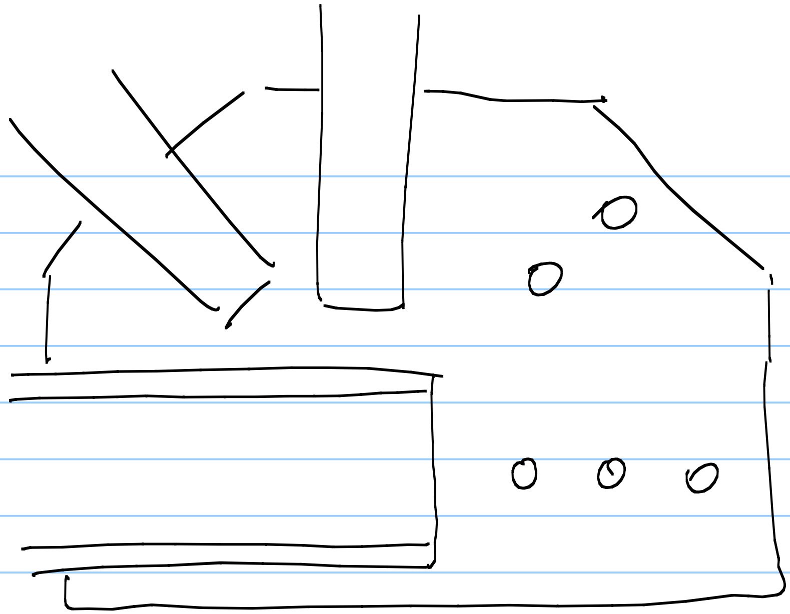
$$F_{V,Rd} = A \, 0.6 \, \frac{f_{ub}}{\gamma_{M2}}$$

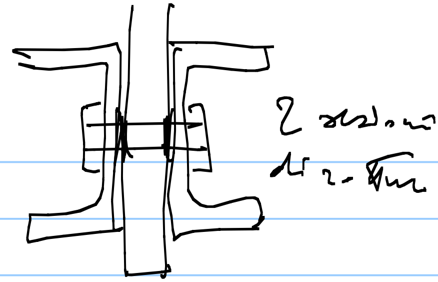


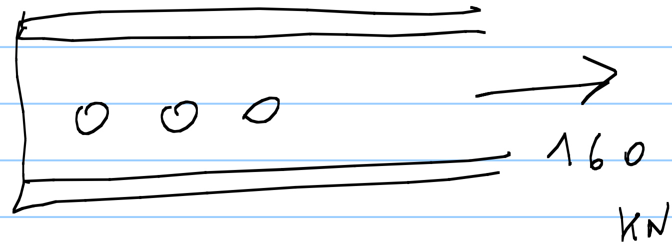
$$A_{res} \, 0.6 \, \frac{f_{ub}}{\gamma_{M2}}$$

0.5 per 6.8 e 10.9

2 UPE80







2UPE 80

$N_{Ed} = 160$ KN

3 M18 8.8

$$F_{v,Rd} = 0.6\, A \,\frac{f_{ub}}{\gamma_{M2}}\, n_b\, n_s$$

M18 → $A = 254\ mm^2$ 8.8 → $f_{ub} = 800$ MPa

$n_b = 3 \qquad n_s = 2$

$$F_{v,RA} = 0.6 \times 254 \times \frac{800}{1.25} \times 3 \times 2 \times 10^{-3} = 585 \text{ KN}$$

provo con 3 bulloni classe 4.6 – quale diametro ?

$$F_{v,Rd} = 0.6 \, A \, \frac{f_{ub}}{\gamma_{M2}} \, n_b \, n_s$$

$$A \geq \frac{N_{EA} \; \gamma_{M2}}{0.6 \; f_{ub} \; n_b \; n_s} = \frac{160 \times 10^3 \times 1.25}{0.6 \times 400 \times 3 \times 2} = 139 \text{ mm}^2$$

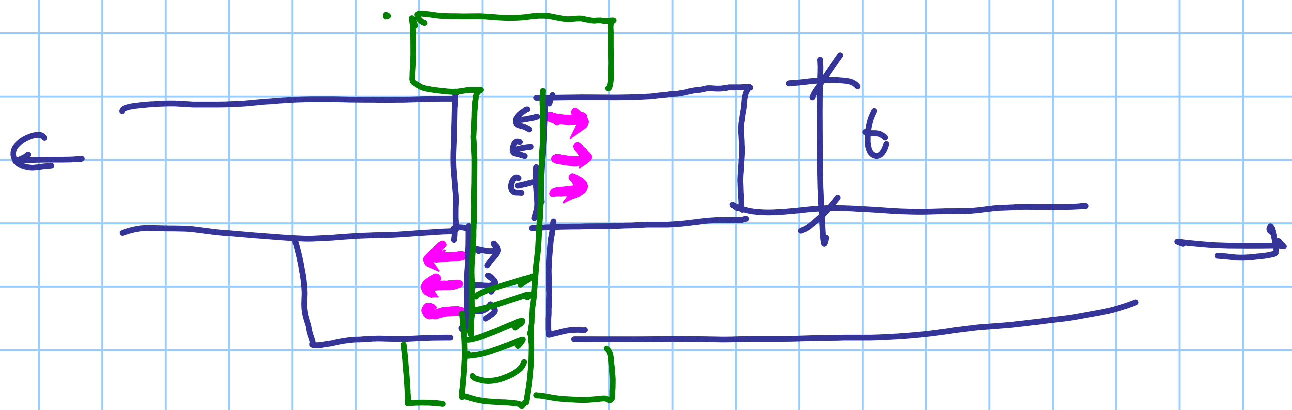
M 14 → $A = 154 \text{ mm}^2$

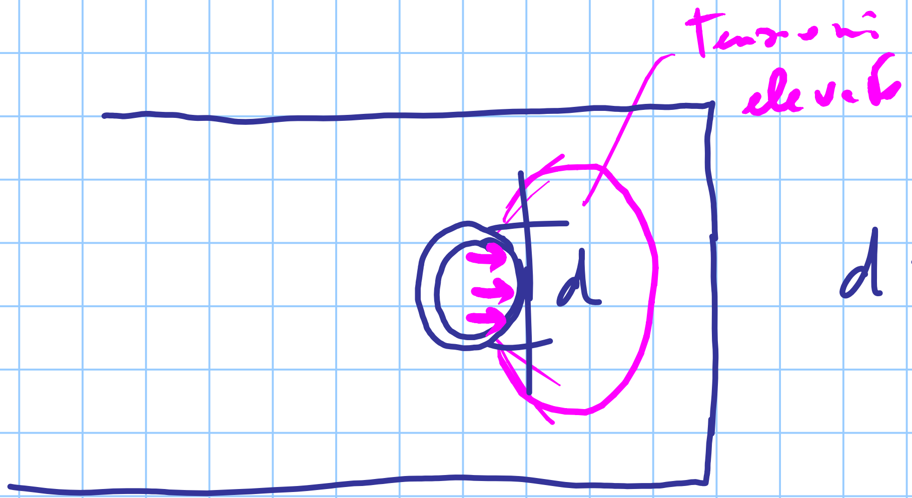
Titolo nota 08/01/2015

Tabella 3 - Passo della filettatura p (mm) e area nominale A e resistente A_{res} (mm^2)

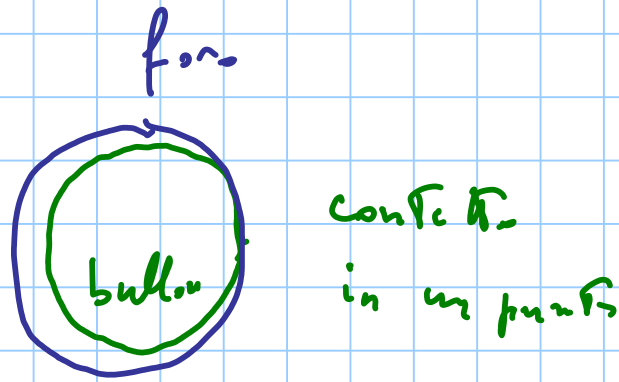
diametro d	12	14	16	18	20	22	24	27	30
passo p	1.75	2.00	2.00	2.50	2.50	2.50	3.00	3.00	3.50
A	113	154	201	254	314	380	452	573	707
A_{res}	84.3	115	157	192	245	303	353	459	581
A_{res} / A	0.75	0.75	0.78	0.75	0.78	0.80	0.78	0.80	0.82

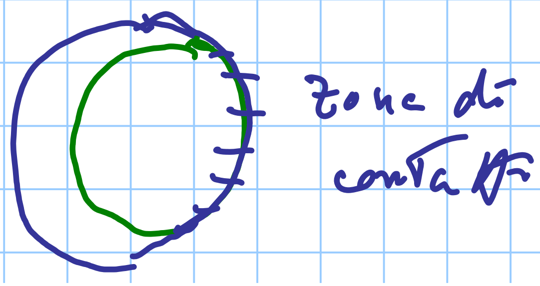
VERIFICA DEI PIATTI / ASTE



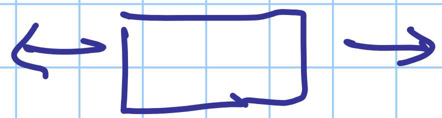


$$d\,t\,\frac{f_u}{\gamma_{M2}}\ ?$$

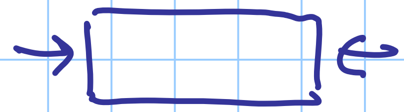




f_y f_u sono ricavate con prove monoassiali

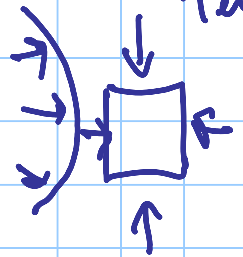


f_y f_u



stessi risultati (a meno di instabilità)

zona adiacente al foro



tensioni ortogonali "di confinamento"

la tensione è >> f_u (monoassiale)

fin a $2.5\, f_u$

RIFOLLAMENTO

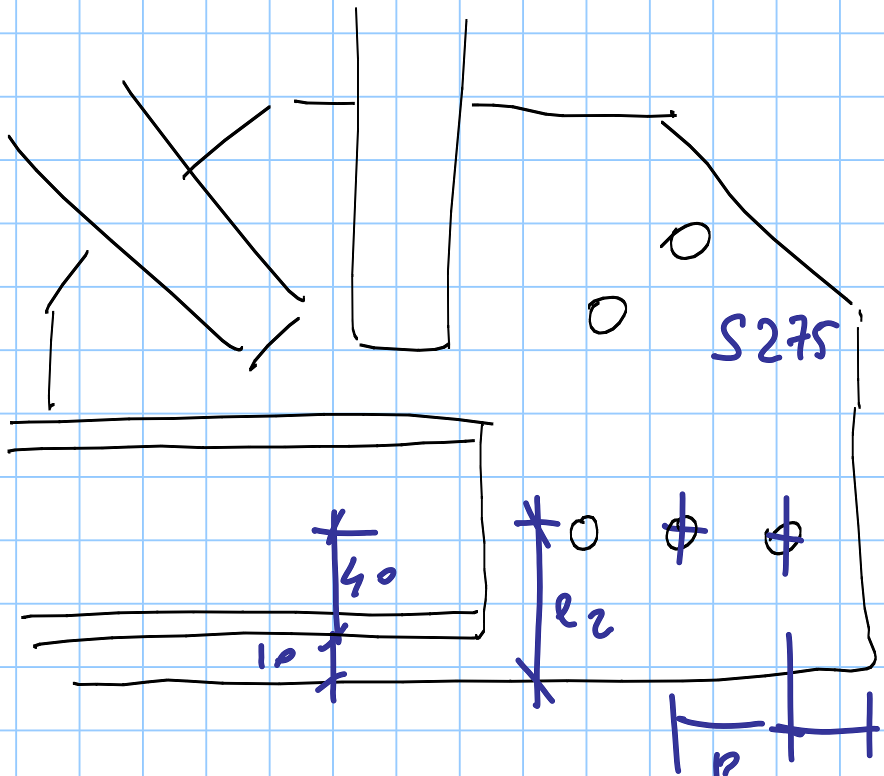
$$f_{b,Rd} = d\,t\,\underbrace{K\,\alpha}_{\leq 2.5}\,\frac{f_u}{\gamma_{M2}}$$

$$\alpha = f(e_1, p_1) = \mathrm{MIN}\left(\frac{e_1}{3d_0};\ \frac{p_1}{3d_0} - 0,25;\ \frac{f_{ub}}{f_u};\ 1\right)$$

$$K = f(e_2, p_2) = \mathrm{MIN}\left(\frac{2.8\,e_2}{d_0} - 1.7;\ \frac{1.4\,p_2}{d_0} - 1,7;\ 2,5\right)$$

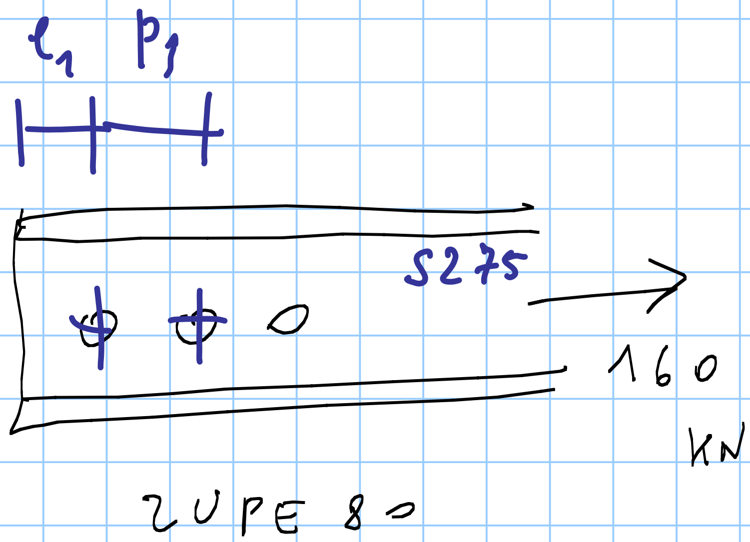
$d = 14$ mm

$d_0 = 15$ mm



$= p_1 \quad e_1 = 25$ mm

40 mm



$e_2 = 50$

$$\frac{2.8\, e_2}{d_0} - 1.7 = \frac{2.8 \times 50}{15} - 1.7 = 7.6$$

$K = 2.5$

affinché $K = 2.5$ deve essere $\frac{2.8\, e_2}{d_0} - 1.7 = 2.5$

$\frac{2.8\, e_2}{d_0} = 2.5 + 1.7 = 4.2$ $\frac{e_2}{d_0} = \frac{4.2}{2.8} = 1.5$

UPE 80 $t_w = 4$ mm

aggiungo un piatto di 8 mm

abbiamo 3 bulloni
l'azione trasmessa da
1 bullone è $N_{Ed}/3$

$$F_{b,Rd} = K\, \alpha\, d\, t\, \frac{f_u}{\gamma_{M2}} \rightarrow d \geq \frac{N_{Ed}/3\, \gamma_{M2}}{K\, \alpha\, t\, f_u}$$

$$\alpha \geq \frac{160 \times 10^3 / 3 \times 1.25}{2.5 \times 14 \times 8 \times 430} = 0.554$$

$f_u = 430$ MPa

S275

$$\frac{e_1}{3 d_0} \geq 0.554 \rightarrow e_1 \geq 0.554 \times 3 \times 15 = 24.9 \text{ mm} \rightarrow 25$$

$$\frac{p_1}{3 d_0} - 0.25 \geq 0.554 \rightarrow p_1 \geq 0.804 \times 45 = 36.2 \text{ mm} \rightarrow 40$$

$$F_{v,Rd} = 0.6 \times 154 \times \frac{400}{1.25} \times 3 \times 2 \times 10^{-3} = 177.4 \text{ kN}$$

$$> 160 \text{ kN}$$

$$\alpha = \text{MIN}\left(\frac{25}{45} \; ; \; \frac{40}{45} - 0.25 \; ; \; 1\right) = 0.555$$

$$\frac{25}{45} \rightarrow 0.555 \qquad \frac{40}{45} - 0.25 \rightarrow 0.639$$

$$F_{b,Rd} = 2,5 \times 0.555 \times 14 \times 8 \times \frac{430}{1.25} \times 10^{-3} \times 3 = 160.4 \text{ kN}$$

$$> 160 \text{ kN}$$

COLLEGAMENI

- A PARZIALE RIPRISTINO DI RESISTENZA

  calcolato per la forza da trasmettere (che è minore della resistenza delle aste)

- A TOTALE RIPRISTINO DI RESISTENZA

  calcolato per la resistenza dell'asta

il profilo 2 UPE 80 $A = 2 \times 10.1 \times 10^2 \, mm^2 =$

$= 2020 \, mm^2$

$$N_{Rd} = 2020 \times \frac{275}{1.05} \times 10^{-3} = 529 \, kN > 160 \, kN$$

se avessi usato 3 M18 8.8 $F_{v,Rd} = 585 \, kN$

aumentando e_1 p_1 fino a $\alpha = 1$

$$F_{b,Rd} = 2,5 \times 1 \times 18 \times 8 \times \frac{430}{1.25} \times 10^{-3} \times 3 = 371.5 \, kN$$

resistenza del collegamento 371.5 kN

con 6 bulloni M18 4.6

$F_{v,Rd}$: 585 KN $F_{b,Rd}$: 743 KN

resistenza del collegamento 585 KN > 529 KN

A COMPLETO RIPRISTINO