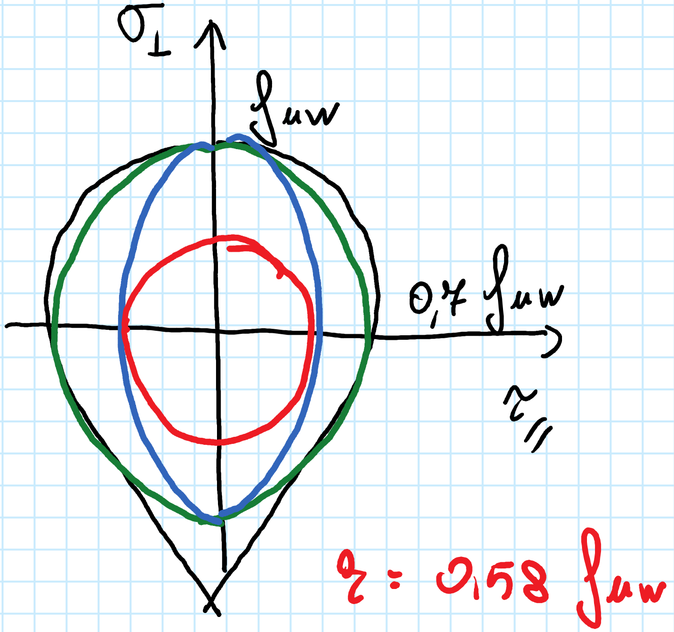
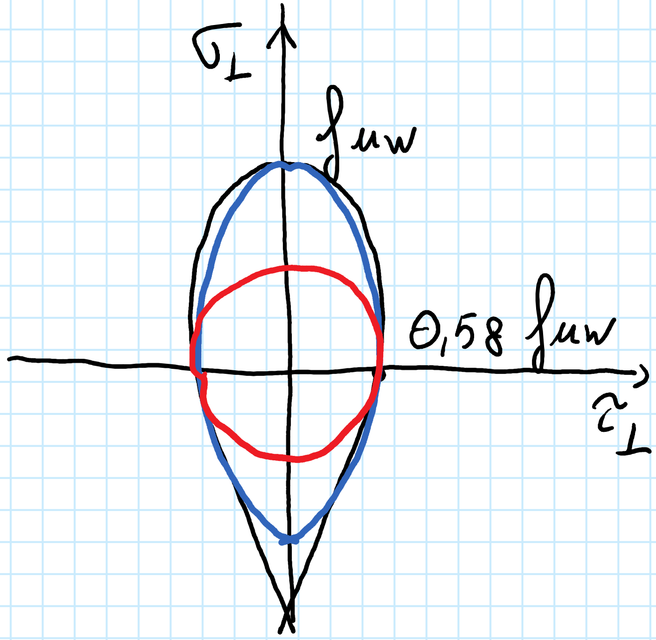




Esistono tre diversi domini, rappresentabili in forma analitica, per approssimare (a favore di sicurezza) il peroide:

1. l'ellissoide (con 3 semiassi diversi)
2. l'ellissoide di rotazione
3. la sfera

L'ellissoide

$$\left(\frac{\sigma_\perp}{f_{uw}}\right)^2 + \left(\frac{\tau_{//}}{0{,}7\, f_{uw}}\right)^2 + \left(\frac{\tau_\perp}{0{,}58\, f_{uw}}\right)^2 \leq 1$$

$$\frac{1}{0{,}7} = \sqrt{2} \qquad \frac{1}{0\,58} = \sqrt{3}$$

$$\frac{\sigma_\perp^2}{f_{uw}^2} + 2\frac{\tau_{//}^2}{f_{uw}^2} + 3\frac{\tau_\perp^2}{f_{uw}^2} \leq 1$$

$$\boxed{\sigma_{id} = \sqrt{\sigma_\perp^2 + 2\,\tau_{//}^2 + 3\,\tau_\perp^2} \leq f_{uw}}$$

L'ellissoide di rotazione

$$\left(\frac{\sigma_\perp}{f_{uw}}\right)^2 + \left(\frac{\tau_{//}}{0{,}58 f_{uw}}\right)^2 + \left(\frac{\tau_\perp}{0{,}58 f_{uw}}\right)^2 \leq 1$$

$$\frac{\sigma_\perp^2}{f_{uw}^2} + 3\frac{\tau_{//}^2}{f_{uw}^2} + 3\frac{\tau_\perp}{f_{uw}^2} \leq 1$$

$$\sqrt{\sigma_\perp^2 + 3\tau_{//}^2 + 3\tau_\perp^2} \leq f_{uw}$$

$$\boxed{\sigma_{id} = \sqrt{\sigma_\perp^2 + 3\tau^2} \leq f_{uw}}$$

Adottato da:

NTC18

EC3

Le sfere

$$\left(\frac{\sigma_\perp}{0{,}58 f_{uw}}\right)^2 + \left(\frac{\tau_{//}}{0{,}58 f_{uw}}\right)^2 + \left(\frac{\tau_\perp}{0{,}58 f_{uw}}\right)^2 \leq 1$$

$$\frac{3\sigma_\perp^2}{f_{uw}^2} + \frac{3\tau_{//}^2}{f_{uw}^2} + \frac{3\tau_\perp^2}{f_{uw}^2} \leq 1$$

$$\underbrace{\sqrt{\sigma_\perp^2 + \tau_{//}^2 + \tau_\perp^2}} \leq \frac{f_{uw}}{\sqrt{3}}$$

$$\boxed{t = \frac{R}{aL} \leq \frac{f_{uw}}{\sqrt{3}}}$$

Adottato da:

NTC 18

EC3

Ma quanto vale la resistenza unitaria di cordone f_{uw}?

$$f_{uw} = \frac{f_u}{\beta_w \gamma_{M2}}$$

β_w:
- 0,8 — S235
- 0,85 — S275
- 0,9 — S355

β_w considera che il cordone è un mix tra materiale base e metallo d'apporto (di norma di migliore qualità)

f_{uw} è la resistenza mobilitata per portare la $\sigma_\perp$

Ellissoide di tensione, formule di normativa

$$\sigma_{id} = \sqrt{\sigma_\perp^2 + 3\tau^2} \leq \frac{f_u}{\beta_w \gamma_{M2}}$$

f_u = tensione di rottura dei pezzi saldati (materiale base)

β_w =
- 0,80 S235
- 0,85 S275
- 0,90 S355

Inoltre $\sigma_\perp \leq 0{,}9 \dfrac{f_u}{\gamma_{M2}}$

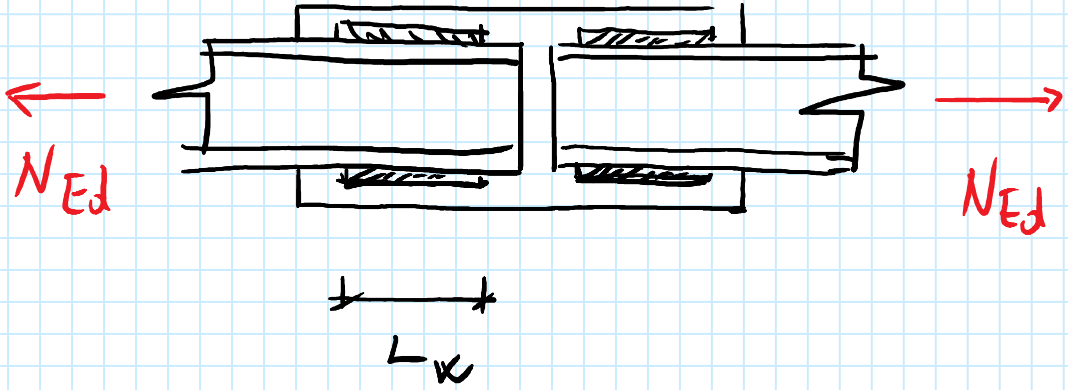
Dominio sferico, formula di normativa

$$t = \frac{R}{a\,L} \leq f_{v,w,d}$$

$$f_{v,w,d} = \frac{f_u}{\sqrt{3}\,\beta_w\,\gamma_{M2}}$$

f_u = tensione di rottura dei pezzi saldati (materiale base)

β_w =
- 0,80 S235
- 0,85 S275
- 0,90 S355



2 UPN 80 , S235

$L_w = 150$ mm

$a = 5$ mm

$N_{Ed} = 200$ KN

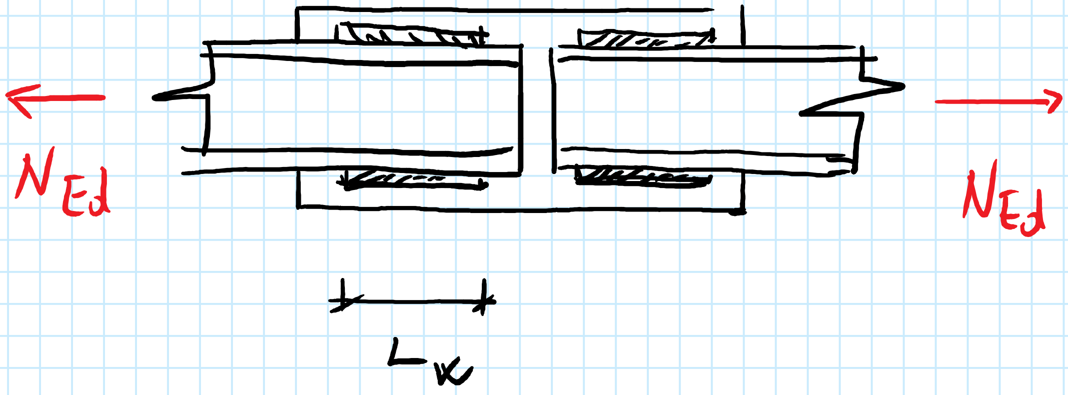
Per avere ripristino di resistenza
Verifica con dominio sferico

$$F_{w,Ed} = \frac{N_{Ed}}{4} = \frac{200}{4} = 50 \text{ KN}$$

$$t = \frac{F_{w,Ed}}{a\,L} = \frac{50}{5 \times 150} \times 10^3 = 66{,}7 \text{ MPa}$$

$t \leq f_{v,w,d}$ OK!

$$f_{v,w,d} = \frac{f_u}{\sqrt{3}\,\beta_w\,\gamma_{M2}} = \frac{360}{\sqrt{3} \times 0{,}8 \times 1{,}25} = 207{,}8 \text{ MPa}$$



2 UPN 80 , S235

$L_w = 150$ mm

$a = 5$ mm

$N_{Ed} = 200$ kN

Completo ripristino di resistenza

Verifica con dominio sferico

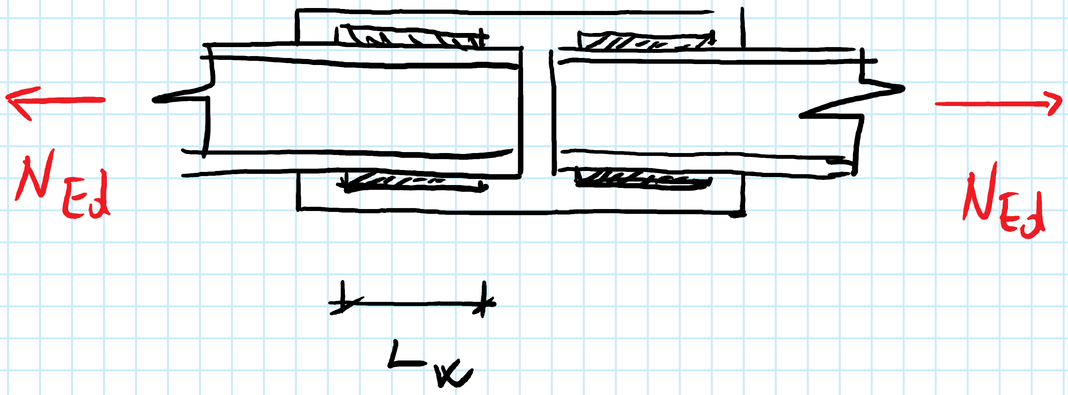
$$N_{pl,Rd} = \frac{A f_y}{\gamma_{M0}} = 22 \times \frac{235}{1,05} \times \frac{1}{10} = 492,4 \text{ kN}$$

$$F_{w,Ed} = \frac{N_{pl,Rd}}{4} = \frac{492,4}{4} = 123,1 \text{ kN}$$

$$\tau = \frac{123,1}{5 \times 150} \times 10^3 = 164,1 \text{ MPa}$$

$\tau \leq f_{v,w,d}$ OK!

$$f_{v,w,d} = \frac{f_u}{\sqrt{3}\,\beta_w\,\gamma_{M2}} = \frac{360}{\sqrt{3} \times 0,8 \times 1,25} = 207,8 \text{ MPa}$$



2 UPN 80 , S235

$L_w = 150\ mm$

$a = 5\ mm$

$N_{Ed} = 200\ KN$

completo ripristino di resistenza

Verifica con ellissoide

$$F_{w,Ed} = \frac{N_{pl,Rd}}{4} = 123{,}1\ KN$$

$$\sigma_\perp = 0 \qquad \tau = \frac{F_{w,Ed}}{a\,L} = \frac{123{,}1}{5 \times 150} \times 10^3 = 164{,}1\ MPa$$

$$\sigma_{id} = \sqrt{\sigma_\perp^2 + 3\tau^2} = \sqrt{0^2 + 3 \times 164{,}1^2} = 284{,}3\ MPa \le \frac{f_u}{\beta_w \gamma_{M2}} = \frac{360}{0{,}80 \times 1{,}25} = 360\ MPa$$

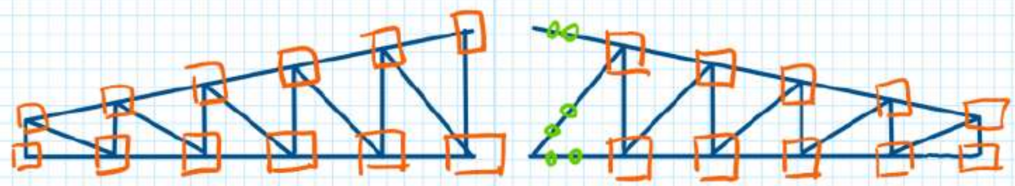
$$\sigma_{id} \le \frac{f_u}{\beta_w \gamma_{M2}} \quad OK!$$

Corrente superiore 2 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	5.46	0.00	5.46	0.00
2	104.63	81.41	-71.91	104.63	-71.91
3	135.27	98.31	-92.32	135.27	-92.32
4	139.50	94.12	-94.35	139.50	-94.35
5	131.29	80.01	-87.72	131.29	-87.72
6	131.29	55.34	-87.72	131.29	-87.72
7	139.50	48.99	-94.35	139.50	-94.35
8	135.27	40.38	-92.32	135.27	-92.32
9	104.63	26.94	-71.91	104.63	-71.91
10	0.00	0.00	0.00	0.00	0.00

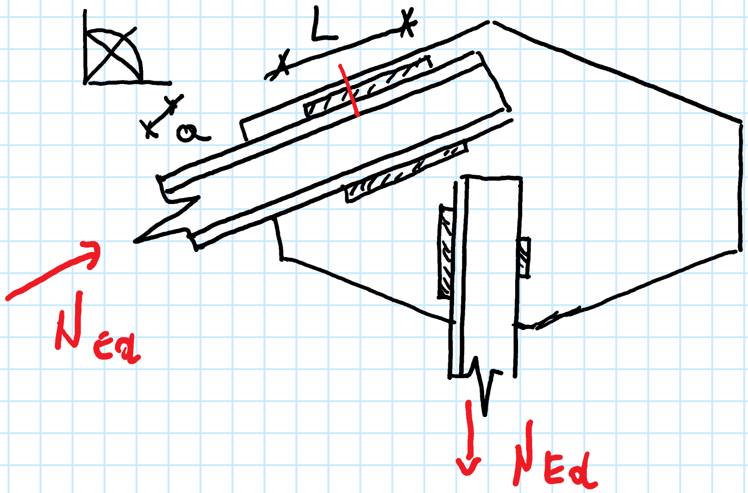
Sforzo normale del corrente superiore					
Asta	1° comb.	2° comb.	3° comb.	Max traz.	Max Comp.
11	-106.70	-77.57	74.42	74.42	-106.70
12	-137.95	-95.03	97.43	97.43	-137.95
13	-142.26	-90.98	101.67	101.67	-142.26
14	-133.89	-76.81	97.10	97.10	-133.89
15	-118.55	-57.07	87.66	87.66	-118.55
16	-118.55	-57.63	87.66	87.66	-118.55
17	-133.89	-53.32	97.10	97.10	-133.89
18	-142.26	-47.74	101.67	101.67	-142.26
19	-137.95	-39.84	97.43	97.43	-137.95
20	-106.70	-27.02	74.42	74.42	-106.70

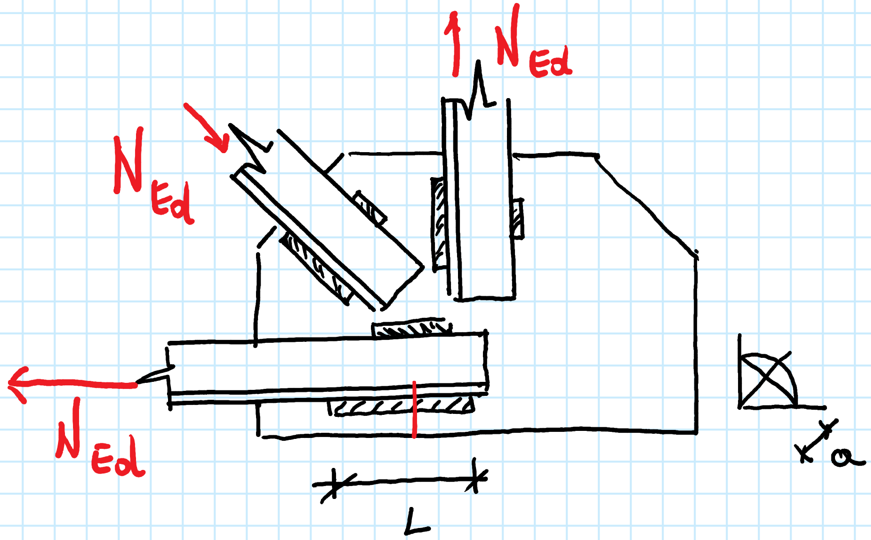
Sforzo normale dei diagonali					
Asta	1° comb.	2° comb.	3° comb.	Max traz.	Max Comp.
21	110.28	80.06	-75.80	110.28	-75.80
22	34.73	19.15	-23.14	34.73	-23.14
23	5.24	-5.20	-2.51	5.24	-5.20
24	-11.22	-19.31	9.07	9.07	-19.31
25	-22.74	-29.58	17.21	17.21	-29.58
26	-22.74	7.70	17.21	17.21	-22.74
27	-11.22	8.68	9.07	9.07	-11.22
28	5.24	10.68	-2.51	10.68	-2.51
29	34.73	15.23	-23.14	34.73	-23.14
30	110.28	28.40	-75.80	110.28	-75.80

Sforzo normale dei montanti					
Asta	1° comb.	2° comb.	3° comb.	Max traz.	Max Comp.
31	-62.00	-46.97	42.85	42.85	-62.00
32	-34.87	-25.32	23.97	23.97	-34.87
33	-16.35	-9.01	10.89	10.89	-16.35
34	-3.10	3.07	1.49	3.07	-3.10
35	7.66	13.17	-6.19	13.17	-6.19
36	34.10	16.41	-25.81	34.10	-25.81
37	7.66	-5.92	-6.19	7.66	-6.19
38	-3.10	-6.32	1.49	1.49	-6.32
39	-16.35	-7.17	10.89	10.89	-16.35
40	-34.88	-8.98	23.97	23.97	-34.88
41	-62.00	-13.93	42.85	42.85	-62.00

Nodo sul corrente superiore

Nodo sul corrente inferiore





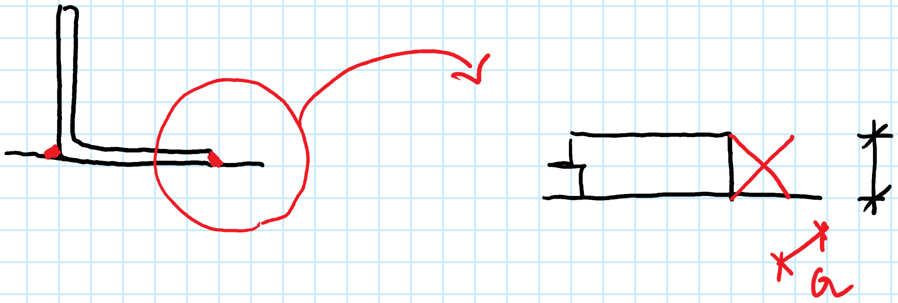
Progetto dei collegamenti saldati

Per ogni cordone bisogna dimensionare a ed L

1. Fissiamo "a" a priori
   a) unico valore di "a" per tutti i cordoni d'angolo
   b) oppure 2 valori: uno per i collegamenti più sollecitati, l'altro per quelli meno sollecitati
2. Determino L imponendo il rispetto delle verifiche allo SLU

L'altezza della sezione di gola "a" deve rispettare limiti di normative e condizioni tecnologiche

$a \geq 3$ mm   EC3, parte 1-8



$$a \leq \frac{t}{\sqrt{2}} = \frac{5}{\sqrt{2}} = 3{,}54 \text{ mm}$$

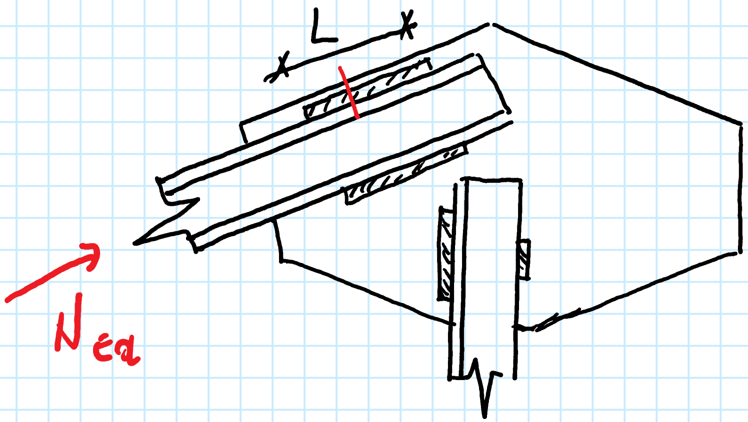
Uso cordoni con $a = 3$ mm

Utilizzo il dominio di resistenza sferico per le verifiche allo SLU dei cordoni

$$\tau = \frac{F_{w,Ed}}{a L} \leq f_{v,w,d} \Rightarrow L \geq \frac{F_{w,Ed}}{a \, f_{v,w,d}}$$

in ogni caso $L \geq 6a \geq$ **30 mm** $(6a = 6 \times 3 = 18 \text{ mm})$

Corrente superiore



$N_{Ed} = 118,6$ KN

S235

a = 3 mm

Dominio (di resistenza) sferico

$$F_{w,Ed} = \frac{N_{Ed}}{4} = \frac{118,6}{4} = 29,7 \text{ KN}$$

Le aste sono realizzate con acciaio S235 → $f_u = 360$ MPa

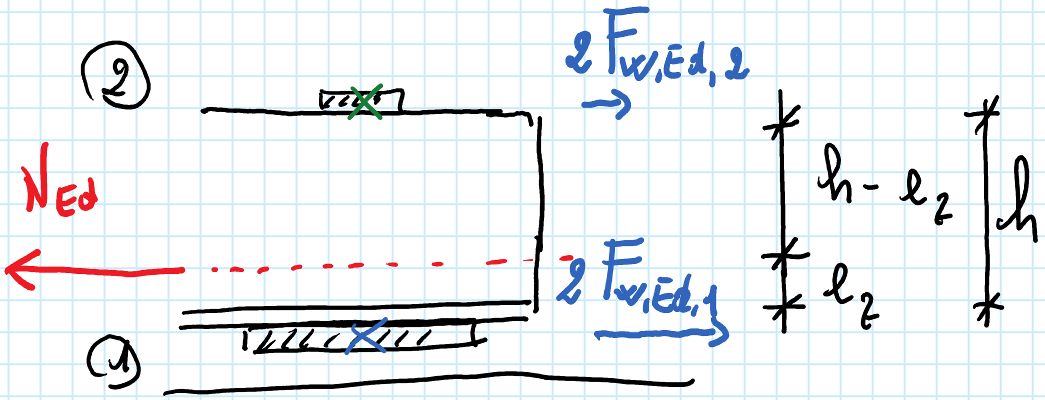
$\beta_w = 0,80$

$$f_{v,w,d} = \frac{f_u}{\sqrt{3}\,\beta_w\,\gamma_{M2}} = \frac{360}{\sqrt{3} \times 0,8 \times 1,25} = 207,8 \text{ MPa}$$

$$L = \frac{F_{w,Ed}}{a\,f_{v,w,d}} = \frac{29,7 \times 10^3}{3 \times 207,8} = ~~47,6~~ \text{ mm}$$

50 mm

Corrente inferiore



$N_{Ed} = 131,3$ kN

S235

a = 3 mm

Dominio (di resistenza) sferico

$$-N_{Ed}(h - e_z) + 2F_{w,Ed,1}\,h = 0 \quad \Rightarrow \quad F_{w,Ed,1} = \frac{h - e_z}{2h} N_{Ed}$$

$$N_{Ed}\,e_z - 2F_{w,Ed,2}\,h = 0 \quad \Rightarrow \quad F_{w,Ed,2} = \frac{e_z}{2h} N_{Ed}$$

Le forze sui due cordoni sono diverse e dunque le lunghezze saranno diverse. Per ogni cordone

$$L_i = \frac{F_{w,Ed,i}}{a\, f_{vw,d}}$$

2L 55×5 $\quad \ell_2 = 1,52$ cm $= 15,2$ mm

$$F_{w,Ed.1} = N_{Ed} \frac{h - \ell_2}{2h} = 131,3 \times \frac{55 - 15,2}{2 \times 55} = 47,5 \text{ KN}$$

$$L_1 = \frac{F_{w,Ed.1}}{a\, f_{vw,d}} = \frac{47,5 \times 10^3}{3 \times 207,8} = \sout{76,2} \text{ mm}$$

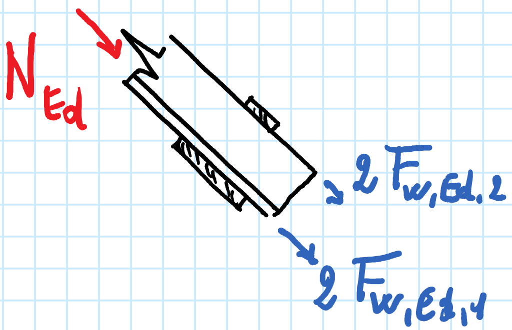
80 mm

$$F_{w,Ed.2} = N_{Ed} \frac{\ell_2}{2h} = 131,3 \times \frac{15,2}{2 \times 55} = 18,1 \text{ KN}$$

$$L_2 = \frac{F_{w,Ed.2}}{a\, f_{v,w,d}} = \frac{18,1}{3 \times 207,8} \times 10^3 = \sout{29,0} \text{ mm}$$

30 mm

Diagonale



$N_{Ed} = 29{,}6$ KN

S 235

a = 3 mm

Dominio (di resistenza) sferico

2L 50×30×5 $e_z = 1{,}73$ cm = 17,3 mm

$$F_{w,Ed,1} = \frac{(h - e_z)}{2h} N_{Ed} = \frac{50 - 17{,}3}{2 \times 50} \times 29{,}6 = 9{,}7 \text{ KN}$$

$$F_{w,Ed,2} = \frac{e_z}{2h} N_{Ed} = \frac{17{,}3}{2 \times 50} \times 29{,}6 = 5{,}1 \text{ KN}$$

$$L_1 = \frac{9{,}7 \times 10^3}{3 \times 207{,}8} = 15{,}6 \text{ mm}$$

$$15{,}6 \times \frac{30}{8{,}2} = 57{,}1 \text{ mm} \quad \rightarrow 60 \text{ mm}$$

$$L_2 = \frac{5{,}1 \times 10^3}{3 \times 207{,}8} = 8{,}2 \text{ mm} \quad \rightarrow 30 \text{ mm}$$