AKCE:

Komunikace pro cyklisty v úseku Čížov - Zbořený Kostelec - Týnec nad Sázavou

ZADAVATEL:

Středočeský kraj

STŘEDOČEKÝ KRAJ
Zborovská 11
150 21 Praha 5

JTSK | Bpv

ZHOTOVITEL :

NOVÁK&PARTNER
INŽENÝRSKÁ PROJEKTOVÁ KANCELÁŘ

120 00 Praha 2, Perucká 5
tel: 221 592 050
fax: 221 592 070
info@novak-partner.cz

vypracoval	Ing. Tomáš Hanslík		investor	Středočeský kraj
zodp. projektant	Ing. Tomáš Hanslík		zak. číslo	13NO03013
hlavní inženýr	Ing. Vladimír Engler		datum	11/2013
tech. kontrola	Ing. Milan Šístek		stupeň	PDPS
obsah:			měřítko	
SO 201 - LÁVKA PŘES SÁZAVU			paré :	
příloha:			**18**	
Statický výpočet				

1. Úvod

1.1. Materiály

Jméno	Typ	Jednotková hmotnost [kg/m³]	E [MPa]	Poisson - nu	G [MPa]	Tep.roztaž. [m/mK]
S 235	Ocel	7850,00	2,1000e+005	0,3	8,0769e+004	0,00

Jméno	Typ	Jednotková hmotnost [kg/m³]	E [MPa]	Poisson - nu	G [MPa]	Tep.roztaž. [m/mK]	Typ dřeva
C22	Dřevo	340,00	1,0000e+004	0	6,3000e+002	0,00	Tělesa
GL24h	Dřevo	380,00	1,1600e+004	0	7,2000e+002	0,00	Lepené, laminované

Jméno	Typ	Jednotková hmotnost [kg/m³]	E [MPa]	Poisson - nu	G [MPa]	Tep.roztaž. [m/mK]	Charakteristická válcová pevnost v tlaku fck(28) [MPa]
C12/15	Beton	2500,00	2,7000e+004	0,2	1,1250e+004	0,00	12,00

Jméno	Typ	Jednotková hmotnost [kg/m³]	E [MPa]	Poisson - nu	G [MPa]	Tep.roztaž. [m/mK]	Typ dřeva
GL24hPOD	Dřevo	380,00	1,1600e+003	0	7,2000e+002	0,00	Lepené, laminované

1.2. Průřezy

Jméno	Pas	
Typ	RECT	
Detailní	220; 1300	
Materiál	GL24h	
Výroba	Dřevo	
Vzpěr y-y, z-z	b	b
Výpočet FEM	×	

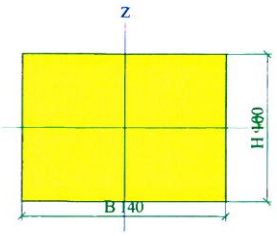
Obrázek

A [m²]	2,8600e-001	
A y, z [m²]	2,8600e-001	2,8600e-001
I y, z [m⁴]	4,0278e-002	1,1535e-003
I w [m⁶], t [m⁴]	0,0000e+000	4,1510e-003
Wel y, z [m³]	6,1967e-002	1,0487e-002
Wpl y, z [m³]	9,2950e-002	1,5730e-002
d y, z [mm]	0	0
c YLSS, ZLSS [mm]	110	650
alfa [deg]	0,00	
AL [m²/m]	3,0400e+000	

Jméno	Sloup	
Typ	RECT	
Detailní	140; 100	

Materiál	C22	
Výroba	Dřevo	
Vzpěr y-y, z-z	b	b
Výpočet FEM	×	

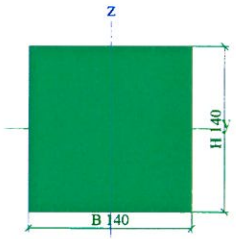
Obrázek



A [m²]	1,4000e-002	
A y, z [m²]	1,4000e-002	1,4000e-002
I y, z [m⁴]	1,1667e-005	2,2867e-005
I w [m⁶], t [m⁴]	0,0000e+000	3,7412e-005
Wel y, z [m³]	2,3333e-004	3,2667e-004
Wpl y, z [m³]	3,5000e-004	4,9000e-004
d y, z [mm]	0	0
c YLSS, ZLSS [mm]	70	50
alfa [deg]	0,00	
AL [m²/m]	4,8000e-001	

Jméno	Diag	
Typ	RECT	
Detailní	140; 140	
Materiál	C22	
Výroba	Dřevo	
Vzpěr y-y, z-z	b	b
Výpočet FEM	×	

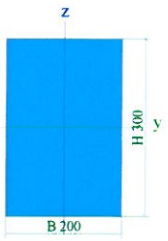
Obrázek



A [m²]	1,9600e-002	
A y, z [m²]	1,9600e-002	1,9600e-002
I y, z [m⁴]	3,2013e-005	3,2013e-005
I w [m⁶], t [m⁴]	0,0000e+000	8,1493e-005
Wel y, z [m³]	4,5733e-004	4,5733e-004
Wpl y, z [m³]	6,8600e-004	6,8600e-004
d y, z [mm]	0	0
c YLSS, ZLSS [mm]	70	70
alfa [deg]	0,00	
AL [m²/m]	5,6000e-001	

Jméno	Pric	
Typ	RECT	
Detailní	200; 300	
Materiál	GL24h	
Výroba	Dřevo	
Vzpěr y-y, z-z	b	b
Výpočet FEM	×	

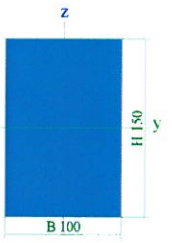
Obrázek	



A [m²]	6,0000e-002	
A y, z [m²]	6,0000e-002	6,0000e-002
I y, z [m⁴]	4,5000e-004	2,0000e-004
I w [m⁶], t [m⁴]	0,0000e+000	6,5794e-004
Wel y, z [m³]	3,0000e-003	2,0000e-003
Wpl y, z [m³]	4,5000e-003	3,0000e-003
d y, z [mm]	0	0
c YLSS, ZLSS [mm]	100	150
alfa [deg]	0,00	
AL [m²/m]	1,0000e+000	

Jméno	Podel	
Typ	RECT	
Detailní	100; 150	
Materiál	GL24hPOD	
Výroba	Dřevo	
Vzpěr y-y, z-z	b	b
Výpočet FEM	×	

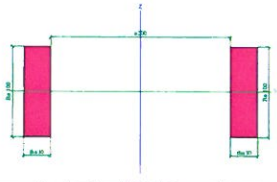
Obrázek	



A [m²]	1,5000e-002	
A y, z [m²]	1,5000e-002	1,5000e-002
I y, z [m⁴]	2,8125e-005	1,2500e-005
I w [m⁶], t [m⁴]	0,0000e+000	4,1122e-005
Wel y, z [m³]	3,7500e-004	2,5000e-004
Wpl y, z [m³]	5,6250e-004	3,7500e-004
d y, z [mm]	0	0
c YLSS, ZLSS [mm]	50	75
alfa [deg]	0,00	
AL [m²/m]	5,0000e-001	

Jméno	Ztuz Zabr	
Typ	2 Rect.	
Detailní	30; 100; 200	
Materiál	GL24h	
Výroba	Dřevo	
Vzpěr y-y, z-z	b	b
Výpočet FEM	×	

Obrázek	

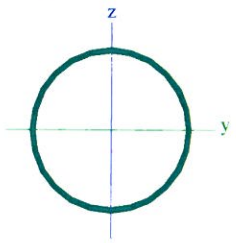


A [m²]	6,0000e-003	

A y, z [m²]	6,0000e-003	6,0000e-003
I y, z [m⁴]	5,0000e-006	7,9800e-005
I w [m⁶], t [m⁴]	0,0000e+000	4,0522e-007
Wel y, z [m³]	1,0000e-004	6,1385e-004
Wpl y, z [m³]	1,5000e-004	6,9000e-004
d y, z [mm]	0	0
c YLSS, ZLSS [mm]	130	50
alfa [deg]	0,00	
AL [m²/m]	5,2000e-001	

Jméno	Pylon	
Typ	CHS508.0/16.0	
Zdroj hodnot	British Standard / BS 5950 part 1 : 1990 & EN 10210-2	
Materiál	S 235	
Výroba	válcovaný	
Vzpěr y-y, z-z	a	a

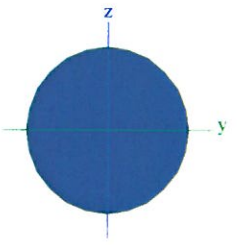
Obrázek



A [m²]	2,4700e-002	
A y, z [m²]	1,5725e-002	1,5725e-002
I y, z [m⁴]	7,4910e-004	7,4910e-004
I w [m⁶], t [m⁴]	0,0000e+000	1,4966e-003
Wel y, z [m³]	2,9490e-003	2,9490e-003
Wpl y, z [m³]	3,8133e-003	3,8133e-003
d y, z [mm]	0	0
c YLSS, ZLSS [mm]	0	0
alfa [deg]	0,00	
AL [m²/m]	1,6118e+000	

Jméno	Lano	
Typ	RD60	
Zdroj hodnot	Stahl im Hochbau / 14.Auflage Band I / Teil 1	
Materiál	S 235	
Výroba	válcovaný	
Vzpěr y-y, z-z	c	c
Výpočet FEM	×	

Obrázek

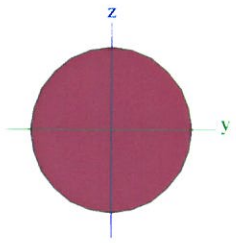


A [m²]	2,8260e-003	
A y, z [m²]	2,4021e-003	2,4021e-003
I y, z [m⁴]	6,2284e-007	6,2284e-007
I w [m⁶], t [m⁴]	0,0000e+000	1,2457e-006
Wel y, z [m³]	2,0761e-005	2,0761e-005
Wpl y, z [m³]	3,5432e-005	3,5432e-005
d y, z [mm]	0	0
c YLSS, ZLSS [mm]	0	0
alfa [deg]	0,00	

AL [m²/m]	1,8849e-001	

Jméno	Zaves	
Typ	RD20	
Zdroj hodnot	Stahl im Hochbau / 14.Auflage Band I / Teil 1	
Materiál	S 235	
Výroba	válcovaný	
Vzpěr y-y, z-z	c	c
Výpočet FEM	×	

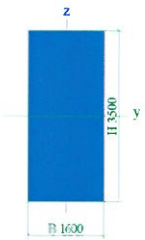
Obrázek



A [m²]	3,1400e-004	
A y, z [m²]	2,6690e-004	2,6690e-004
I y, z [m⁴]	7,6894e-009	7,6894e-009
I w [m⁶], t [m⁴]	0,0000e+000	1,5379e-008
Wel y, z [m³]	7,6894e-007	7,6894e-007
Wpl y, z [m³]	1,3123e-006	1,3123e-006
d y, z [mm]	0	0
c YLSS, ZLSS [mm]	0	0
alfa [deg]	0,00	
AL [m²/m]	6,2829e-002	

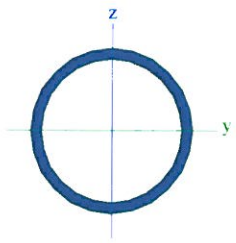
Jméno	Pilir	
Typ	RECT	
Detailní	3500; 1600	
Materiál	C12/15	
Výroba	beton	
Vzpěr y-y, z-z	b	b
Výpočet FEM	×	

Obrázek



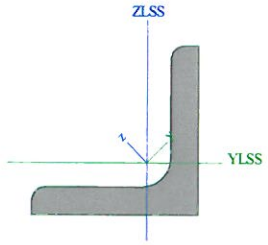
A [m²]	5,6000e+000	
A y, z [m²]	4,6667e+000	4,6667e+000
I y, z [m⁴]	5,7167e+000	1,1947e+000
I w [m⁶], t [m⁴]	0,0000e+000	3,3716e+000
Wel y, z [m³]	3,2667e+000	1,4933e+000
Wpl y, z [m³]	4,9000e+000	2,2400e+000
d y, z [mm]	0	0
c YLSS, ZLSS [mm]	800	1750
alfa [deg]	0,00	
AL [m²/m]	1,0200e+001	

Jméno	Pilon_vz	
Typ	CHS244.5/16.0	
Zdroj hodnot	British Standard / BS 5950 part 1 : 1990 & EN 10210-2	
Materiál	S 235	
Výroba	válcovaný	
Vzpěr y-y, z-z	a	a

Obrázek	

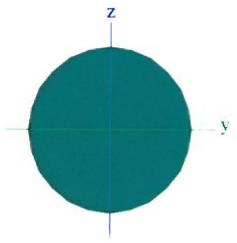
A [m²]	1,1500e-002	
A y, z [m²]	7,3211e-003	7,3211e-003
I y, z [m⁴]	7,5330e-005	7,5330e-005
I w [m⁶], t [m⁴]	0,0000e+000	1,4992e-004
Wel y, z [m³]	6,1600e-004	6,1600e-004
Wpl y, z [m³]	8,2357e-004	8,2357e-004
d y, z [mm]	0	0
c YLSS, ZLSS [mm]	0	0
alfa [deg]	0,00	
AL [m²/m]	7,8408e-001	

Jméno	Vodor Ztuz	
Typ	L30X5	
Zdroj hodnot	Stahl im Hochbau / 14.Auflage Band I / Teil 1	
Materiál	S 235	
Výroba	válcovaný	
Vzpěr y-y, z-z	c	c

Obrázek	

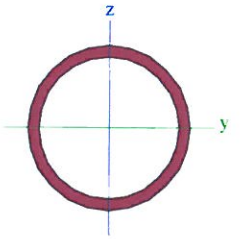
A [m²]	2,7800e-004	
A y, z [m²]	1,1655e-004	1,1601e-004
I y, z [m⁴]	9,1651e-009	3,4101e-008
I YLSS, ZLSS [m⁴]	2,1600e-008	2,1600e-008
I w [m⁶], t [m⁴]	0,0000e+000	2,5000e-009
Wel y, z [m³]	7,0592e-007	1,6075e-006
Wpl y, z [m³]	1,3697e-006	2,6406e-006
d y, z [mm]	10	0
c YLSS, ZLSS [mm]	21	9
alfa [deg]	45,00	
IYZLSS [m⁴]	1,2468e-008	
AL [m²/m]	1,1569e-001	

Jméno	Vodor Ztuz1	
Typ	RD35	
Zdroj hodnot	Stahl im Hochbau / 14.Auflage Band I / Teil 1	
Materiál	S 235	
Výroba	válcovaný	
Vzpěr y-y, z-z	c	c
Výpočet FEM	×	

Obrázek	

A [m²]	9,6162e-004	
A y, z [m²]	8,1738e-004	8,1738e-004
I y, z [m⁴]	7,2118e-008	7,2118e-008
I w [m⁶], t [m⁴]	0,0000e+000	1,4424e-007
Wel y, z [m³]	4,1210e-006	4,1210e-006
Wpl y, z [m³]	7,0331e-006	7,0331e-006
d y, z [mm]	0	0
c YLSS, ZLSS [mm]	0	0
alfa [deg]	0,00	
AL [m²/m]	1,0995e-001	

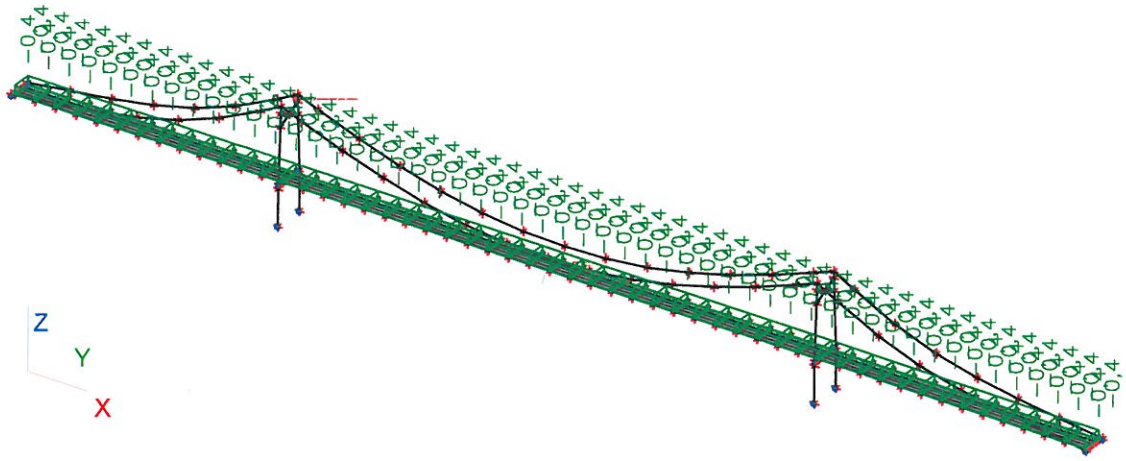
Jméno	Vodor Ztuz2	
Typ	RO70X5	
Zdroj hodnot	Stahl im Hochbau / 14.Auflage Band I / Teil 1	
Materiál	S 235	
Výroba	válcovaný	
Vzpěr y-y, z-z	a	a

Obrázek	

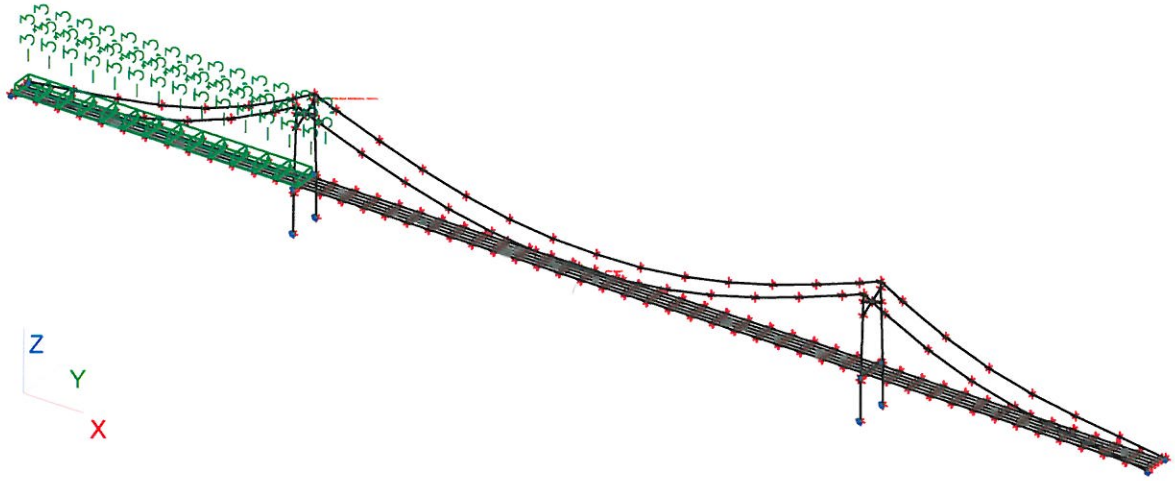
A [m²]	1,0200e-003	
A y, z [m²]	6,4935e-004	6,4935e-004
I y, z [m⁴]	5,4200e-007	5,4200e-007
I w [m⁶], t [m⁴]	0,0000e+000	1,0784e-006
Wel y, z [m³]	1,5500e-005	1,5500e-005
Wpl y, z [m³]	2,1000e-005	2,1000e-005
d y, z [mm]	0	0
c YLSS, ZLSS [mm]	0	0
alfa [deg]	0,00	
AL [m²/m]	2,2490e-001	

2. Zatěžovací stavy

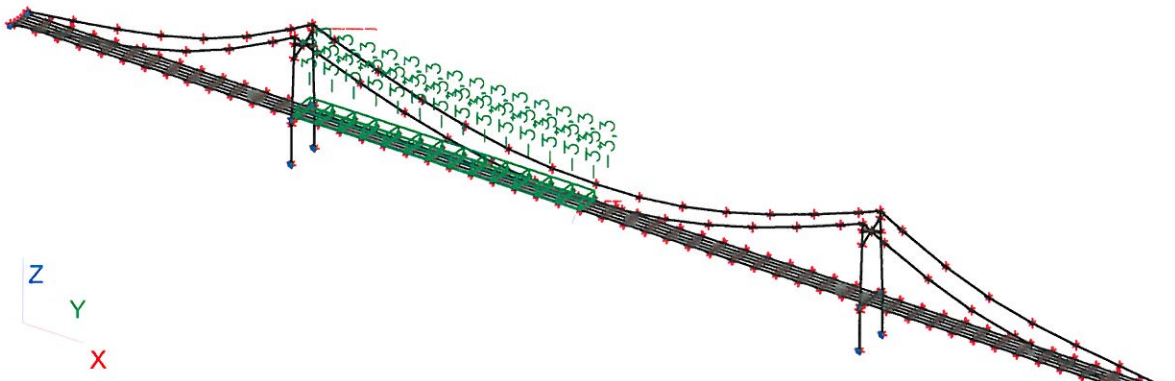
2.1. Ost st



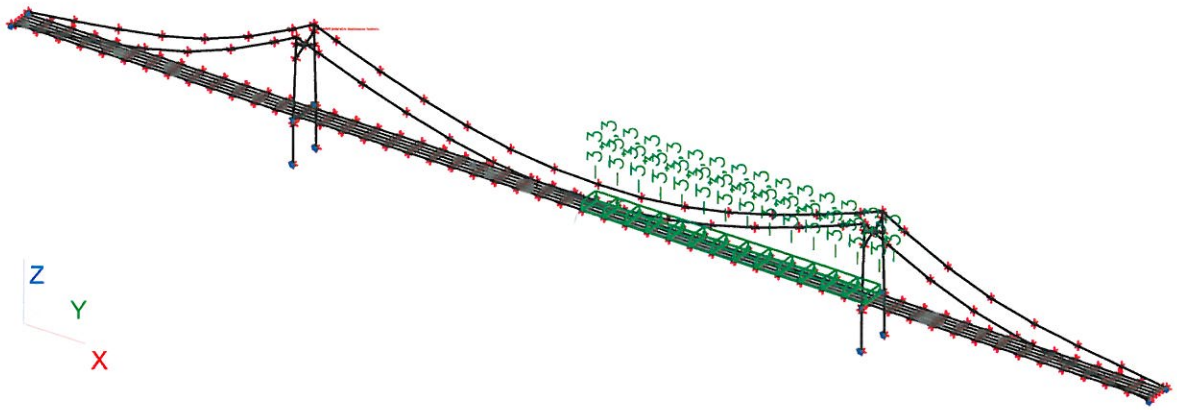
2.2. Ch S 1



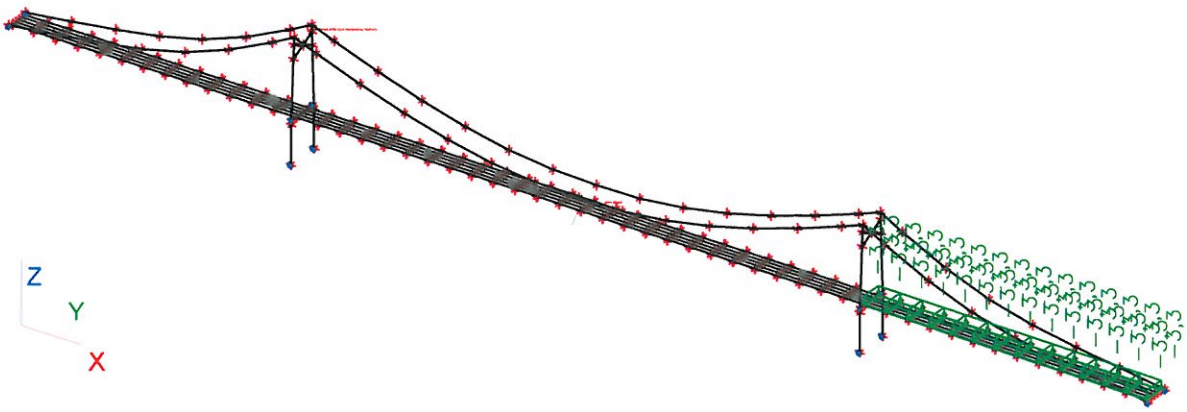
2.3. Ch S 2



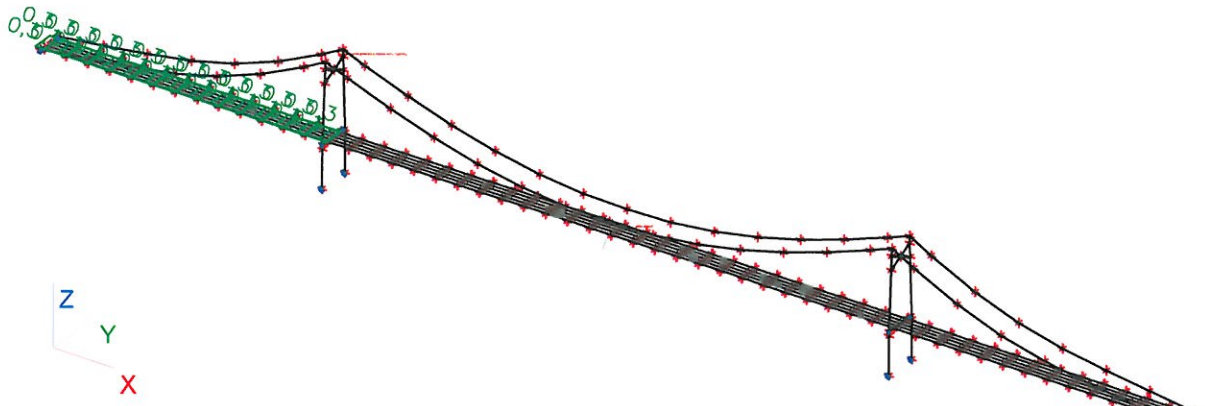
2.4. Ch S 3



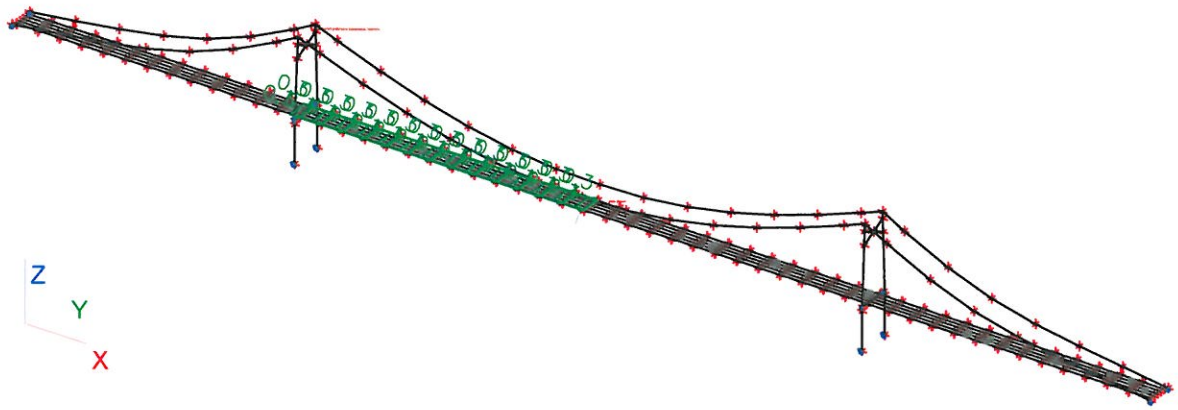
2.5. Ch S 4



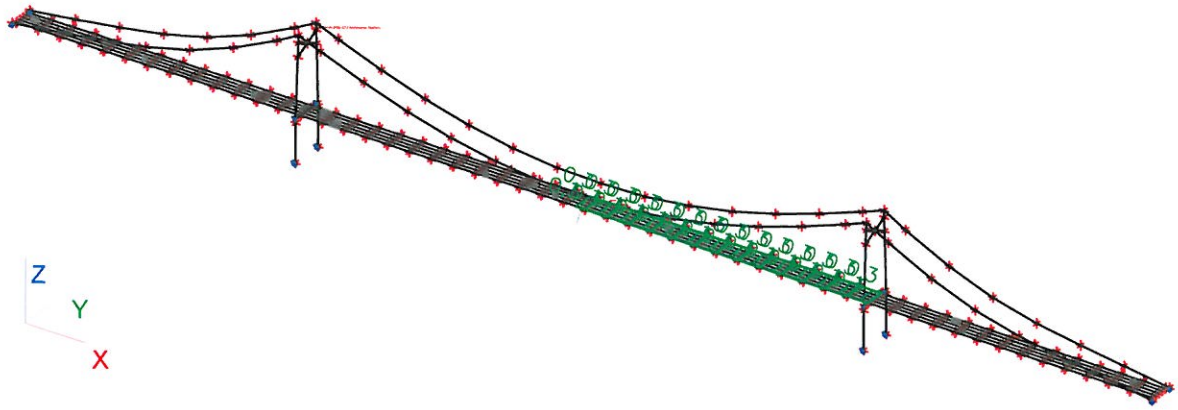
2.6. Ch V 1



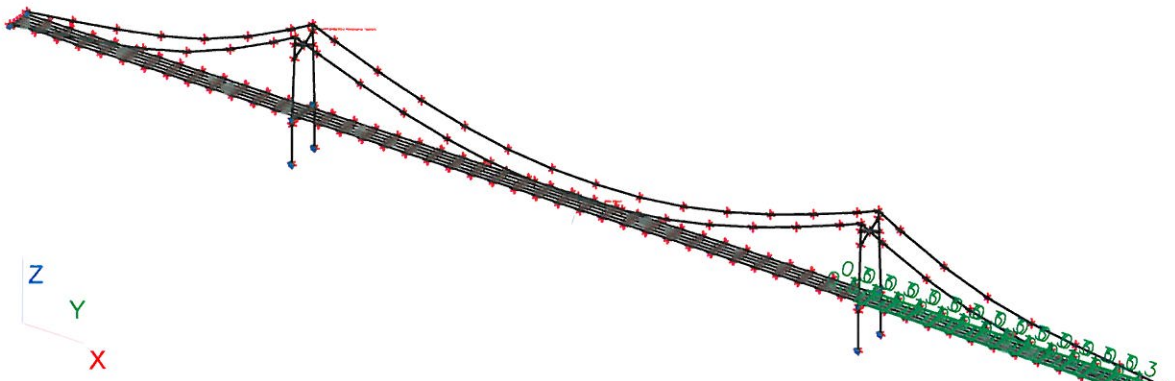
2.7. Ch V 2



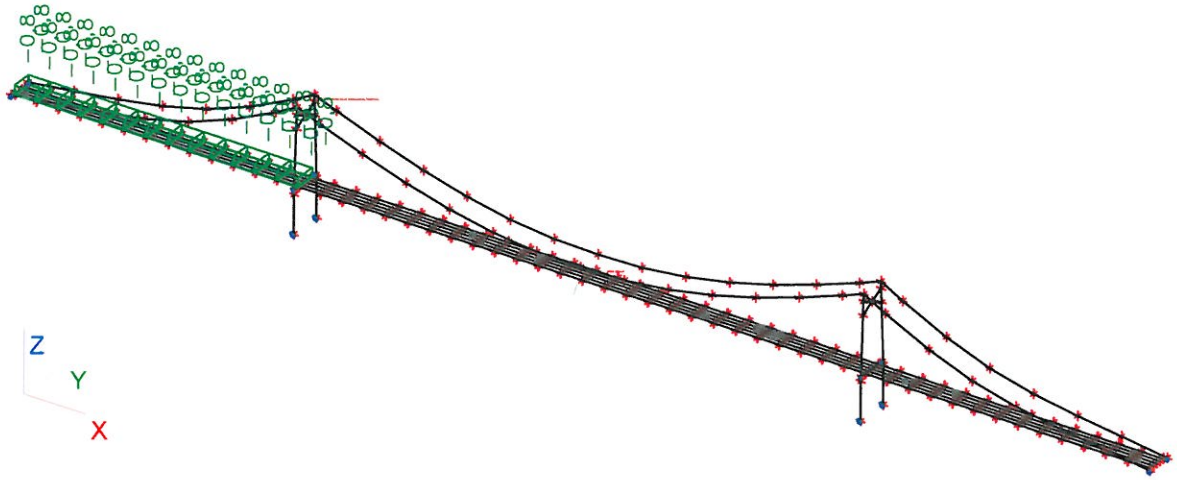
2.8. Ch V 3



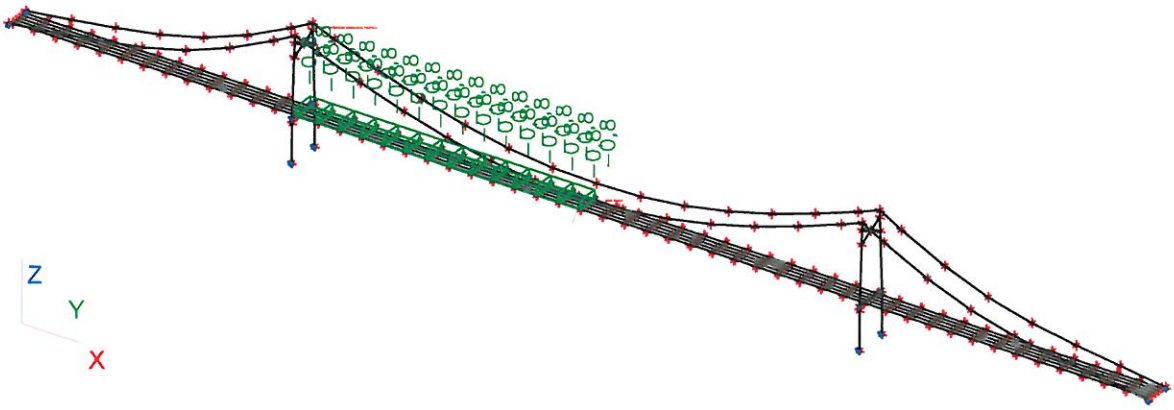
2.9. Ch V 4



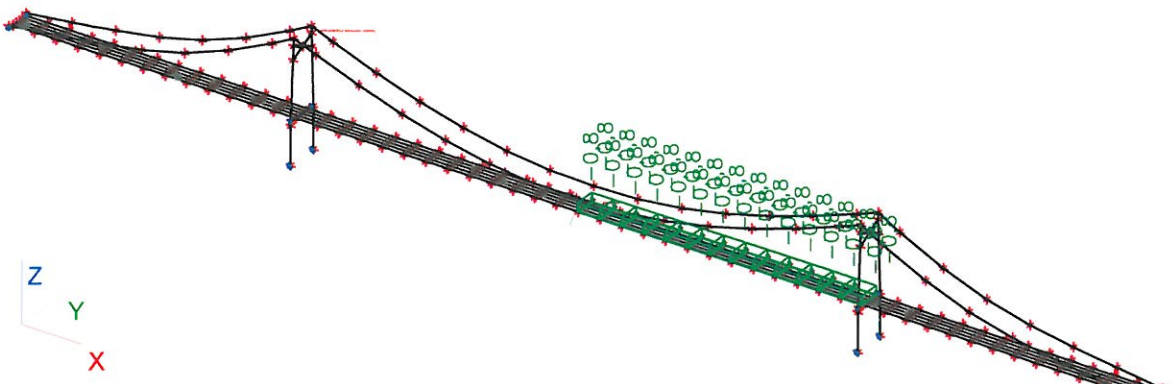
2.10. Vitr Z 1



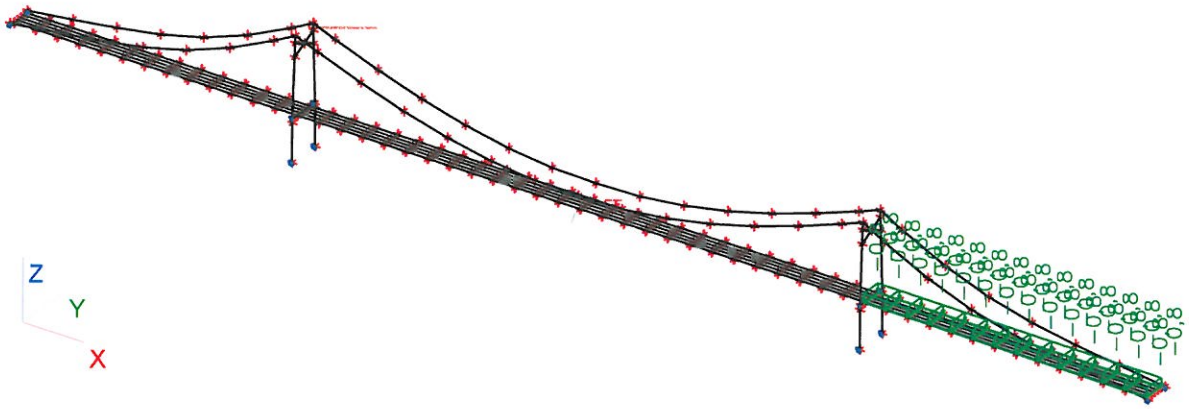
2.11. Vitr Z 2



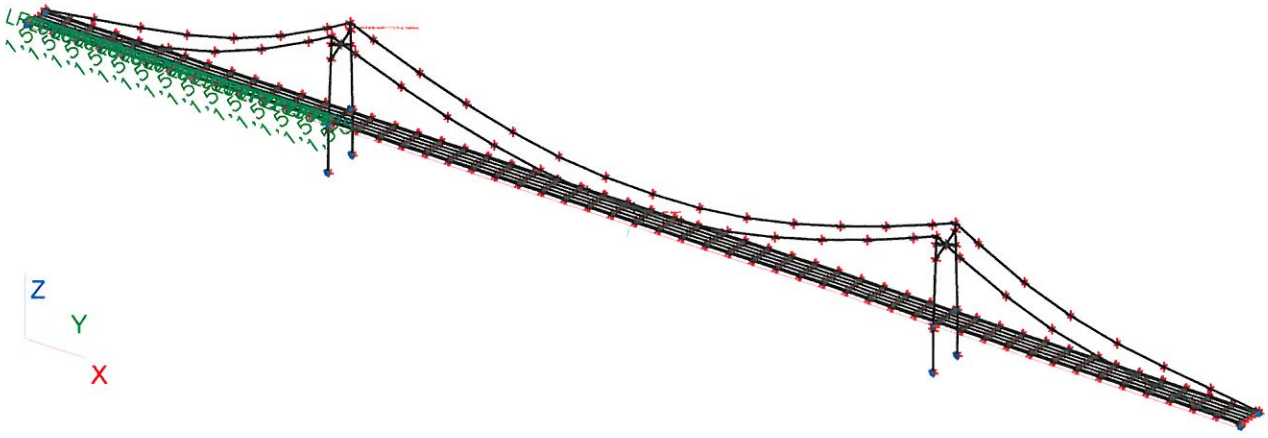
2.12. Vitr Z 3



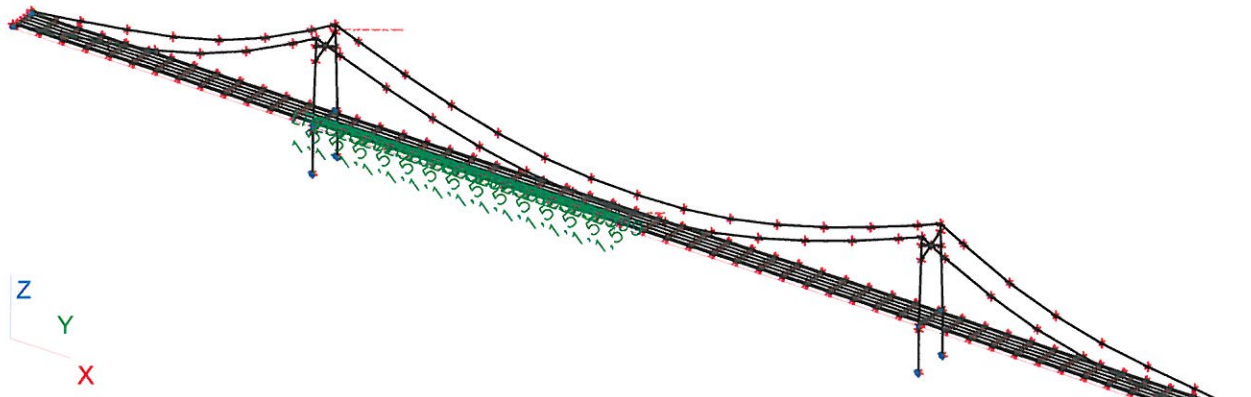
2.13. Vitr Z 4



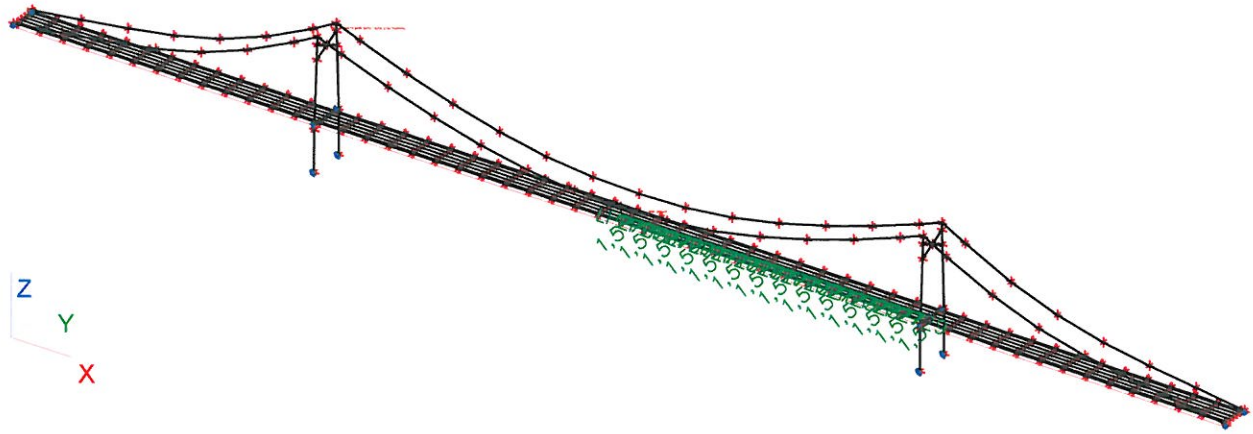
2.14. Vitr Y 1



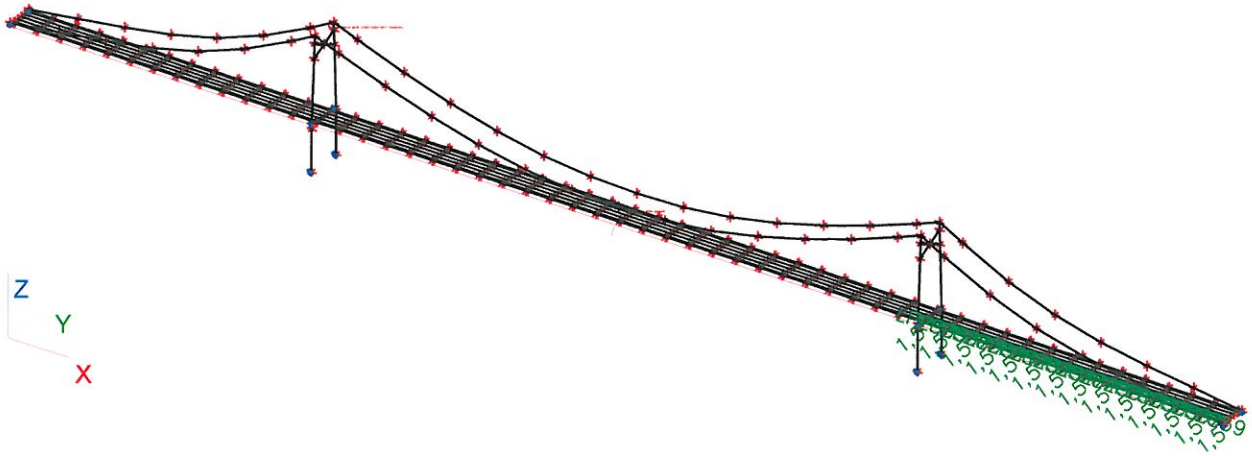
2.15. Vitr Y 2



2.16. Vitr Y 3



2.17. Vitr Y 4



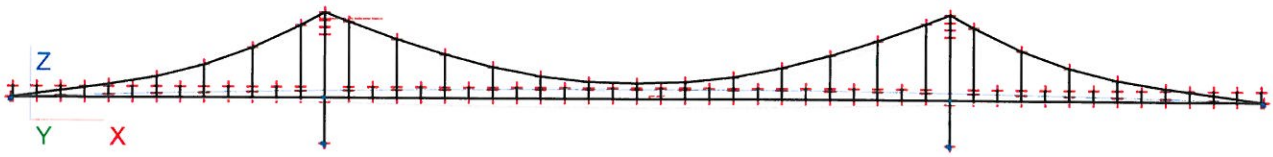
2.18. Nelineární kombinace

Typ jméno	Jméno	Typ	Zatěžovací stavy	Souč. [-]	Imperfekce prutu	Celková imperfekce	Nelineární výpočet po výpočtu
Nelineární kombinace	SW P	Použitelnost	LC1	1,00	Žádná	Žádná	×
			Ost st	1,00			
Nelineární kombinace	ChallP	Použitelnost	LC1	1,00	Žádná	Žádná	×
			Ost st	1,00			
			Ch S 1	1,00			
			Ch S 2	1,00			
			Ch S 3	1,00			
			Ch S 4	1,00			
Nelineární kombinace	Ch1P	Použitelnost	LC1	1,00	Žádná	Žádná	×
			Ost st	1,00			
			Ch S 1	1,00			
Nelineární kombinace	Ch23P	Použitelnost	LC1	1,00	Žádná	Žádná	×
			Ost st	1,00			
			Ch S 2	1,00			
			Ch S 3	1,00			
Nelineární kombinace	Ch14P	Použitelnost	LC1	1,00	Žádná	Žádná	×
			Ost st	1,00			
			Ch S 1	1,00			
			Ch S 4	1,00			
Nelineární kombinace	ChallU	Únosnost	LC1	1,35	Žádná	Žádná	×
			Ost st	1,35			
			Ch S 1	1,50			
			Ch S 2	1,50			
			Ch S 3	1,50			
			Ch S 4	1,50			
			Ch V 1	1,50			
			Ch V 2	1,50			
			Ch V 3	1,50			
			Ch V 4	1,50			
			Vitr Z1	0,90			
			Vitr Z2	0,90			
			Vitr Z3	0,90			
			Vitr Z4	0,90			
			Vitr Y1	0,90			
			Vitr Y2	0,90			
			Vitr Y3	0,90			
			Vitr Y4	0,90			
Nelineární kombinace	Ch1U	Únosnost	LC1	1,35	Žádná	Žádná	×
			Ost st	1,35			
			Ch S 1	1,50			
			Ch V 1	1,50			
			Vitr Z1	0,90			

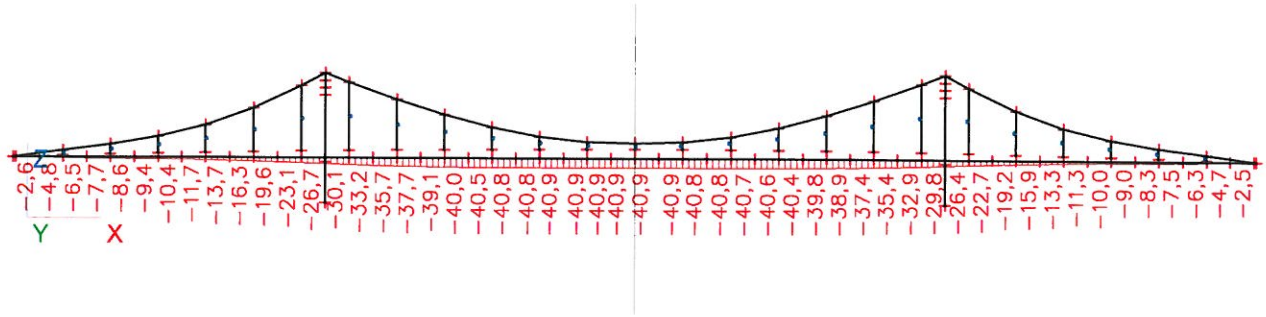
Typ jméno	Jméno	Typ	Zatěžovací stavy	Souč. [-]	Imperfekce prutu	Celková imperfekce	Nelineární výpočet po výpočtu
Nelineární kombinace	Ch1U	Únosnost	Vitr Z3	-0,90	Žádná	Žádná	×
			Vitr Z4	-0,90			
			Vitr Y1	0,90			
Nelineární kombinace	Ch23U	Únosnost	LC1	1,35	Žádná	Žádná	×
			Ost st	1,35			
			Ch S 2	1,50			
			Ch S 3	1,50			
			Ch V 2	1,50			
			Ch V 3	1,50			
			Vitr Z1	-0,90			
			Vitr Z2	0,90			
			Vitr Z3	0,90			
			Vitr Z4	-0,90			
			Vitr Y2	0,90			
			Vitr Y3	0,90			
Nelineární kombinace	Ch14U	Únosnost	LC1	1,35	Žádná	Žádná	×
			Ost st	1,35			
			Ch S 1	1,50			
			Ch S 4	1,50			
			Ch V 1	1,50			
			Ch V 4	1,50			
			Vitr Z1	0,90			
			Vitr Z2	-0,90			
			Vitr Z3	-0,90			
			Vitr Z4	0,90			
			Vitr Y1	0,90			
			Vitr Y4	0,90			

3. Použitelnost

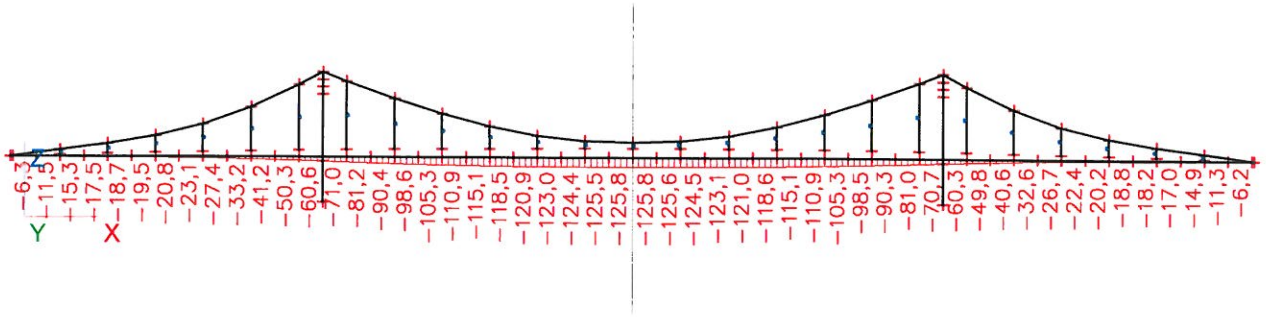
3.1. CSalIP



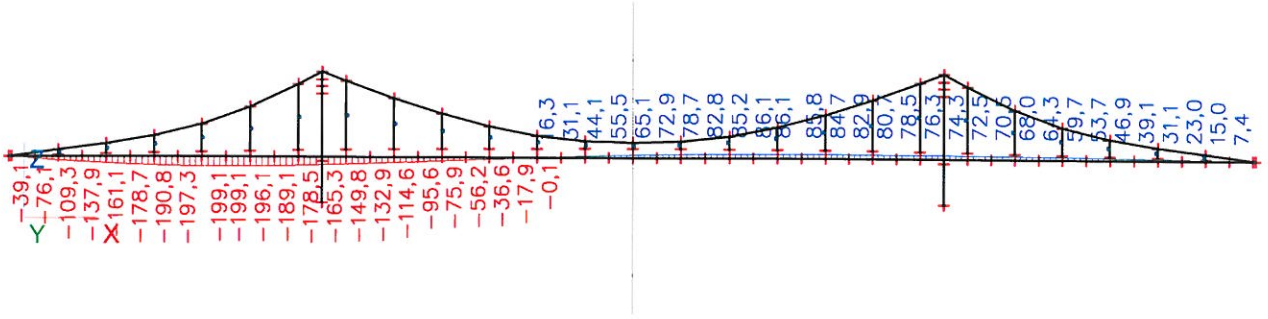
3.2. Pas D SW



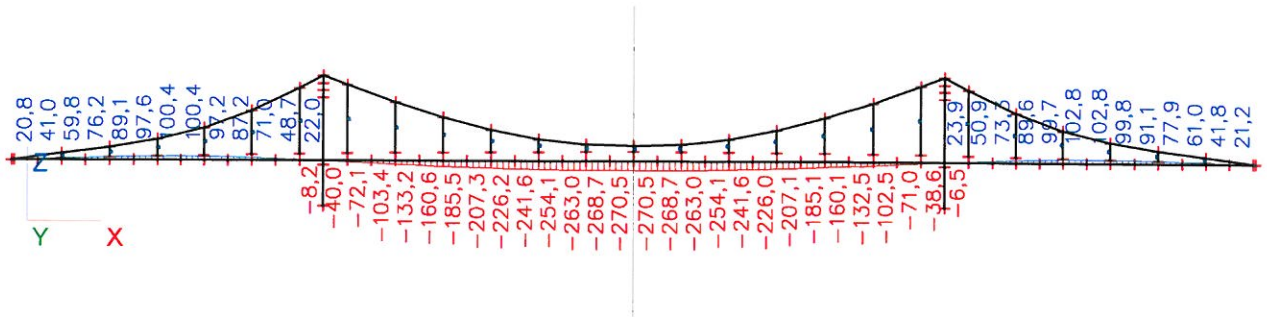
3.3. Pas D CSalIP



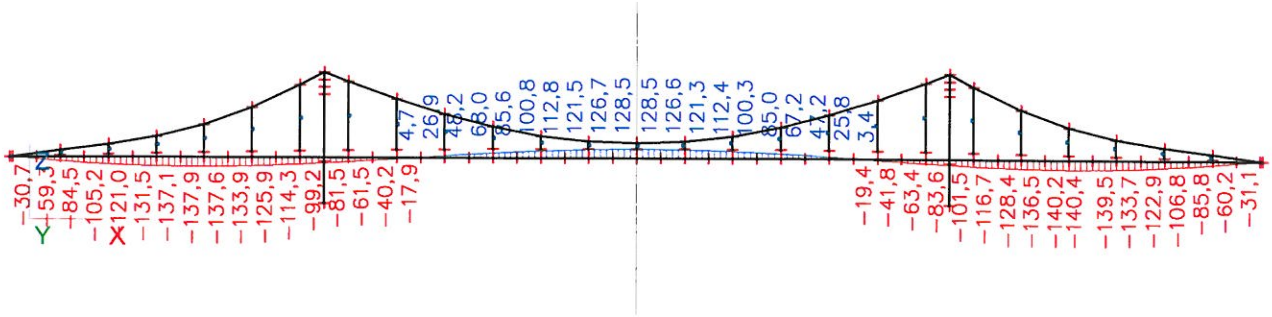
3.4. Pas D CS1P



3.5. Pas D CS23P

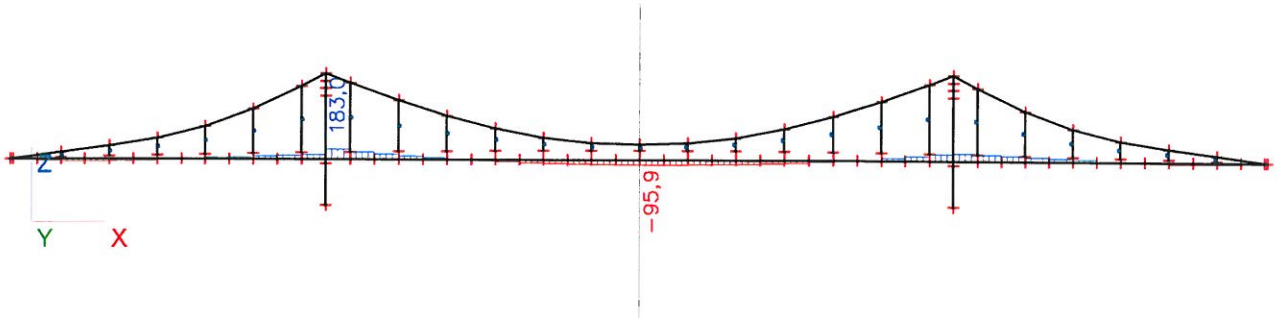


3.6. Pas D CS14P

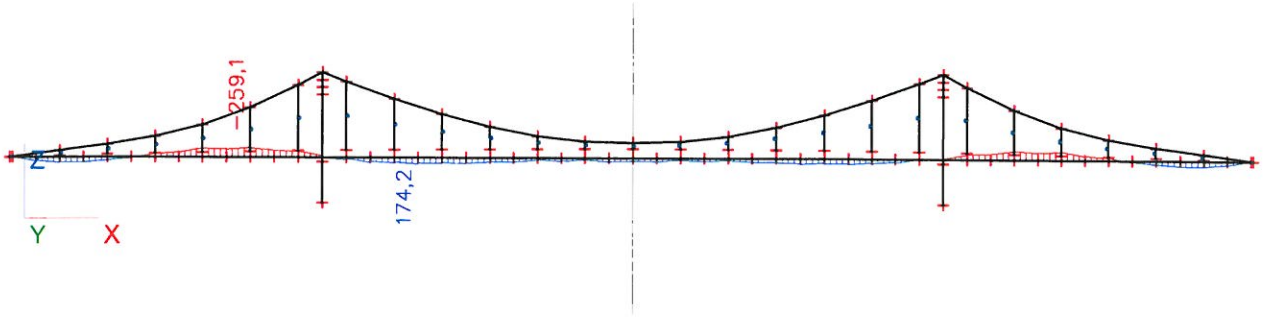


4. Pasy

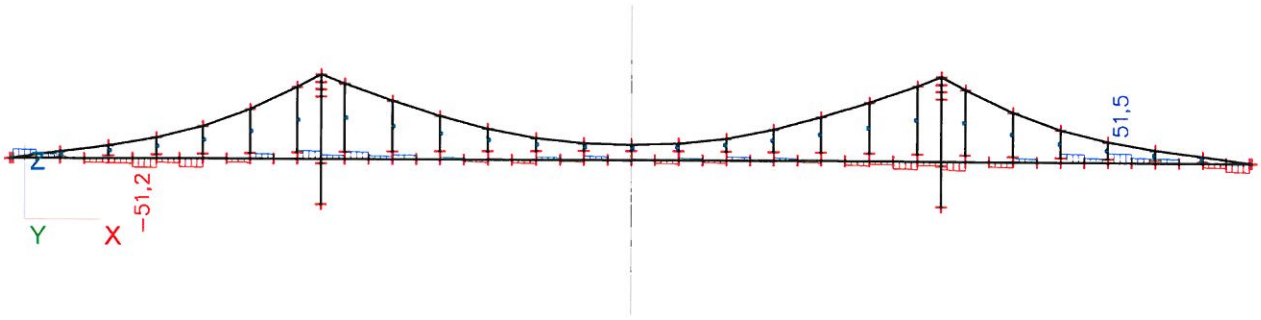
4.1. Pas D N CSallU



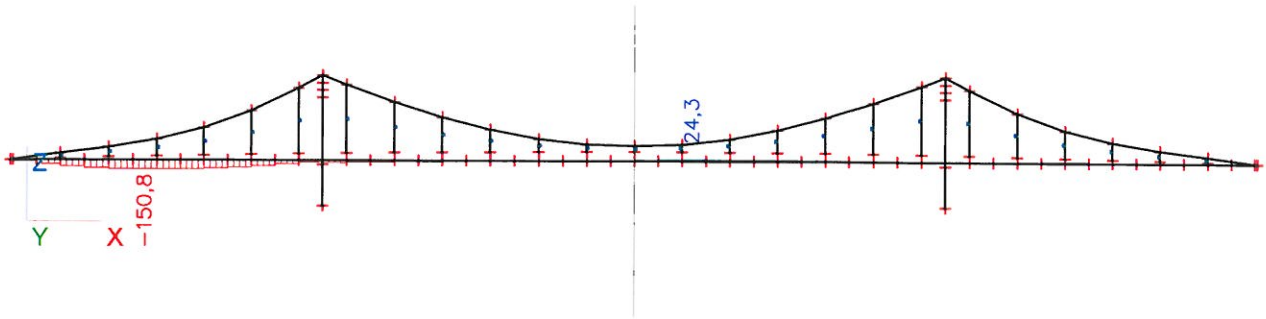
4.2. Pas D My CSallU



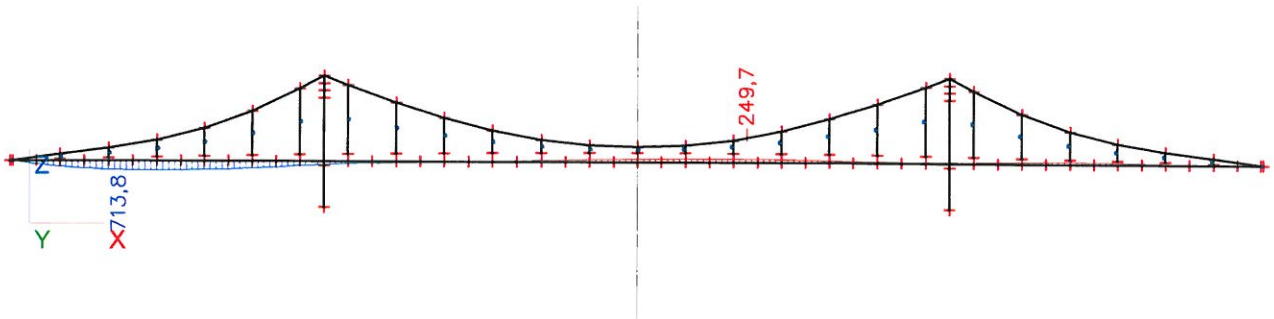
4.3. Pas D Vz CSallU



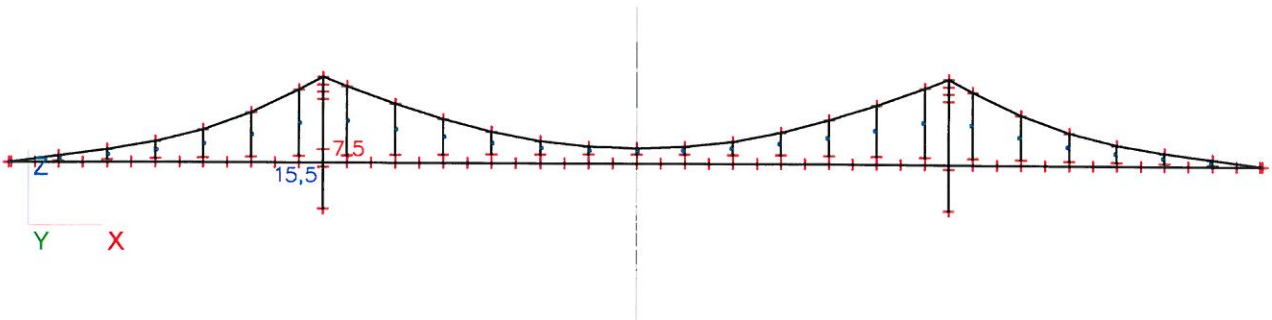
4.4. Pas D N CS1U



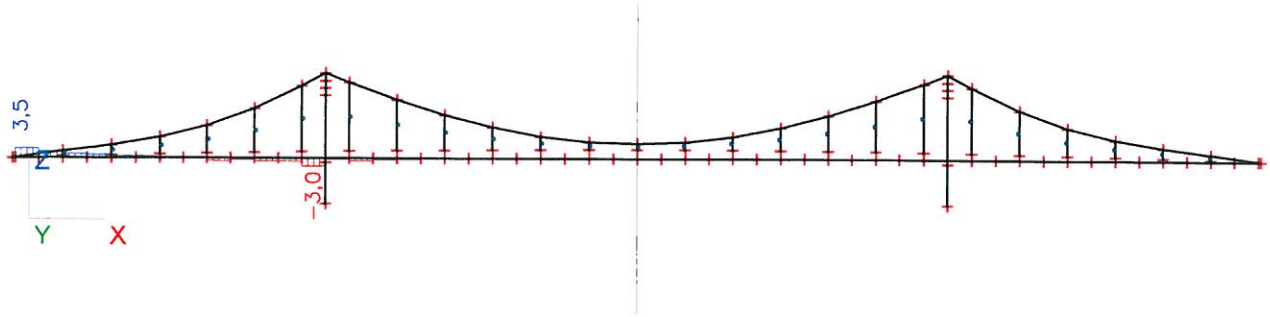
4.5. Pas D My CS1U



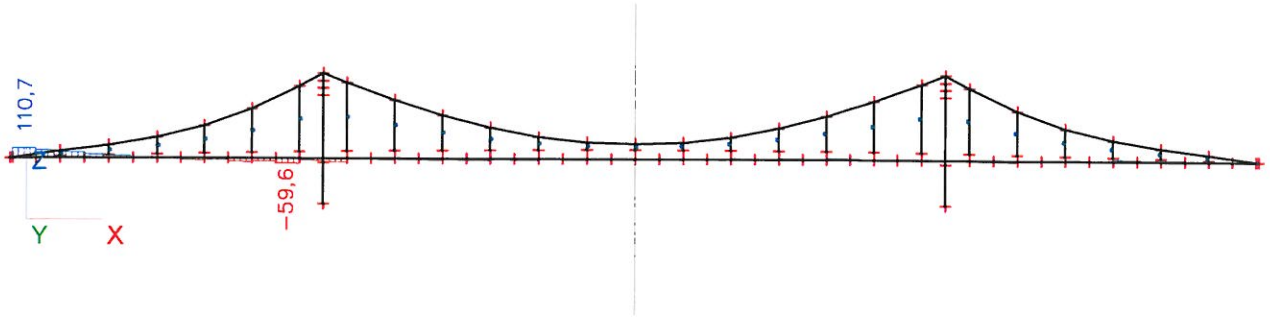
4.6. Pas D Mz CS1U



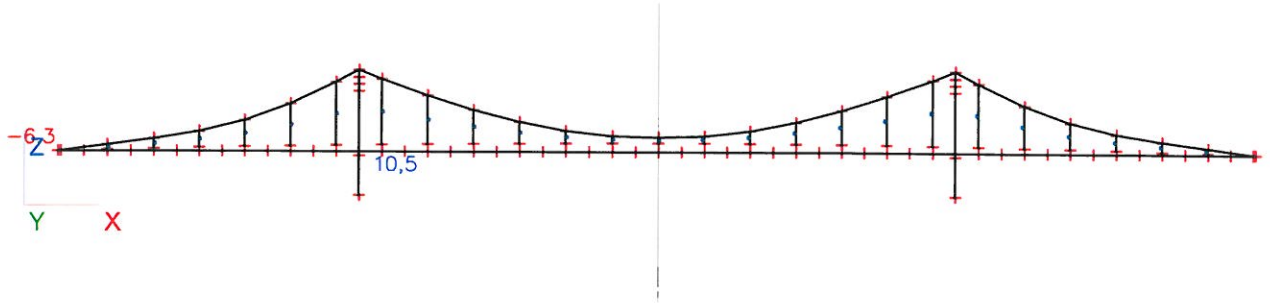
4.7. Pas D Mx CS1U



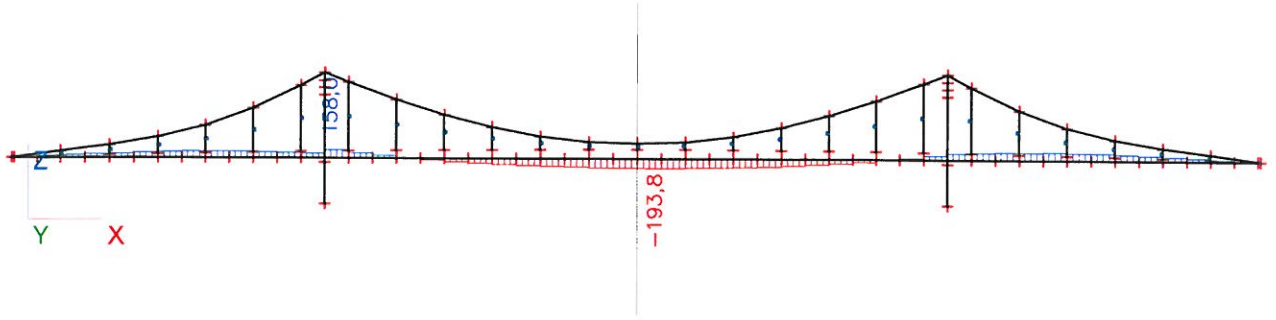
4.8. Pas D Vz CS1U



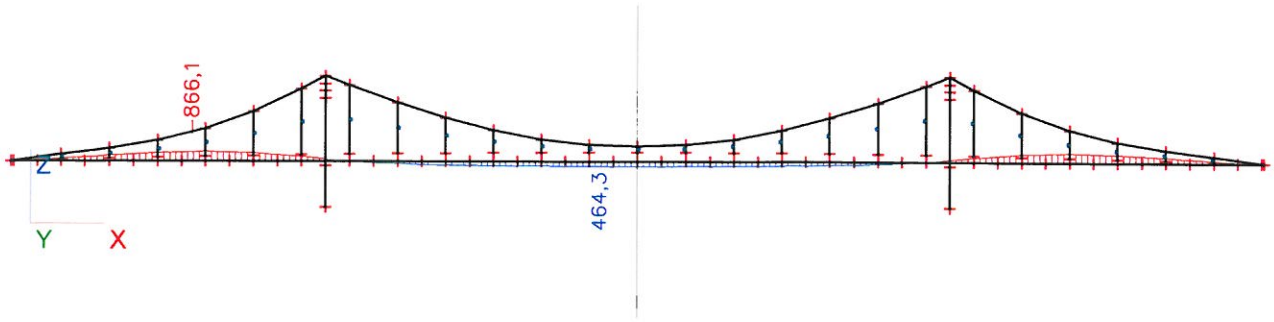
4.9. Pas D Vy CS1U



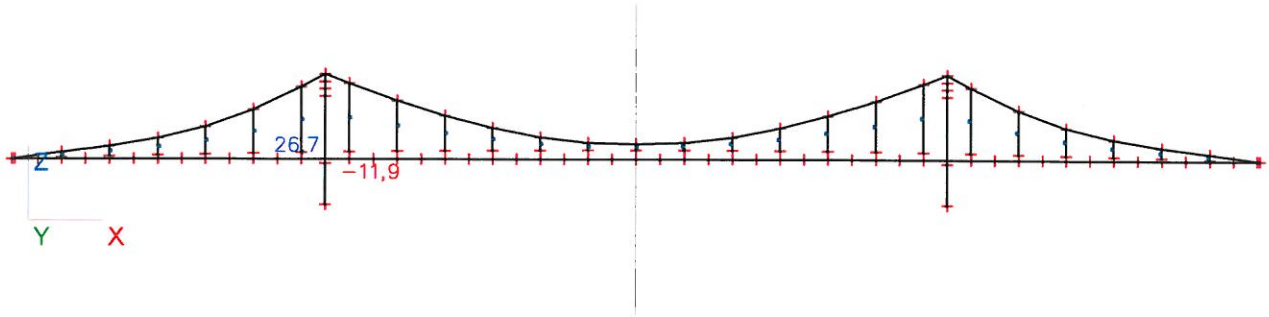
4.10. Pas D N CS23U



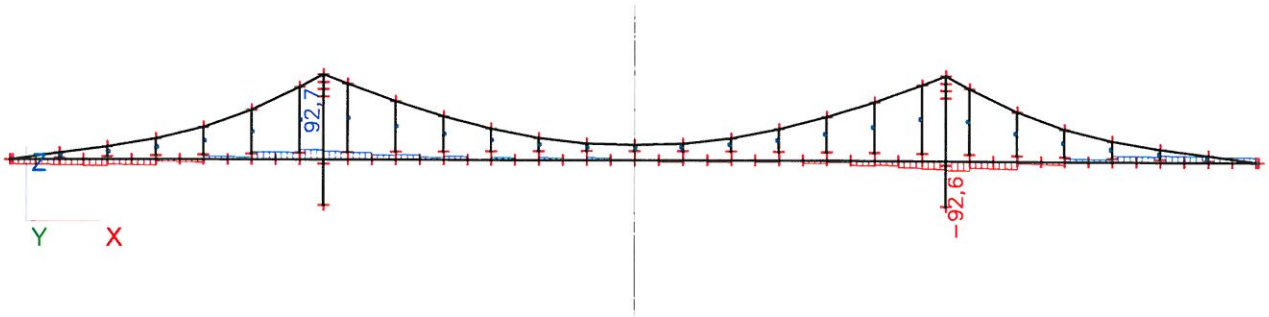
4.11. Pas D My CS23U



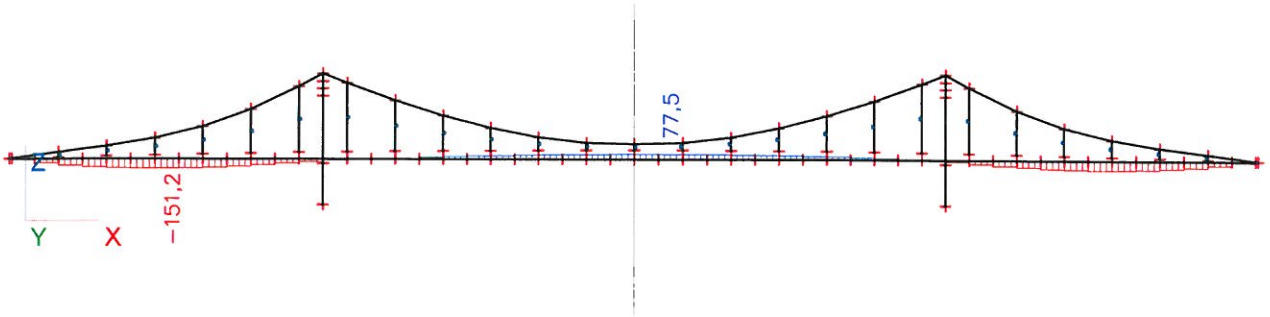
4.12. Pas D Mz CS23U



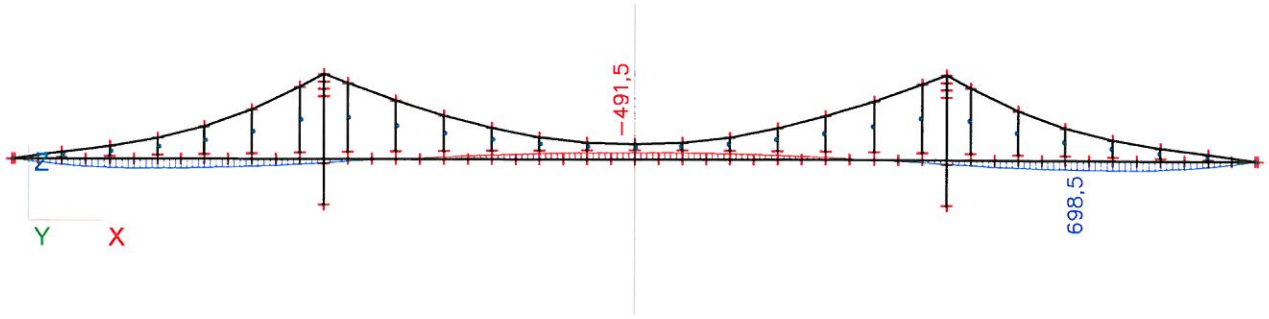
4.13. Pas D Vz CS23U



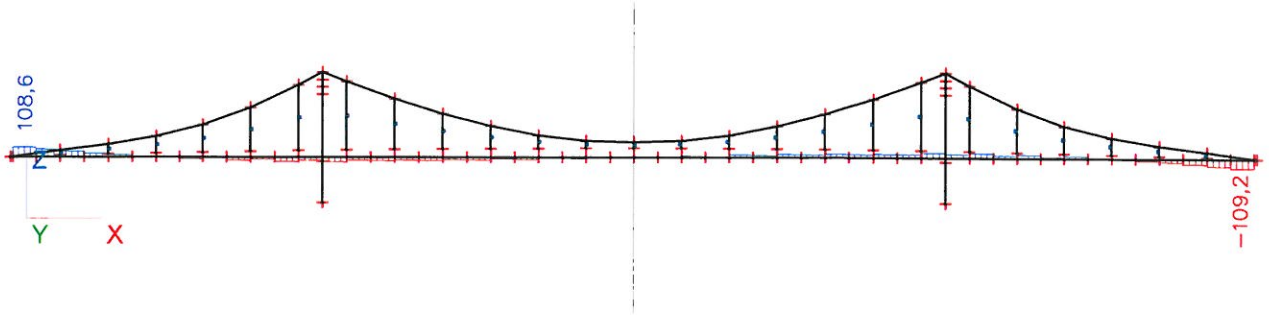
4.14. Pas D N CS14U



4.15. Pas D My CS14U

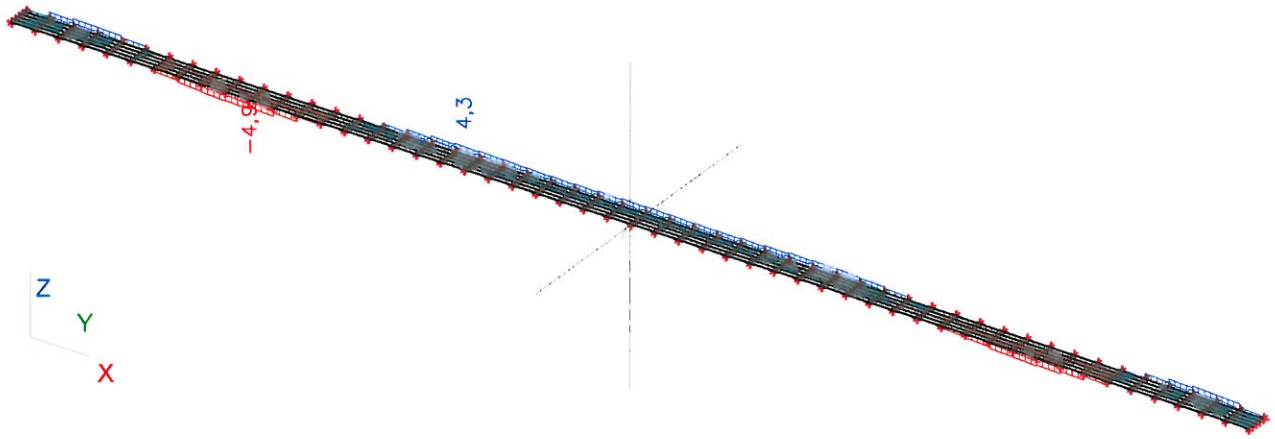


4.16. Pas D Vz CS14U

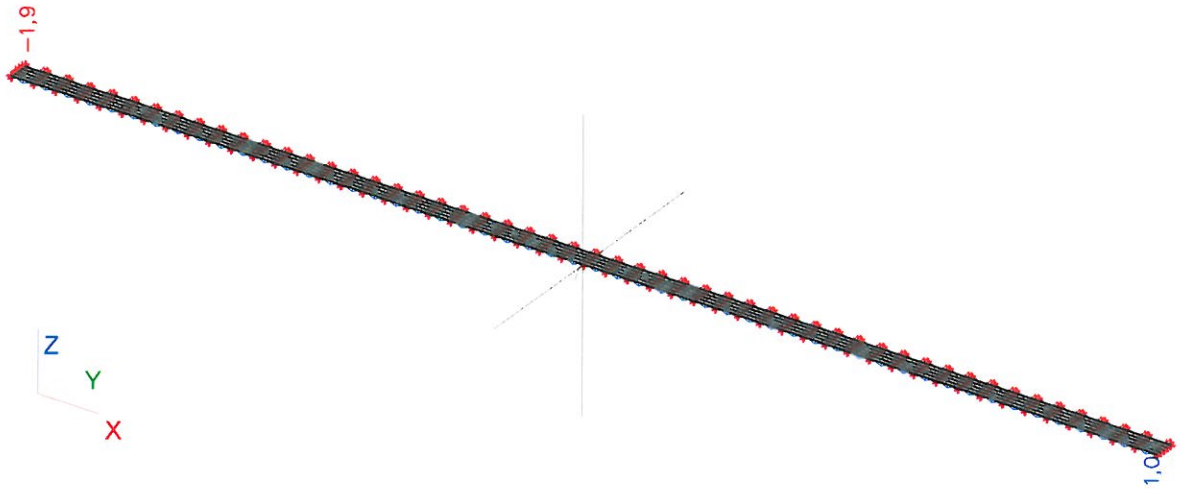


5. Podélníky

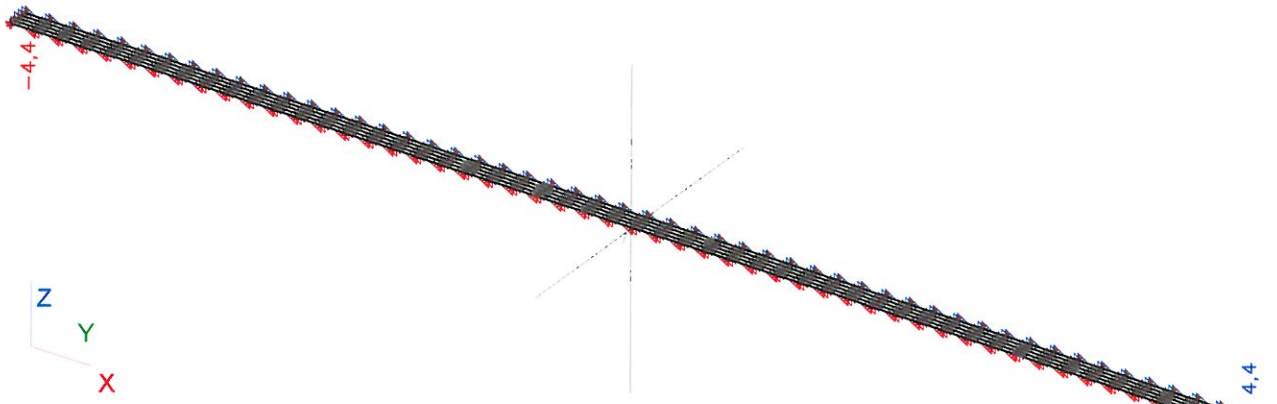
5.1. Pod N ChallU



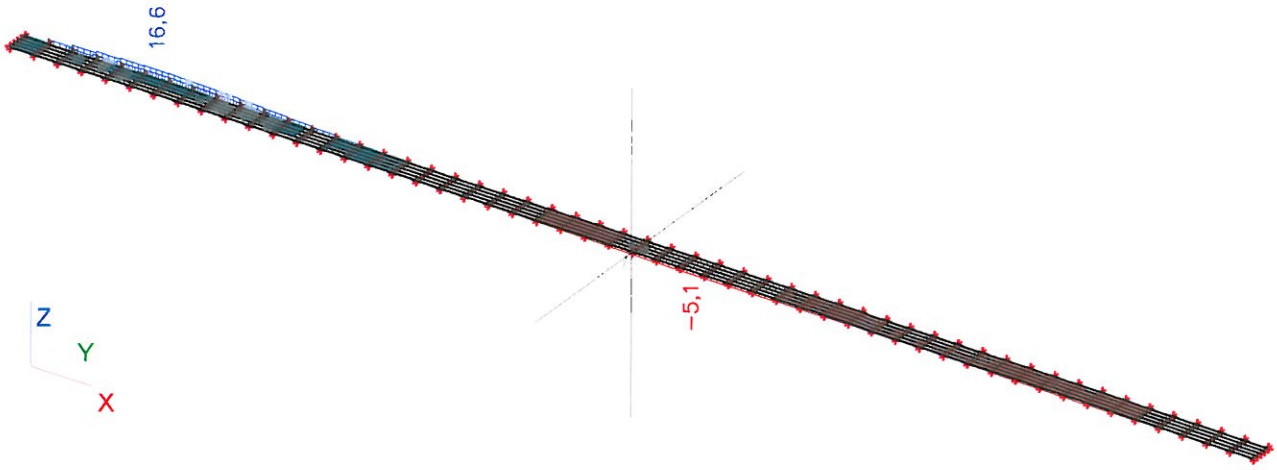
5.2. Pod My ChallU



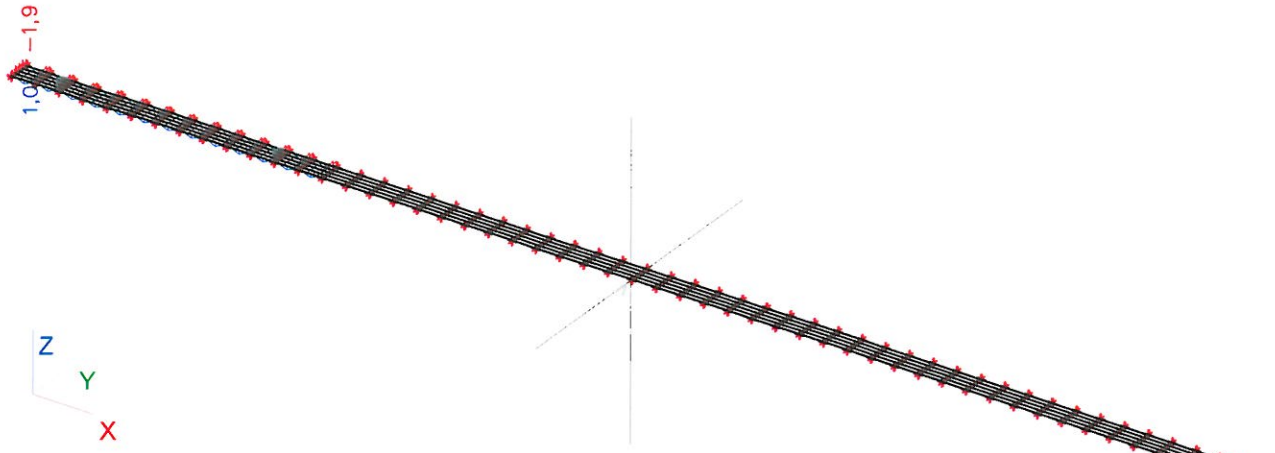
5.3. Pod Vz ChallU



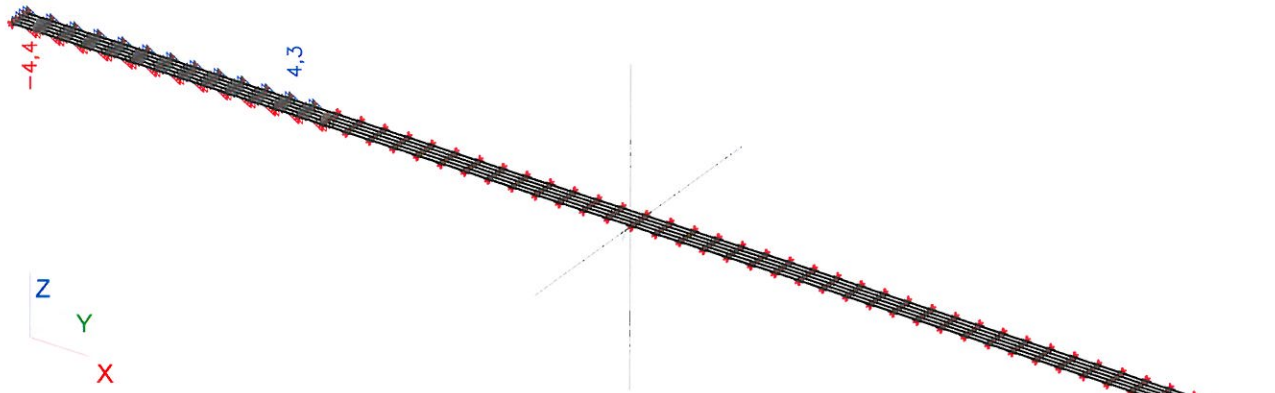
5.4. Pod N Ch1U



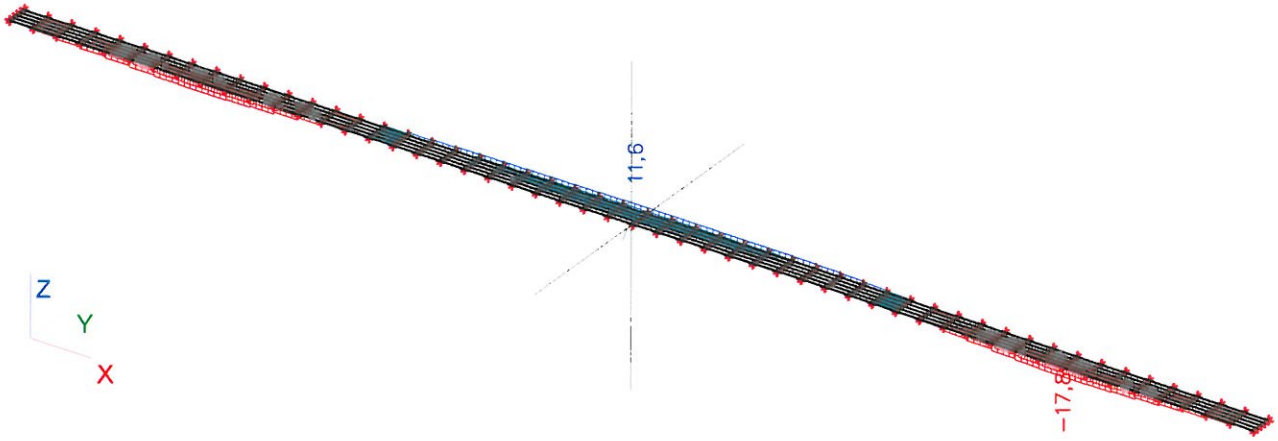
5.5. Pod My Ch1U



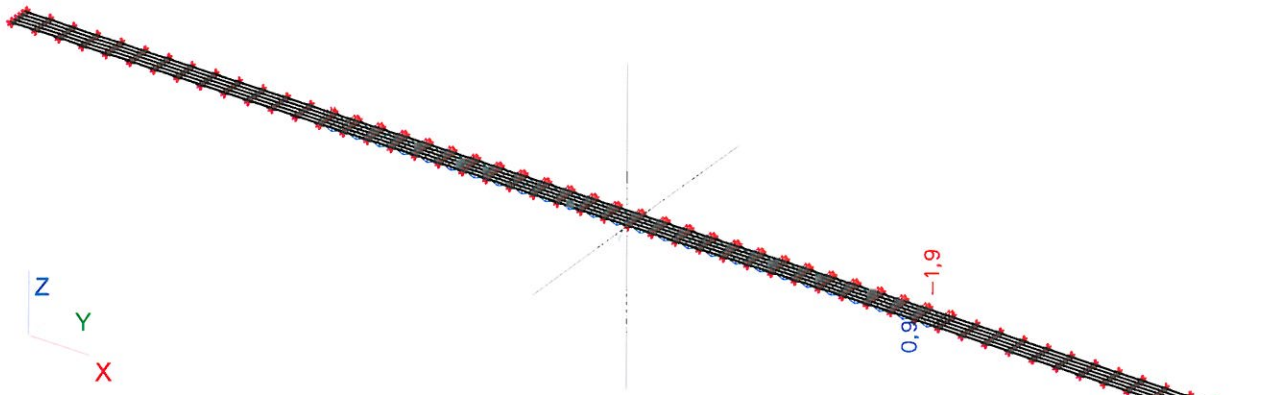
5.6. Pod Vz Ch1U



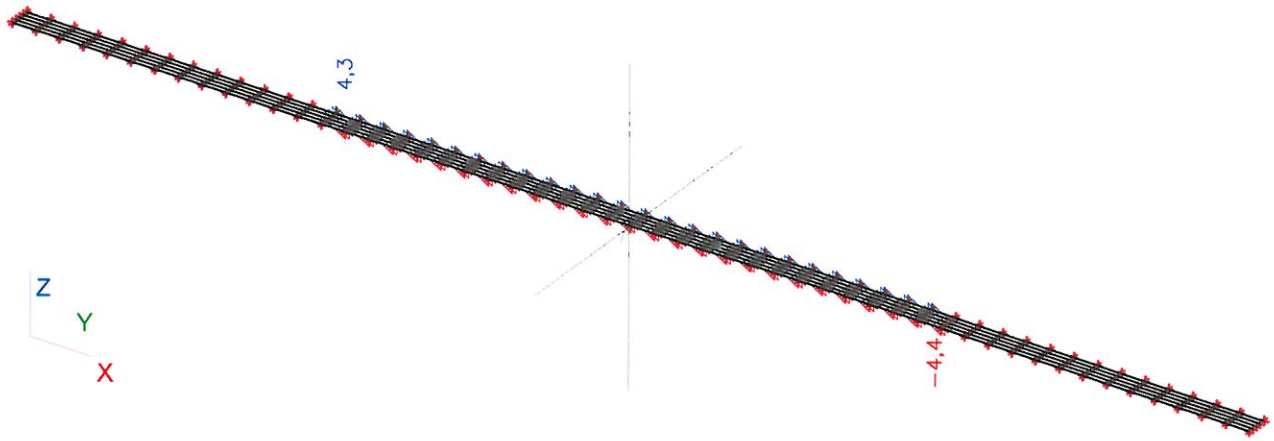
5.7. Pod N Ch23U



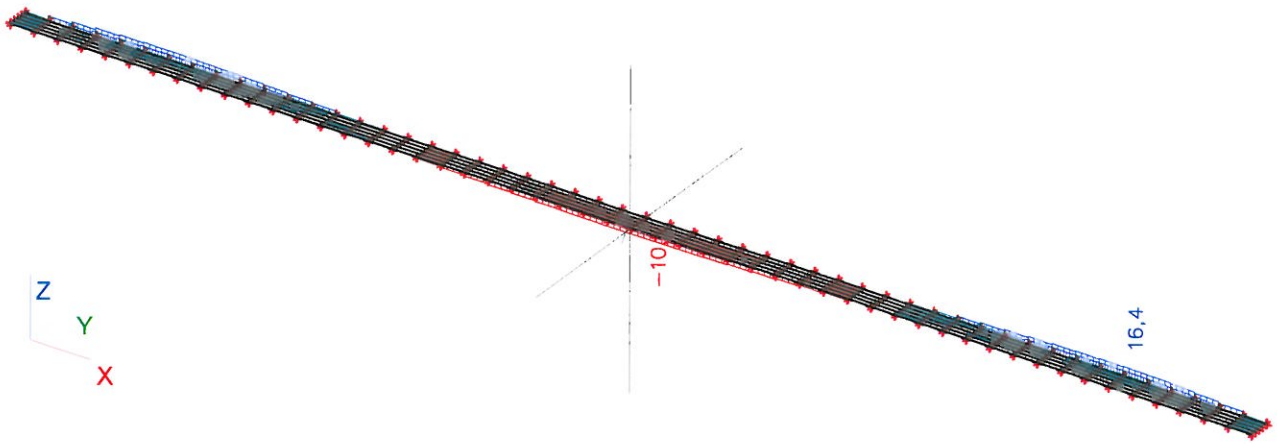
5.8. Pod My Ch23U



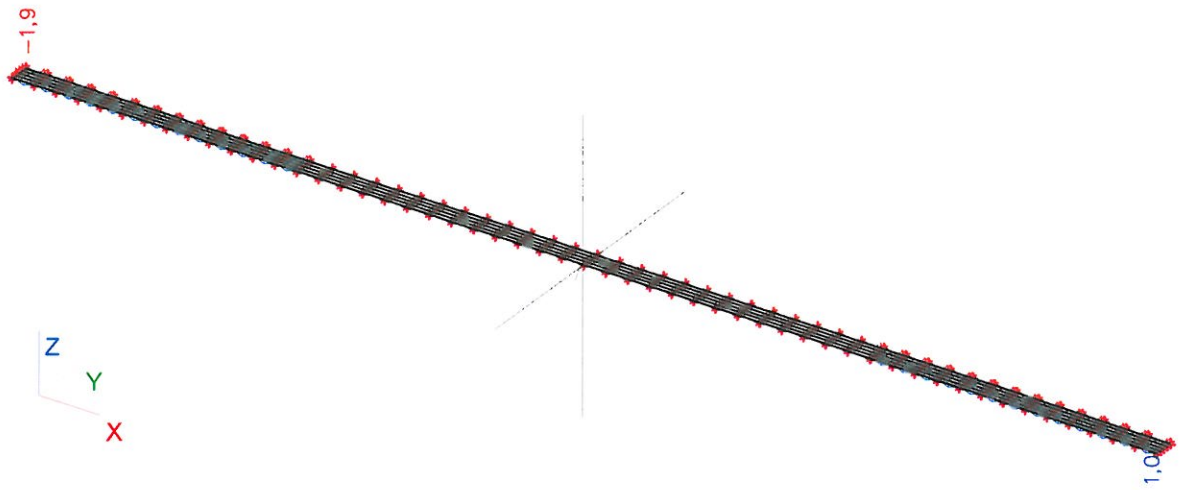
5.9. Pod Vz Ch23U



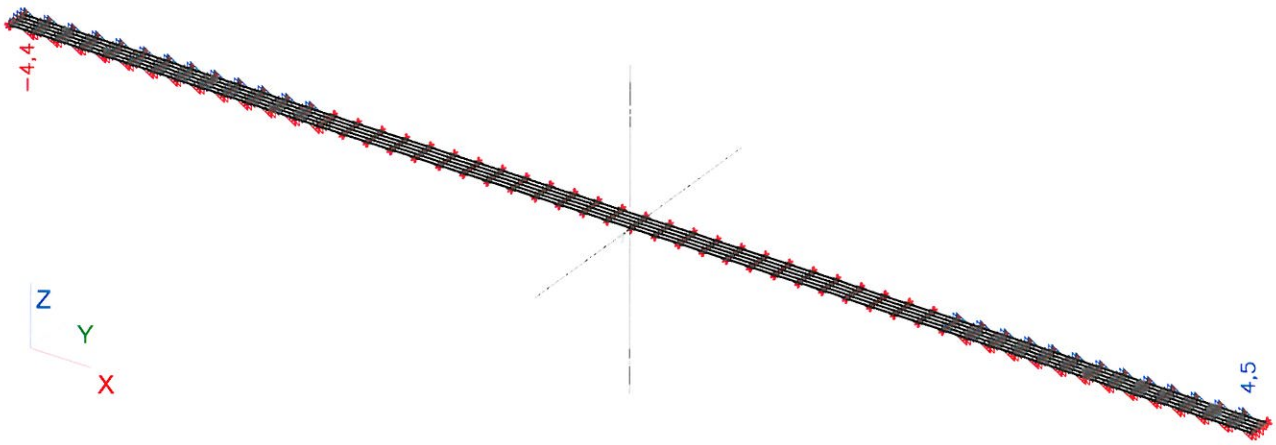
5.10. Pod N Ch14U



5.11. Pod My Ch14U

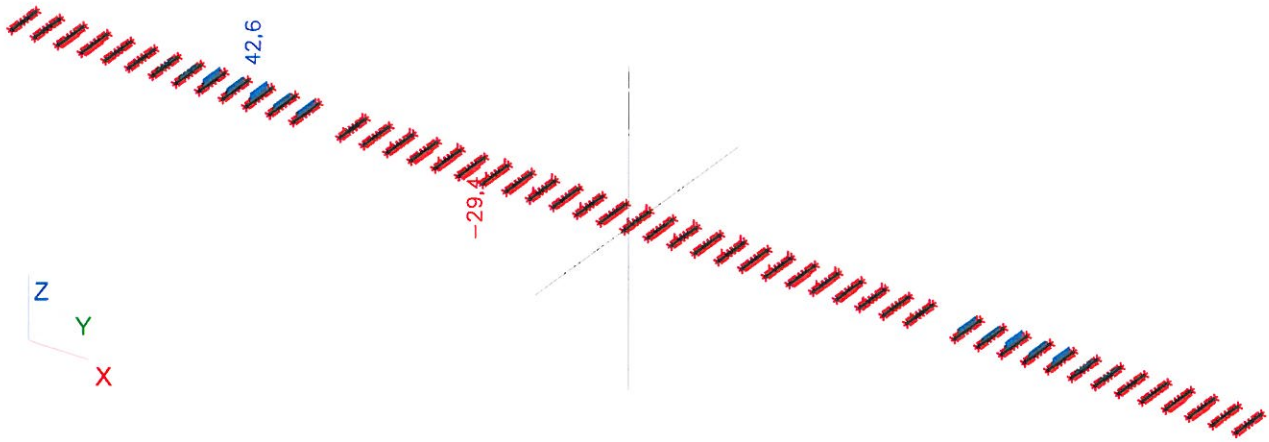


5.12. Pod Vz Ch14U

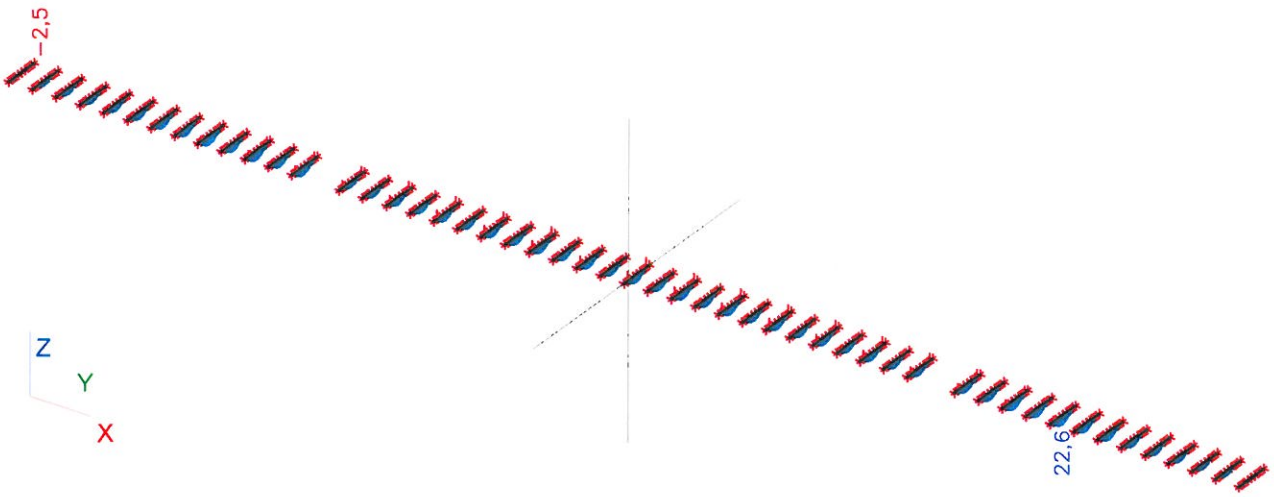


6. Příčníky

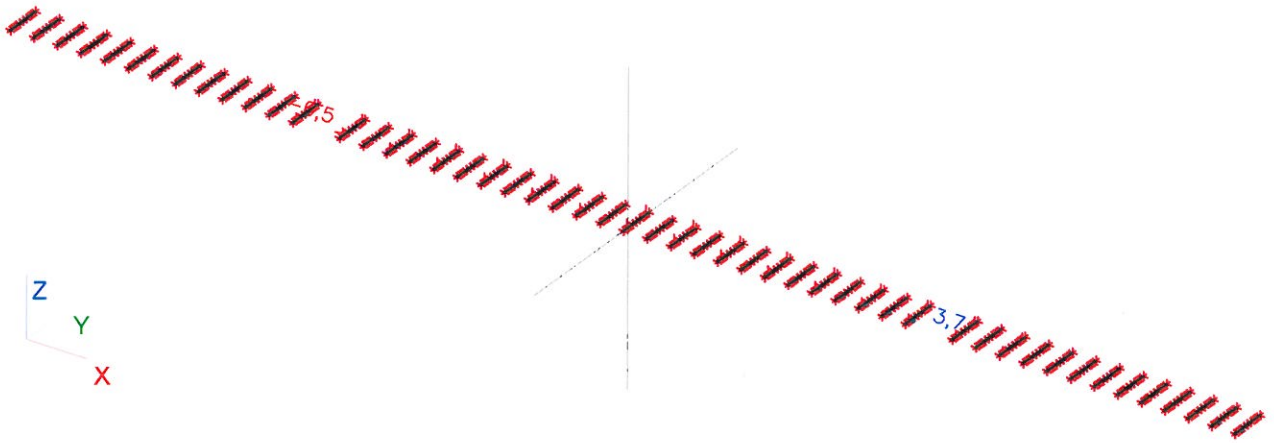
6.1. Pr N ChAIIU



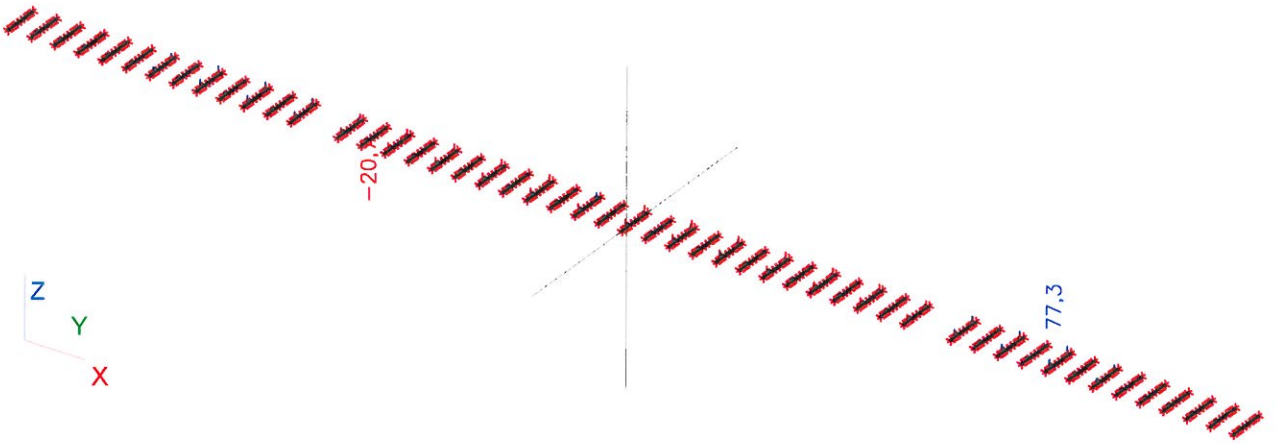
6.2. Pr My ChAIIU



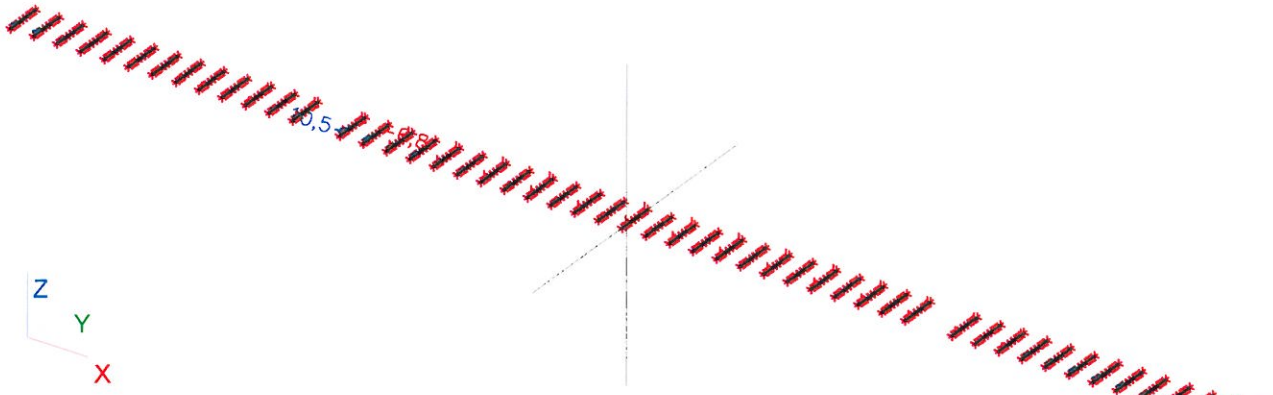
6.3. Pr Mz ChAIIU



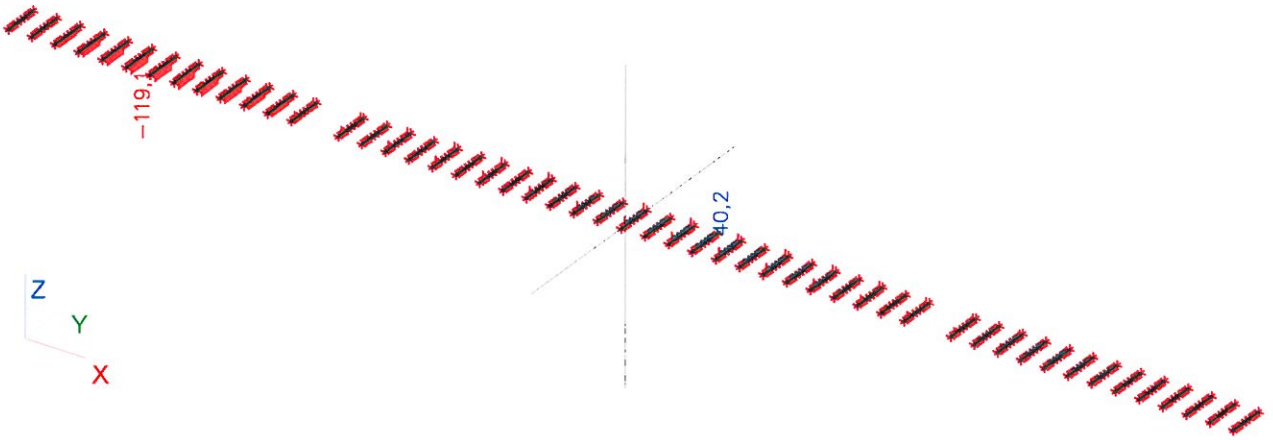
6.4. Pr Vz ChAIIU



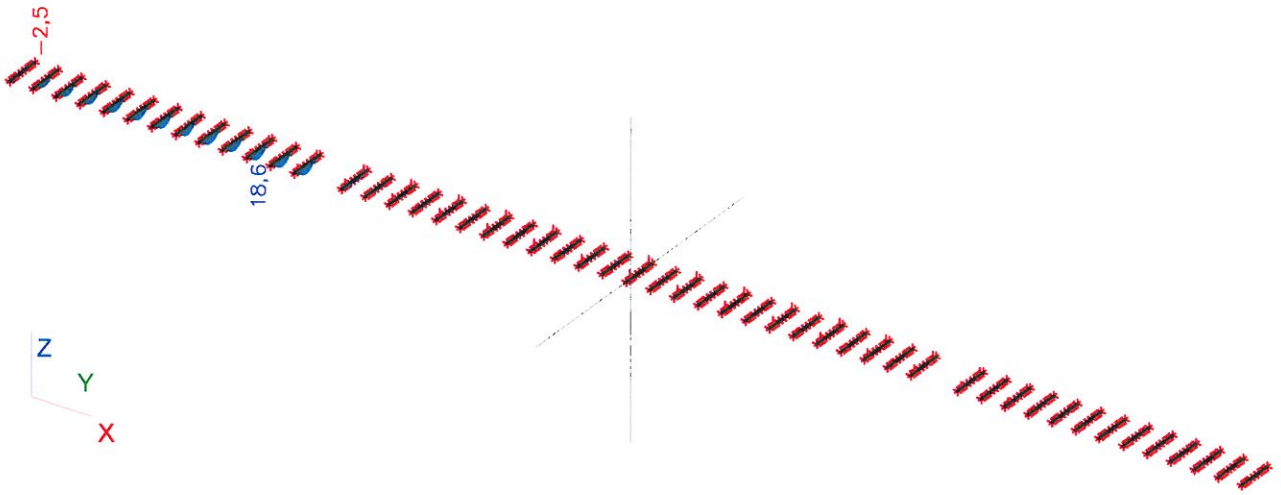
6.5. Pr Vy ChAIIU



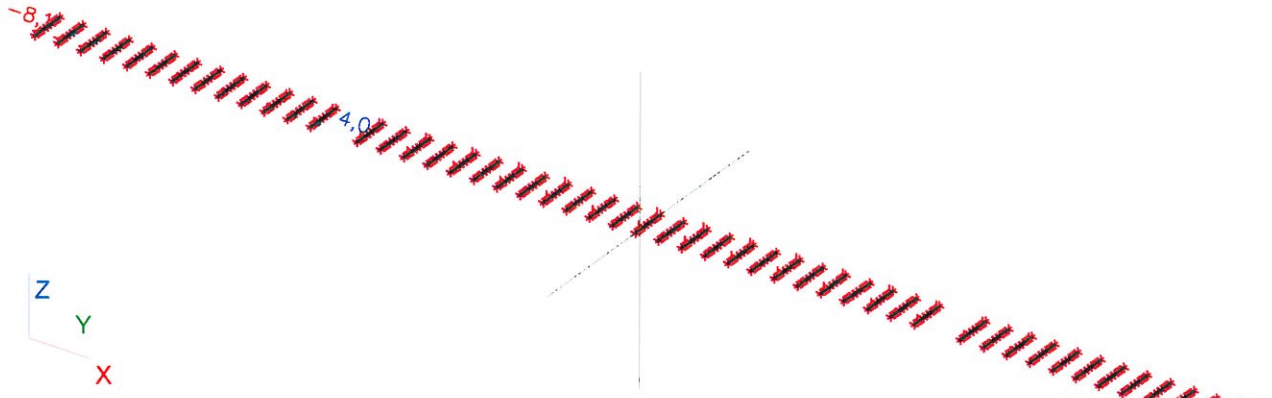
6.6. Pr N Ch1U



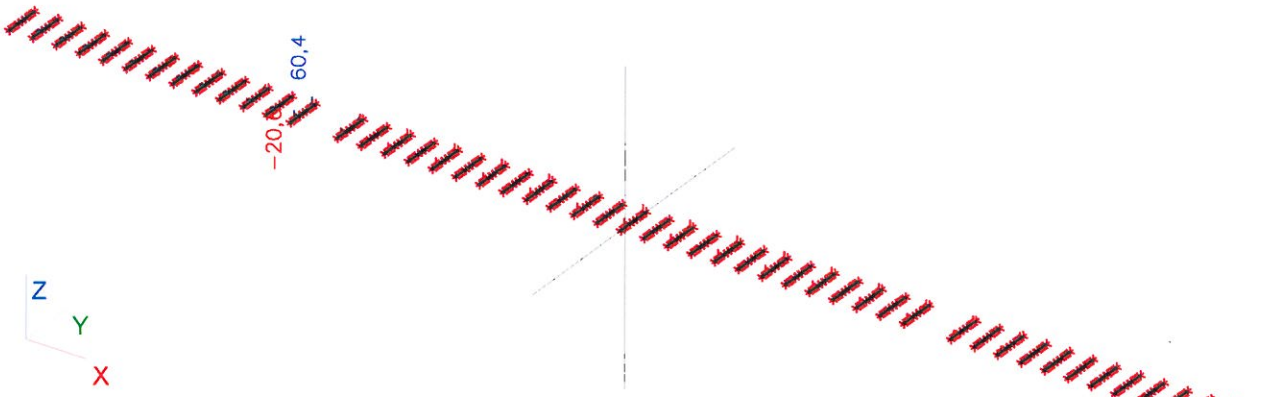
6.7. Pr My Ch1U



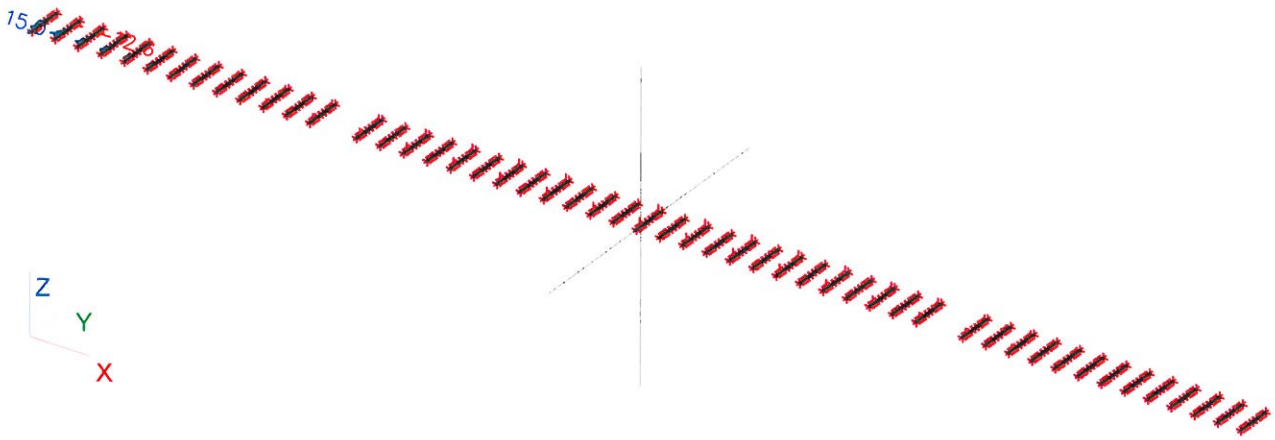
6.8. Pr Mz Ch1U



6.9. Pr Vz Ch1U



6.10. Pr Vy Ch1U



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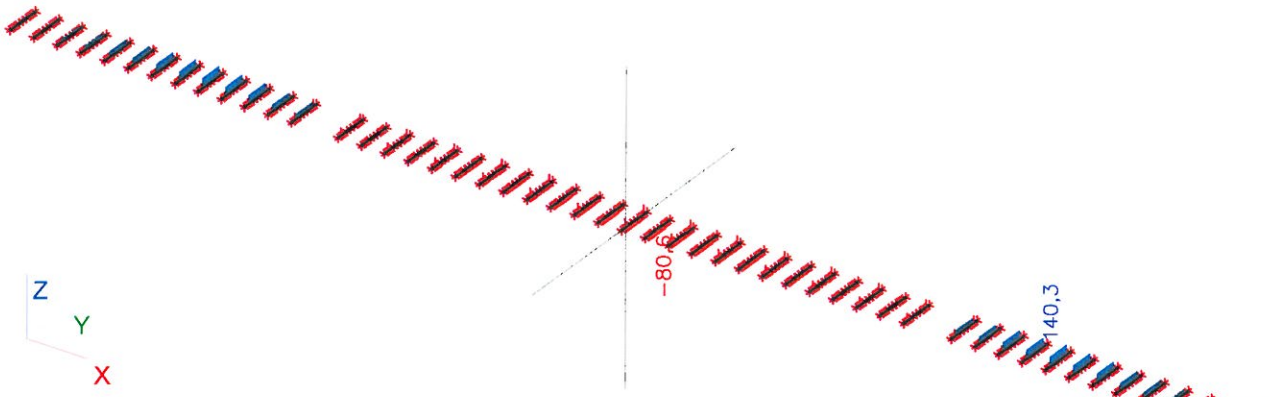
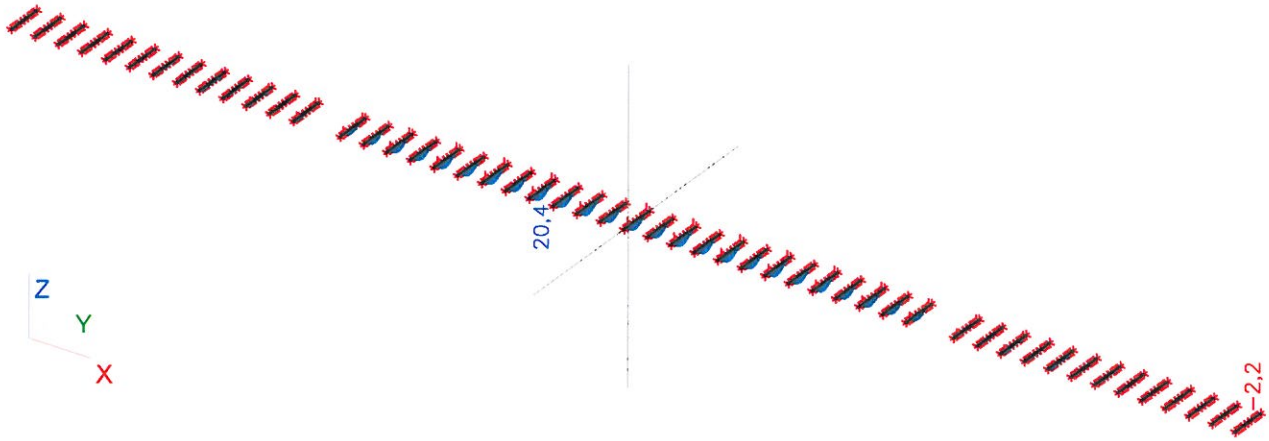


6.12. Pr My Ch23U



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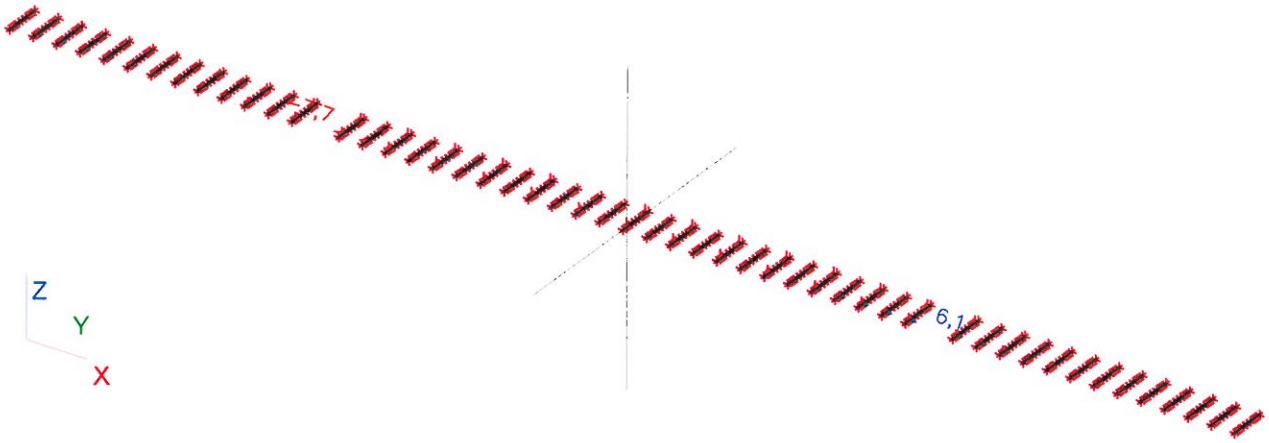

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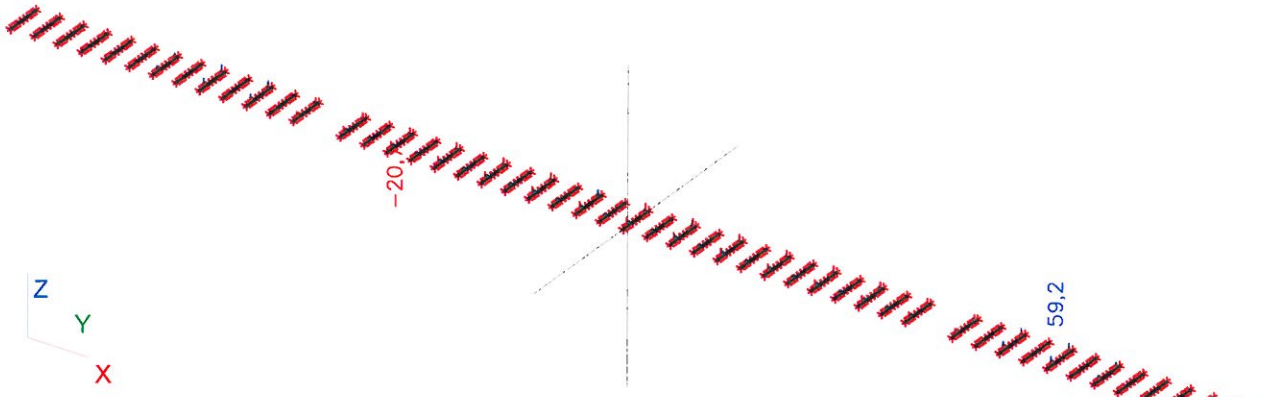

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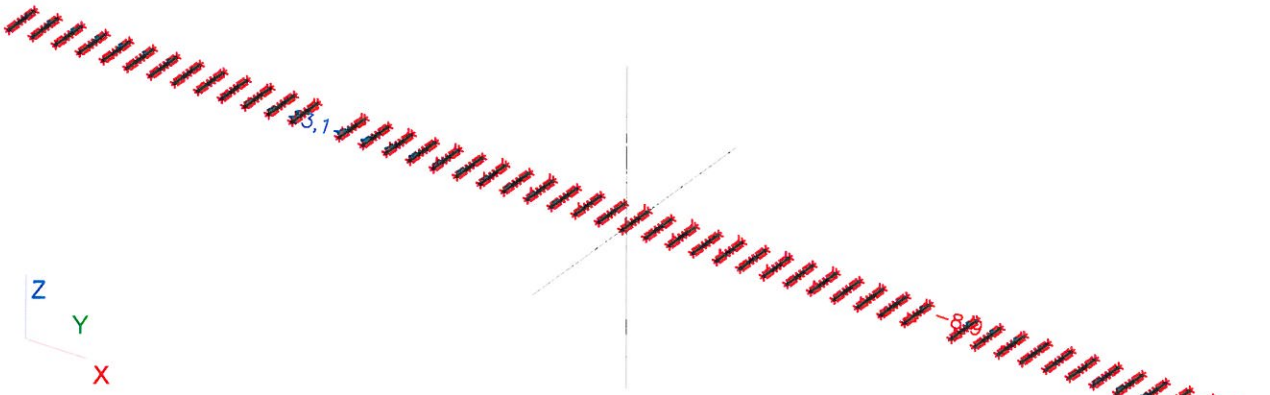

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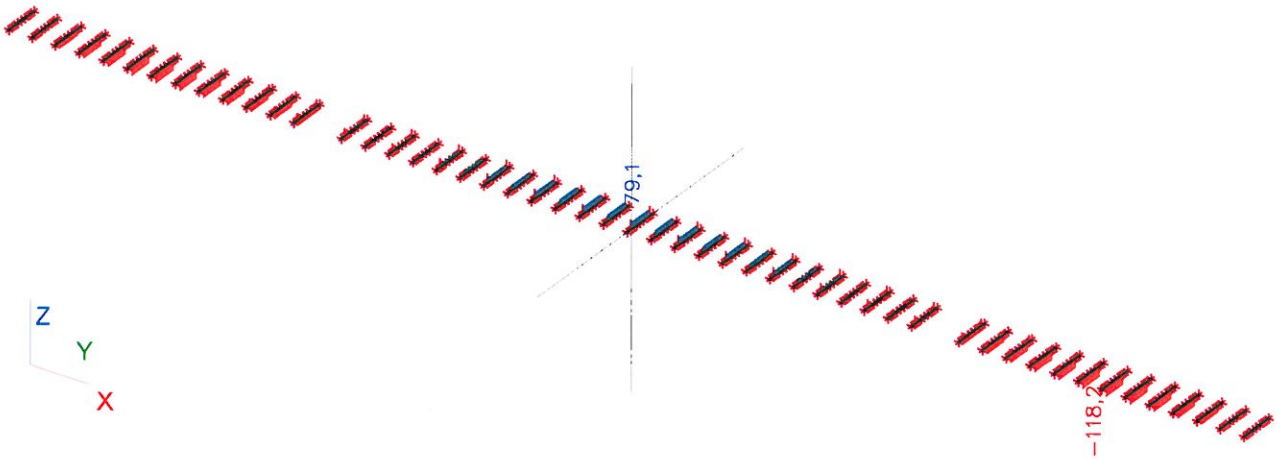

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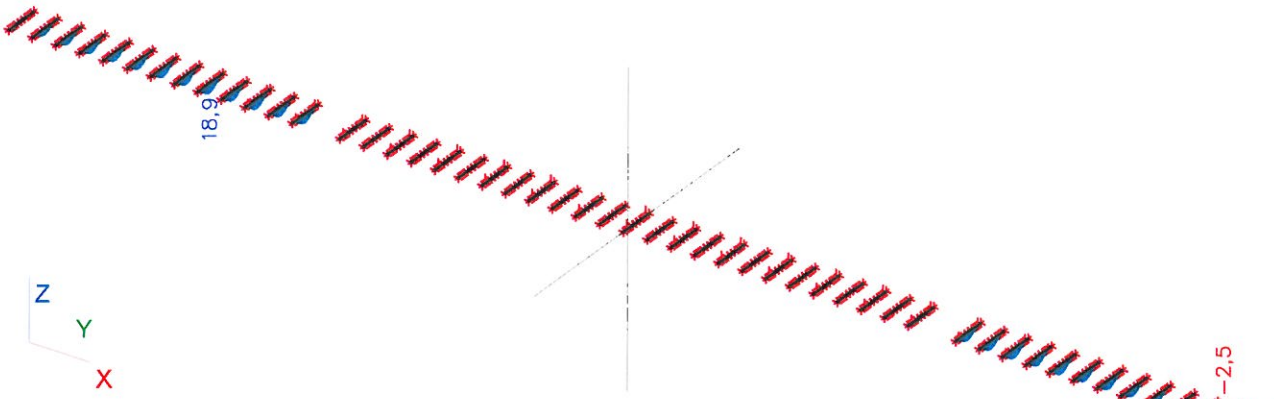

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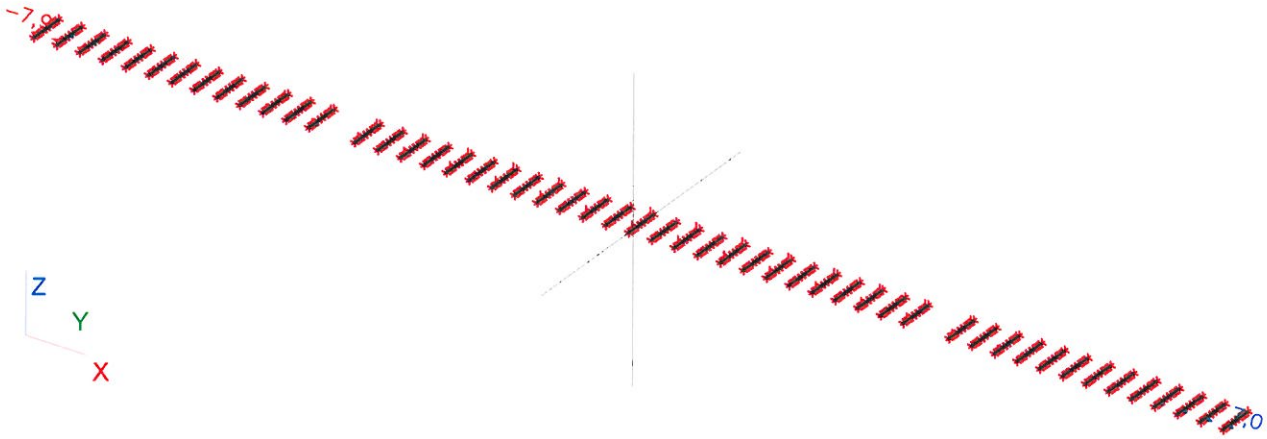

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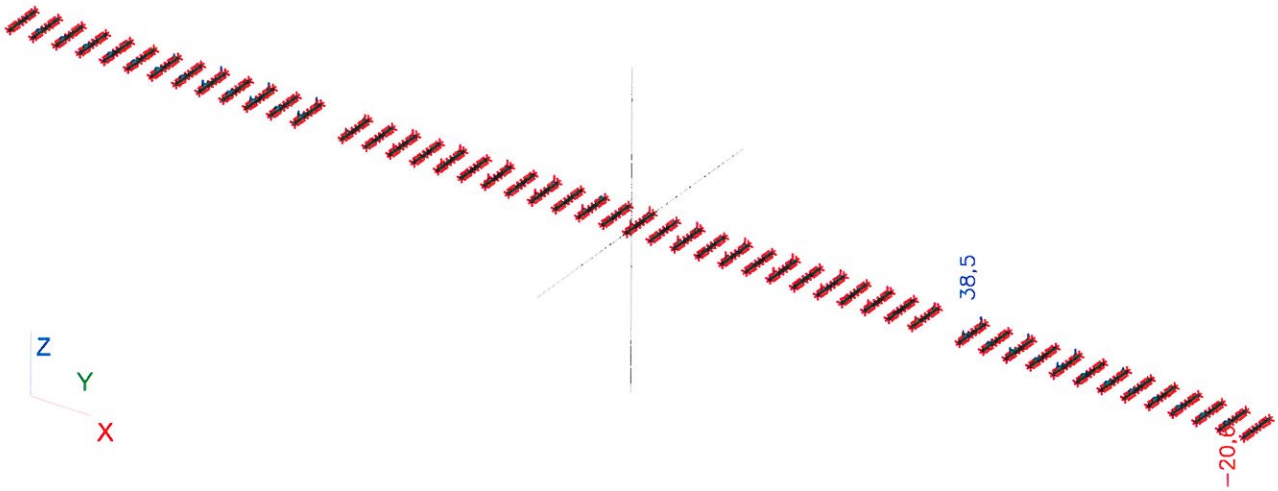

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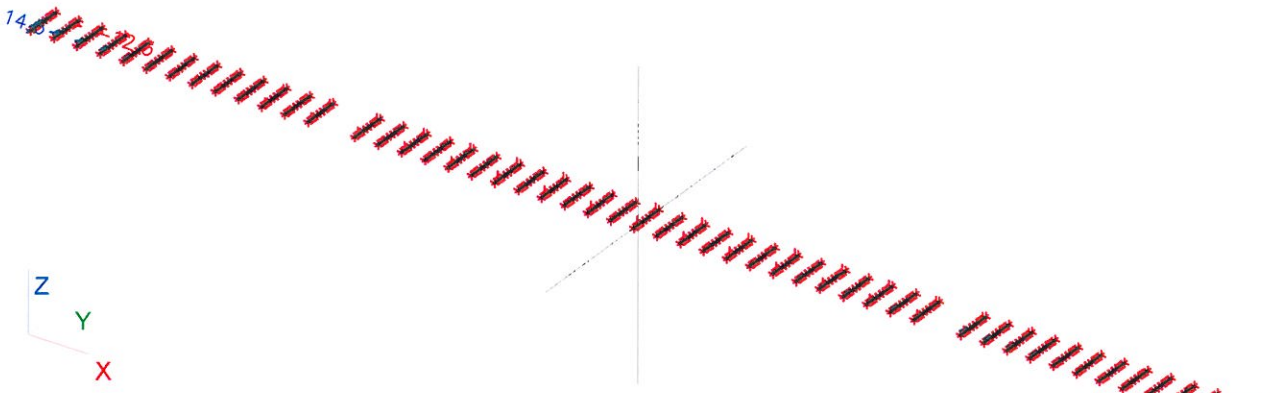
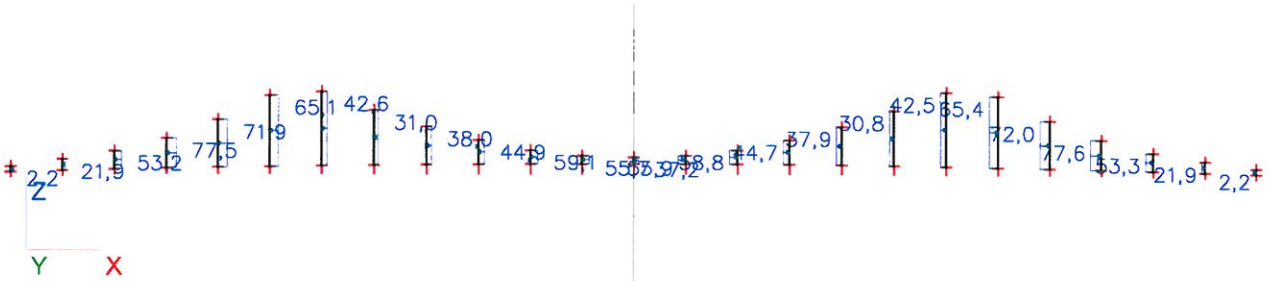
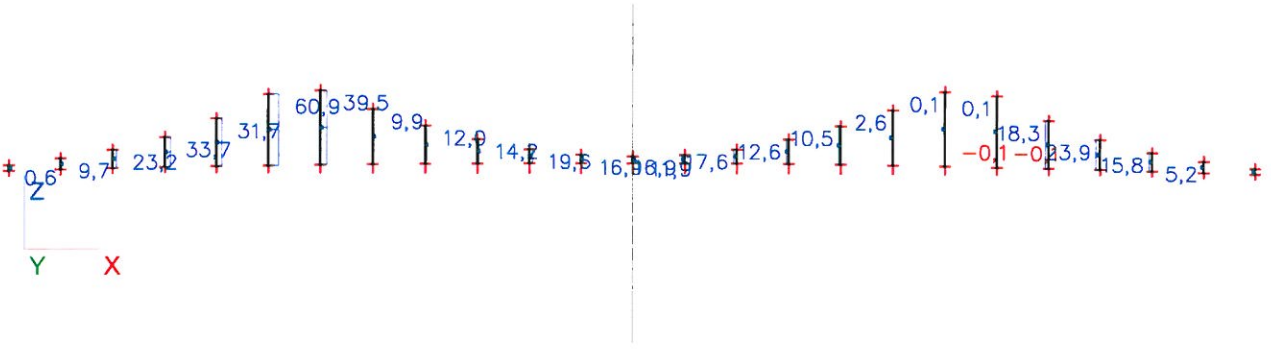


7. Závěsy

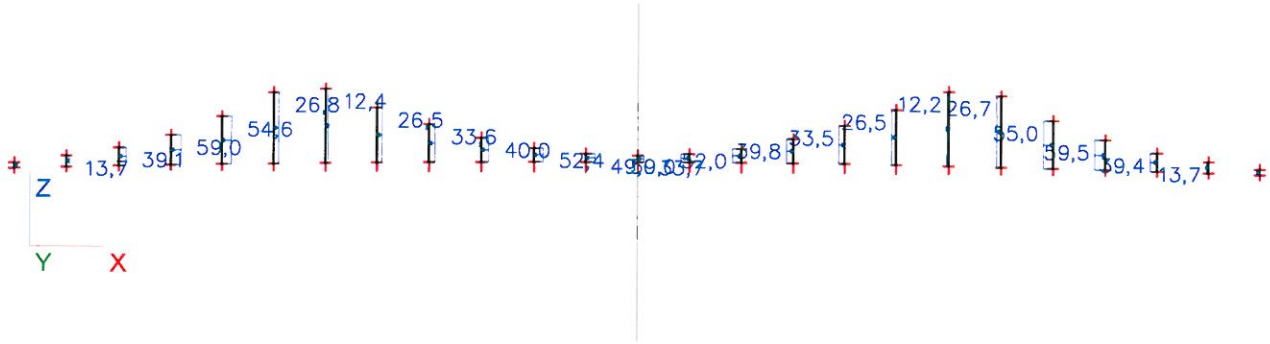
7.1. Z N ChallU



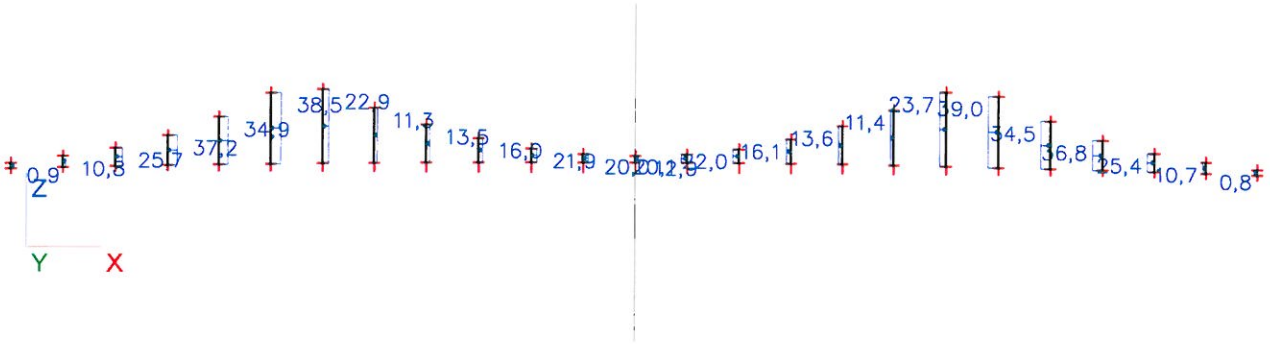
7.2. Z N Ch1U



7.3. Z N Ch23U

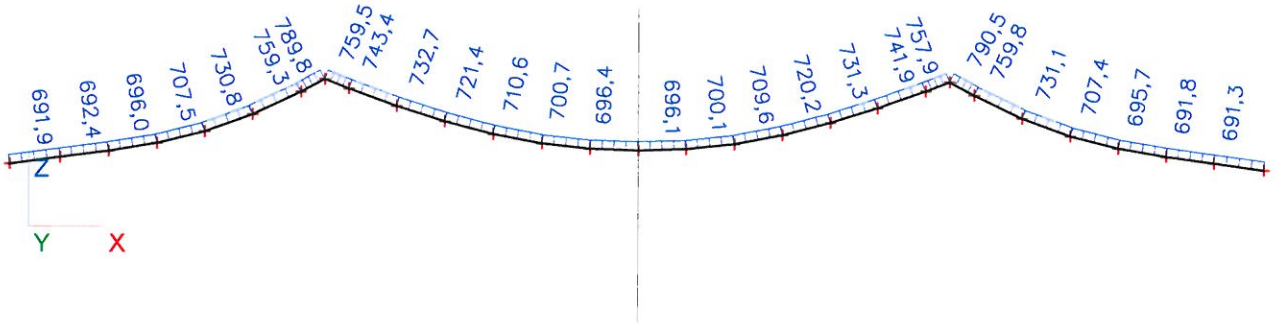


7.4. Z N Ch14U



8. Lano

8.1. L N ChaIIU



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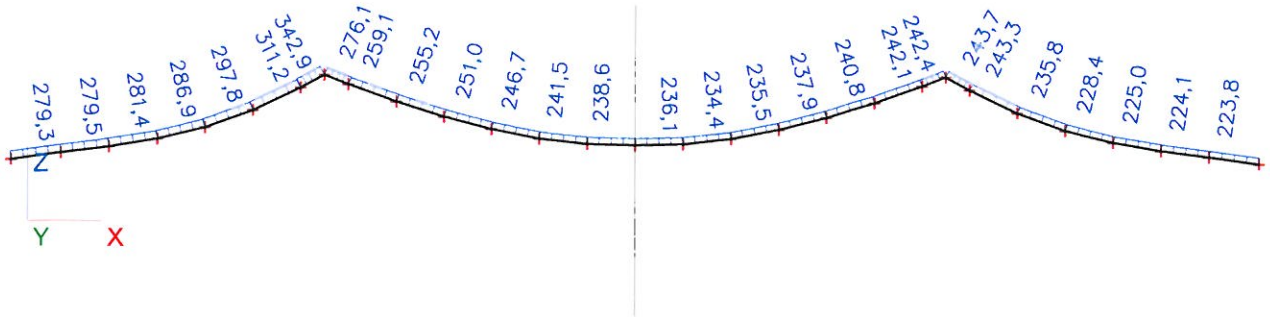

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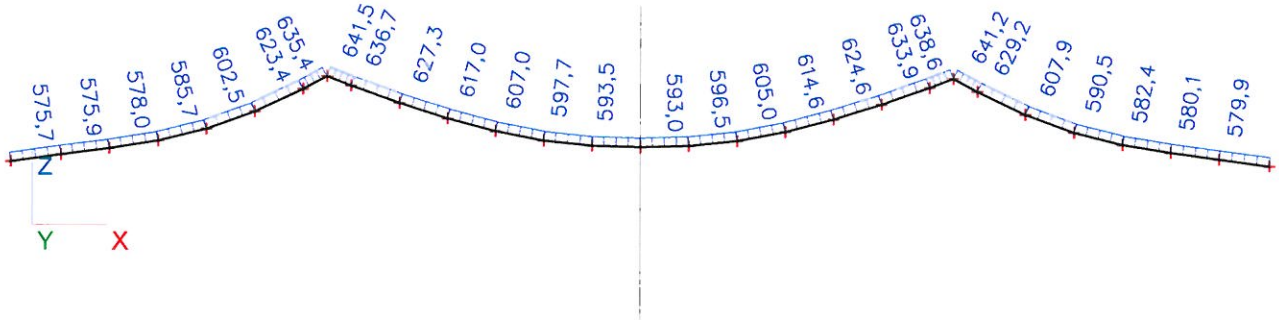
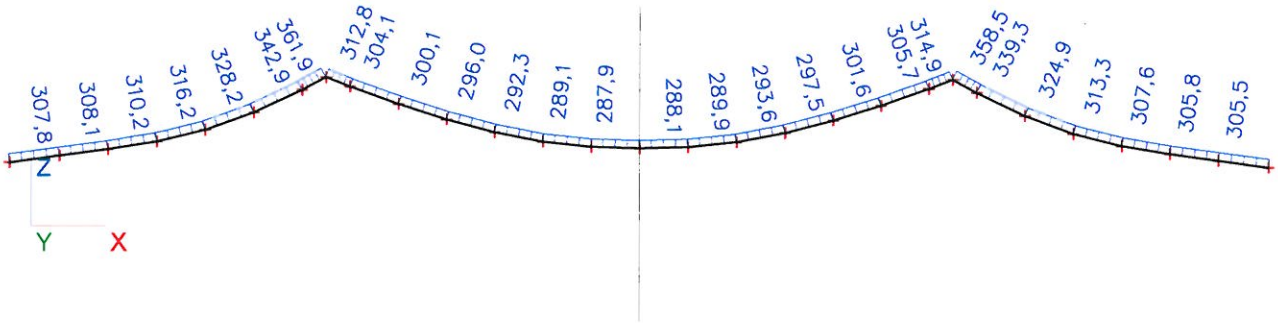
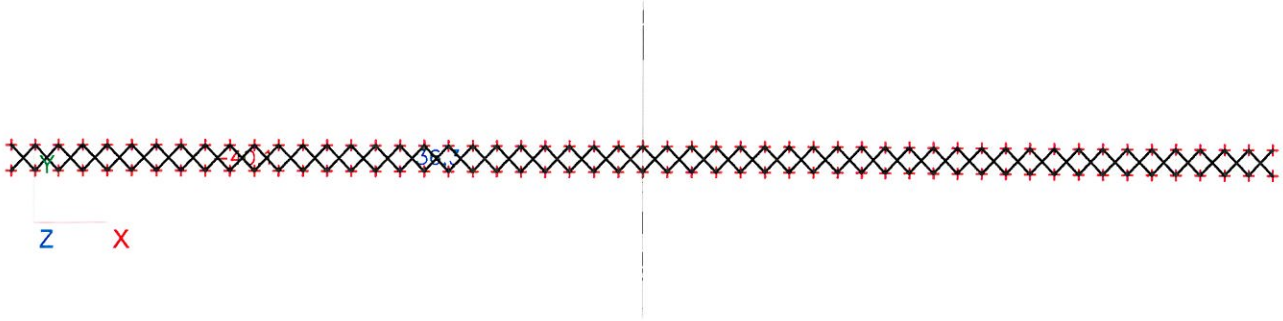


8.4. L N Ch14U

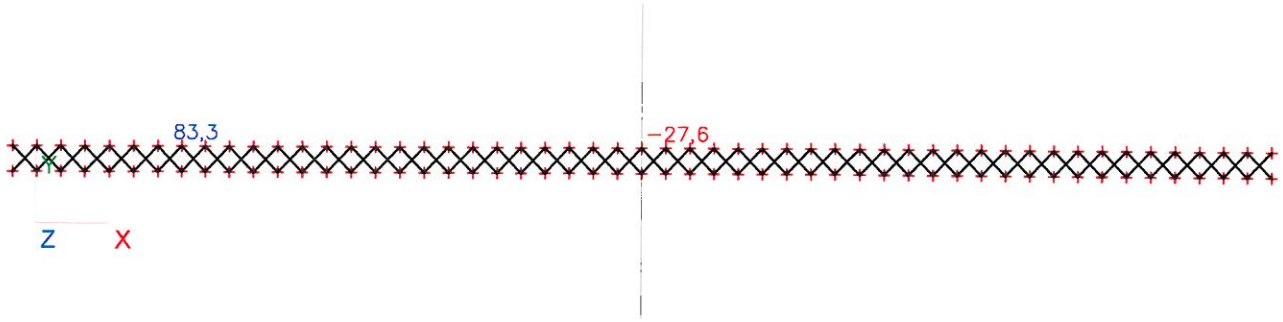


9. Ztužení

9.1. Zt N ChallU



9.2. Zt N Ch1U



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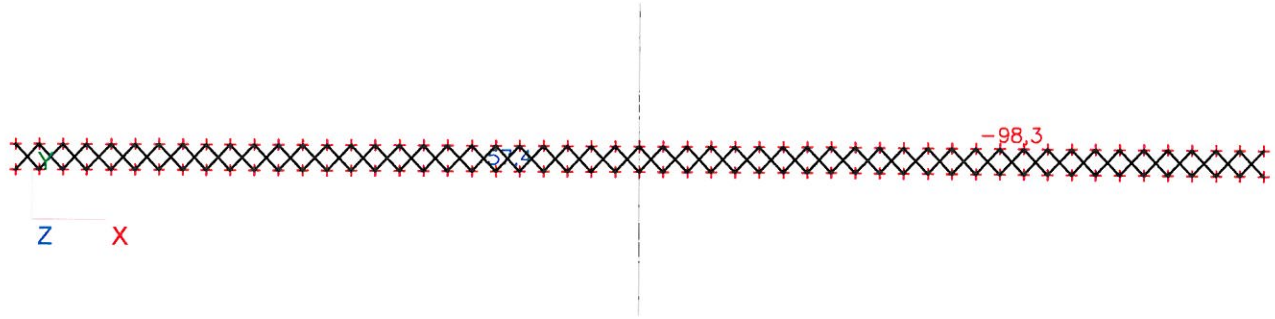
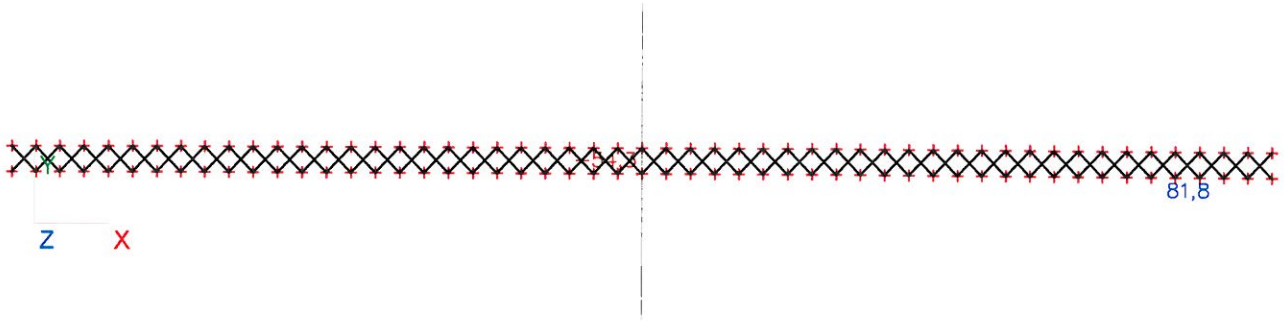
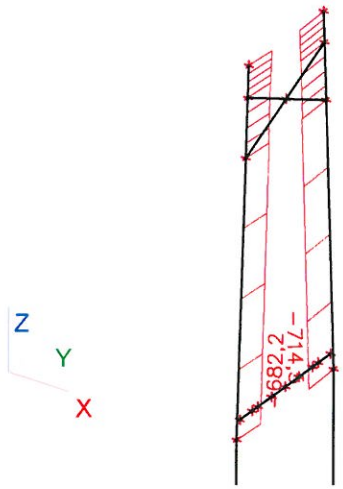


9.4. Zt N Ch14U

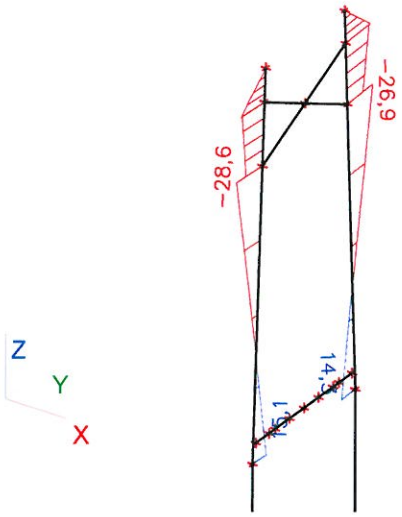


10. Pylon

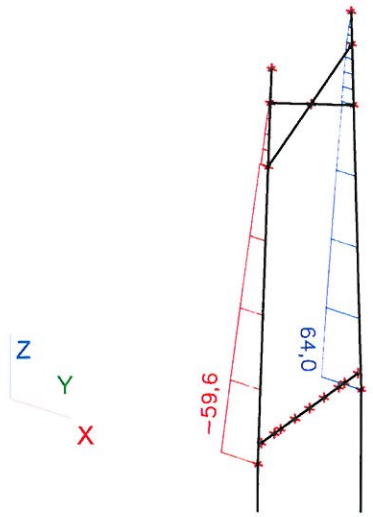
10.1. N ChallU



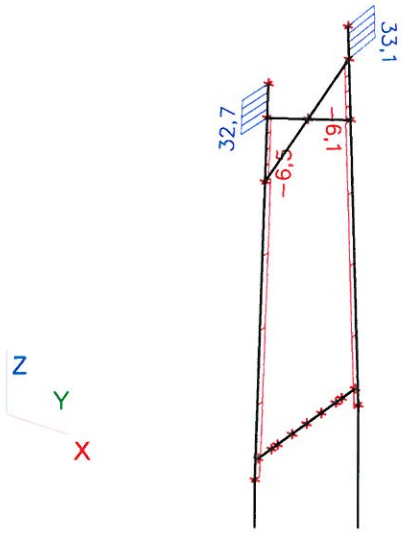
10.2. My ChallU



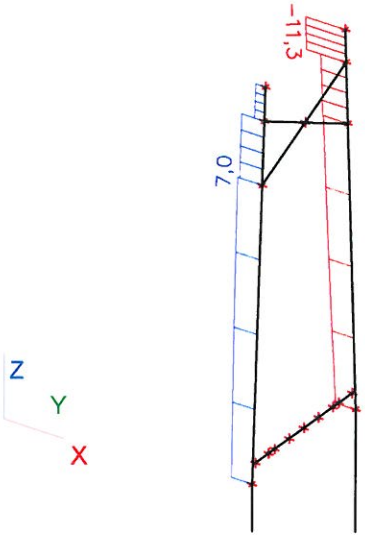
10.3. Mz ChallU



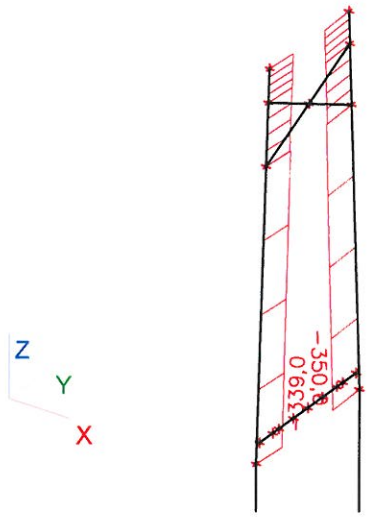
10.4. Vz ChallU



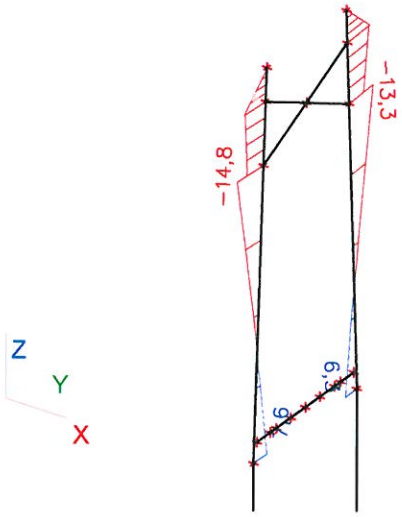
10.5. Vy ChallU



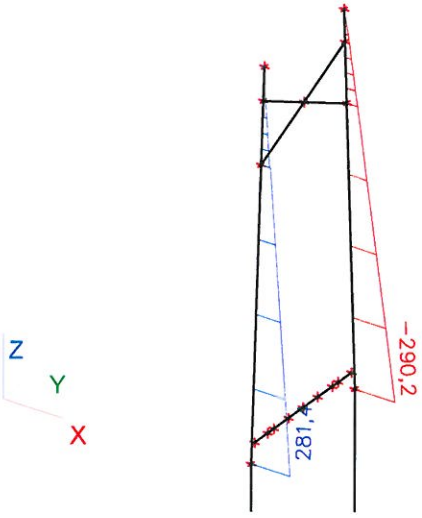
10.6. N Ch1U



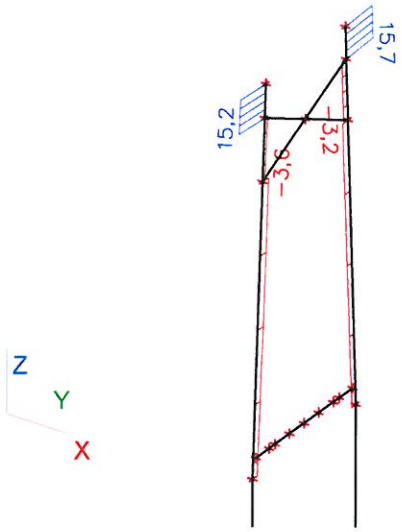
10.7. My Ch1U



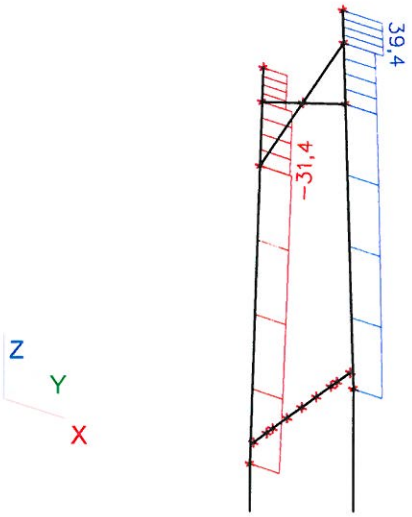
10.8. Mz Ch1U



10.9. Vz Ch1U



10.10. Vy Ch1U



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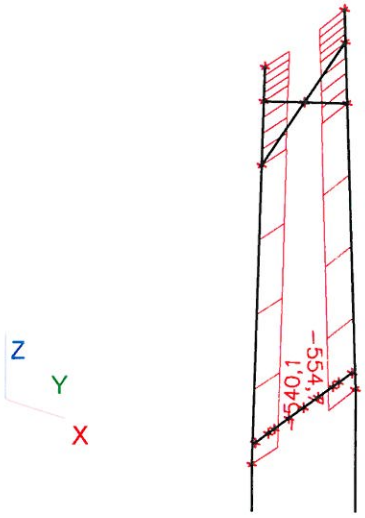
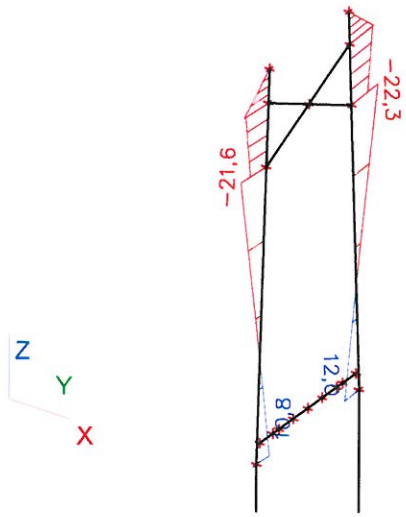
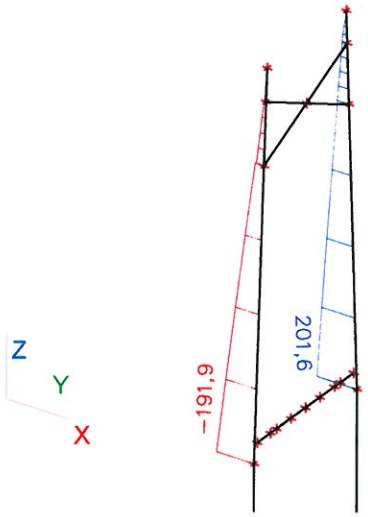


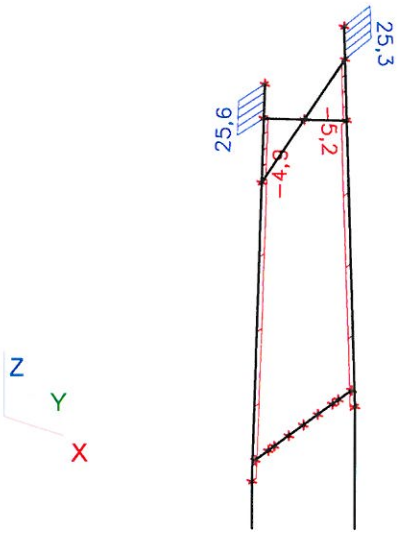
10.12. My Ch23U



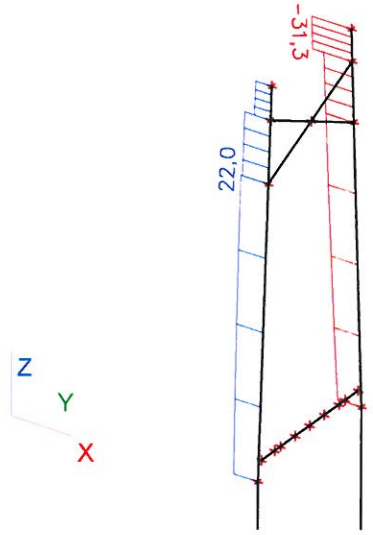
10.13. Mz Ch23U



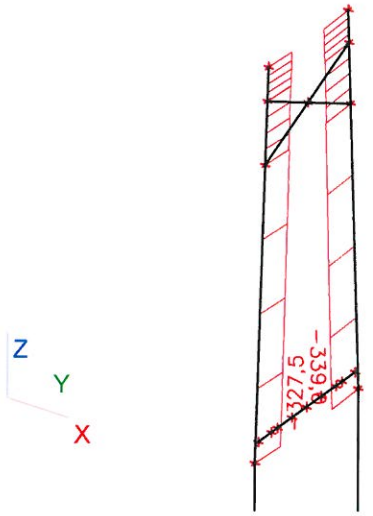
10.14. Vz Ch23U



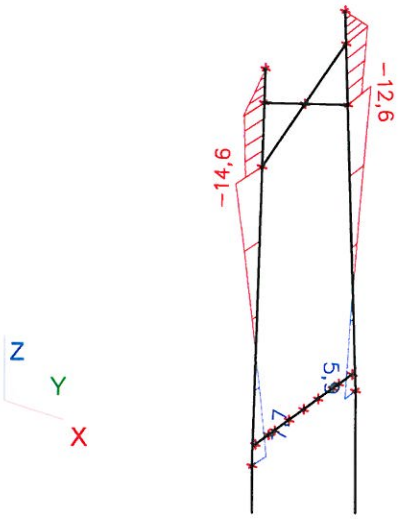
10.15. Vy Ch23U



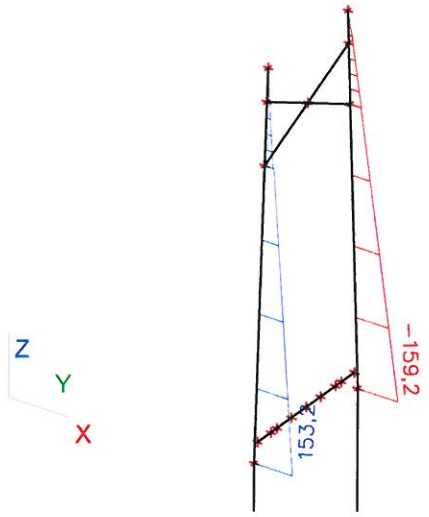
10.16. N Ch14U



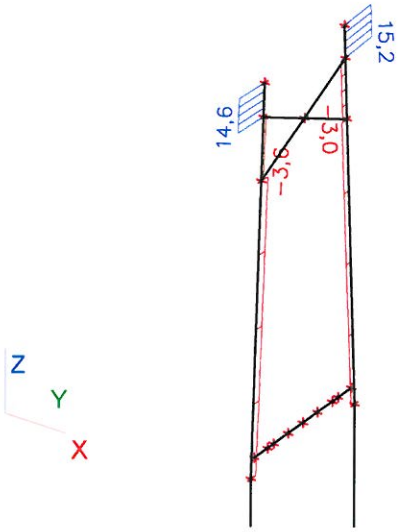
10.17. My Ch14U



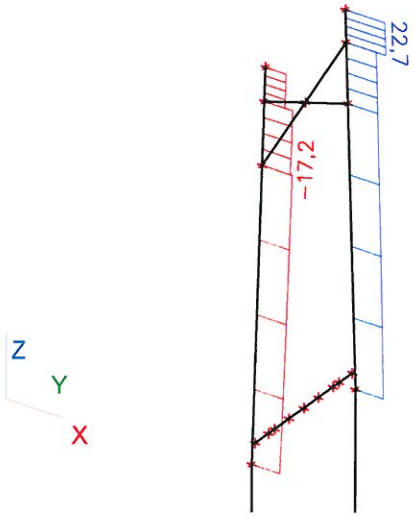
10.18. Mz Ch14U



10.19. Vz Ch14U

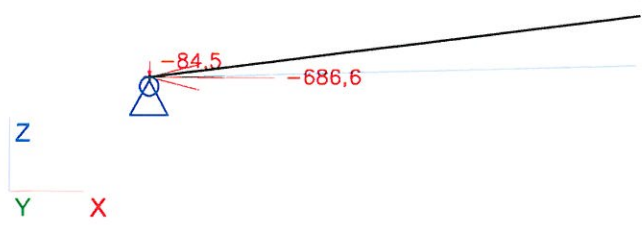


10.20. Vy Ch14U

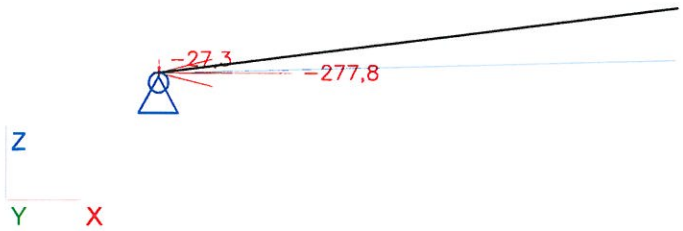


11. Základ

11.1. R ChallU

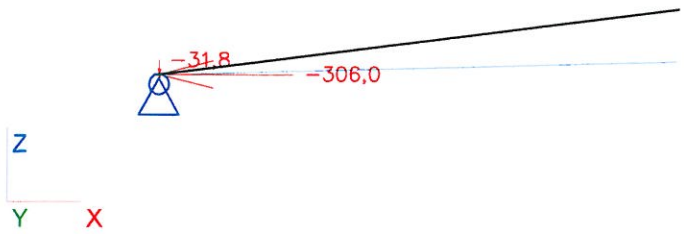


11.2. R Ch1U

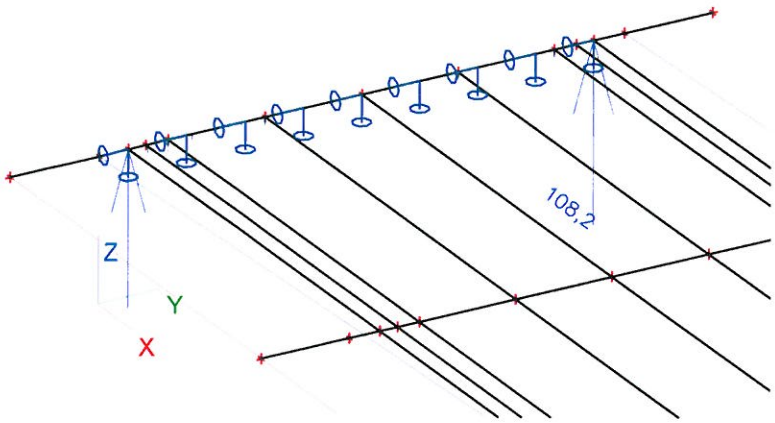


11.3. R Ch23U

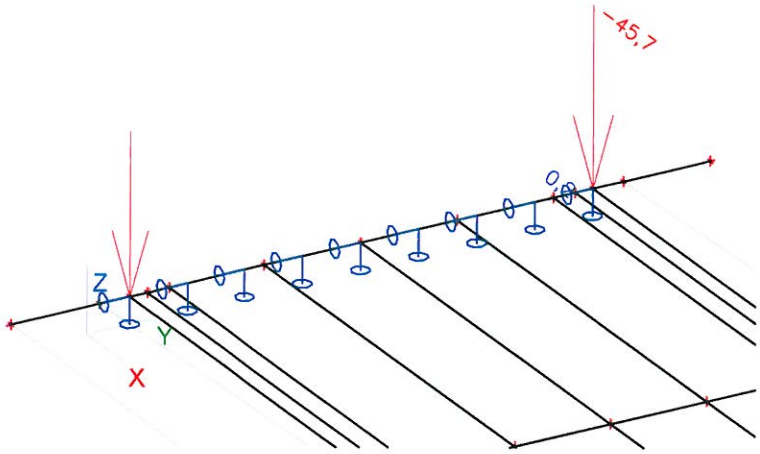
11.4. R Ch14U



11.5. Rz Ch1U



11.6. Rz Ch23U



12. Příčník u pylonu

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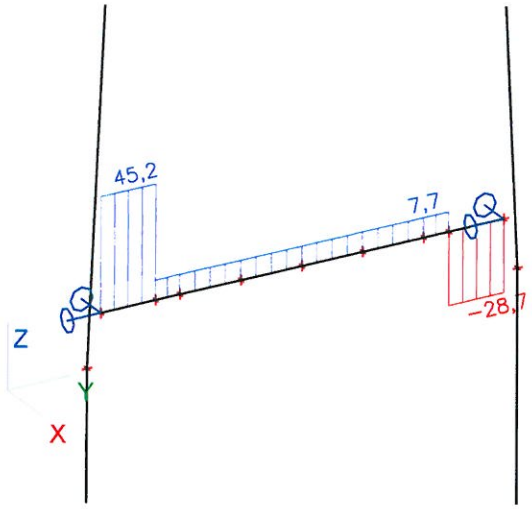
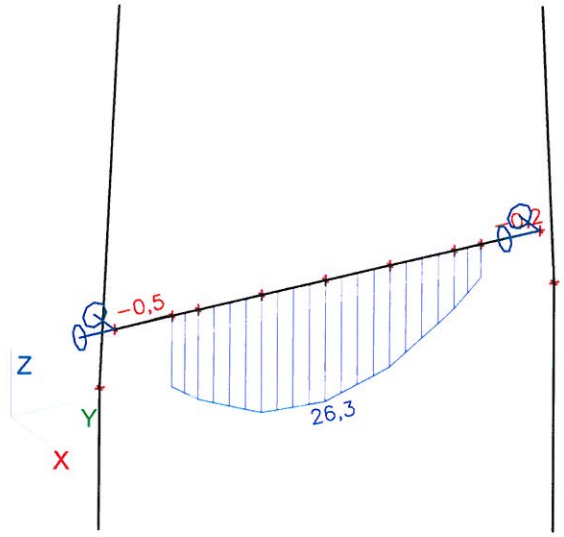
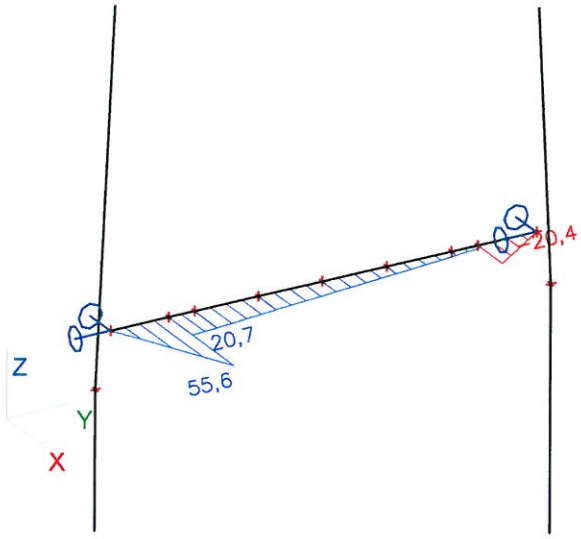


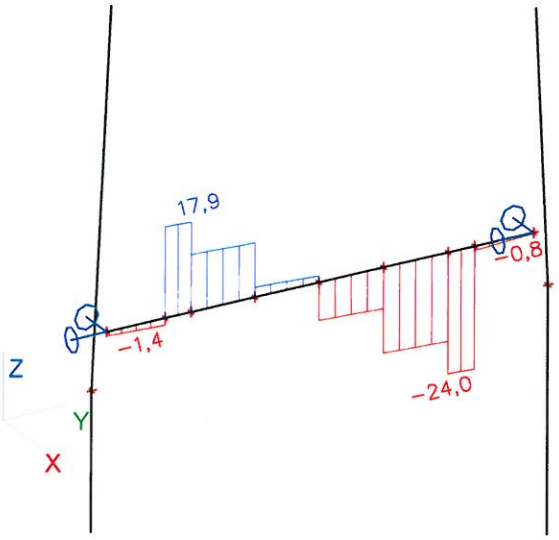
12.2. PP My ChallU



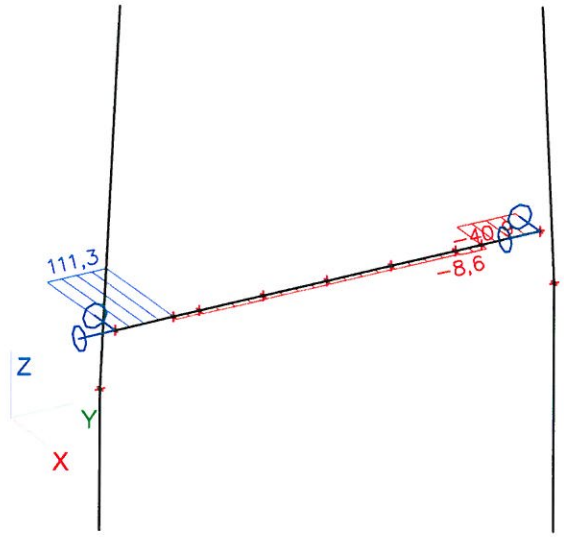
12.3. PP Mz ChallU



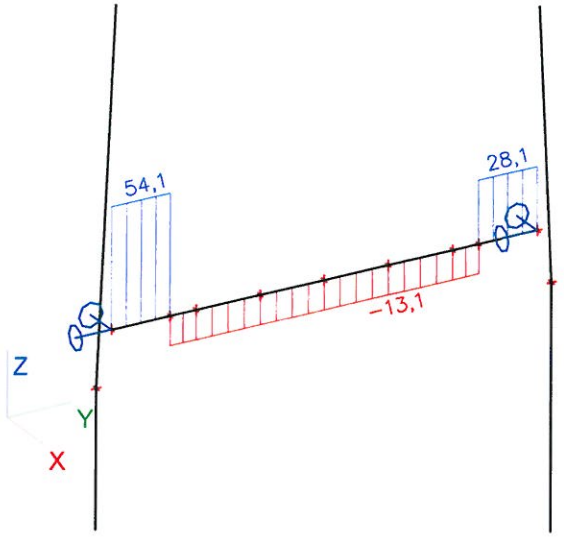
12.4. PP Vz ChallU



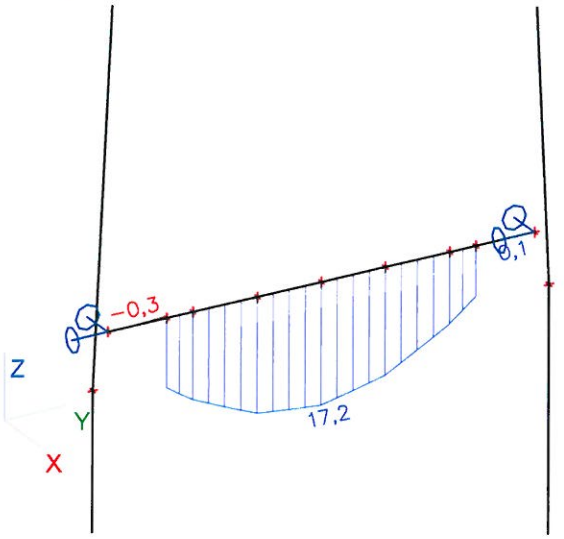
12.5. PP Vy ChalIU



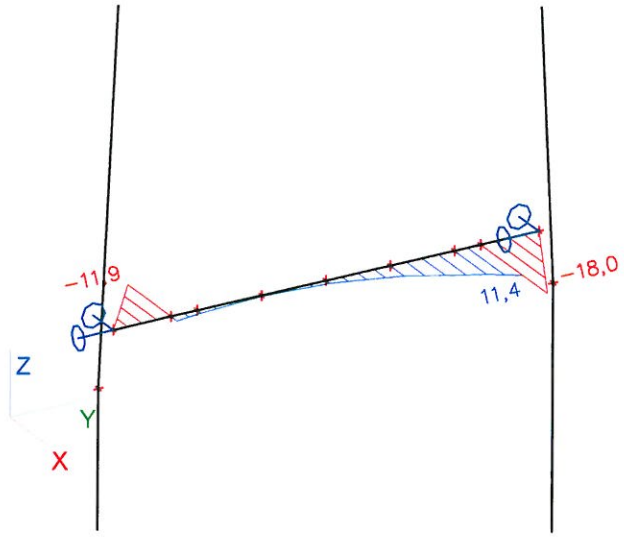
12.6. PP N Ch1U



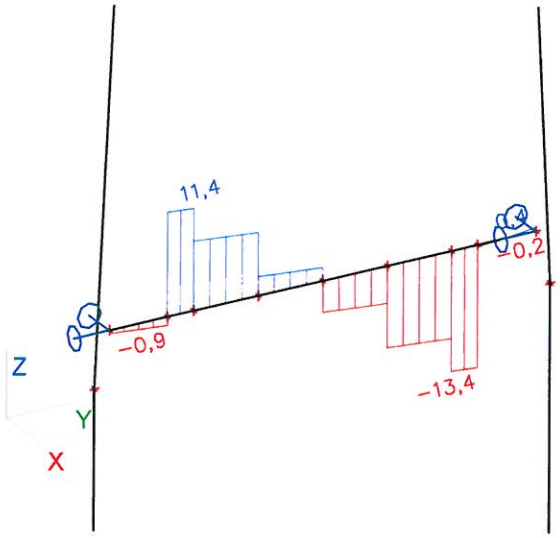
12.7. PP My Ch1U



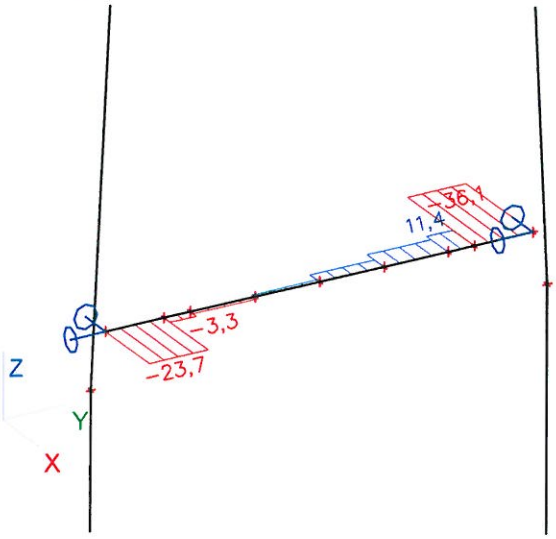
12.8. PP Mz Ch1U



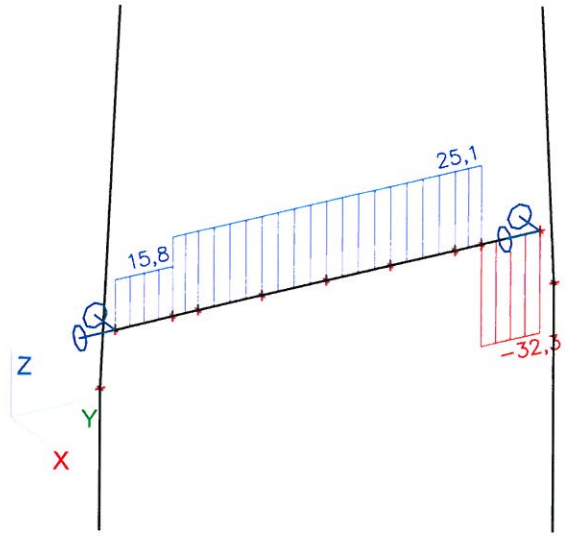
12.9. PP Vz Ch1U



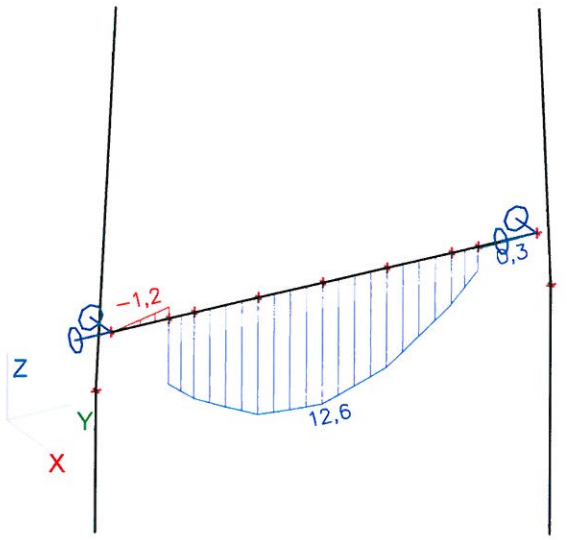
12.10. PP Vy Ch1U



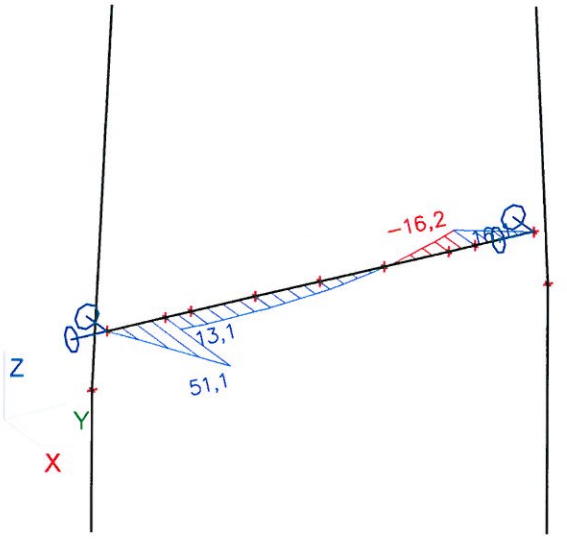
12.11. PP N Ch23U



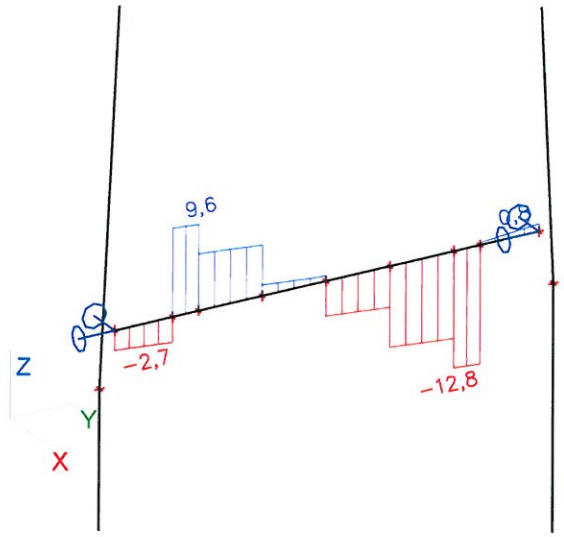
12.12. PP My Ch23U



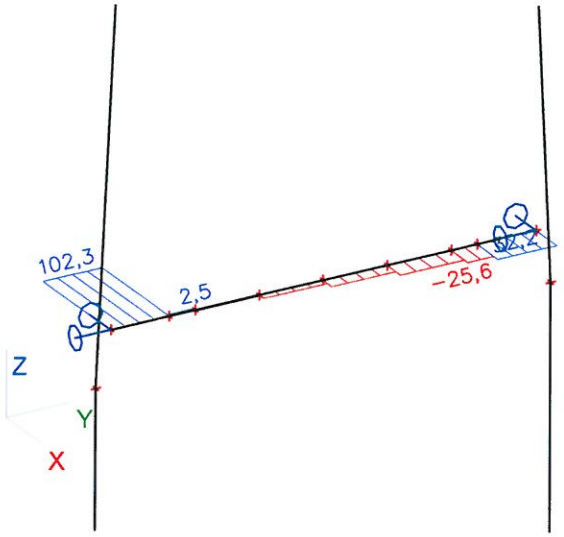
12.13. PP Mz Ch23U



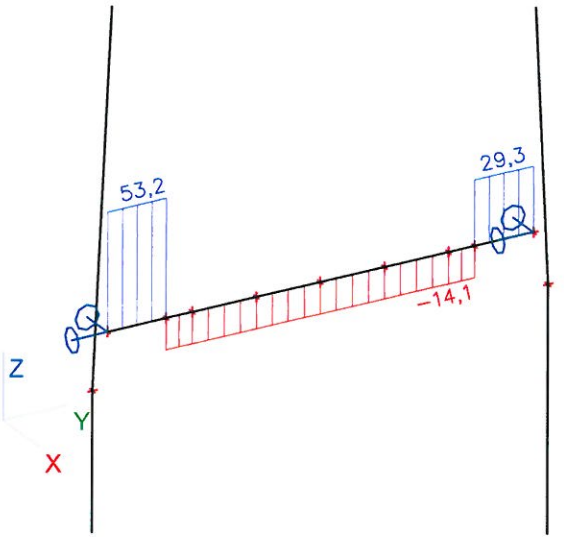
12.14. PP Vz Ch23U



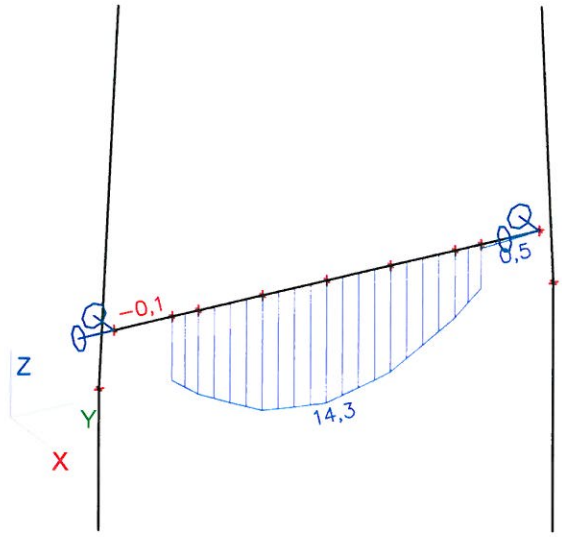
12.15. PP Vy Ch23U



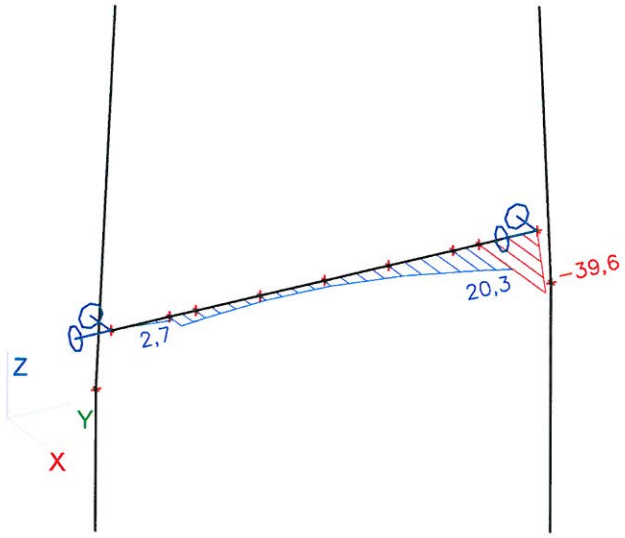
12.16. PP N Ch14U



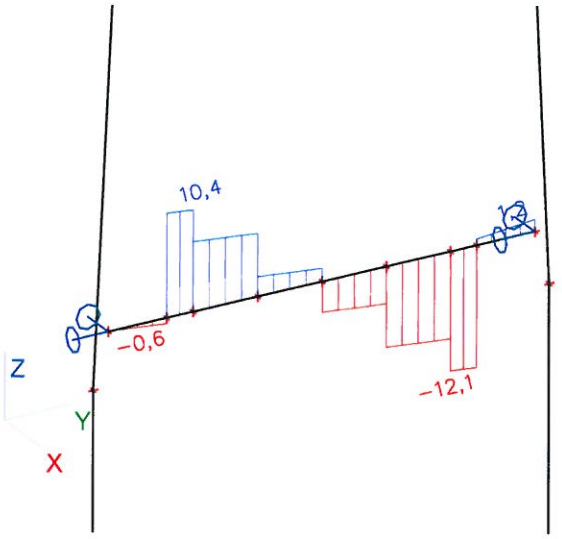
12.17. PP My Ch14U



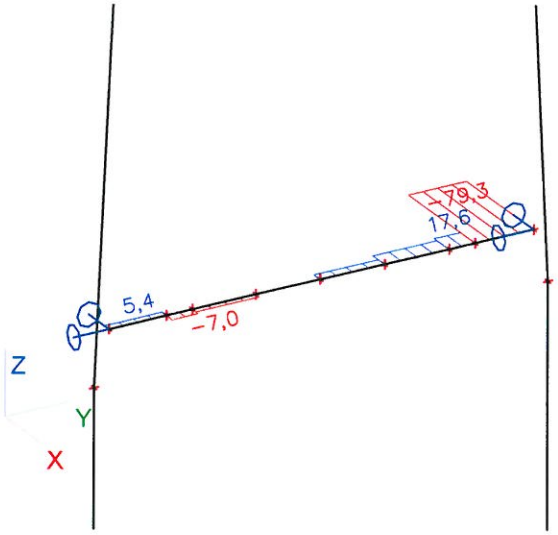
12.18. PP Mz Ch14U



12.19. PP Vz Ch14U



12.20. PP Vy Ch14U



Nosníky

Dřevo

dřevo:	GL32h				
k_{mod} =	0,70	f_{c0k} =	29 MPa	γ_m =	1,25
		f_{mk} =	32 MPa	β_c =	0,10
		f_{vk} =	3,8 MPa	E_{005} =	11100 MPa

Geometrie

profil	b =	220 mm		k_m =	0,7		
	h =	1300 mm		A =	2,86E+05	mm^2	
krit. délky	$L_{cri,Y}$ =	5000 mm		$L_{cri,Z}$ =	5000 mm		
l -klopení	L =	5000 mm			Prostě podepřený - spojité zatížení		
	W_y =	6,20E+07	mm^3	W_z =	1,05E+07	mm^3	
	I_y =	4,0E+10		I_z =	1,2E+09		
	i_y =	375,28		i_z =	63,51		
	λ_y =	13,32 mm		λ_Z =	78,73 mm		

Zatížení

N =	160 kN	M_y =	870 kNm	M_z =	30 kNm	V_z =	100 kNm
zatížení	○ Tlačený okraj		○ Těžiště		◉ Tažený okraj		

Pevnosti

$$f_{c0d} = 0{,}70 \cdot \frac{29{,}00}{1{,}25} = 16{,}2 \text{ MPa}$$

$$R_d = k_{mod}\frac{R_k}{\gamma_M}$$

$$f_{m0d} = 0{,}70 \cdot \frac{32{,}00}{1{,}25} = 17{,}9 \text{ MPa}$$

$$f_{vd} = 0{,}70 \cdot \frac{3{,}80}{1{,}25} = 2{,}1 \text{ MPa}$$

Napětí

$$\sigma_{c0d} = \frac{N}{A} = \frac{160{,}00}{3E+05} = 0{,}6 \text{ MPa}$$

$$\sigma_{c,my,d} = \frac{My}{Wy} = \frac{870{,}00}{6E+07} = 14 \text{ MPa}$$

$$\tau_d = \frac{3 \cdot V}{2 \cdot A} = \frac{300{,}00}{6E+05} = 0{,}5 \text{ MPa}$$

$$\sigma_{c,mz,d} = \frac{Mz}{Wz} = \frac{30{,}00}{1E+07} = 3 \text{ MPa}$$

M + N s vlivem stability - sloup

$$\lambda_{rel,y} = \frac{\lambda_y}{\pi}\sqrt{\frac{f_{c,0,k}}{E_{0,05}}} = \frac{13{,}32}{3{,}14}\cdot\sqrt{\frac{29}{11100}} = 0{,}22$$

$$\lambda_{rel,z} = \frac{\lambda_z}{\pi}\sqrt{\frac{f_{c,0,k}}{E_{0,05}}} = \frac{78{,}73}{3{,}14}\cdot\sqrt{\frac{29}{11100}} = 1{,}28$$

$$k_y = 0{,}5\left(1+\beta_c\left(\lambda_{rel,y} - 0{,}3\right)-\lambda_{rel,y}^2\right) = \frac{1 + 0{,}10\,(\,0{,}22 - 0{,}3\,) + 0{,}05}{2} = 0{,}519$$

$$k_z = 0{,}5\left(1+\beta_c\left(\lambda_{rel,z} - 0{,}3\right)-\lambda_{rel,z}^2\right) = \frac{1 + 0{,}10\,(\,1{,}28 - 0{,}3\,) + 1{,}64}{2} = 1{,}369$$

$$k_{c,y} = \frac{1}{k_y + \sqrt{k_y^2 - \lambda_{rel,y}^2}} = \frac{1}{0{,}519 + \sqrt{0{,}27} - 0{,}05} = 1{,}009$$

$$k_{c,z} = \frac{1}{k_z + \sqrt{k_z^2 - \lambda_{rel,z}^2}} = \frac{1}{1{,}369 + \sqrt{1{,}88} - 1{,}64} = 0{,}539$$

$$\frac{\sigma_{c,0,d}}{k_{c,y} f_{c,0,d}} + \frac{\sigma_{m,y,d}}{f_{m,y,d}} + k_m\frac{\sigma_{m,z,d}}{f_{m,z,d}} = \frac{0{,}56}{1{,}009 \cdot 16{,}24} + \frac{14{,}04}{17{,}92} + 0{,}7 \cdot \frac{2{,}86}{17{,}92} =$$

$$= \mathbf{0{,}034} + \mathbf{0{,}783} + \mathbf{0{,}112} = \boxed{\mathbf{0{,}929}} < \boxed{1} \quad \textbf{vyhoví}$$

$$\frac{\sigma_{c,0,d}}{k_{c,z} f_{c,0,d}} + k_m\frac{\sigma_{m,y,d}}{f_{m,y,d}} + \frac{\sigma_{m,z,d}}{f_{m,z,d}} = \frac{0{,}56}{0{,}539 \cdot 16{,}24} + 0{,}7 \cdot \frac{14{,}04}{17{,}92} + \frac{2{,}86}{17{,}92} =$$

$$= \mathbf{0{,}064} + \mathbf{0{,}548} + \mathbf{0{,}160} = \boxed{\mathbf{0{,}772}} < \boxed{1} \quad \textbf{vyhoví}$$

M + N s vlivem klopení - nosník

l_{ef}/l = 0,8 $l_{ef} = l_{ef}/l.l + (+2h/-0,5h)$ = 0,8 . 5,00 + -0,65 = 3,350 m

$$\sigma_{m,crit} = \frac{0,78 b^2}{h l_{ef}} E_{0,05} = \frac{0,78}{1,3} \cdot \frac{0,0484}{3,350} \cdot 11100 = 96,2 \text{ Mpa}$$

$$\lambda_{rel,m} = \sqrt{\frac{f_{m,k}}{\sigma_{m,crit}}} = (32,00 / 96,22)^{1/2} = 0,577$$

k_{crit} = 1 pro $\lambda_{rel,m} \leq 0,75$ $1,56 - 0,75\lambda_{rel,m}$ pro $0,75 < \lambda_{rel,m} \leq 1,4$ $\frac{1}{\lambda_{rel,m}^2}$ pro $1,4 < \lambda_{rel,m}$

k_{crit} = 1

Pouze M_y:

$\sigma_{c,my,d}$ = 14 MPa < $k_{crit}.f_{m,d}$ = 1,00 . 17,9 = 17,92 Mpa **vyhoví**

Kombinace M_y a N_c:

$$\left(\frac{\sigma_{m,d}}{k_{crit} f_{m,d}}\right)^2 + \frac{\sigma_{c,d}}{k_{c,z} f_{c,0,d}} = \left(\frac{14,040}{1 \cdot 17,92}\right)^2 + \frac{0,559}{0,539 \cdot 16,240} =$$

= 0,61383 + 0,06386 = **0,614** < **1** **vyhoví**

M + N bez vlivu stability

$$\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + \frac{\sigma_{m,y,d}}{f_{m,y,d}} + k_m \frac{\sigma_{m,z,d}}{f_{m,z,d}} = \left[\frac{0,56}{16,24}\right]^2 + \frac{14,04}{17,92} + 0,7 \cdot \frac{2,86}{17,92} =$$

= **0,00119 + 0,78347 + 0,11175** = **0,896** < **1** **vyhoví**

$$\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 - k_m \frac{\sigma_{m,y,d}}{f_{m,y,d}} + \frac{\sigma_{m,z,d}}{f_{m,z,d}} = \left[\frac{0,56}{16,24}\right]^2 + 0,7 \cdot \frac{14,04}{17,92} + \frac{2,86}{17,92} =$$

= **0,00119 + 0,54843 + 0,15964** = **0,709** < **1** **vyhoví**

Smyk

τ_d = 0,52 MPa < f_{vd} = 2,13 MPa **vyhoví**

Podélníky

Dřevo

dřevo:	GL24h				
k_{mod} =	0,70	f_{c0k} =	24 MPa	γ_m =	1,25
		f_{mk} =	24 MPa	β_c =	0,20
		f_{vk} =	2,7 MPa	E_{005} =	9400 MPa

Geometrie

profil	b =	100 mm		k_m =	0,7		
	h =	150 mm		A =	1,50E+04	mm^2	
délky	$L_{cri,y}$ =	2500 mm		$L_{cri,z}$ =	2500 mm		
	W_y =	3,75E+05	mm^3	W_z =	2,50E+05	mm^3	
	i_y =	43,30		i_z =	28,87		
	λ_y =	58 mm		λ_z =	87 mm		

Zatížení

N =	20,0 kN	M_y =	2 kNm	M_z =	0 kNm	V_z =	5 kNm

Pevnosti

$$f_{c0d} = 0{,}70 \cdot \frac{24{,}00}{1{,}25} = 13{,}4 \text{ MPa}$$

$$f_{m0d} = 0{,}70 \cdot \frac{24{,}00}{1{,}25} = 13{,}4 \text{ MPa}$$

$$R_d = k_{mod} \frac{R_k}{\gamma_M}$$

$$f_{vd} = 0{,}70 \cdot \frac{2{,}70}{1{,}25} = 1{,}5 \text{ MPa}$$

Napětí

$$\sigma_{c0d} = \frac{N}{A} = \frac{20{,}00}{2E+04} = 1{,}3 \text{ MPa}$$

$$\tau_d = \frac{3 \cdot V}{2 \cdot A} = \frac{15{,}00}{3E+04} = 0{,}5 \text{ MPa}$$

$$\sigma_{c,my,d} = \frac{My}{Wy} = \frac{2{,}00}{4E+05} = 5 \text{ MPa}$$

$$\sigma_{c,mz,d} = \frac{Mz}{Wz} = \frac{0{,}00}{3E+05} = 0 \text{ MPa}$$

M + N s vlivem stability

$$\lambda_{rel,y} = \frac{\lambda_y}{\pi}\sqrt{\frac{f_{c,0,k}}{E_{0,05}}} = \frac{57{,}74}{3{,}14} \cdot \sqrt{\frac{24}{9400}} = 0{,}93$$

$$\lambda_{rel,z} = \frac{\lambda_z}{\pi}\sqrt{\frac{f_{c,0,k}}{E_{0,05}}} = \frac{86{,}60}{3{,}14} \cdot \sqrt{\frac{24}{9400}} = 1{,}39$$

$$k_y = 0.5\left(1+\beta_c\left(\lambda_{rel,y} - 0.3\right)+\lambda_{rel,y}^2\right) = \frac{1 + 0{,}20\,(\,0{,}93 - 0{,}3\,) + 0{,}86}{2} = 0{,}994$$

$$k_z = 0.5\left(1+\beta_c\left(\lambda_{rel,z} - 0.3\right)+\lambda_{rel,z}^2\right) = \frac{1 + 0{,}20\,(\,1{,}39 - 0{,}3\,) + 1{,}94}{2} = 1{,}579$$

$$k_{c,y} = \frac{1}{k_y + \sqrt{k_y^2 - \lambda_{rel,y}^2}} = \frac{1}{0{,}994 + \sqrt{0{,}99 - 0{,}86}} = 0{,}741$$

$$k_{c,z} = \frac{1}{k_z + \sqrt{k_z^2 - \lambda_{rel,z}^2}} = \frac{1}{1{,}579 + \sqrt{2{,}49 - 1{,}94}} = 0{,}430$$

$$\frac{\sigma_{c,0,d}}{k_{c,y} f_{c,0,d}} + \frac{\sigma_{m,y,d}}{f_{m,y,d}} + k_m \frac{\sigma_{m,z,d}}{f_{m,z,d}} = \frac{1{,}33}{0{,}741 \cdot 13{,}44} + \frac{5{,}33}{13{,}44} + 0{,}7 \cdot \frac{0{,}00}{13{,}44} =$$

$$= \mathbf{0{,}134} + \mathbf{0{,}397} + \mathbf{0{,}000} = \boxed{\mathbf{0{,}531}} < \boxed{\mathbf{1}} \quad \textbf{vyhoví}$$

$$\frac{\sigma_{c,0,d}}{k_{c,z} f_{c,0,d}} + k_m \frac{\sigma_{m,y,d}}{f_{m,y,d}} + \frac{\sigma_{m,z,d}}{f_{m,z,d}} = \frac{1{,}33}{0{,}430 \cdot 13{,}44} + 0{,}7 \cdot \frac{5{,}33}{13{,}44} + \frac{0{,}00}{13{,}44} =$$

$$= \mathbf{0{,}231} + \mathbf{0{,}278} + \mathbf{0{,}000} = \boxed{\mathbf{0{,}508}} < \boxed{\mathbf{1}} \quad \textbf{vyhoví}$$

Smyk

τ_d = 0,50 MPa < f_{vd} = 1,51 MPa **vyhoví**

Příčníky

Dřevo

dřevo:	GL32h
k_{mod} =	0,70

f_{c0k} = 29 MPa
f_{t0k} = 22,5 MPa
f_{mk} = 32 MPa
f_{vk} = 3,8 MPa

γ_m = 1,25
β_c = 0,20
E_{005} = 11100 MPa

Geometrie

profil: b = 200 mm; h = 300 mm; k_m = 0,7; A = 6,00E+04 mm^2

délky: $L_{cri,Y}$ = 550 mm; $L_{cri,Z}$ = 550 mm

W_y = 3,00E+06 mm^3; W_z = 2,00E+06 mm^3

i_y = 86,60; i_z = 57,74

λ_Y = 6 mm; λ_Z = 10 mm

Zatížení

N = 145,0 kN; M_y = 25,00 kNm; M_z = 10,00 kNm; V_z = 80,0 kNm

Pevnosti

$$f_{c0d} = 0{,}70 \cdot \frac{29{,}00}{1{,}25} = 16{,}2 \text{ MPa} \qquad f_{t0d} = 0{,}70 \cdot \frac{22{,}50}{1{,}25} = 13 \text{ MPa}$$

$$f_{m0d} = 0{,}70 \cdot \frac{32{,}00}{1{,}25} = 17{,}9 \text{ MPa} \qquad f_{vd} = 0{,}70 \cdot \frac{3{,}80}{1{,}25} = 2{,}1 \text{ MPa}$$

Napětí

$$\sigma_{c0d} = \frac{N}{A} = \frac{145{,}00}{6E+04} = 2{,}4 \text{ MPa} \qquad \sigma_{c,my,d} = \frac{My}{Wy} = \frac{25{,}00}{3E+06} = 8 \text{ MPa}$$

$$\tau_d = \frac{3 \cdot V}{2 \cdot A} = \frac{240{,}00}{1E+05} = 2{,}0 \text{ MPa} \qquad \sigma_{c,mz,d} = \frac{Mz}{Wz} = \frac{10{,}00}{2E+06} = 5 \text{ MPa}$$

M + N s vlivem stability

$$\lambda_{rel,y} = \frac{\lambda_y}{\pi}\sqrt{\frac{f_{c,0,k}}{E_{0,05}}} = \frac{6{,}35}{3{,}14} \cdot \sqrt{\frac{29}{11100}} = 0{,}10$$

$$\lambda_{rel,z} = \frac{\lambda_z}{\pi}\sqrt{\frac{f_{c,0,k}}{E_{0,05}}} = \frac{9{,}53}{3{,}14} \cdot \sqrt{\frac{29}{11100}} = 0{,}15$$

$$k_y = 0.5\left(1+\beta_c\left(\lambda_{rel,y} - 0.3\right)+\lambda_{rel,y}^2\right) = \frac{1 + 0{,}20\ (\ 0{,}10 - 0{,}3\ ) + 0{,}01}{2} = 0{,}486$$

$$k_z = 0.5\left(1+\beta_c\left(\lambda_{rel,z} - 0.3\right)+\lambda_{rel,z}^2\right) = \frac{1 + 0{,}20\ (\ 0{,}15 - 0{,}3\ ) + 0{,}02}{2} = 0{,}498$$

$$k_{c,y} = \frac{1}{k_y + \sqrt{k_y^2 - \lambda_{rel,y}^2}} = \frac{1}{0{,}486 + \sqrt{0{,}24} - 0{,}01} = 1{,}041$$

$$k_{c,z} = \frac{1}{k_z + \sqrt{k_z^2 - \lambda_{rel,z}^2}} = \frac{1}{0{,}498 + \sqrt{0{,}25} - 0{,}02} = 1{,}031$$

$$\frac{\sigma_{c,0,d}}{k_{c,y} f_{c,0,d}} + \frac{\sigma_{m,y,d}}{f_{m,y,d}} + k_m \frac{\sigma_{m,z,d}}{f_{m,z,d}} = \frac{2{,}42}{1{,}041 \cdot 16{,}24} + \frac{8{,}33}{17{,}92} + 0{,}7 \cdot \frac{5{,}00}{17{,}92} =$$

$$= \mathbf{0{,}143} + \mathbf{0{,}465} + \mathbf{0{,}195} = \boxed{\mathbf{0{,}803}} < \boxed{1} \quad \text{vyhoví}$$

$$\frac{\sigma_{c,0,d}}{k_{c,z} f_{c,0,d}} + k_m \frac{\sigma_{m,y,d}}{f_{m,y,d}} + \frac{\sigma_{m,z,d}}{f_{m,z,d}} = \frac{2{,}42}{1{,}031 \cdot 16{,}24} + 0{,}7 \cdot \frac{8{,}33}{17{,}92} + \frac{5{,}00}{17{,}92} =$$

$$= \mathbf{0{,}144} + \mathbf{0{,}326} + \mathbf{0{,}279} = \boxed{\mathbf{0{,}749}} < \boxed{1} \quad \text{vyhoví}$$

Smyk

τ_d = 2,00 MPa < f_{vd} = 2,13 MPa — vyhoví

Prkno mostovky

Dřevo

dřevo:	D30
k_{mod} =	0,70

f_{c0k} = 23 MPa
f_{mk} = 30 MPa
f_{vk} = 3,0 MPa

γ_m = 1,30
β_c = 0,10
E_{005} = 8000 MPa

Geometrie

profil: b = 50 mm; h = 50 mm; k_m = 0,7; A = 2,50E+03 mm^2

délky: $L_{cri,Y}$ = 550 mm; $L_{cri,Z}$ = 550 mm

W_y = 2,08E+04 mm^3; W_z = 2,08E+04 mm^3

i_y = 14,43; i_z = 14,43

λ_Y = 38 mm; λ_Z = 38 mm

Zatížení

N = 0,0 kN; M_y = 0,275 kNm; M_z = 0 kNm; V_z = 1 kNm

Pevnosti

$f_{c0d} = 0{,}70 \cdot \frac{23{,}00}{1{,}30} = 12{,}4$ MPa

$f_{m0d} = 0{,}70 \cdot \frac{30{,}00}{1{,}30} = 16{,}2$ MPa

$$R_d = k_{mod} \frac{R_k}{\gamma_M}$$

$f_{vd} = 0{,}70 \cdot \frac{3{,}00}{1{,}30} = 1{,}6$ MPa

Napětí

$\sigma_{c0d} = \frac{N}{A} = \frac{0{,}00}{3E+03} = 0{,}0$ MPa

$\tau_d = \frac{3 \cdot V}{2 \cdot A} = \frac{3{,}00}{5E+03} = 0{,}6$ MPa

$\sigma_{c,my,d} = \frac{My}{Wy} = \frac{0{,}28}{2E+04} = 13$ MPa

$\sigma_{c,mz,d} = \frac{Mz}{Wz} = \frac{0{,}00}{2E+04} = 0$ MPa

M + N bez vlivu stability

$$\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + \frac{\sigma_{m,y,d}}{f_{m,y,d}} + k_m \frac{\sigma_{m,z,d}}{f_{m,z,d}} = \left[\frac{0{,}00}{12{,}38}\right]^2 + \frac{13{,}20}{16{,}15} + 0{,}7 \cdot \frac{0{,}00}{16{,}15} =$$

$= 0 + 0{,}81714 + 0 = \boxed{0{,}817} < \boxed{1}$ **vyhoví**

$$\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + k_m \frac{\sigma_{m,y,d}}{f_{m,y,d}} + \frac{\sigma_{m,z,d}}{f_{m,z,d}} = \left[\frac{0{,}00}{12{,}38}\right]^2 + 0{,}7 \cdot \frac{13{,}20}{16{,}15} + \frac{0{,}00}{16{,}15} =$$

$= 0 + 0{,}572 + 0 = \boxed{0{,}572} < \boxed{1}$ **vyhoví**

Smyk

τ_d = 0,60 MPa < f_{vd} = 1,62 MPa **vyhoví**

POSOUZENÍ MIKROPILOTY - OPĚRA

Ocel

f_y = 235 MPa E = 210 GPa γ_m = 1

Geometrie

D = 88,9 mm t = 6,3 mm Křivka vzp. pevnosti:

tř. průřezu 1 A = 1635 mm^2 a (válc. za tepla)

I_y = 1,40E+06 mm^4 I_z = 1,40E+06 mm^4 souč. imperfekce:

i_y = 29,29 mm i_z = 29,29 mm α = 0,21

$W_{pl,y}$ = 4,31E+04 mm^3 $W_{pl,z}$ = 4,31E+04 mm^3

Vzpěrné délky: L_y = 3000 mm L_z = 3000 mm

Zatížení

N_{Ed} = 215 kN M_{dy} = 0 kN M_{Edz} = 0 kN

Plastická únosnost průřezu v tlaku

$$N_{c,Rd} = \frac{A f_y}{\gamma_{M0}} = \frac{1634{,}82 \cdot 235}{1} = 384\ \text{kN} > 215\ \text{kN}$$ vyhoví

Plastická únosnost průřezu v ohybu

$$M_{c,Rd} = M_{pl,Rd} = \frac{W_{pl} f_y}{\gamma_{M0}} = \frac{43066{,}7 \cdot 235}{1} = 10\ \text{kNm} > 0\ \text{kN}$$ vyhoví

$$M_{c,Rd} = M_{pl,Rd} = \frac{W_{pl} f_y}{\gamma_{M0}} \quad \frac{43066{,}7 \cdot 235}{1} = 10\ \text{kNm} > 0\ \text{kN}$$ vyhoví

Návrhová únosnost průřezu M+N

$$\lambda_1 = \pi\sqrt{\frac{E}{f_y}} = 93{,}9\sqrt{\frac{235}{f_y}} = 93{,}90 \cdot \frac{235}{235} = 93{,}90$$

$$\bar{\lambda} = \sqrt{\frac{A f_y}{N_{cr}}} = \frac{L_{cr}}{i}\frac{1}{\lambda_1} = \frac{3000}{29{,}2883 \cdot 93{,}90} = 1{,}091$$ směr Y

$$\bar{\lambda} = \sqrt{\frac{A f_y}{N_{cr}}} = \frac{L_{cr}}{i}\frac{1}{\lambda_1} = \frac{3000}{29{,}2883 \cdot 93{,}90} = 1{,}091$$ směr Z

$$\phi = 0{,}5\left[1 + \alpha(\bar{\lambda} - 0{,}2) + \bar{\lambda}^2\right] = 0{,}21 \cdot 1{,}091 = 1{,}189$$ směr Y

$$\phi = 0{,}5\left[1 + \alpha(\bar{\lambda} - 0{,}2) + \bar{\lambda}^2\right] = 0{,}21 \cdot 1{,}091 = 1{,}189$$ směr Z

$$\chi = \frac{1}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}} = \frac{1{,}000}{1{,}189 + 1{,}413 - 1{,}190} = 0{,}602$$ směr Y

$$\chi = \frac{1}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}} = \frac{1{,}000}{1{,}189 + 1{,}413 - 1{,}190} = 0{,}602$$ směr Z

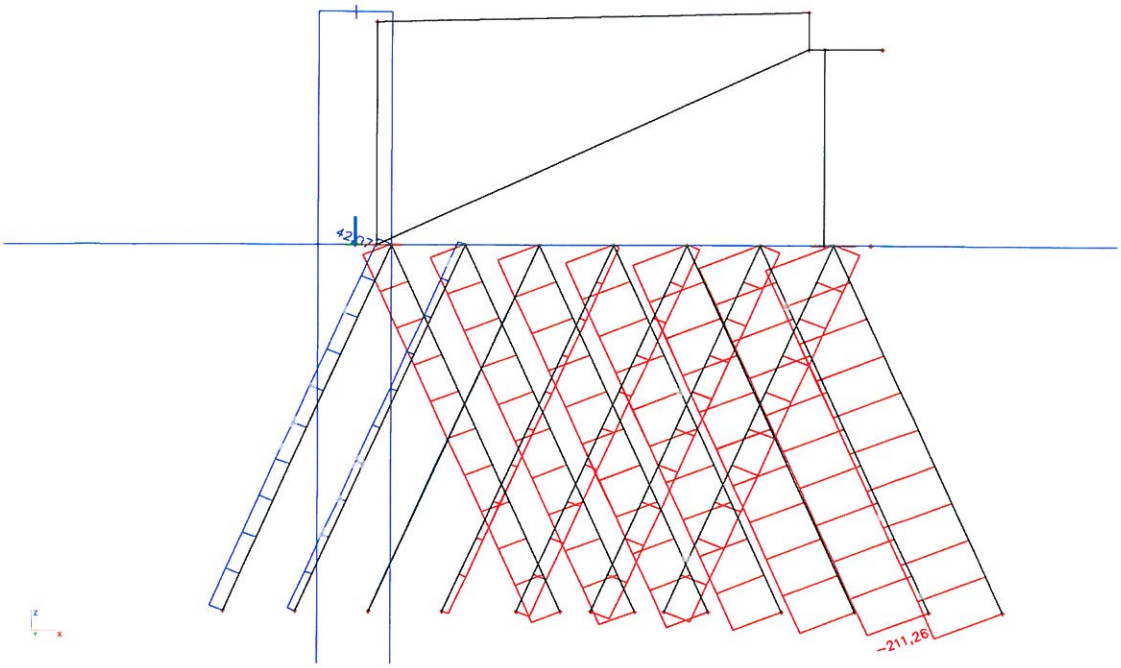
Posouzení, zanedbány součinitele interakce a vliv klopení

$$\frac{N_{Ed}}{\frac{\chi_y N_{Rk}}{\gamma_{M1}}} + k_{yy}\frac{M_{y,Ed} + \Delta M_{y,Ed}}{\frac{\chi_{LT} M_{y,Rk}}{\gamma_{M1}}} + k_{yz}\frac{M_{z,Ed} + \Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} = \frac{215}{0{,}602 \cdot 384} + \frac{0}{10} + \frac{0}{10} =$$

$$= 0{,}929 + 0{,}000 + 0{,}000 = \boxed{0{,}929} < \boxed{1}$$ vyhoví

$$\frac{N_{Ed}}{\frac{\chi_z N_{Rk}}{\gamma_{M1}}} + k_{zy}\frac{M_{y,Ed} + \Delta M_{y,Ed}}{\frac{\chi_{LT} M_{y,Rk}}{\gamma_{M1}}} + k_{zz}\frac{M_{z,Ed} + \Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} = \frac{215}{0{,}602 \cdot 384} + \frac{0}{10} + \frac{0}{10} =$$

$$= 0{,}929 + 0{,}000 + 0{,}000 = \boxed{0{,}929} < \boxed{1}$$ vyhoví


-211,26

Patní deska

Ocel

fy = 355 MPa E_s = 210 GPa

Geometrie pilonu

D = 508 mm t = 16 mm

Geometrie patní desky

t = 40 mm f_{cd} = 17,0 MPa t_c = 280 mm

Zatížení

N_{Ed} = 360 kN M_{dy} = 15 kN M_{Edz} = 300 kN

Uvažovaný průřez (dle ENV)

$t_c = 2 \cdot c + t = 2 \cdot 129{,}90 + 16 = 275{,}80$ mm

$$c = t\left[\frac{f_y}{3 f_j \gamma_{M0}}\right]^{0,5} = 40 \cdot \left(\frac{355}{3 \cdot 11{,}22 \cdot 1}\right)^{0,5} = 129{,}90 \text{ mm}$$

$f_j = \beta_j k_j f_{cd} = 0{,}66 \cdot 1 \cdot 17{,}0 = 11{,}22$ MPa

Únosnost

x = 252,3 mm ε_c = 1,5 promile f_{ub} = 800 MPa

A_s = 353 mm² (M24) 2 . A = 706,0 mm² $f_{ub,d}$ = 422 MPa

$N_C = A_c \cdot f_j = 98348 \cdot 11{,}2 = 1103{,}5$ kN

	R_b	ε_b	$\sigma_{b,linear}$	σ_b	N_{BE}	R_b-x	M_{BE}
1	435	1,09	228	228	161,04	182,7	29,42
2	575	1,92	403	403	284,44	322,7	91,79
3	655	2,39	503	422	297,98	402,7	120,00
4	0	0,00	0	0	0,00	0,0	0
					743,47 kN		241,21 kNm

$N_R = \Sigma N_B - N_C = 743{,}47 - 1103{,}5 = -360{,}0$ kN

$M_R = N_C \cdot 0{,}6x + \Sigma(M_{BE}) = 1103{,}5 \cdot 151{,}38 + 241{,}21 = 408{,}3$ kNm

N_E **360,0 kN** = **360,0 kN** **shoda**

M_E **300,0 kNm** < **408,3 kNm** **vyhoví**

Obsah úseče mezikruží

r_1 = 392 mm r_2 = 116,098 mm x = 80% x 201,84 mm

$$\cos \alpha/2 = \frac{r - x}{r} = \frac{391,902 - 201,84}{391,9023812} = 0,5$$

$$\sin \alpha/2 = \frac{\text{sqrt}(r^2-(r-x)^2)}{r} = \frac{(\ 153587 - (\ 391,9 - 201,84\ )^2\ )^{1/2}}{391,9023812} = 0,875$$

$$S_1 = r^2 . (\alpha/2 . \pi / 180 - \cos \alpha/2 . \sin \alpha/2) =$$

$$= 153587 .(\ 60,99 . 3,14159 / 180,0 - 0,5 . 0,875\ ) = 98348 \text{ mm}^2$$

$$x_2 = x - (r_1-r_2) = 201,84 - (\ 391,9 - 116,098\ ) = -74,0 \text{ mm}$$

$$\cos \alpha/2 = \frac{r - x}{r} = \frac{116,098 - -74,0}{116,0976188} = 1,6$$

$$\sin \alpha/2 = \frac{\text{sqrt}(r^2-(r-x)^2)}{r} = \frac{(\ 13478,7 - (\ 116,1 - -74,0\ )^2\ )^{1/2}}{116,0976188} = \text{\#NUM!}$$

$$S_2 = r^2 . (\alpha/2 . \pi / 180 - \cos \alpha/2 . \sin \alpha/2) =$$

$$= 13478,7 .(\ \text{\#NUM!} . 3,14159 / 180,0 - 1,6 . \text{\#NUM!}\ ) = \text{\#NUM!} \text{ mm}^2$$

$$A_c = S_1 - S_2 = 98348 - 0 = 98348 \text{ mm}^2$$

POSOUZENÍ PŘÍČNÍKU U PYLONU NA TLAK S OHYBEM

Ocel

fy = 355 MPa E = 210 GPa gama M = 1

Geometrie

D = 244,5 mm t = 16 mm Křivka vzp. pevnosti:

tř. průřezu 1 A = 11486 mm2 a (válc. za tepla)

Iy = 7,53E+07 mm4 Iz = 7,53E+07 mm souč. imperfekce:

iy = 80,98 mm iz = 80,98 mm alfa = 0,21

Wpl,y = 8,37E+05 mm3 Wpl,z = 8,37E+05 mm3

Vzpěrné délky: Ly = 3200 mm Lz = 3200 mm

Zatížení

N_{Ed} = 50 kN M_{Edy} = 30 kN M_{Edz} = 60 kN

Plastická únosnost průřezu v tlaku

$$N_{c,Rd} = \frac{A f_y}{\gamma_{M0}} = \frac{11485{,}7 \cdot 355}{1} = \mathbf{4077\ kN} > \mathbf{50\ kN}$$ vyhoví

Plastická únosnost průřezu v ohybu

$$M_{c,Rd} = M_{pl,Rd} = \frac{W_{pl} f_y}{\gamma_{M0}} = \frac{836761 \cdot 355}{1} = \mathbf{297\ kNm} > \mathbf{30\ kN}$$ vyhoví

$$M_{c,Rd} = M_{pl,Rd} = \frac{W_{pl} f_y}{\gamma_{M0}} \quad \frac{836761 \cdot 355}{1} = \mathbf{297\ kNm} > \mathbf{60\ kN}$$ vyhoví

Návrhová únosnost průřezu M+N

$$\lambda_1 = \pi\sqrt{\frac{E}{f_y}} = 93{,}9\sqrt{\frac{235}{f_y}} = 93{,}90 \cdot \frac{235}{355} = 76{,}40$$

$$\bar{\lambda} = \sqrt{\frac{A f_y}{N_{cr}}} = \frac{L_{cr}}{i}\frac{1}{\lambda_1} = \frac{3200}{80{,}9848 \cdot 76{,}40} = 0{,}517 \quad \text{směr Y}$$

$$\bar{\lambda} = \sqrt{\frac{A f_y}{N_{cr}}} = \frac{L_{cr}}{i}\frac{1}{\lambda_1} = \frac{3200}{80{,}9848 \cdot 76{,}40} = 0{,}517 \quad \text{směr Z}$$

$$\phi = 0{,}5\left[1 + \alpha(\bar{\lambda} - 0{,}2) + \bar{\lambda}^2\right] = 0{,}21 \quad 0{,}517 = 0{,}667 \quad \text{směr Y}$$

$$\phi = 0{,}5\left[1 + \alpha(\bar{\lambda} - 0{,}2) + \bar{\lambda}^2\right] = 0{,}21 \quad 0{,}517 = 0{,}667 \quad \text{směr Z}$$

$$\chi = \frac{1}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}} = \frac{1{,}000}{0{,}667 + 0{,}445 - 0{,}267} = 0{,}919 \quad \text{směr Y}$$

$$\chi = \frac{1}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}} = \frac{1{,}000}{0{,}667 + 0{,}445 - 0{,}267} = 0{,}919 \quad \text{směr Z}$$

Posouzení, zanedbány součinitele interakce a vliv klopení

$$\frac{N_{Ed}}{\frac{\chi_y N_{Rk}}{\gamma_{M1}}} + k_{yy}\frac{M_{y,Ed} + \Delta M_{y,Ed}}{\frac{\chi_{LT} M_{y,Rk}}{\gamma_{M1}}} + k_{yz}\frac{M_{z,Ed} + \Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} = \frac{50}{0{,}919 \cdot 4077} + \frac{30}{297} + \frac{60}{297} =$$

$$= \mathbf{0{,}013} + \mathbf{0{,}101} + \mathbf{0{,}202} = \boxed{\mathbf{0{,}316}} < \boxed{\mathbf{1}}$$ vyhoví

$$\frac{N_{Ed}}{\frac{\chi_z N_{Rk}}{\gamma_{M1}}} + k_{zy}\frac{M_{y,Ed} + \Delta M_{y,Ed}}{\frac{\chi_{LT} M_{y,Rk}}{\gamma_{M1}}} + k_{zz}\frac{M_{z,Ed} + \Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} = \frac{50}{0{,}919 \cdot 4077} + \frac{30}{297} + \frac{60}{297} =$$

$$= \mathbf{0{,}013} + \mathbf{0{,}101} + \mathbf{0{,}202} = \boxed{\mathbf{0{,}316}} < \boxed{\mathbf{1}}$$ vyhoví

POSOUZENÍ PYLONU NA TLAK S OHYBEM

Ocel

f_y = 355 MPa E = 210 GPa γ_m = 1

Geometrie

D = 508 mm t = 16 mm Křivka vzp. pevnosti:

tř. průřezu 1 A = 24731 mm^2 a (válc. za tepla)

I_y = 7,49E+08 mm^4 I_z = 7,49E+08 mm^4 souč. imperfekce:

i_y = 174,04 mm i_z = 174,04 mm α = 0,21

$W_{pl,y}$ = 3,87E+06 mm^3 $W_{pl,z}$ = 3,87E+06 mm^3

Vzpěrné délky: L_y = 18600 mm L_z = 8300 mm

Zatížení

N_{Ed} = 360 kN M_{dy} = 15 kN M_{Edz} = 300 kN

Plastická únosnost průřezu v tlaku

$$N_{c,Rd} = \frac{A f_y}{\gamma_{M0}} = \frac{24730{,}6 \cdot 355}{1} = \mathbf{8779\ kN} > \mathbf{360\ kN}$$ vyhoví

Plastická únosnost průřezu v ohybu

$$M_{c,Rd} = M_{pl,Rd} = \frac{W_{pl} f_y}{\gamma_{M0}} = \frac{3874389 \cdot 355}{1} = \mathbf{1375\ kNm} > \mathbf{15\ kN}$$ vyhoví

$$M_{c,Rd} = M_{pl,Rd} = \frac{W_{pl} f_y}{\gamma_{M0}} \quad \frac{3874389 \cdot 355}{1} = \mathbf{1375\ kNm} > \mathbf{300\ kN}$$ vyhoví

Návrhová únosnost průřezu M+N

$$\lambda_1 = \pi\sqrt{\frac{E}{f_y}} = 93{,}9\sqrt{\frac{235}{f_y}} = 93{,}90 \cdot \frac{235}{355} = 76{,}40$$

$$\bar{\lambda} = \sqrt{\frac{A f_y}{N_{cr}}} = \frac{L_{cr}}{i}\frac{1}{\lambda_1} = \frac{18600}{174{,}04 \cdot 76{,}40} = 1{,}399$$ směr Y

$$\bar{\lambda} = \sqrt{\frac{A f_y}{N_{cr}}} = \frac{L_{cr}}{i}\frac{1}{\lambda_1} = \frac{8300}{174{,}04 \cdot 76{,}40} = 0{,}624$$ směr Z

$$\phi = 0{,}5\left[1 + \alpha(\bar{\lambda} - 0{,}2) + \bar{\lambda}^2\right] = 0{,}21 \quad 1{,}399 = 1{,}604$$ směr Y

$$\phi = 0{,}5\left[1 + \alpha(\bar{\lambda} - 0{,}2) + \bar{\lambda}^2\right] = 0{,}21 \quad 0{,}624 = 0{,}739$$ směr Z

$$\chi = \frac{1}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}} = \frac{1{,}000}{1{,}604 + 2{,}574 - 1{,}957} = 0{,}418$$ směr Y

$$\chi = \frac{1}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}} = \frac{1{,}000}{0{,}739 + 0{,}547 - 0{,}390} = 0{,}881$$ směr Z

Posouzení, zanedbány součinitele interakce a vliv klopení

$$\frac{N_{Ed}}{\frac{\chi_y N_{Rk}}{\gamma_{M1}}} + k_{yy}\frac{M_{y,Ed} + \Delta M_{y,Ed}}{\frac{\chi_{LT} M_{y,Rk}}{\gamma_{M1}}} + k_{yz}\frac{M_{z,Ed} + \Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} = \frac{360}{0{,}418 \cdot 8779} + \frac{15}{1375} + \frac{300}{1375} =$$

$$= \mathbf{0{,}098} + \mathbf{0{,}011} + \mathbf{0{,}218} = \boxed{\mathbf{0{,}327}} < \boxed{\mathbf{1}}$$ vyhoví

$$\frac{N_{Ed}}{\frac{\chi_z N_{Rk}}{\gamma_{M1}}} + k_{zy}\frac{M_{y,Ed} + \Delta M_{y,Ed}}{\frac{\chi_{LT} M_{y,Rk}}{\gamma_{M1}}} + k_{zz}\frac{M_{z,Ed} + \Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} = \frac{360}{0{,}881 \cdot 8779} + \frac{15}{1375} + \frac{300}{1375} =$$

$$= \mathbf{0{,}047} + \mathbf{0{,}011} + \mathbf{0{,}218} = \boxed{\mathbf{0{,}276}} < \boxed{\mathbf{1}}$$ vyhoví

VODOROVNÉ ZTUŽENÍ

Ocel

f_y = 355 MPa E = 210 GPa γ_m = 1

Geometrie

D = 70 mm t = 5 mm Křivka vzp. pevnosti:

tř. průřezu 1 A = 1021 mm^2 a (válc. za tepla)

I_y = 5,42E+05 mm^4 I_z = 5,42E+05 mm^4 souč. imperfekce:

i_y = 23,05 mm i_z = 23,05 mm α = 0,21

Vzpěrné délky: L_y = 2828 mm L_z = 2828 mm

Zatížení

N_{Ed} = 100 kN

Plastická únosnost průřezu v tlaku/tahu

$$N_{c,Rd} = \frac{A f_y}{\gamma_{M0}} = \frac{1021{,}02 \cdot 355}{1} = \mathbf{362\ kN} > \mathbf{100\ kN}$$ vyhoví

Únosnost ve vzpěru

$$\lambda_1 = \pi\sqrt{\frac{E}{f_y}} = 93{,}9\sqrt{\frac{235}{f_y}} = 93{,}90 \cdot \frac{235}{355} = 76{,}40$$

$$\bar{\lambda} = \sqrt{\frac{A f_y}{N_{cr}}} = \frac{L_{cr}}{i}\frac{1}{\lambda_1} = \frac{2828}{23{,}0489 \cdot 76{,}40} = 1{,}606$$ směr Y

$$\bar{\lambda} = \sqrt{\frac{A f_y}{N_{cr}}} = \frac{L_{cr}}{i}\frac{1}{\lambda_1} = \frac{2828}{23{,}0489 \cdot 76{,}40} = 1{,}606$$ směr Z

$$\phi = 0{,}5\left[1 + \alpha(\bar{\lambda} - 0{,}2) + \bar{\lambda}^2\right] = 0{,}21 \quad 1{,}606 = 1{,}938$$ směr Y

$$\phi = 0{,}5\left[1 + \alpha(\bar{\lambda} - 0{,}2) + \bar{\lambda}^2\right] = 0{,}21 \quad 1{,}606 = 1{,}938$$ směr Z

$$\chi = \frac{1}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}} = \frac{1{,}000}{1{,}938 + 3{,}755 - 2{,}580} = 0{,}331$$ směr Y

$$\chi = \frac{1}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}} = \frac{1{,}000}{1{,}938 + 3{,}755 - 2{,}580} = 0{,}331$$ směr Z

$$N_{b,Rd} = \frac{\chi A f_y}{\gamma_{M1}} = \frac{0{,}331 \cdot 1021 \cdot 355}{1} =$$

$$= \mathbf{120\ kN} > \mathbf{100\ kN}$$ vyhoví směr Y

$$N_{b,Rd} = \frac{\chi A f_y}{\gamma_{M1}} = \frac{0{,}331 \cdot 1021 \cdot 355}{1} =$$

$$= \mathbf{120\ kN} > \mathbf{100\ kN}$$ vyhoví směr Z

Šroubový přípoj - pas příhradoviny

Šrouby

Třída:	8,8	$f_{u,k}$	=	800	Mpa			celkem šroubů:	4	
Označení:	M 16	d	=	16	mm			A	= 201	mm^2
$\gamma_{m,spoje}$ =	1,3	d_0	=	18	mm			A_s	= 157	mm^2

$M_{y,Rk} = 0,3 f_{u,k} d^{2,6}$ = 0,3 . 800 . 1351,2 = 324 Nm

Plech

ocel:	S 235	f_y	=	235	MPa			f_u	= 360	MPa
t =	10 mm									

Dřevo

dřevo:	GL32h	ρ_k	=	430	kg/m^3			$f_{c,90,k}$	= 3,3	MPa
t =	145 mm	b	=	220	mm			K_{mod}	= 0,7	
h =	1300 mm	h_e	=	175	mm					

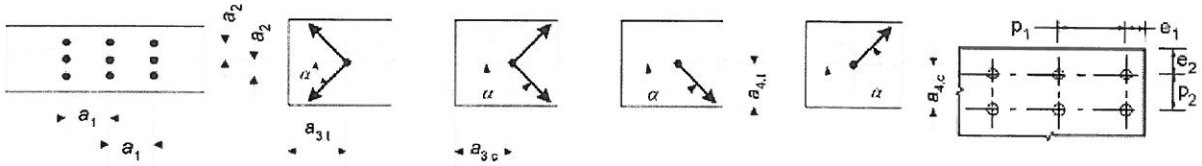
$f_{h,0,k} = 0,082 (1 - 0,01 d) \rho_k$ = 0,082 (1 - 0,16) 430 = 29,62 MPa

$$f_{h,\alpha,k} = \frac{f_{h,0,k}}{k_{90} \sin^2\alpha + \cos^2\alpha} = \frac{29,62}{1,59 \cdot 1 + 3,8E\text{-}33} = 18,63 \text{ MPa}$$

Zatížení

$F_{v,Ed}$ = 60 kN $F_{t,Ed}$ = 0 kN α = 90 úhel mezi silou a vlákny (0-90)

Rozmístění



	a_1/p_1		a_2/p_2		$a_{3,t}/e_1$		$a_{3,c}/e_1$		$a_{4,t}/e_2$		$a_{4,c}/e_2$	
min. dřevo	64,00		64,00		112,00		112,00		64,00		48,00	
min. ocel	39,6		43,2		21,6		21,60		21,6		21,60	
navržené	**150**		**80**		**150**		**100**		**70**		**70**	
max. ocel	140		140		80		80		80		80	při vlivu povětrnosti

Redukce

$n_{ef,0}$ = 3,21 $n_{ef,\alpha}$ = **4,00** $n_{ef,90}$ = 4,00

☐ 1 řada jednostřižných $F_{b,Rd}$ neomezen $F_{b,Rd\,MAX} = 1,5 f_u d t / \gamma_{M2}$ = 59,59 kN

Únosnost na vytažení:

svorník v tahu:	$F_{ax,R,k,b}$	=	A_S	.	$f_{u,k}$	=	157	.	800	= 125,6 kN
průměr podložky:	d_w	=	$\min(12t_s, 4d)$			=	64	mm		
účinná plocha:	A_w	=	$A_{ex} - A_{int}$	=	3217	-	254	=	2963	mm^2
podložka:	$F_{ax,R,k,w}$	=	A_w	.	$3f_{c,90,k}$	=	2963	.	9,9	= 29,3 kN
únosnost:	$F_{ax,R,k}$	=	$\min(F_{ax,R,k,b}, F_{ax,R,k,w})$			=	29,33	kN		

$F_{ax,R,d}$ = $F_{ax,R,k}$ .K_{mod} /$\gamma_{m,spoje}$ .n = 29,33 . 0,54 . 4 = 63,17 kN

$F_{t,Ed}$ = 0,00 kN

vyhoví

Únosnost na smyk - dřevo:

počet střihů - jednostřižný spoj: 0

počet střihů - dvojstřižný spoj, ocel uvnitř: 8 ocel vně: 0

tenká deska		$t_{skutecne}$	tlustá deska	
$F_{v,Rk} = \min \begin{cases} 0{,}4 f_{h,k} t_1 d \\ 1{,}15\sqrt{2 M_{y,Rk} f_{h,k} d} + \frac{F_{ax,Rk}}{4} \end{cases}$	17,29 kN 23,32 kN	20,045 kN	$F_{v,Rk} = \min \begin{cases} f_{h,1,k} t_1 d \left[\sqrt{2 + \frac{4 M_{y,Rk}}{f_{h,1,k} d t_1^2}} - 1\right] + \frac{F_{ax,Rk}}{4} \\ 2{,}3\sqrt{M_{y,Rk} f_{h,1,k} d} + \frac{F_{ax,Rk}}{4} \\ f_{h,1,k} t_1 d \end{cases}$	28,32 kN 29,94 kN 43,22 kN
$F_{v,Rk} = \min \begin{cases} f_{h,1,k} t_1 d \\ f_{h,2,k} t_2 d \left[\sqrt{2 + \frac{4 M_{y,Rk}}{f_{h,2,k} d t_2^2}} - 1\right] + \frac{F_{ax,Rk}}{4} \\ 2{,}3\sqrt{M_{y,Rk} f_{h,2,k} d} + \frac{F_{ax,Rk}}{4} \end{cases}$	43,22 kN 28,32 kN 29,94 kN	28,318 kN	nerozlišuje se	
$F_{v,Rk} = \min \begin{cases} 0{,}5 f_{h,2,k} t_2 d \\ 1{,}15\sqrt{2 M_{y,Rk} f_{h,2,k} d} + \frac{F_{ax,Rk}}{4} \end{cases}$	21,61 kN 23,32 kN	21,608 kN	$F_{v,Rk} = \min \begin{cases} 0{,}5 f_{h,2,k} t_2 d \\ 2{,}3\sqrt{M_{y,Rk} f_{h,2,k} d} + \frac{F_{ax,Rk}}{4} \end{cases}$	21,61 kN 29,94 kN

$F_{v,R,d}$ = $F_{v,R,k}$ .K_{mod} / $\gamma_{m,spoje}$ .n_{ef}/n = 226,55 . 0,54 . 1,00 = 121,99 kN

$F_{v,Ed}$ = 60,00 kN

vyhoví

Únosnost v otlačení plechu

šroubů:	v rohu: 4	u rov. kraje: 0	u kol. kraje: 0	uvnitř: 0
a_b	1,000	1,000	1,000	1,000
k_1	2,500	2,500	2,500	2,500
$\Sigma k_1.a_b$ =	10,000 +	0,000 +	0,000 +	0,000

$$F_{b,Rd} = \frac{k_1 a_b f_u dt}{\gamma_{M2}} = \frac{10{,}00 \cdot 360 \cdot 16 \cdot 10}{1{,}25} = 460{,}8 \text{ kN}$$

$F_{b,Rd\ MAX}$ = 4 . 59,6 = 238,3 kN

$F_{b,Rd}$ = **460,8 kN**

$F_{v,Ed}$ = **60,0 kN**

vyhoví

Únosnost na roztržení

$$F_{90,Rk} = 14\, b w \sqrt{\frac{h_e}{\left(1 - \frac{h_e}{h}\right)}} = 14 \cdot 220 \cdot \left(\frac{175}{1 - 175 / 1300}\right)^{1/4} = 43{,}8 \text{ kN}$$

$F_{90,Rd}$ = K_{mod}.$F_{90,Rd}$/γ_m = 0,7 . 43,8 / 1,3 = 23,58 kN

$F_{v,Ed,90}$ = $F_{v,Ed}$. sin(α) = 60 . 1 = 15 kN

vyhoví

Šroubový přípoj - příčník

Šrouby

Třída:	8,8		$f_{u,k}$	=	800	Mpa		celkem šroubů:	3	
Označení:	M 16		d	=	16	mm		A	=	201	mm^2
$\gamma_{m,spoje}$ =	1,3		d_0	=	18	mm		A_S	=	157	mm^2

$M_{y,Rk} = 0,3 f_{u,k} d^{2,6}$ = 0,3 . 800 . 1351,2 = 324 Nm

Plech

ocel:	S 235		f_y	=	235	MPa		f_u	=	360	MPa
t =	10	mm								

Dřevo

dřevo:	GL32h		ρ_k	=	430	kg/m^3		$f_{c,90,k}$	=	3,3	MPa
t =	90	mm	b	=	200	mm		K_{mod}	=	0,7	
h =	300	mm	h_e	=	150	mm					

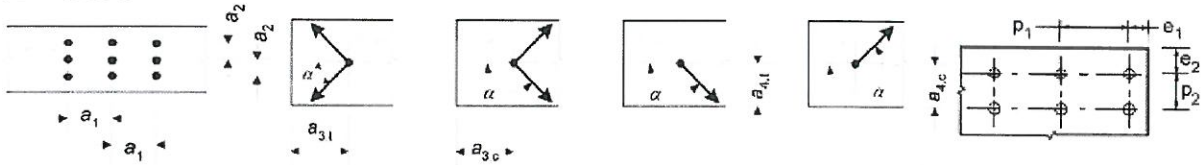
$f_{h,0,k} = 0,082 (1 - 0,01 d) \rho_k$ = 0,082 (1 - 0,16) 430 = 29,62 MPa

$$f_{h,\alpha,k} = \frac{f_{h,0,k}}{k_{90} \sin^2\alpha + \cos^2\alpha} = \frac{29,62}{1,59 \cdot 1 + 3,8E\text{-}33} = 18,63 \text{ MPa}$$

Zatížení

$F_{v,Ed}$ = 20 kN $F_{t,Ed}$ = 0 kN α = 90 úhel mezi silou a vlákny (0-90)

Rozmístění



	a_1/p_1		a_2/p_2		$a_{3,t}/e_1$		$a_{3,c}/e_1$		$a_{4,t}/e_2$		$a_{4,c}/e_2$	
min. dřevo	64,00		64,00		112,00		112,00		64,00		48,00	
min. ocel	39,6		43,2		21,6		21,60		21,6		21,60	
navržené	**150**		**80**		**150**		**100**		**70**		**70**	
max. ocel	140		140		80		80		80		80	při vlivu povětrnosti

Redukce

$n_{ef,0}$ = 2,48 $n_{ef,\alpha}$ = **3,00** $n_{ef,90}$ = 3,00

☐ 1 řada jednostřižných $F_{b,Rd}$ neomezen $F_{b,Rd\,MAX} = 1,5 f_{u,d} t l_{ef} / \gamma_{M2}$ = 59,59 kN

Únosnost na vytažení:

svorník v tahu:	$F_{ax,R,k,b}$	=	A_S	.	$f_{u,k}$	=	157	.	800	= 125,6 kN
průměr podložky:	d_w	=	$\min(12t_s,\ 4d)$			=	64	mm		
účinná plocha:	A_w	=	$A_{ex} - A_{int}$	=	3217	-	254	=	2963	mm^2
podložka:	$F_{ax,R,k,w}$	=	A_w	.	$3f_{c,90,k}$	=	2963	.	9,9	= 29,3 kN
únosnost:	$F_{ax,R,k}$	=	$\min(F_{ax,R,k,b}, F_{ax,R,k,w})$			=	29,33	kN		

$F_{ax,R,d}$ = $F_{ax,R,k} . K_{mod} / \gamma_{m,spoje} . n$ = 29,33 . 0,54 . 3 = 47,38 kN

$F_{t,Ed}$ = 0,00 kN

vyhoví

Únosnost na smyk - dřevo:

počet střihů - jednostřižný spoj: 0

počet střihů - dvojstřižný spoj, ocel uvnitř: 6 ocel vně: 0

tenká deska		$t_{skutecne}$	tlustá deska	
$F_{v,Rk} = \min \begin{cases} 0,4 f_{h,k} t_1 d \\ 1,15\sqrt{2 M_{y,Rk} f_{h,k} d} + \frac{F_{ax,Rk}}{4} \end{cases}$	10,73 kN 23,32 kN	13,856 kN	$F_{v,Rk} = \min \begin{cases} f_{h,k} t_1 d \left[\sqrt{2 + \frac{4 M_{y,Rk}}{f_{h,k} d t_1^2}} - 1\right] + \frac{F_{ax,Rk}}{4} \\ 2,3\sqrt{M_{y,Rk} f_{h,k} d} + \frac{F_{ax,Rk}}{4} \\ f_{h,k} t_2 d \end{cases}$	23,24 kN 29,94 kN 26,82 kN
$F_{v,Rk} = \min \begin{cases} f_{h,1,k} t_1 d \\ f_{h,2,k} t_2 d \left[\sqrt{2 + \frac{4 M_{y,Rk}}{f_{h,2,k} d t_2^2}} - 1\right] + \frac{F_{ax,Rk}}{4} \\ 2,3\sqrt{M_{y,Rk} f_{h,1,k} d} + \frac{F_{ax,Rk}}{4} \end{cases}$	26,82 kN 23,24 kN 29,94 kN	23,236 kN	nerozlišuje se	
$F_{v,Rk} = \min \begin{cases} 0,5 f_{h,2,k} t_2 d \\ 1,15\sqrt{2 M_{y,Rk} f_{h,2,k} d} + \frac{F_{ax,Rk}}{4} \end{cases}$	13,41 kN 23,32 kN	13,412 kN	$F_{v,Rk} = \min \begin{cases} 0,5 f_{h,2,k} t_2 d \\ 2,3\sqrt{M_{y,Rk} f_{h,2,k} d} + \frac{F_{ax,Rk}}{4} \end{cases}$	13,41 kN 29,94 kN

$F_{v,R,d}$ = $F_{v,R,k} . K_{mod} / \gamma_{m,spoje} . n_{ef}/n$ = 139,42 . 0,54 . 1,00 = 75,07 kN

$F_{v,Ed}$ = 20,00 kN

vyhoví

Únosnost v otlačení plechu

šroubů:	v rohu: 3	u rov. kraje: 0	u kol. kraje: 0	uvnitř: 0
a_b	1,000	1,000	1,000	1,000
k_1	2,500	2,500	2,500	2,500
$\Sigma k_1 . a_b$ =	7,500 +	0,000 +	0,000 +	0,000

$$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}} = \frac{7,50 . 360 . 16 . 10}{1,25} = 345,6 \text{ kN}$$

$F_{b,Rd\ MAX}$ = 3 . 59,6 = 178,8 kN

$F_{b,Rd}$ = **345,6 kN**

$F_{v,Ed}$ = **20,0 kN**

vyhoví

Únosnost na roztržení

$$F_{90,Rk} = 14 b w \sqrt{\frac{h_c}{\left(1 - \frac{h_c}{h}\right)}} = 14 . 200 . \left(\frac{150}{1 - 150 / 300}\right)^{1/2} = 48,5 \text{ kN}$$

$F_{90,Rd}$ = $K_{mod} . F_{90,Rd} / \gamma_m$ = 0,7 . 48,5 / 1,3 = 26,11 kN

$F_{v,Ed,90}$ = $F_{v,Ed}$. $\sin(\alpha)$ = 20 . 1 = 20 kN

vyhoví