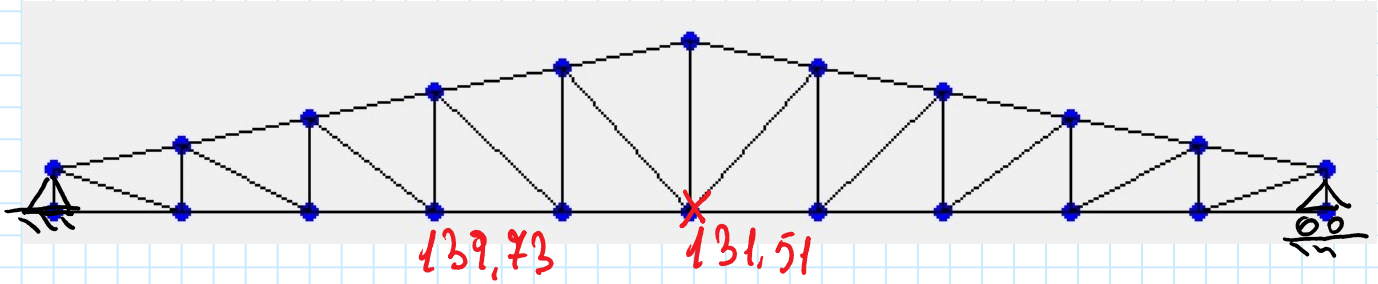
Progetto del corrente inferiore

1. Verifica della sezione netta (se ci sono aste indebolite da fori o intagli)
2. Verifica di stabilità

Vale per qualunque asta progettata a trazione

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
	Massimo N trazione			139.725	kN
	Massimo C compressione			-91.244	kN



C'è un'asta indebolita dai fori e voglio che sia duttile

Verifica di resistenza

$N_{Ed} = 131,51$ kN

$N_{Ed} \leq N_{t,Rd} = \min\left(N_{pl,Rd}, N_{u,Rd}\right)$

$N_{Ed} \leq N_{u,Rd}$

Posso non farle se faccio la verifica di duttilità

Verifica alla duttilità

$N_{pl,Rd} \leq N_{u,Rd}$

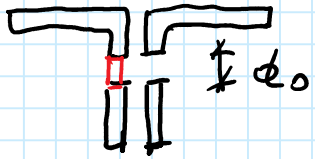
Anno scelto 2L 45×5

$N_{pl,Rd} = 192,5$ kN

d'estate se è fragile...
... cambio sezione

$$N_{u,Rd} = 0,9\, A_{net} \frac{f_u}{\gamma_{M2}} = 0,9 \times 7,3 \times \frac{360}{1,25} \times \frac{1}{10} = 189,2 \text{ kN}$$

$A_{net} = A - A_{fori}$



M12 → $d_0 = 13$ mm

$= 8{,}6 - 2 \times 0{,}5 \times 1{,}3 = 7{,}3\ cm^2$

Scelgo una sezione più grande $2L\ 50\times5 \Rightarrow A = 4{,}80\ cm^2$

Ho mantenuto lo spessore e aumentato le dimensioni delle ali

$$N_{pl,Rd} = \frac{A f_y}{\gamma_{M0}} = 2 \times 4{,}80 \times \frac{235}{1{,}05} \times \frac{1}{10} = 214{,}9\ kN$$

$$A_{net} = A - A_{fori} = 2 \times 4{,}80 - 2 \times 0{,}5 \times 1{,}3 = 8{,}3\ cm^2$$

$$N_{u,Rd} = 0{,}9\, A_{net} \frac{f_u}{\gamma_{M2}} = 0{,}9 \times 8{,}3 \times \frac{360}{1{,}25} \times \frac{1}{10} = 215{,}1\ kN$$

$N_{pl,Rd} < N_{u,Rd}$ adesso l'asta è duttile

Eseguiamo di nuovo le verifiche di resistenza

Aste imbullonate dei fori

$N_{Ed} = 131.50\ kN$ $N_{t,Rd} = \min(N_{pl,Rd}, N_{u,Rd}) = 215,1\ kN$

$N_{Ed} < N_{t,Rd}$ OK!

Aste maggiormente sollecitate

$N_{Ed} = 139,73\ kN$ $N_{t,Rd} = N_{pl,Rd} = 215,1\ kN$

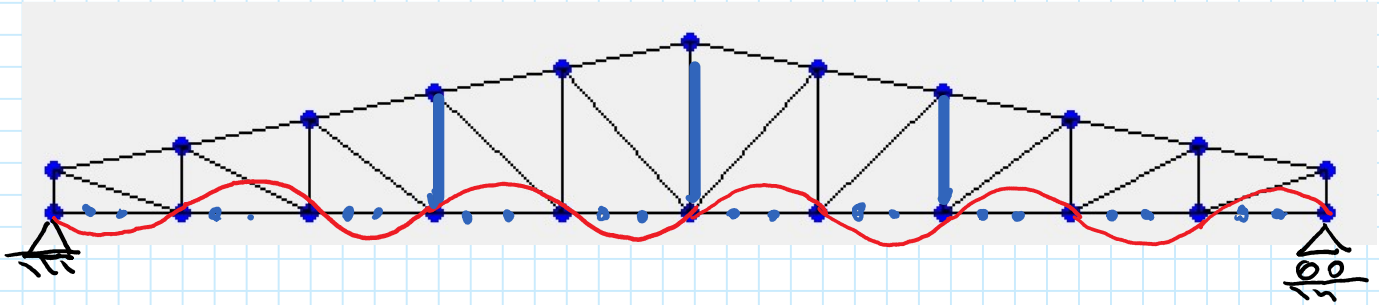
$N_{Ed} < N_{t,Rd}$ OK!

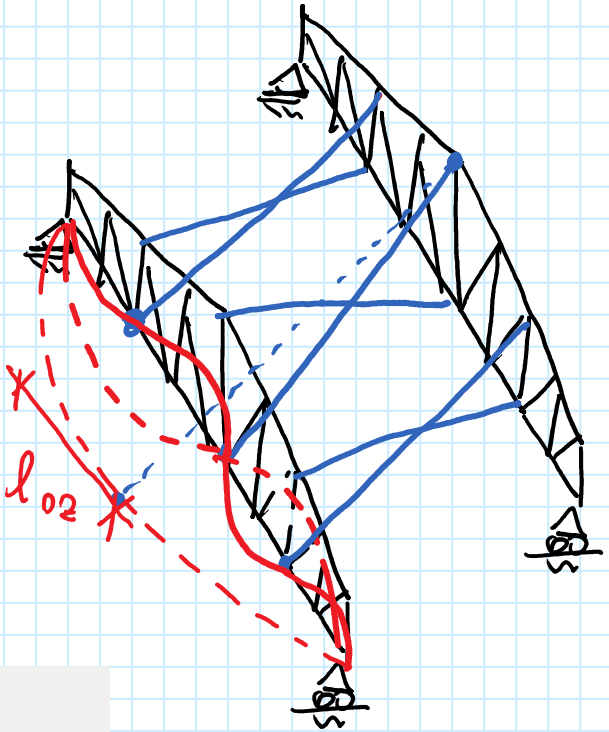
Verifica a compressione del corrente inferiore

Il corrente inferiore è compreso nelle 3° combinazione di carico.

Le lunghezze libere di inflessione nei piani verticale e orizzontale sono diverse.

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
	Massimo N trazione			139.725	kN
	Massimo C compressione			-91.244	kN





$l_{0y} = i$

Bisogna controllare:

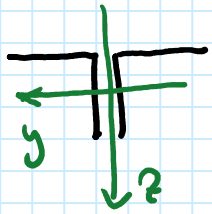
1. Limiti di snellezza delle NTC 18

$\lambda \leq 200$

$\lambda_z \leq 200$

$\lambda_y \leq 200$

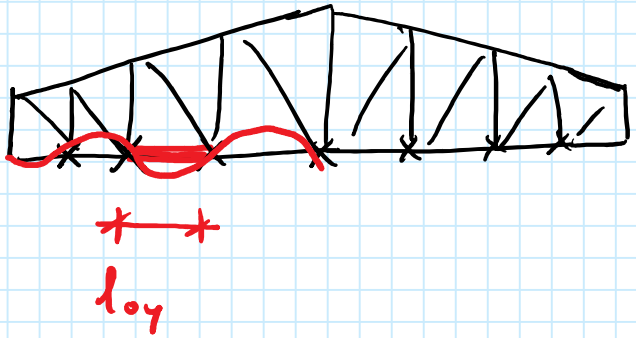
2. Verifica di stabilità nei due piani

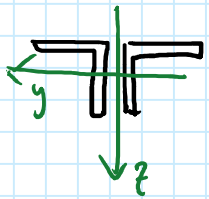


Nel piano verticale $N_{Ed} = N_{max} \leq N_{b,Rd,y}$

Nel piano orizzontale $N_{Ed} = N_{max,lo} \leq N_{b,Rd,z}$

Verifica della snellezza nel piano verticale...



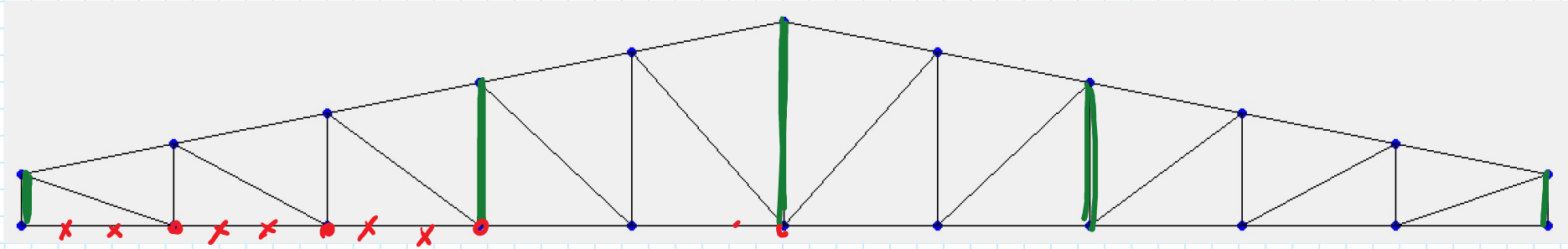


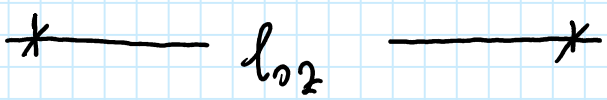
$l_{0y} = i = 1{,}50$ m

$i_y = 1{,}51$ cm

$\lambda_y = \frac{150}{1{,}51} = 99{,}3 < 200$ (NTC 18)

Verifica della snellezza nel piano orizzontale...





$l_{02} = 3\,i = 4{,}5$ m

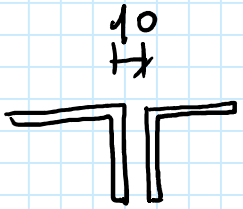
$i_2 = 2{,}43$ cm

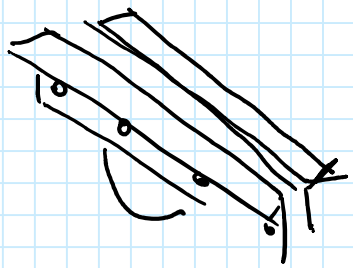
$\lambda_2^{2L} = \frac{450}{2{,}43} = 185{,}2$

$l_{02}^{1L} = \frac{450}{9} = 50$ cm

$l_2^{1L} = i_{min}^{1L} = 0{,}97$ cm

$\lambda_2^{1L} = \frac{50}{0{,}97} = 51{,}5$





$\lambda_{2,tp} = \sqrt{(\lambda_2^{2L})^2 + (\lambda_2^{1L})^2} = \sqrt{185{,}2^2 + 51{,}5^2} =$

$= 192{,}3 < 200$

Verifica di stabilità del tratto lungo

NO

$$N_{Ed} : \frac{0 + 69{,}6 + 89{,}3}{3} = 53{,}0 \text{ KN} > N_{b,Rd,2} = 43{,}1 \text{ KN}$$

Profilo =	2 L 50 x 5		Acciaio =	S235	f_{yk} =	235 MPa			
Doppio profilo	SI		GammaM1=	1.05	f_{uk} =	360 MPa			
Distanza =	1	cm			E_s =	210000 MPa			
					2256				
Area =	9.6	cm^2							
ρ_y =	1.51	cm	l_{oy} =	150.0 cm			λ_y =	99.1	
ρ_z =	2.43	cm	l_{oz} =	450.0 cm			λ_z =	185.2	$\lambda_{z\,eq}$ = 192.3
$\rho_{min\ SP}$ =	0.97	cm	$l_{o\ SP}$ =	50.0 cm			$\lambda_{min\ SP}$ =	51.5	
Curva =	b	α_y =	0.34	$N_{cr,y}$ =	202.5	kN	λ_{Sy} =	1.06	
Curva =	b	α_z =	0.34	$N_{cr,z}$ =	53.8	kN	λ_{Sz} =	2.05	
ϕ_y =	1.2026	χ_y =	0.5622	$N_{b,Rd,y}$ =	120.79	kN			
ϕ_z =	2.9122	χ_z =	0.2007	$N_{b,Rd,z}$ =	43.12	kN			
		χ_{min} =	0.2007	$N_{b,Rd}$ =	43.12	kN			

Combio maiorne trasversale e uso 2L 55×5

Piano verticale

$N_{Ed} = 91,2 \leq N_{b,Rd,y} = 148,1\ KN$ OK!

Piano orizzontale

Tratto lungo

$N_{Ed} = 53,1\ KN < N_{b,Rd,z} = 54,7\ KN$ OK!

Tratto corto

$N_{Ed} = \frac{91,2 + 84,8}{2} = 88,0\ KN$ Ok!

$N_{Ed} = 88,0\ KN < N_{b,Rd,z} = 99,5\ KN$

Traliccio diagonale

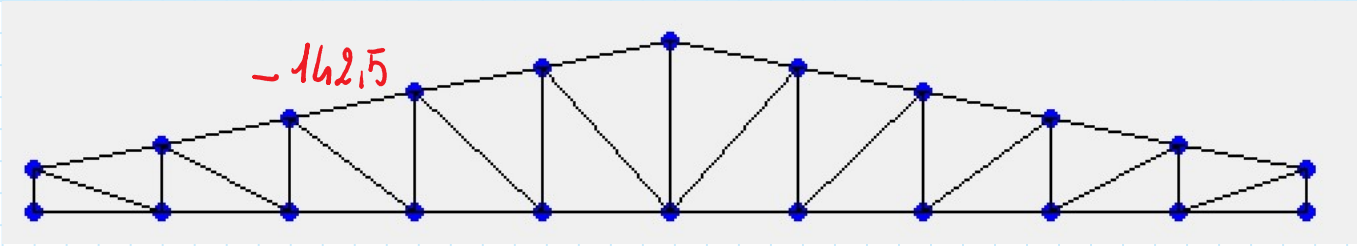
Profilo =	2 L 55 x 5		Acciaio =	S235	f_{yk} =	235	MPa		
Doppio profilo	SI		GammaM1=	1.05	f_{uk} =	360	MPa		
Distanza =	1	cm			E_s =	210000	MPa		
Area =	10.6	cm^2							
ρ_y =	1.66	cm	l_{oy} =	150.0 cm		λ_y =	90.2		
ρ_z =	2.62	cm	l_{oz} =	450.0 cm		λ_z =	172.0	$\lambda_{z\,eq}$ =	178.3
$\rho_{min\ SP}$ =	1.07	cm	$l_{o\ SP}$ =	50.0 cm		$\lambda_{min\ SP}$ =	46.7		
Curva =	b	α_y =	0.34	$N_{cr,y}$ =	270.5	kN	λ_{Sy} =	0.96	
Curva =	b	α_z =	0.34	$N_{cr,z}$ =	69.3	kN	λ_{Sz} =	1.90	
ϕ_y =	1.0915	χ_y =	0.6217	$N_{b,Rd,y}$ =	148.05	kN			
ϕ_z =	2.5919	χ_z =	0.2296	$N_{b,Rd,z}$ =	54.67	kN			
		χ_{min} =	0.2296	$N_{b,Rd}$ =	54.67	kN			

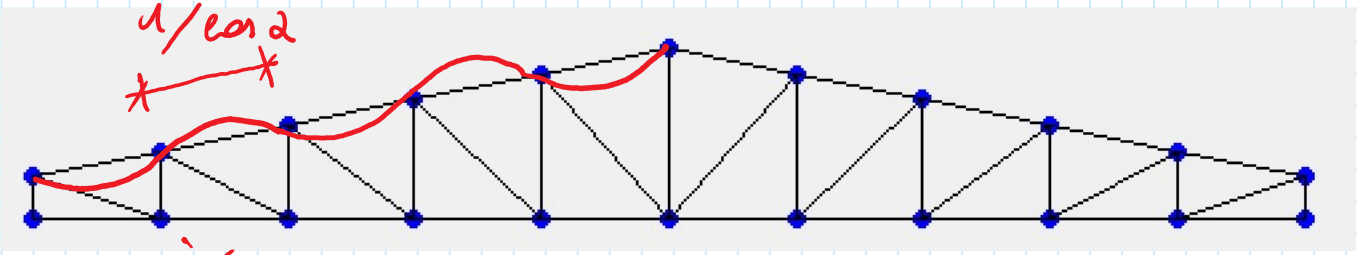
Tratto corto

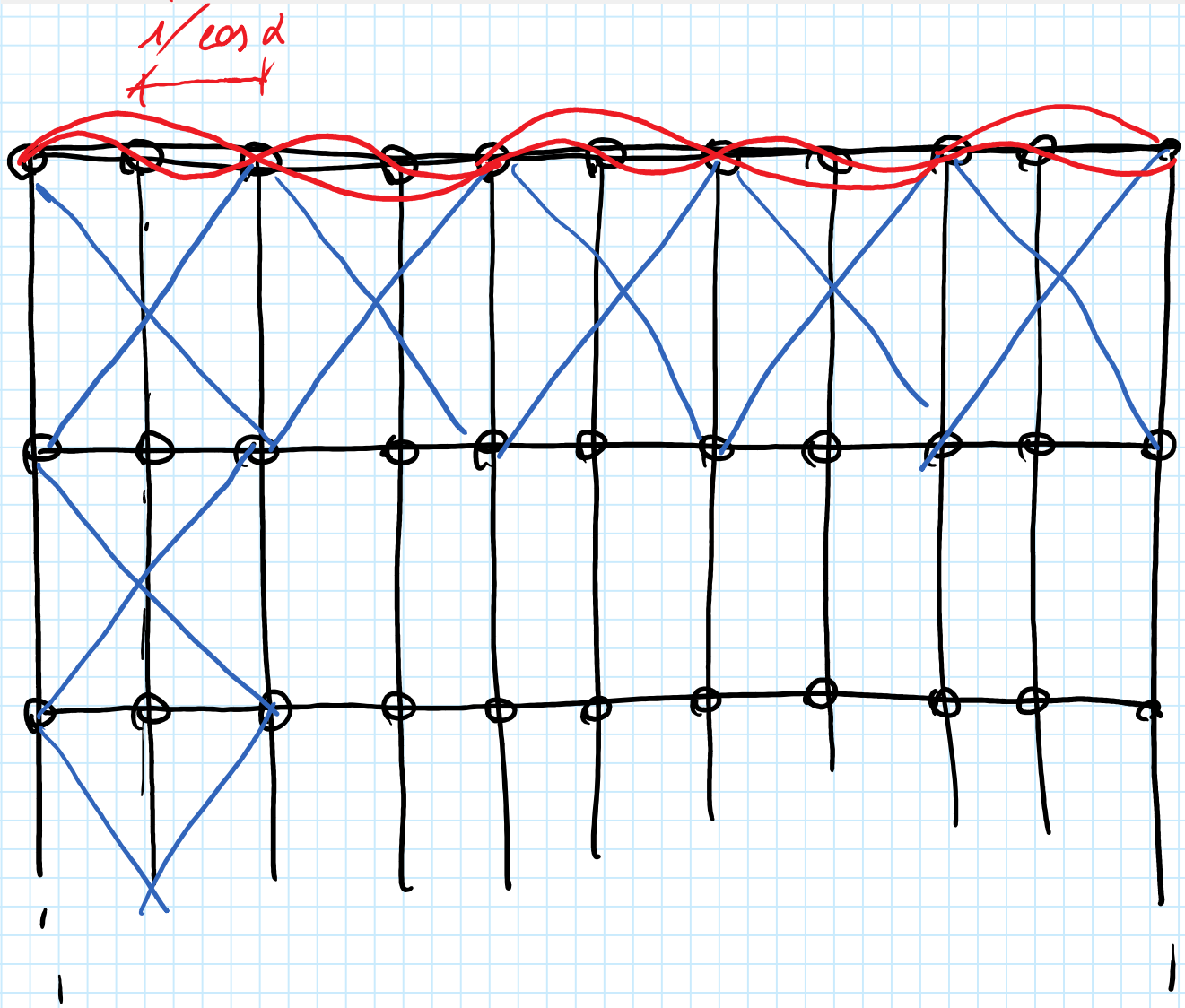
Profilo =	2 L 55 x 5		Acciaio =	S235	f_{yk} =	235	MPa		
Doppio profilo	SI		GammaM1=	1.05	f_{uk} =	360	MPa		
Distanza =	1	cm			E_s =	210000	MPa		
Area =	10.6	cm^2							
ρ_y =	1.66	cm	l_{oy} =	150.0 cm		λ_y =	90.2		
ρ_z =	2.62	cm	l_{oz} =	300.0 cm		λ_z =	114.7	$\lambda_{z\,eq}$ =	123.8
$\rho_{min\ SP}$ =	1.07	cm	$l_{o\ SP}$ =	50.0 cm		$\lambda_{min\ SP}$ =	46.7		
Curva =	b	α_y =	0.34	$N_{cr,y}$ =	270.5	kN	λ_{Sy} =	0.96	
Curva =	b	α_z =	0.34	$N_{cr,z}$ =	143.7	kN	λ_{Sz} =	1.32	
ϕ_y =	1.0915	χ_y =	0.6217	$N_{b,Rd,y}$ =	148.05	kN			
ϕ_z =	1.5605	χ_z =	0.4177	$N_{b,Rd,z}$ =	99.47	kN			
		χ_{min} =	0.4177	$N_{b,Rd}$ =	99.47	kN			

Progetto del corrente superiore

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
	Massimo N trazione			98.384	kN
	Massimo C compressione			-142.492	kN







La lunghezza libera d'inflessione è uguale a l/cos α sia nel piano verticale che in quello delle falde

$$N_{Ed} = -142{,}5 \quad kN$$

$$N_{Ed} \leq N_{b,Rd} = \chi A \frac{f_y}{\gamma_{M1}}$$

$$N_{Ed} \leq \chi A \frac{f_y}{\gamma_{M1}} \Rightarrow A = \frac{\gamma_{M1} N_{Ed}}{\chi f_y}$$

$$\chi \leq 1 \qquad \chi = 0{,}5$$

$$A = \frac{1{,}05 \times 142{,}5}{0{,}5 \times 235} \times \frac{10^3}{10^2} = 12{,}73 \ cm^2$$

Uso 2 UPN 50x38 $\Rightarrow$ $A = 14{,}2 \ cm^2$

2 UPN 50x38

$N_{Ed} = 142{,}7\ kN < N_{b,Rd} = 193{,}7\ kN$

Calcolare $N_{b,Rd}$

OK!

$$l_0 = \frac{i}{\cos\alpha} = \frac{150}{\cos 11°3} = 153\ cm$$

Profilo =	2 UPN 50 x 38		Acciaio =	S235	f_{yk} =	235	MPa		
Doppio profilo	SI		GammaM1=	1.05	f_{uk} =	360	MPa		
Distanza =	1	cm			E_s =	210000	MPa		
Area =	14.2	cm^2							
ρ_y =	1.92	cm	l_{oy} =	153.0 cm		λ_y =	79.7		
ρ_z =	2.19	cm	l_{oz} =	153.0 cm		λ_z =	70.0	$\lambda_{z\,eq}$ =	83.3
$\rho_{min\ SP}$ =	1.13	cm	$l_{o\ SP}$ =	51.0 cm		$\lambda_{min\ SP}$ =	45.1		
Curva =	c	α_y =	0.49	$N_{cr,y}$ =	464.3 kN		λ_{Sy} =	0.85	
Curva =	c	α_z =	0.49	$N_{cr,z}$ =	425.1 kN		λ_{Sz} =	0.89	
ϕ_y =	1.0194	χ_y =	0.6315	$N_{b,Rd,y}$ =	201.25	kN			
ϕ_z =	1.0620	χ_z =	0.6077	$N_{b,Rd,z}$ =	193.66	kN			
		χ_{min} =	0.6077	$N_{b,Rd}$ =	193.66	kN			

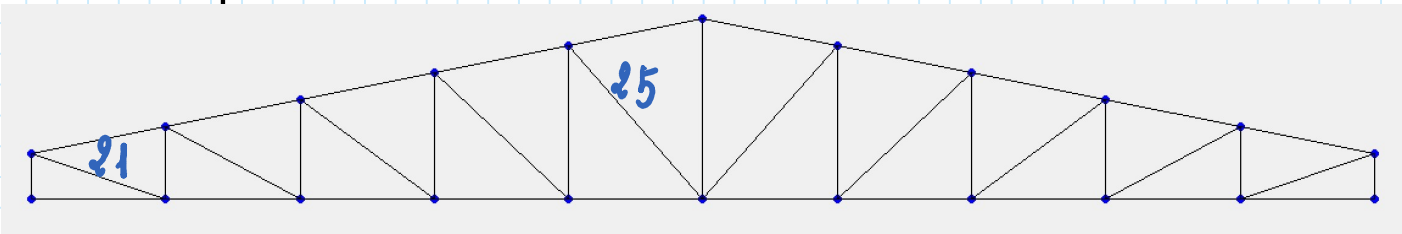
Progetto dei diagonali

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
	Massimo N trazione			110.462	kN
	Massimo C compressione			-73.315	kN

① Progetto a trazione $N_{Ed} = 110,46$ kN (asta 21)

② Verifico asta 21 a compressione $N_{Ed} = -73,32$ kN max compressione

③ Verifico asta 25 a compressione $N_{Ed} = -31,59$ kN max sollecit.



Progetto dei montanti

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
	Massimo N trazione			41.455	kN
	Massimo C compressione			-62.1	kN

① Progetto a compressione asta 31 $N_{Ed} = -43{,}32$ kN max compressione

② Verifica a compressione asta 36 $N_{Ed} = -24{,}99$ kN max sollecitazione