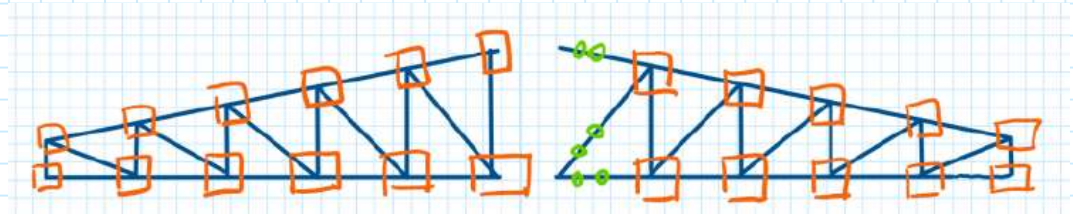


Corrente superiore 1 UPN 50x38

Corrente inferiore 2L 55x5

Diagonali e montanti 2L 50x30x5

Progetto dei collegamenti



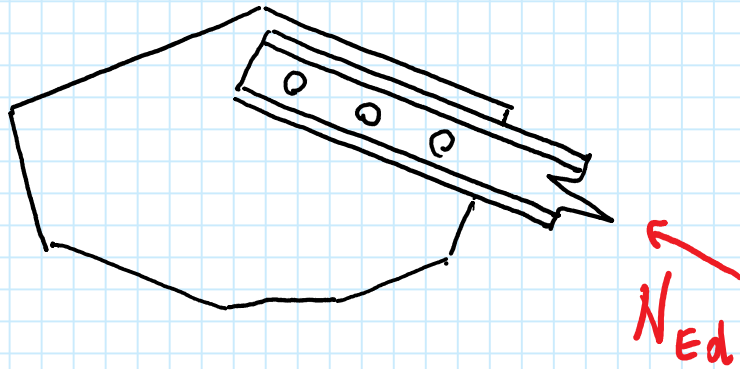
Sforzo normale del corrente inferiore					
Asta	1° comb.	2° comb.	3° comb.	Max traz.	Max Comp.
1	0.00	5.50	0.00	5.50	0.00
2	104.79	69.99	-69.55	104.79	-69.55
3	135.49	81.69	-89.29	135.49	-89.29
4	139.73	74.55	-91.24	139.73	-91.24
5	131.51	58.53	-84.82	131.51	-84.82
6	131.51	33.88	-84.82	131.51	-84.82
7	139.73	29.47	-91.24	139.73	-91.24
8	135.49	23.82	-89.29	135.49	-89.29
9	104.79	15.57	-69.55	104.79	-69.55
10	0.00	0.00	0.00	0.00	0.00

Sforzo normale dei diagonali					
Asta	1° comb.	2° comb.	3° comb.	Max traz.	Max Comp.
21	110.46	67.98	-73.32	110.46	-73.32
22	34.79	13.26	-22.37	34.79	-22.37
23	5.25	-8.87	-2.42	5.25	-8.87
24	-11.24	-21.91	8.78	8.78	-21.91
25	-22.78	-31.59	16.67	16.67	-31.59
26	-22.78	5.66	16.67	16.67	-22.78
27	-11.24	6.04	8.78	8.78	-11.24
28	5.25	7.00	-2.42	7.00	-2.42
29	34.79	9.36	-22.37	34.79	-22.37
30	110.46	16.41	-73.32	110.46	-73.32

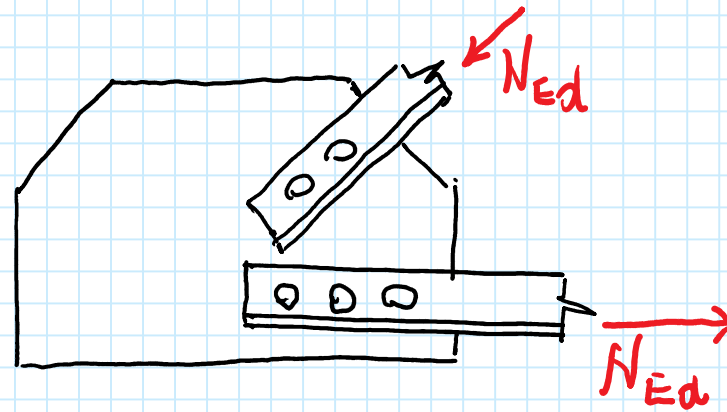
Sforzo normale del corrente superiore					
Asta	1° comb.	2° comb.	3° comb.	Max traz.	Max Comp.
11	-106.87	-65.88	72.00	72.00	-106.87
12	-138.17	-78.04	94.26	94.26	-138.17
13	-142.49	-70.97	98.38	98.38	-142.49
14	-134.11	-54.86	93.97	93.97	-134.11
15	-118.74	-33.77	84.85	84.85	-118.74
16	-118.74	-34.33	84.85	84.85	-118.74
17	-134.11	-31.41	93.97	93.97	-134.11
18	-142.49	-27.81	98.38	98.38	-142.49
19	-138.17	-22.95	94.26	94.26	-138.17
20	-106.87	-15.43	72.00	72.00	-106.87

Sforzo normale dei montanti					
Asta	1° comb.	2° comb.	3° comb.	Max traz.	Max Comp.
31	-62.10	-40.86	41.46	41.46	-62.10
32	-34.93	-21.50	23.18	23.18	-34.93
33	-16.37	-6.24	10.53	10.53	-16.37
34	-3.11	5.24	1.43	5.24	-3.11
35	7.67	14.95	-5.99	14.95	-5.99
36	34.16	19.45	-24.99	34.16	-24.99
37	7.67	-4.12	-5.99	7.67	-5.99
38	-3.11	-4.14	1.43	1.43	-4.14
39	-16.37	-4.40	10.53	10.53	-16.37
40	-34.93	-5.19	23.18	23.18	-34.93
41	-62.10	-7.86	41.46	41.46	-62.10

Nodo sul corrente superiore



Nodo sul corrente inferiore

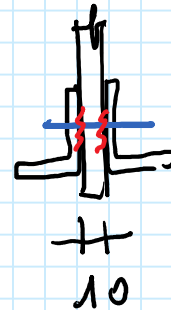


m_b
d
e_{corr} \leq | Verifica
dei bulloni

e_1, P_1
 e_2, P_2 \leq | Verifica a
sfollamento

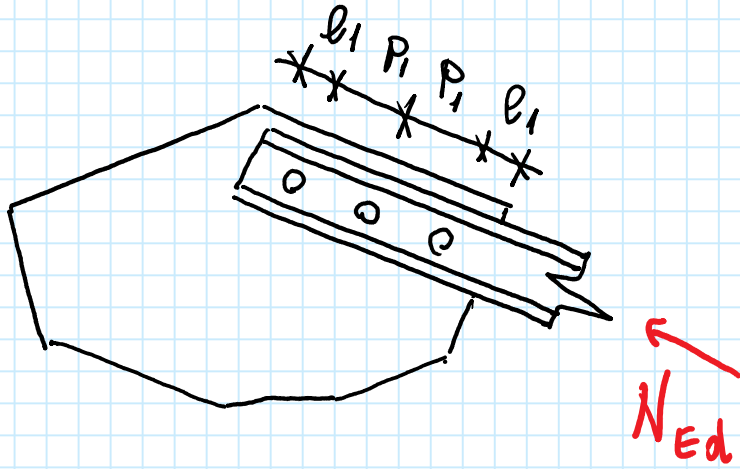
e_2 è assegnato ($e_2 = h/2$ del profilo)

Art. 412 6.8



2 sezioni resistenti
per bullone

Corrente superiore



$$N_{Ed} = 118,74 \text{ KN}$$

S235

M12 di classe 6.8 con gambo interamente filettato

sigla	M12	M14	M16
A (mm ²)	113	154	201
A _{res} (mm ²)	84.3	115	157
A _{res} / A	0.75	0.75	0.78

1. Progetto dei bulloni

$$F_{V,Ed} = \frac{N_{Ed}}{2 m_b} \leq F_{V,Rd}$$

$$F_{V,Rd} = 0,5 A_{res} \frac{f_{ub}}{\gamma_{M2}} = 0,5 \times 84,3 \times \frac{600}{1,25} \times \frac{1}{10^3} = 20,2 \text{ KN}$$

$$\frac{N_{Ed}}{2 m_b} = F_{V,Rd} \Rightarrow m_b = \frac{N_{Ed}}{2 F_{V,Rd}} = \frac{118,74}{2 \times 20,2} = 2,9$$

3 bulloni

2. Progetto delle distanze e_1 e P_1

$$t_p = 10 \text{ mm}$$

$$2t_w = 2 \times 5 = 10 \text{ mm}$$

$$2 F_{V,Ed} \leq k \alpha d t_p \frac{f_u}{\gamma_{M2}} \Rightarrow \alpha = \frac{2 F_{V,Ed} \gamma_{M2}}{k d t_p f_u}$$

$$e_2 = \frac{h}{2} = \frac{50}{2} = 25 \text{ mm} \quad \frac{e_2}{d_0} = \frac{25}{13} = 1,92 > 1,5 \Rightarrow k = 2,5$$

$$\alpha = \frac{2 \times 19,8 \times 1,25 \times 10^3}{2,5 \times 12 \times 10 \times 360} = 0,4583$$

$$F_{V,Ed} = \frac{N_{Ed}}{m_s m_b} = \frac{418,74}{2 \times 3} = 18,79 \text{ kN}$$

$$\frac{e_1}{3d_0} = \alpha \Rightarrow e_1 = 3 \alpha d_0 = 3 \times 0,4583 \times 13 = \underline{\underline{17,9 \text{ mm}}} \quad 20 \text{ mm}$$

$$e_1 \geq 1,2 d_0 = 1,2 \times 13 = 15,6 \text{ mm}$$

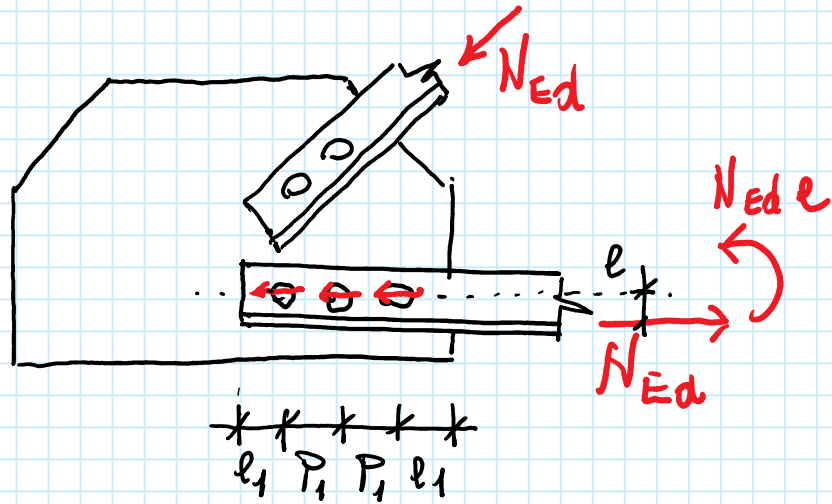
$$\frac{P_1}{3d_0} - 0,25 = \alpha \Rightarrow \frac{P_1}{3d_0} = \alpha + 0,25 \Rightarrow P_1 = 3(\alpha + 0,25)d_0$$

$$P_1 = 3 \times (0,4583 + 0,25) \times 13 = 27,6 \text{ mm}$$

$$P_1 \geq 2,2 d_0 = 2,2 \times 13 = \underline{28,6} \text{ } 30 \text{ mm}$$

Adesso che conosciamo il numero di bulloni e tutte le distanze si può eseguire la verifica del collegamento.

Corrente inferiore



$$N_{Ed} = 131,51 \text{ kN}$$

S235

M12 di classe 6.8 con gambo interamente filettato

sigla	M12	M14	M16
A (mm ²)	113	154	201
A _{res} (mm ²)	84.3	115	157
A _{res} / A	0.75	0.75	0.78

N_{Ed} e e le coppie parente

In prime battute le trave sono me "abbondolo" su numero di bulloni e distanze ottenute dal progetto

Dopo aver dimensionato il collegamento, lo verifico considerando anche l'effetto delle coppie parente

1. Progetto dei bulloni

$$F_{V,Rd} = 20,2 \text{ kN}$$

bulloni H12 di classe 6.8



$$n_b = \frac{N_{Ed}}{2 F_{V,Rd}} = \frac{131,51}{2 \times 20,2} = 3,26$$

4 bulloni

2. Progetto delle distanze e_1 e P_1

$$t_p = 10 \text{ mm}$$

$$2 t_w = 2 \times 5 = 10 \text{ mm}$$

$$\alpha = \frac{2 F_{V,Ed} \gamma_{H2}}{k \alpha t_p f_u} = \frac{2 \times 16,4 \times 1,25 \times 10^3}{2,5 \times 12 \times 10 \times 360} = 0,3796$$

$$e_2 = \frac{h}{2} = \frac{50}{2} = 25 \text{ mm} \quad \frac{e_2}{d_b} = \frac{25}{13} = 1,92 > 1,5 \Rightarrow k = 2,5$$

$$F_{V,Ed} = \frac{N_{Ed}}{2 \times 4} = \frac{131,51}{2 \times 4} = 16,4 \text{ kN}$$

$$\frac{d_1}{3d_0} = \alpha \Rightarrow d_1 = 3 \alpha d_0 = 3 \times 0,3496 \times 13 = 14,8 \text{ mm}$$

$$d_1 \geq 1,2 d_0 = 1,2 \times 13 = \underline{15,6} \text{ mm} \quad 25 \text{ mm}$$

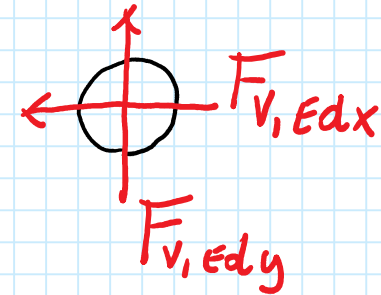
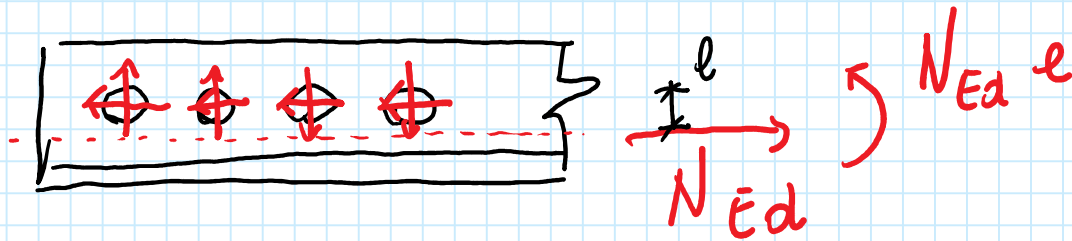
$$\frac{P_1}{3d_0} - 0,25 = \alpha \Rightarrow \frac{P_1}{3d_0} = \alpha + 0,25 \Rightarrow P_1 = 3(\alpha + 0,25) d_0$$

$$P_1 = 3 \times (0,3496 + 0,25) \times 13 = 24,6 \text{ mm}$$

$$P_1 \geq 2,2 d_0 = 2,2 \times 13 = \underline{28,6} \text{ mm} \quad 35 \text{ mm}$$

Adesso che conosciamo il numero di bulloni e tutte le distanze eseguo le verifiche del collegamento...

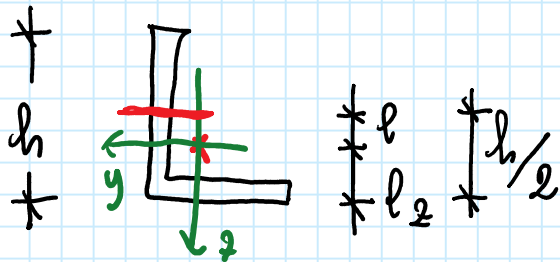
3. Verifica del collegamento



$$F_{V,Edx} = \frac{N_{Ed}}{2 \times m_b} = \frac{131,51}{2 \times 4} = 16,4 \text{ kN} \quad (\text{lo avremo già determinato})$$

$$N_{Ed} \cdot e - 2 F_{V,Edy} (3 P_1) - 2 F_{V,Edy} P_1 = 0$$

$$F_{V,Edy} = \frac{N_{Ed} \cdot e}{2 (4 P_1)} = \frac{131,51 \times 12,3}{2 \times 4 \times 35} = 5,8 \text{ kN}$$



$$e = \frac{h}{2} - l_2 = \frac{55}{2} - 15,2 = 12,3 \text{ mm}$$

$$F_{V,Ed} = \sqrt{F_{V,Edx}^2 + F_{V,Edy}^2} = \sqrt{16,4^2 + 5,8^2} = 17,4 \text{ kN}$$

$$F_{V,Ed} = 17,4 \text{ kN} \leq F_{V,Rd} = 20,2 \text{ kN} \quad \text{OK!}$$

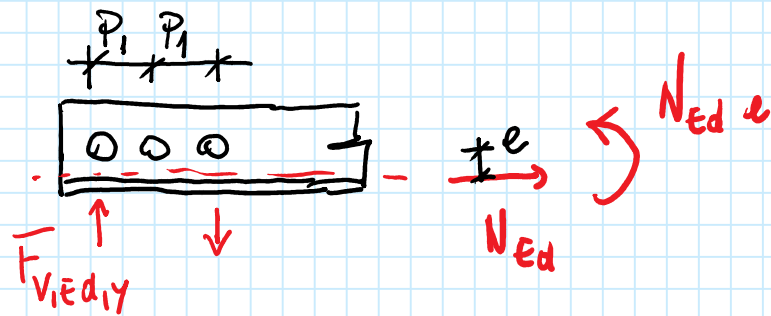
$$2 F_{V,Ed} \leq F_{b,Rd}$$

$$F_{b,Rd} = k \alpha d t_p \frac{f_u}{\gamma_{M2}} = 2,5 \times 0,6410 \times 12 \times 10 \times \frac{360}{1,25} \times \frac{1}{10^3} = 55,4 \text{ kN}$$

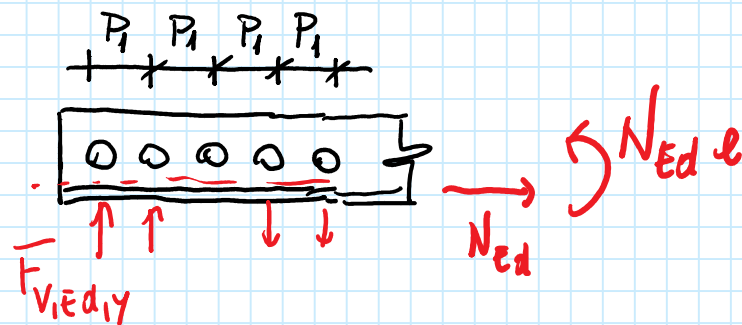
$$\alpha = \frac{d_1}{3d_0} = \frac{25}{3 \times 13} = \underline{0,6410}$$

$$\alpha = \frac{P_1}{3d_0} - 0,25 = \frac{35}{3 \times 13} - 0,25 = 0,6476$$

$$2 F_{V,Ed} = 2 \times 17,4 = 34,8 \text{ kN} \leq F_{b,Rd} = 55,4 \text{ kN} \quad \text{OK!}$$



$$2 F_{V,Ed,y} (2 P_1) = N_{Ed} l \Rightarrow F_{V,Ed,y} = \frac{N_{Ed} l}{4 P_1}$$

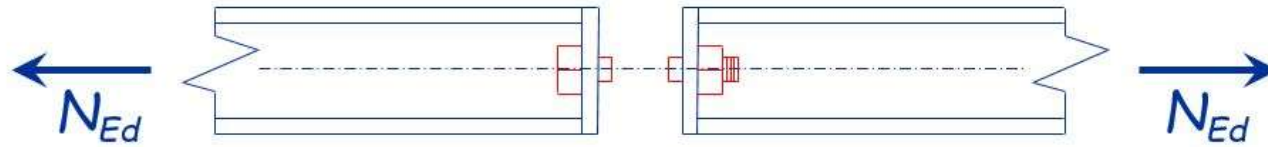


$$2 F_{V,Ed,y} (4 P_1) + 2 F_{V,Ed,y} (2 P_1) = N_{Ed} l \Rightarrow F_{V,Ed,y} = \frac{N_{Ed} l}{12 P_1}$$

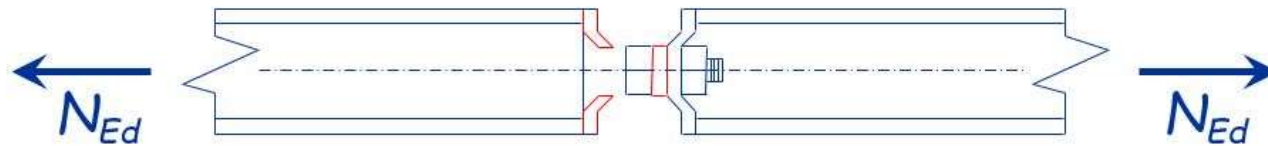
Collegamenti bullonati con bulloni che lavorano a trazione

Meccanismi di rottura

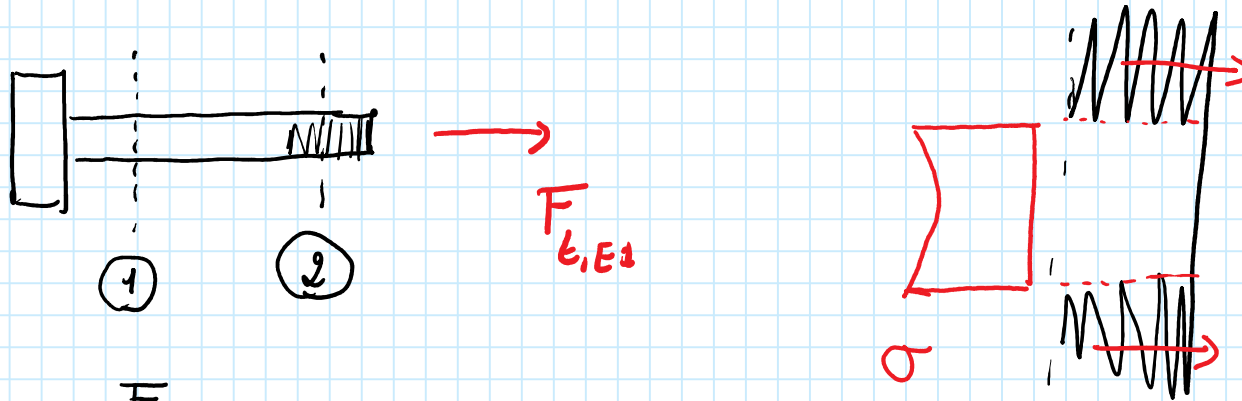
1 - Rottura dei bulloni a trazione



2 - Punzonamento della piastra



Verifica a trazione dei bulloni



Le tensioni sulle sezioni non sono costanti.

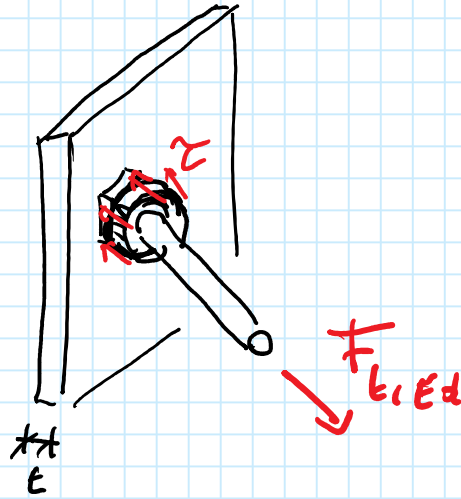
$$\sigma_1 = \frac{F_{t,Ed}}{A}$$

$$\sigma_2 = \frac{F_{t,Ed}}{A_{res}}$$

Il bullone teso si rompe sempre nelle porte filettate.

$$f_{ub} = \frac{F_{t,Rd}}{A_{res}} \Rightarrow F_{t,Rd} = 0,9 A_{res} \frac{f_{ub}}{\gamma_{M2}} \Rightarrow F_{t,Ed} \leq F_{t,Rd}$$

Verifica e punto momento delle lamiere



Le teste del bullone preme sulle piastre fino strapparle un pezzo ed allargare il foro.

$$\tau \pi d_m t = F_{t,Ed} \Rightarrow \tau = \frac{F_{t,Ed}}{\pi d_m t}$$

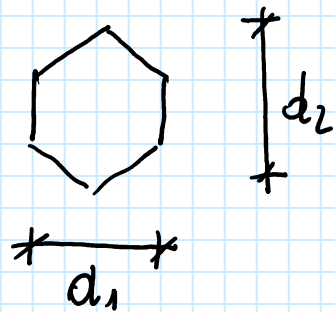
$$\tau_u = \frac{B_{p,Ed}}{\pi d_m t}$$

$$\tau_u = \frac{f_u}{\sqrt{3}}$$

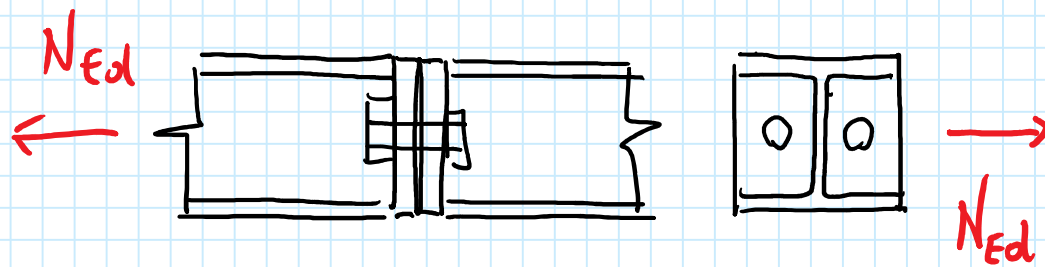
$$\Rightarrow B_{p,Ed} = \frac{0,6}{\sqrt{3}} \pi d_m t \frac{f_u}{\gamma_{H2}}$$

$$F_{t,Ed} \leq B_{p,Rd}$$

$$B_{p,Rd} = 0,6 \pi d_m f \frac{f_u}{\gamma_{H2}}$$



$$d_m = \frac{d_1 + d_2}{2}$$



HEA 100 S235
 $t_p = 12 \text{ mm}$ S235
 M16 6.8
 $N_{Ed} = 100 \text{ kN}$

Bulbomi

$$F_{t,Ed} = \frac{N_{Ed}}{m_b} = \frac{100}{2} = 50 \text{ kN}$$

$$F_{t,Rd} = 0,9 A_{res} \frac{f_{ub}}{\gamma_{M2}} = 0,9 \times 154 \times \frac{600}{1,25} \times \frac{1}{10^3} = 67,8 \text{ kN}$$

sigla	M12	M14	M16
A (mm ²)	113	154	201
A _{res} (mm ²)	84.3	115	157
A _{res} / A	0.75	0.75	0.78

$$F_{t,Ed} = 50 \text{ kN} \leq F_{t,Rd} = 67,8 \text{ kN}$$

OK!

Verifica e dimensionamento delle piastre

$$F_{t,Ed} = 50 \text{ kN}$$

$$B_{p,Rd} = 0,6 \pi d_m t \frac{f_u}{\gamma_{M2}} = 0,6 \times 3,14 \times 25,21 \times 12 \times \frac{360}{1,25} \times \frac{1}{10^3}$$
$$d_1 = 26,75 \text{ mm} \quad = 164,1 \text{ kN}$$

$$d_2 = 23,76 \text{ mm}$$

$$d_m = \frac{d_1 + d_2}{2} = \frac{26,75 + 23,76}{2} = 25,21 \text{ mm}$$

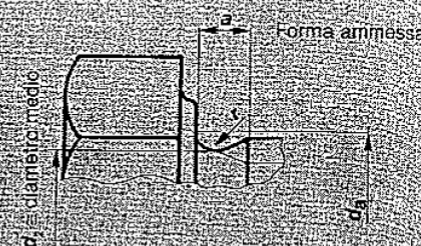
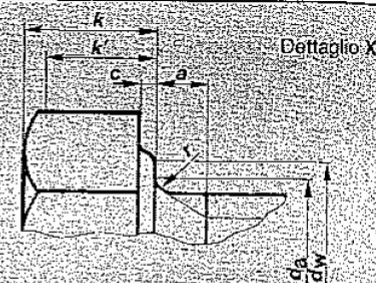
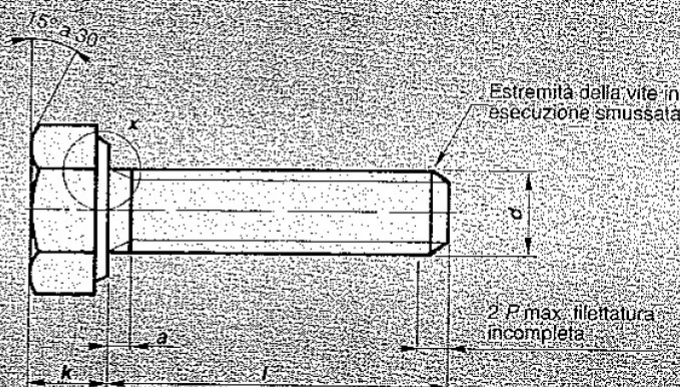
$$F_{t,Ed} = 50 \text{ kN} \leq B_{p,Rd} = 164,1 \text{ kN} \quad \text{OK!}$$



FONTANA

ESTRATTO

UNI
5739



Viti a testa esagonale con gambo interamente filettato

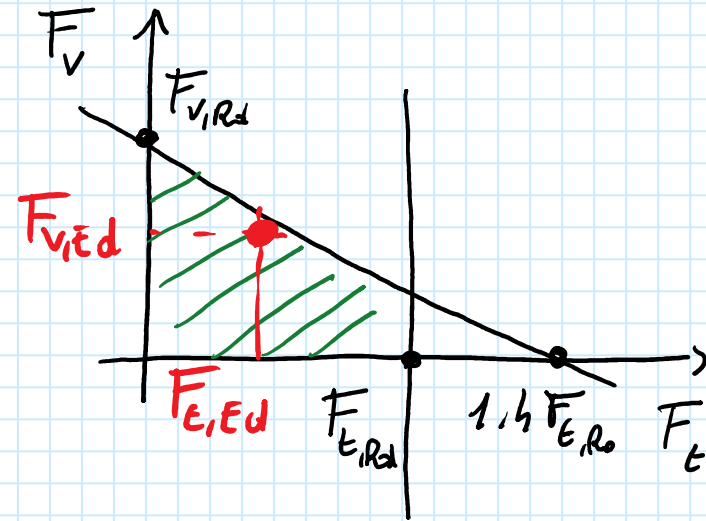
Filettatura metrica ISO a passo grosso - Categoria A

Dimensioni in mm

filettatura d		M4	M5	M6	M7	M8	M10	M12	M14	M16	M18	M20	M22	M24	M27	M30
passo P		0,7	0,8	1	1	1,25	1,5	1,75	2	2	2,5	2,5	2,5	3	3	3,5
a	max	2,1	2,4	3	3	3,75	4,5	5,25	6	6	7,5	7,5	7,5	9	9	10,5
	min	0,7	0,8	1	1	1,25	1,5	1,75	2	2	2,5	2,5	2,5	3	3	3,5
c	min	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,2	0,2	0,2	0,2	0,2	0,2	0,2
	max	0,4	0,5	0,5	0,5	0,6	0,6	0,6	0,6	0,8	0,8	0,8	0,8	0,8	0,8	0,8
d_a	max	4,7	5,7	6,8	7,8	9,2	11,2	13,7	15,7	17,7	20,2	22,4	24,4	26,4	30,4	33,4
d_w	min	5,9	6,9	8,9	9,6	11,6	15,6	17,4	20,5	22,5	25,3	28,2	30	33,6	38	42,7
e	min	7,66	8,79	11,05	12,12	14,38	18,90	21,10	24,49	26,75	30,14	35,53	35,72	39,98	45,20	50,85
k	min	2,68	3,35	3,85	4,65	5,15	6,22	7,32	8,62	9,82	11,28	12,28	13,78	14,78	16,65	18,28
	max	2,92	3,65	4,15	4,95	5,45	6,58	7,68	8,98	10,18	11,72	12,72	14,22	15,22	17,35	19,12
k'	min	1,9	2,3	2,7	3,2	3,6	4,4	5,1	6	6,9	7,9	8,6	9,6	10,3	11,7	12,8
r	min	0,2	0,2	0,25	0,25	0,4	0,4	0,6	0,6	0,6	0,6	0,8	0,8	0,8	1	1
s	max	7	8	10	11	13	17	19	22	24	27	30	32	36	41	46
	min	6,78	7,78	9,78	10,73	12,73	16,73	18,67	21,67	23,67	26,67	29,67	31,61	35,38	40	45

Bulloni sulle cerniere a taglio e l'Acciaio

$$\left\{ \begin{array}{l} \frac{F_{V,Ed}}{F_{V,Rd}} + \frac{F_{t,Ed}}{1,4 F_{t,Rd}} \leq 1 \\ F_{t,Ed} \leq F_{t,Rd} \end{array} \right.$$



Verifica e riassorbimento

Verifica e preassorbimento