STRUCTURAL ANALYSIS

PROJECT

Antenna structures A0-70

CLIENT

CREATED BY

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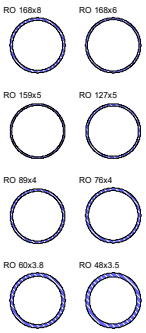
CONTENTS

1.3 MATERIALS

Matl. No.	Modulus E [kN/cm²]	Modulus G [kN/cm²]	Poisson's Ratio ν [-]	Spec. Weight γ [kN/m³]	Coeff. of Th. Ex α [1/°C]	Partial Factor γ_M [-]	Material Model
1	Steel S 235 H | TaEN 10210-1:1994-09						
	21000.00	8076.92	0.300	78.50	1.20E-05	1.00	Isotropic Linear Elastic

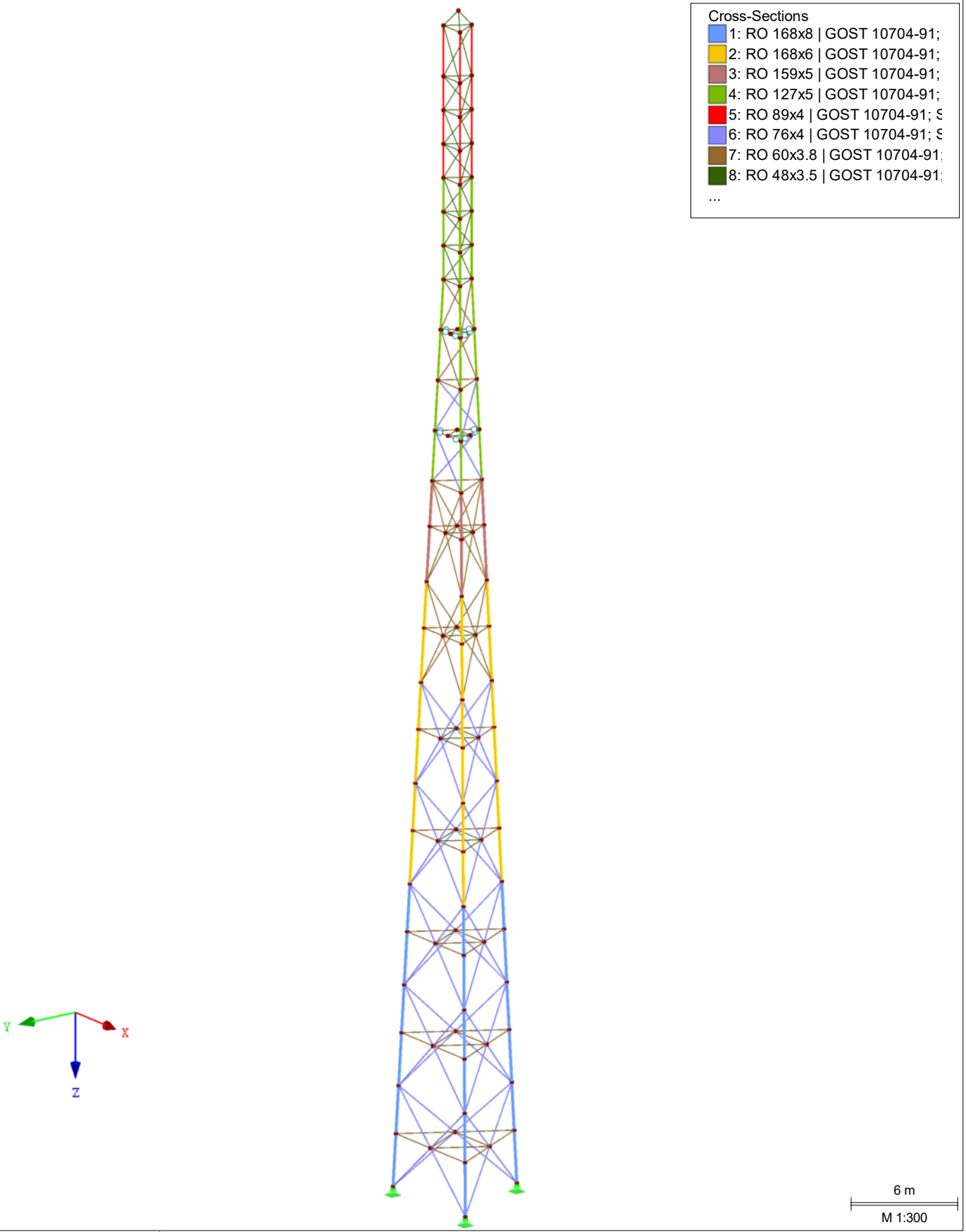
1.13 CROSS-SECTIONS



Section No.	Matl. No.	J [cm⁴]	I_y [cm⁴]	I_z [cm⁴]	Principal Axes α [°]	Rotation α' [°]	Overall Dimensions [mm] Width b	Height h
1	RO 168x8 | GOST 10704-91							
	1	2580.03	1290.01	1290.01	0.00	0.00	168.0	168.0
		40.21	20.06	20.06				
2	RO 168x6 | GOST 10704-91							
	1	2006.23	1003.12	1003.12	0.00	0.00	168.0	168.0
		30.54	15.22	15.22				
3	RO 159x5 | GOST 10704-91							
	1	1435.75	717.88	717.88	0.00	0.00	159.0	159.0
		24.19	12.06	12.06				
4	RO 127x5 | GOST 10704-91							
	1	714.28	357.14	357.14	0.00	0.00	127.0	127.0
		19.16	9.56	9.56				
5	RO 89x4 | GOST 10704-91							
	1	193.36	96.68	96.68	0.00	0.00	89.0	89.0
		10.68	5.33	5.33				
6	RO 76x4 | GOST 10704-91							
	1	117.62	58.81	58.81	0.00	0.00	76.0	76.0
		9.05	4.52	4.52				
7	RO 60x3.8 | GOST 10704-91							
	1	53.22	26.61	26.61	0.00	0.00	60.0	60.0
		6.71	3.35	3.35				
8	RO 48x3.5 | GOST 10704-91							
	1	24.37	12.19	12.19	0.00	0.00	48.0	48.0
		4.89	2.45	2.45				

MODEL

Isometric



2.1 LOAD CASES

Load Case	Load Case Description	EN 1990 | CEN* | Israil Action Category	Self-Weight - Factor in Direction Active	X	Y	Z
LC1	Self-weight	Permanent	☒	0.000	0.000	1.100
LC2	Ice weight - Class G	Snow (Finland, Iceland, Norway, Sweden)	☐			
LC3	Ice weight - Class R	Snow (Finland, Iceland, Norway, Sweden)	☐			
LC4	Wind 0 °	Wind	☐			
LC5	Wind 90 °	Wind	☐			
LC6	Wind 270	Wind	☐			

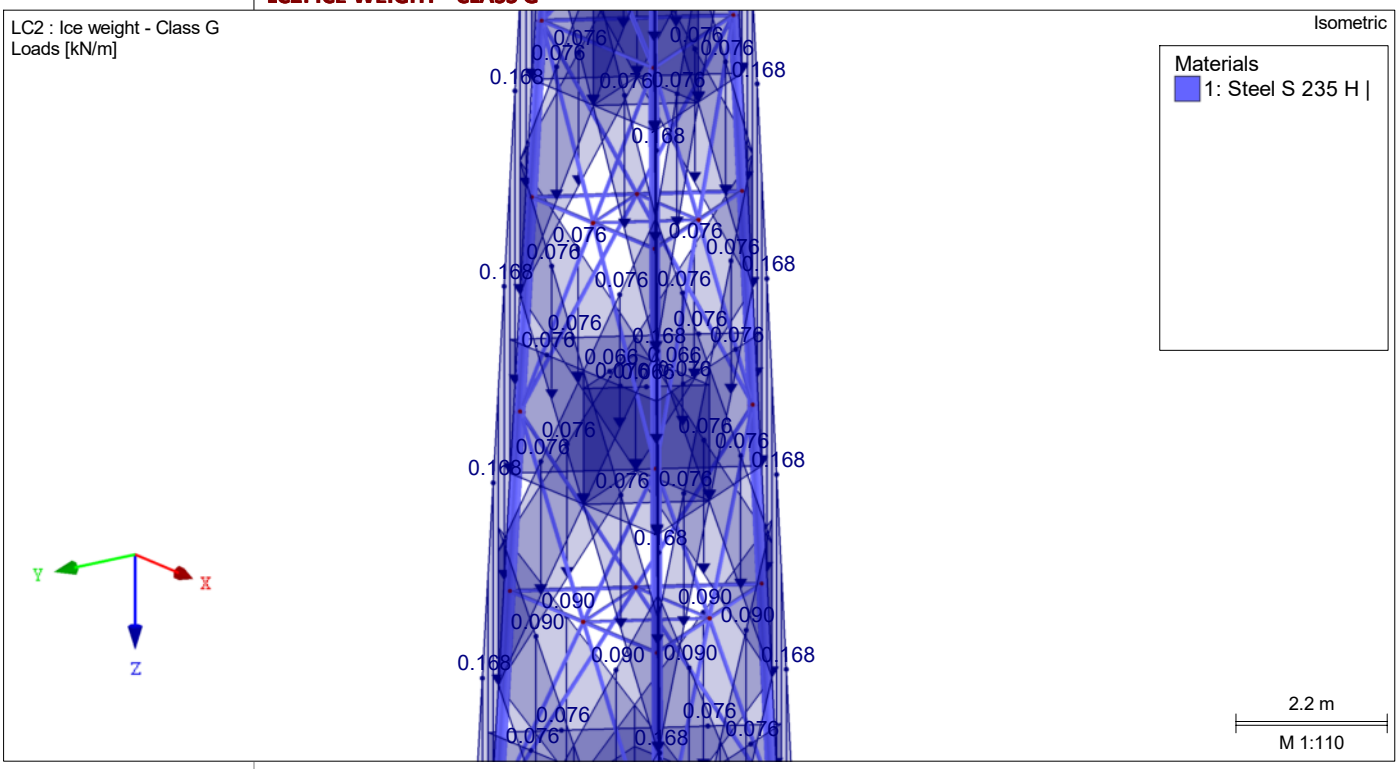
2.1.1 LOAD CASES

Load Case	Load Case Description	Calculation Parameters	
LC1	Self-weight	Method of analysis	: Geometrically linear analysis
		Method for solving system of nonlinear algebraic equations	: Newton-Raphson
LC2	Ice weight - Class G	Method of analysis	: Geometrically linear analysis
		Method for solving system of nonlinear algebraic equations	: Newton-Raphson
LC3	Ice weight - Class R	Method of analysis	: Geometrically linear analysis
		Method for solving system of nonlinear algebraic equations	: Newton-Raphson
LC4	Wind 0 °	Method of analysis	: Geometrically linear analysis
		Method for solving system of nonlinear algebraic equations	: Newton-Raphson
LC5	Wind 90 °	Method of analysis	: Geometrically linear analysis
		Method for solving system of nonlinear algebraic equations	: Newton-Raphson
LC6	Wind 270	Method of analysis	: Geometrically linear analysis
		Method for solving system of nonlinear algebraic equations	: Newton-Raphson

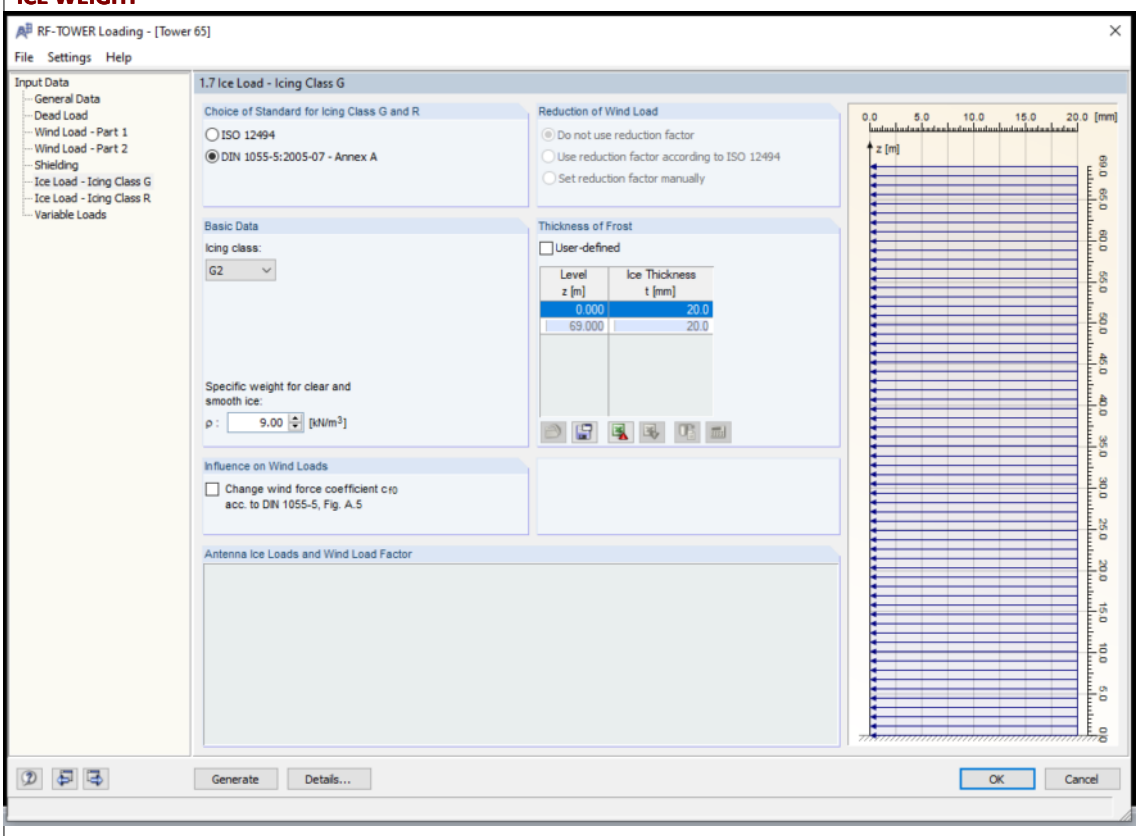
2.5 LOAD COMBINATIONS

Load Combin.	DS	Load Combination Description	No.	Factor	Load Case	
CO1		1.4*LC1 + 1.6*LC2 + 0.9*LC4	1	1.40	LC1	Self-weight
			2	1.60	LC2	Ice weight - Class G
			3	0.90	LC4	Wind 0 °
CO2		1.4*LC1 + 0.9*LC2 + 1.5*LC4	1	1.40	LC1	Self-weight
			2	0.90	LC2	Ice weight - Class G
			3	1.50	LC4	Wind 0 °
CO3		1.4*LC1 + 1.6*LC2 + 0.9*LC5	1	1.40	LC1	Self-weight
			2	1.60	LC2	Ice weight - Class G
			3	0.90	LC5	Wind 90 °
CO4		1.4*LC1 + 0.9*LC2 + 1.5*LC5	1	1.40	LC1	Self-weight
			2	0.90	LC2	Ice weight - Class G
			3	1.50	LC5	Wind 90 °
CO5		1.4*LC1 + 1.6*LC2 + 0.9*LC6	1	1.40	LC1	Self-weight
			2	1.60	LC2	Ice weight - Class G
			3	0.90	LC6	Wind 270
CO6		1.4*LC1 + 0.9*LC2 + 1.5*LC6	1	1.40	LC1	Self-weight
			2	0.90	LC2	Ice weight - Class G
			3	1.50	LC6	Wind 270
CO7		1.4*LC1 + 1.5*LC4	1	1.40	LC1	Self-weight
			2	1.50	LC4	Wind 0 °
CO8		1.4*LC1 + 1.5*LC5	1	1.40	LC1	Self-weight
			2	1.50	LC5	Wind 90 °
CO9		1.4*LC1 + 1.5*LC6	1	1.40	LC1	Self-weight
			2	1.50	LC6	Wind 270
CO10		1.4*LC1 + 1.6*LC2	1	1.40	LC1	Self-weight
			2	1.60	LC2	Ice weight - Class G

LC2: ICE WEIGHT - CLASS G



ICE WEIGHT



Ice weight - Class G3

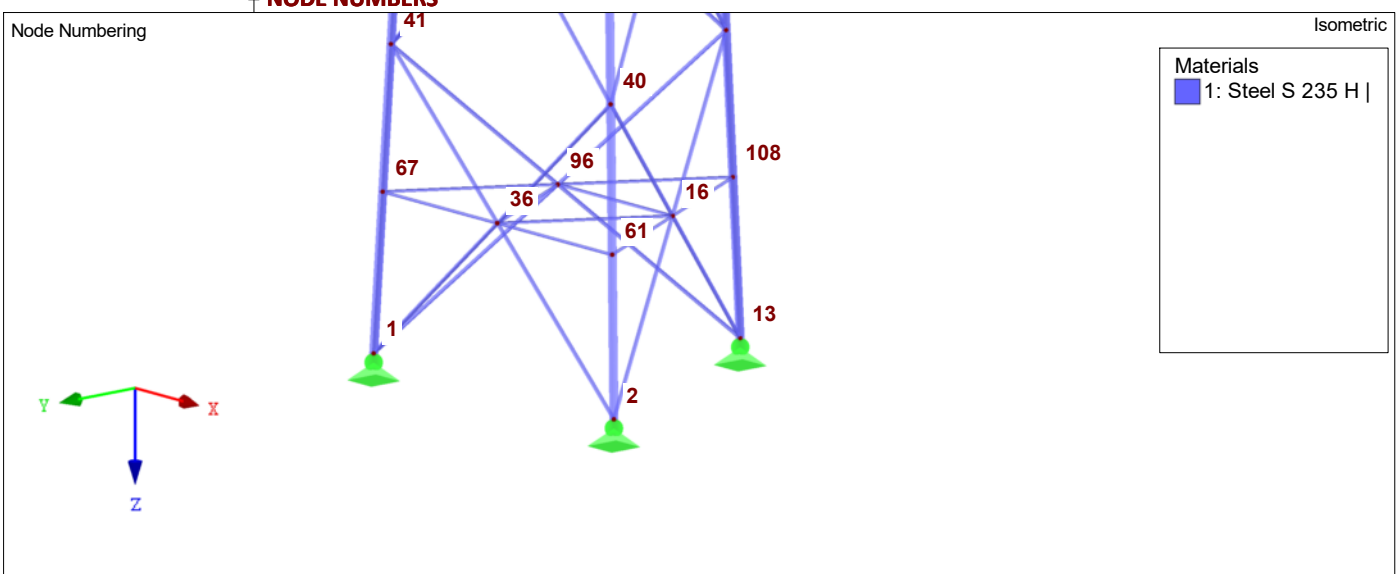
4.1 NODES - SUPPORT FORCES

Node No.	LC/CO	Support Forces [kN] $P_{X'}$	$P_{Y'}$	$P_{Z'}$	Support Moments [kNm] $M_{X'}$	$M_{Y'}$	$M_{Z'}$	
1	LC1	-2.23	1.29	29.93	0.00	0.00	0.00	Self-weight
	LC2	-2.21	1.28	27.79	0.00	0.00	0.00	Ice weight - Class G
	LC3	-0.21	0.12	2.59	0.00	0.00	0.00	Ice weight - Class R
	LC4	31.01	-13.21	-280.60	0.00	0.00	-0.03	Wind 0 °
	LC5	-18.72	16.75	216.92	0.00	0.00	-0.01	Wind 90 °
	LC6	22.54	-19.64	-261.50	0.00	0.00	0.02	Wind 270
	CO1	21.32	-8.16	-167.99	0.00	0.00	-0.02	
	CO2	41.55	-17.16	-356.28	0.00	0.00	-0.04	
	CO3	-23.33	18.91	283.06	0.00	0.00	0.00	
	CO4	-32.77	28.06	394.13	0.00	0.00	-0.01	
	CO5	13.83	-13.86	-150.83	0.00	0.00	0.02	
	CO6	29.21	-26.56	-327.68	0.00	0.00	0.03	
	CO7	43.54	-18.31	-380.36	0.00	0.00	-0.05	
	CO8	-30.80	26.92	368.36	0.00	0.00	-0.01	
	CO9	31.19	-27.70	-351.75	0.00	0.00	0.03	
	CO10	-6.63	3.83	86.36	0.00	0.00	0.01	
2	LC1	2.23	1.28	29.93	0.00	0.00	0.00	Self-weight
	LC2	2.21	1.27	27.79	0.00	0.00	0.00	Ice weight - Class G
	LC3	0.21	0.12	2.59	0.00	0.00	0.00	Ice weight - Class R
	LC4	43.27	21.97	445.11	0.00	0.00	0.01	Wind 0 °
	LC5	18.67	16.88	218.02	0.00	0.00	0.02	Wind 90 °
	LC6	-22.51	-19.59	-262.75	0.00	0.00	-0.03	Wind 270
	CO1	45.56	23.56	490.11	0.00	0.00	0.02	
	CO2	69.98	35.81	738.56	0.00	0.00	0.02	
	CO3	23.29	19.02	284.07	0.00	0.00	0.03	
	CO4	32.70	28.26	395.81	0.00	0.00	0.04	
	CO5	-13.81	-13.83	-151.97	0.00	0.00	-0.02	
	CO6	-29.18	-26.50	-329.58	0.00	0.00	-0.04	
	CO7	68.00	34.67	711.93	0.00	0.00	0.02	
	CO8	30.72	27.11	370.02	0.00	0.00	0.03	
	CO9	-31.16	-27.64	-353.64	0.00	0.00	-0.04	
	CO10	6.63	3.83	86.36	0.00	0.00	0.01	
13	LC1	0.00	-2.57	29.93	0.00	0.00	0.00	Self-weight
	LC2	0.00	-2.55	27.79	0.00	0.00	0.00	Ice weight - Class G
	LC3	0.00	-0.25	2.59	0.00	0.00	0.00	Ice weight - Class R
	LC4	4.94	14.73	-163.81	0.00	0.00	0.01	Wind 0 °
	LC5	-0.05	49.48	-435.32	0.00	0.00	-0.01	Wind 90 °
	LC6	0.07	-58.14	525.84	0.00	0.00	0.01	Wind 270
	CO1	4.41	5.74	-62.43	0.00	0.00	0.01	
	CO2	7.29	16.60	-180.51	0.00	0.00	0.02	
	CO3	-0.04	36.87	-308.40	0.00	0.00	0.00	
	CO4	-0.07	68.34	-589.79	0.00	0.00	-0.01	
	CO5	0.06	-59.95	563.31	0.00	0.00	0.02	
	CO6	0.10	-93.01	860.36	0.00	0.00	0.03	
	CO7	7.29	18.88	-204.83	0.00	0.00	0.02	
	CO8	-0.07	70.63	-613.26	0.00	0.00	-0.01	
	CO9	0.10	-90.73	833.46	0.00	0.00	0.02	
	CO10	0.00	-7.66	86.36	0.00	0.00	0.01	
Σ Supp.	LC1	0.00	0.00	89.78				
Σ Loads	LC1	0.00	0.00	89.78				
Σ Supp.	LC2	0.00	0.00	83.36				
Σ Loads	LC2	0.00	0.00	83.36				
Σ Supp.	LC3	0.00	0.00	7.77				
Σ Loads	LC3	0.00	0.00	7.77				
Σ Supp.	LC4	79.22	23.49	0.70				
Σ Loads	LC4	79.22	23.49	0.70				
Σ Supp.	LC5	-0.10	83.11	-0.37				
Σ Loads	LC5	-0.10	83.11	-0.37				
Σ Supp.	LC6	0.09	-97.38	1.59				

4.1 NODES - SUPPORT FORCES

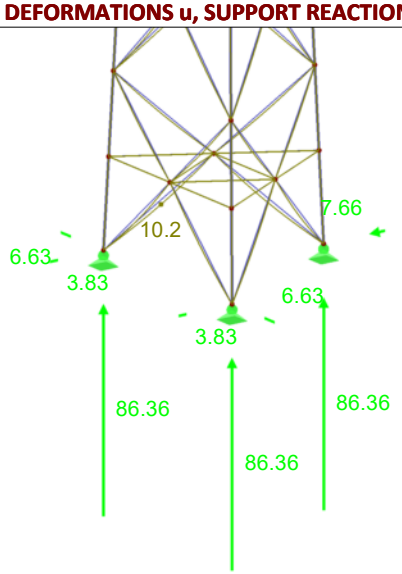
Node No.	LC/CO	Support Forces [kN] $P_{X'}$	$P_{Y'}$	$P_{Z'}$	Support Moments [kNm] $M_{X'}$	$M_{Y'}$	$M_{Z'}$
Σ Loads	LC6	0.09	-97.38	1.59			
Σ Supp.	CO1	71.29	21.14	259.70			
Σ Supp.	CO1	71.29	21.14	259.70			
Σ Supp.	CO2	118.82	35.24	201.77			
Σ Supp.	CO2	118.82	35.24	201.77			
Σ Supp.	CO3	-0.09	74.80	258.73			
Σ Supp.	CO3	-0.09	74.80	258.73			
Σ Supp.	CO4	-0.14	124.66	200.16			
Σ Supp.	CO4	-0.14	124.66	200.16			
Σ Supp.	CO5	0.08	-87.64	260.50			
Σ Supp.	CO5	0.08	-87.64	260.50			
Σ Supp.	CO6	0.14	-146.07	203.10			
Σ Supp.	CO6	0.14	-146.07	203.10			
Σ Supp.	CO7	118.82	35.24	126.74			
Σ Supp.	CO7	118.82	35.24	126.74			
Σ Supp.	CO8	-0.14	124.66	125.13			
Σ Supp.	CO8	-0.14	124.66	125.13			
Σ Supp.	CO9	0.14	-146.07	128.08			
Σ Supp.	CO9	0.14	-146.07	128.08			
Σ Supp.	CO10	0.00	0.00	259.07			
Σ Supp.	CO10	0.00	0.00	259.07			

NODE NUMBERS



GLOBAL DEFORMATIONS u, SUPPORT REACTIONS

CO10 : 1.4*LC1 + 1.6*LC2
Support Reactions[kN]



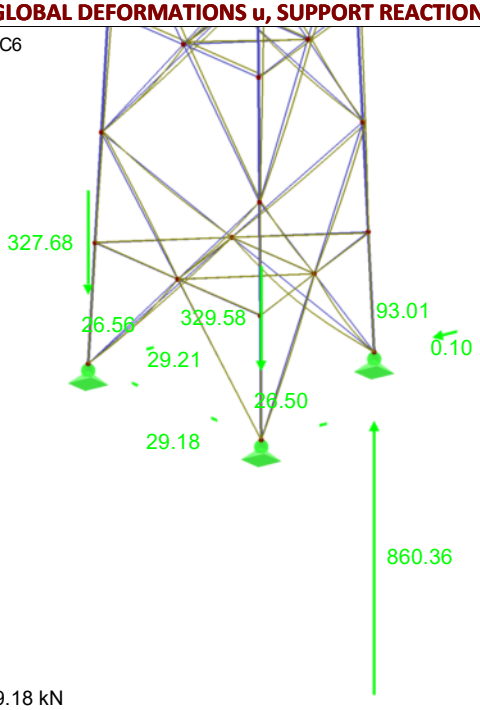
Isometric

Materials
1: Steel S 235 H |

Factor of deformations: 11.25
Max P-X': 6.63, Min P-X': -6.63 kN
Max P-Y': 3.83, Min P-Y': -7.66 kN
Max P-Z': 86.36, Min P-Z': 86.36 kN
Max u: 10.2, Min u: 0.0 mm

GLOBAL DEFORMATIONS u, SUPPORT REACTIONS

CO6 : 1.4*LC1 + 0.9*LC2 + 1.5*LC6
Support Reactions[kN]



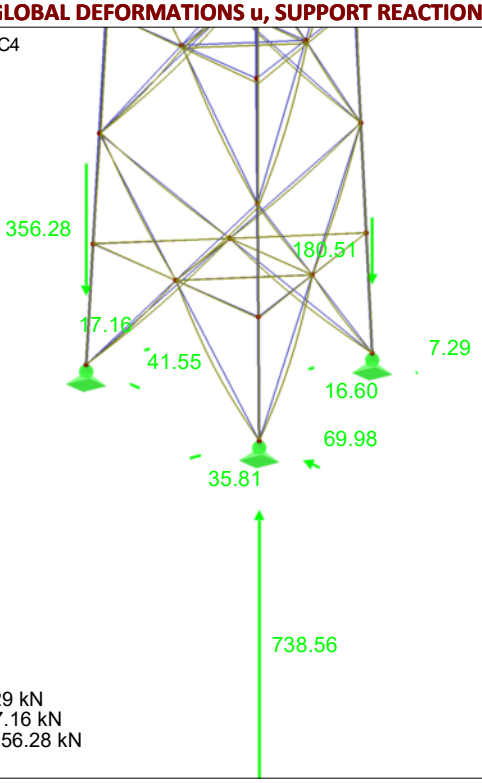
Isometric

Materials
1: Steel S 235 H |

Factor of deformations: 11.00
Max P-X': 29.21, Min P-X': -29.18 kN
Max P-Y': -26.50, Min P-Y': -93.01 kN
Max P-Z': 860.36, Min P-Z': -329.58 kN
Max u: 635.7, Min u: 0.0 mm

GLOBAL DEFORMATIONS u, SUPPORT REACTIONS

CO2 : 1.4*LC1 + 0.9*LC2 + 1.5*LC4
Support Reactions[kN]



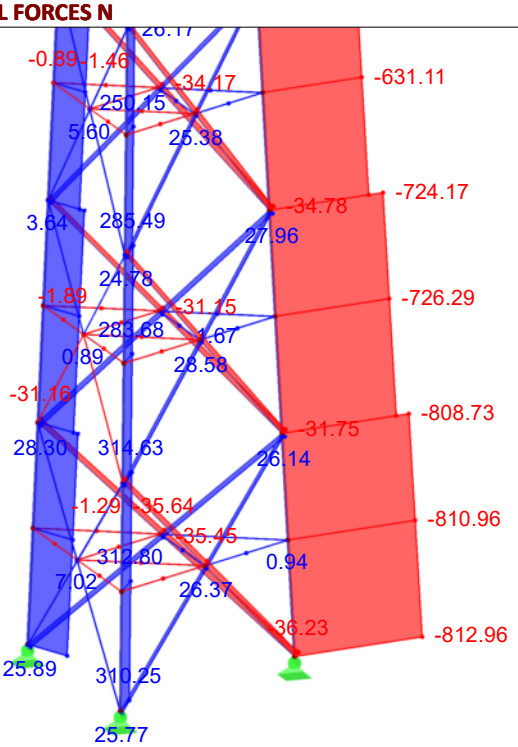
Isometric

Materials
1: Steel S 235 H |

Factor of deformations: 13.00
Max P-X': 69.98, Min P-X': 7.29 kN
Max P-Y': 35.81, Min P-Y': -17.16 kN
Max P-Z': 738.56, Min P-Z': -356.28 kN
Max u: 550.4, Min u: 0.0 mm

INTERNAL FORCES N

CO6 : 1.4*LC1 + 0.9*LC2 + 1.5*LC6
Internal Forces N



Isometric

Materials
1: Steel S 235 H |

Max N: 314.63, Min N: -812.96 [kN]

RF-STEEL EC3
CA1
Design of steel members according to Eurocode 3

1.1 GENERAL DATA

Members to design:	All	
Sets of members to design:		
National Annex:	CEN	
Ultimate Limit State Design		
Load combinations to design:	CO1	1.4*LC1 + 1.6*LC2 + 0.9*LC4
	CO2	1.4*LC1 + 0.9*LC2 + 1.5*LC4
	CO3	1.4*LC1 + 1.6*LC2 + 0.9*LC5
	CO4	1.4*LC1 + 0.9*LC2 + 1.5*LC5
	CO5	1.4*LC1 + 1.6*LC2 + 0.9*LC6
	CO6	1.4*LC1 + 0.9*LC2 + 1.5*LC6
	CO7	1.4*LC1 + 1.5*LC4
	CO8	1.4*LC1 + 1.5*LC5
	CO9	1.4*LC1 + 1.5*LC6
	CO10	1.4*LC1 + 1.6*LC2

1.1.1 DETAILS

Stability Analysis	
Stability Check	☒
Bending About the Major y-Axis	
Equivalent Member Method acc. to 6.3	☒
Include second-order effects acc. to 5.2.2(4) by increasing bending moment	☐
Bending About the Minor z-Axis	
Equivalent Member Method acc. to 6.3	☒
Include second-order effects acc. to 5.2.2(4) by increasing bending moment	☐
Determination of elastic critical moment for lateral-torsional buckling	
For members:	Automatically by Eigenvalue Method
Load application of positive transverse loads:	On cross-section edge directed to shear center (e.g. top flange, destabilizing effect)
Model type acc. to Table B.3	
Sway y - y (C_{my} = 0.9)	☐
Sway z - z (C_{mz} = 0.9)	☐
Limit Values for Stability Analysis	
Do not consider small moments and compression forces if:	
$N_{c,Ed} / N_{pl} \leq$	0.01
$M_{y,Ed} / M_{pl,y,Rd} \leq$	0.01
$M_{z,Ed} / M_{pl,z,Rd} \leq$	0.01
Limit shear stress due to torsion:	
$\tau_{t,Ed} / \tau_{t,Rd} \leq$	0.05
Stability analysis method for sets of members acc. to	6.3.1 - 6.3.3 Equivalent Member Method
Classification of Cross-Sections	
Type of determination of ψ and α acc. to Table 5.2:	Increase N_{Ed} and M_{Ed} uniformly
For limit c/t of Class 3, increase material factor ε acc. to 5.5.2(9)	☒
Use SHAPE-THIN for classification of all supported cross-section types (only Classes 3 and 4 possible)	☐
Ignore classification of curved parts	☒
if c/t ≤	5.00
Options	
Elastic Design (also for cross-sections of Class 1 or 2)	☒
Stability Analyses with Second-Order Internal Forces	
Use γ_{M1} for determination of the cross-section resistance	☐
Cross-section check for M+N	
Use linear interaction acc. to 6.2.1(7)	☐

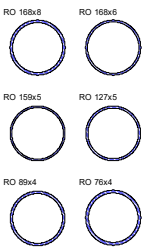
1.1.1 DETAILS

Cross-sections with Class 4 and torsion	
$\tau_{t,Ed} / \tau_{t,Rd} \leq$	0.05
Warping Torsion	
Perform warping analysis (7 degrees of freedom)	☐
Plasticity	
Perform advanced plastic design checks acc. to [1] and [2]	☐
Cold-Formed	
Perform design for cold-formed cross-sections acc. to EN 1993-1-3	☐
Member Slendernesses	
Members with	λ_{limit}
Tension only:	300
Compression / flexure:	200
Design of Welds	
Allow design of welds	☐

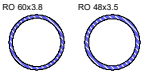
1.2 MATERIALS

Matl. No.	Material Description	E- Modulus E [kN/cm²]	Shear Modulus G [kN/cm²]	Poisson's Ratio ν [-]	Yield Stress f_{yk} [kN/cm²]	Max. Thickness t [mm]
1	Steel S 235 H | TaEN 10210-1:1994-09	21000.00	8076.92	0.300	23.50	40.0
					21.50	80.0

1.3 CROSS-SECTIONS



Sect. No.	Matl. No.	Cross-Section Description	Cross-Section Type	Max Design Ratio	Comment
1	1	RO 168x8 | GOST 10704-91	Pipe	1.17	
2	1	RO 168x6 | GOST 10704-91	Pipe	1.03	
3	1	RO 159x5 | GOST 10704-91	Pipe	0.71	
4	1	RO 127x5 | GOST 10704-91	Pipe	0.83	
5	1	RO 89x4 | GOST 10704-91	Pipe	0.24	
6	1	RO 76x4 | GOST 10704-91	Pipe	0.48	
7	1	RO 60x3.8 | GOST 10704-91	Pipe	0.71	
8	1	RO 48x3.5 | GOST 10704-91	Pipe	0.79	



2.1 DESIGN BY LOAD CASE

LC/CO/RC	Load Case or CO/RC Description	Membe No.	Location x [m]	Design		Equation No.	Description
	Ultimate Limit State Design						
CO1	1.4*LC1 + 1.6*LC2 + 0.9*LC4	12	0.000	0.66	≤ 1	ST364)	PT
CO2	1.4*LC1 + 0.9*LC2 + 1.5*LC4	12	0.000	1.00	≤ 1	ST364)	PT
CO3	1.4*LC1 + 1.6*LC2 + 0.9*LC5	13	0.000	0.38	≤ 1	ST364)	PT
CO4	1.4*LC1 + 0.9*LC2 + 1.5*LC5	15	0.000	0.66	≤ 1	CS184)	PT
CO5	1.4*LC1 + 1.6*LC2 + 0.9*LC6	11	0.000	0.76	≤ 1	ST364)	PT
CO6	1.4*LC1 + 0.9*LC2 + 1.5*LC6	11	0.000	1.17	> 1	ST364)	PT
CO7	1.4*LC1 + 1.5*LC4	12	0.000	0.96	≤ 1	ST364)	PT
CO8	1.4*LC1 + 1.5*LC5	15	0.000	0.68	≤ 1	CS184)	PT
CO9	1.4*LC1 + 1.5*LC6	11	0.000	1.13	> 1	ST364)	PT
CO10	1.4*LC1 + 1.6*LC2	19	2.350	0.16	≤ 1	CS184)	PT

2.2 DESIGN BY CROSS-SECTION

Sect. No.	Membe No.	Location x [m]	LC/CO/ RC	Design		Equation No.	Description
1	**RO 168x8 | GOST 10704-91**						
	15	2.870	CO8	0.61	≤ 1	CS101)	Cross-section check - Tension acc. to 6.2.3
	11	0.000	CO6	0.86	≤ 1	CS102)	Cross-section check - Compression acc. to 6.2.4
	40	3.153	CO8	0.01	≤ 1	CS122)	Cross-section check - Shear force in z-axis acc. to 6.2.6(4) - Class 3 or 4
	13	0.000	CO4	0.00	≤ 1	CS124)	Cross-section check - Shear force in y-axis acc. to 6.2.6(4) - Class 3 or 4
	42	2.627	CO4	0.01	≤ 1	CS129)	Cross-section check - Resulting shear force acc. to 6.2.6(4)
	11	3.140	CO6	0.94	≤ 1	CS184)	Cross-section check - Bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	13	1.435	CO2	0.74	≤ 1	CS204)	Cross-section check - Bending about z-axis, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	13	2.870	CO2	0.80	≤ 1	CS224)	Cross-section check - Biaxial bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	11	0.000	CO10	0.11	≤ 1	ST301)	Stability analysis - Flexural buckling about y-axis acc. to 6.3.1.1 and 6.3.1.2(4)
	10	0.000	CO4	0.50	≤ 1	ST302)	Stability analysis - Flexural buckling about y-axis acc. to 6.3.1.1 and 6.3.1.2
	11	0.000	CO10	0.11	≤ 1	ST311)	Stability analysis - Flexural buckling about z-axis acc. to 6.3.1.1 and 6.3.1.2(4)
	10	0.000	CO4	0.50	≤ 1	ST312)	Stability analysis - Flexural buckling about z-axis acc. to 6.3.1.1 and 6.3.1.2
	11	0.000	CO6	1.17	> 1	ST364)	Stability analysis - Bending and compression acc. to 6.3.3, Method 2
2	**RO 168x6 | GOST 10704-91**						
	87	2.821	CO8	0.54	≤ 1	CS101)	Cross-section check - Tension acc. to 6.2.3
	82	0.000	CO6	0.76	≤ 1	CS102)	Cross-section check - Compression acc. to 6.2.4
	87	0.000	CO8	0.01	≤ 1	CS122)	Cross-section check - Shear force in z-axis acc. to 6.2.6(4) - Class 3 or 4
	82	0.000	CO1	0.00	≤ 1	CS124)	Cross-section check - Shear force in y-axis acc. to 6.2.6(4) - Class 3 or 4
	162	2.761	CO7	0.01	≤ 1	CS129)	Cross-section check - Resulting shear force acc. to 6.2.6(4)
	82	3.189	CO6	0.88	≤ 1	CS184)	Cross-section check - Bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	83	1.367	CO2	0.67	≤ 1	CS204)	Cross-section check - Bending about z-axis, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	85	0.470	CO2	0.74	≤ 1	CS224)	Cross-section check - Biaxial bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	113	0.000	CO10	0.06	≤ 1	ST301)	Stability analysis - Flexural buckling about y-axis acc. to 6.3.1.1 and 6.3.1.2(4)
	113	0.000	CO10	0.06	≤ 1	ST311)	Stability analysis - Flexural buckling about z-axis acc. to 6.3.1.1 and 6.3.1.2(4)
	82	0.000	CO6	1.03	> 1	ST364)	Stability analysis - Bending and compression acc. to 6.3.3, Method 2
3	**RO 159x5 | GOST 10704-91**						
	168	2.714	CO8	0.36	≤ 1	CS101)	Cross-section check - Tension acc. to 6.2.3
	163	0.000	CO6	0.50	≤ 1	CS102)	Cross-section check - Compression acc. to 6.2.4
	163	3.296	CO8	0.01	≤ 1	CS122)	Cross-section check - Shear force in z-axis acc. to 6.2.6(4) - Class 3 or 4
	163	0.000	CO1	0.00	≤ 1	CS124)	Cross-section check - Shear force in y-axis acc. to 6.2.6(4) - Class 3 or 4
	163	0.000	CO7	0.01	≤ 1	CS129)	Cross-section check - Resulting shear force acc. to 6.2.6(4)
	168	0.452	CO6	0.59	≤ 1	CS184)	Cross-section check - Bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	168	2.714	CO9	0.50	≤ 1	CS204)	Cross-section check - Bending about z-axis, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	163	3.296	CO6	0.60	≤ 1	CS224)	Cross-section check - Biaxial bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	166	0.000	CO10	0.05	≤ 1	ST301)	Stability analysis - Flexural buckling about y-axis acc. to 6.3.1.1 and 6.3.1.2(4)

2.2 DESIGN BY CROSS-SECTION

Sect. No.	Membe No.	Location x [m]	LC/CO/ RC	Design		Equation No.	Description
	166	0.000	CO10	0.05	≤ 1	ST311)	Stability analysis - Flexural buckling about z-axis acc. to 6.3.1.1 and 6.3.1.2(4)
	163	0.000	CO6	0.71	≤ 1	ST364)	Stability analysis - Bending and compression acc. to 6.3.3, Method 2
4	**RO 127x5 | GOST 10704-91**						
	208	3.005	CO8	0.39	≤ 1	CS101)	Cross-section check - Tension acc. to 6.2.3
	208	0.000	CO6	0.55	≤ 1	CS102)	Cross-section check - Compression acc. to 6.2.4
	208	3.005	CO4	0.01	≤ 1	CS122)	Cross-section check - Shear force in z-axis acc. to 6.2.6(4) - Class 3 or 4
	205	0.000	CO1	0.00	≤ 1	CS124)	Cross-section check - Shear force in y-axis acc. to 6.2.6(4) - Class 3 or 4
	240	0.000	CO2	0.01	≤ 1	CS129)	Cross-section check - Resulting shear force acc. to 6.2.6(4)
	208	1.288	CO6	0.56	≤ 1	CS184)	Cross-section check - Bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	208	1.717	CO6	0.56	≤ 1	CS204)	Cross-section check - Bending about z-axis, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	208	3.005	CO6	0.61	≤ 1	CS224)	Cross-section check - Biaxial bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	205	0.000	CO10	0.06	≤ 1	ST301)	Stability analysis - Flexural buckling about y-axis acc. to 6.3.1.1 and 6.3.1.2(4)
	205	0.000	CO10	0.06	≤ 1	ST311)	Stability analysis - Flexural buckling about z-axis acc. to 6.3.1.1 and 6.3.1.2(4)
	208	0.000	CO6	0.83	≤ 1	ST364)	Stability analysis - Bending and compression acc. to 6.3.3, Method 2
5	**RO 89x4 | GOST 10704-91**						
	295	0.500	CO3	0.00	≤ 1	CS100)	Negligible internal forces
	287	2.000	CO8	0.11	≤ 1	CS101)	Cross-section check - Tension acc. to 6.2.3
	287	0.000	CO6	0.16	≤ 1	CS102)	Cross-section check - Compression acc. to 6.2.4
	295	0.000	CO3	0.03	≤ 1	CS112)	Cross-section check - Bending about y-axis acc. to 6.2.5 - Class 3
	296	1.500	CO9	0.07	≤ 1	CS117)	Cross-section check - Bending about z-axis acc. to 6.2.5 - Class 3
	295	0.000	CO4	0.01	≤ 1	CS122)	Cross-section check - Shear force in z-axis acc. to 6.2.6(4) - Class 3 or 4
	273	0.000	CO1	0.00	≤ 1	CS124)	Cross-section check - Shear force in y-axis acc. to 6.2.6(4) - Class 3 or 4
	297	0.000	CO4	0.01	≤ 1	CS129)	Cross-section check - Resulting shear force acc. to 6.2.6(4)
	295	0.000	CO3	0.03	≤ 1	CS144)	Cross-section check - Bending and shear force acc. to 6.2.9.2 and 6.2.10 - Class 3 - Pipe
	296	1.500	CO9	0.07	≤ 1	CS154)	Cross-section check - Bending about z-axis and shear force acc. to 6.2.9.2 and 6.2.10 - Class 3 - Pipe
	296	0.000	CO9	0.07	≤ 1	CS164)	Cross-section check - Biaxial bending and shear force acc. to 6.2.9.2 and 6.2.10 - Class 3 - Pipe
	286	1.000	CO7	0.14	≤ 1	CS184)	Cross-section check - Bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	287	1.500	CO6	0.17	≤ 1	CS204)	Cross-section check - Bending about z-axis, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	287	0.000	CO6	0.19	≤ 1	CS224)	Cross-section check - Biaxial bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	289	0.000	CO5	0.10	≤ 1	ST301)	Stability analysis - Flexural buckling about y-axis acc. to 6.3.1.1 and 6.3.1.2(4)
	286	0.000	CO1	0.13	≤ 1	ST302)	Stability analysis - Flexural buckling about y-axis acc. to 6.3.1.1 and 6.3.1.2
	289	0.000	CO5	0.10	≤ 1	ST311)	Stability analysis - Flexural buckling about z-axis acc. to 6.3.1.1 and 6.3.1.2(4)
	286	0.000	CO1	0.13	≤ 1	ST312)	Stability analysis - Flexural buckling about z-axis acc. to 6.3.1.1 and 6.3.1.2
	287	0.000	CO6	0.24	≤ 1	ST364)	Stability analysis - Bending and compression acc. to 6.3.3, Method 2
6	**RO 76x4 | GOST 10704-91**						

2.2 DESIGN BY CROSS-SECTION

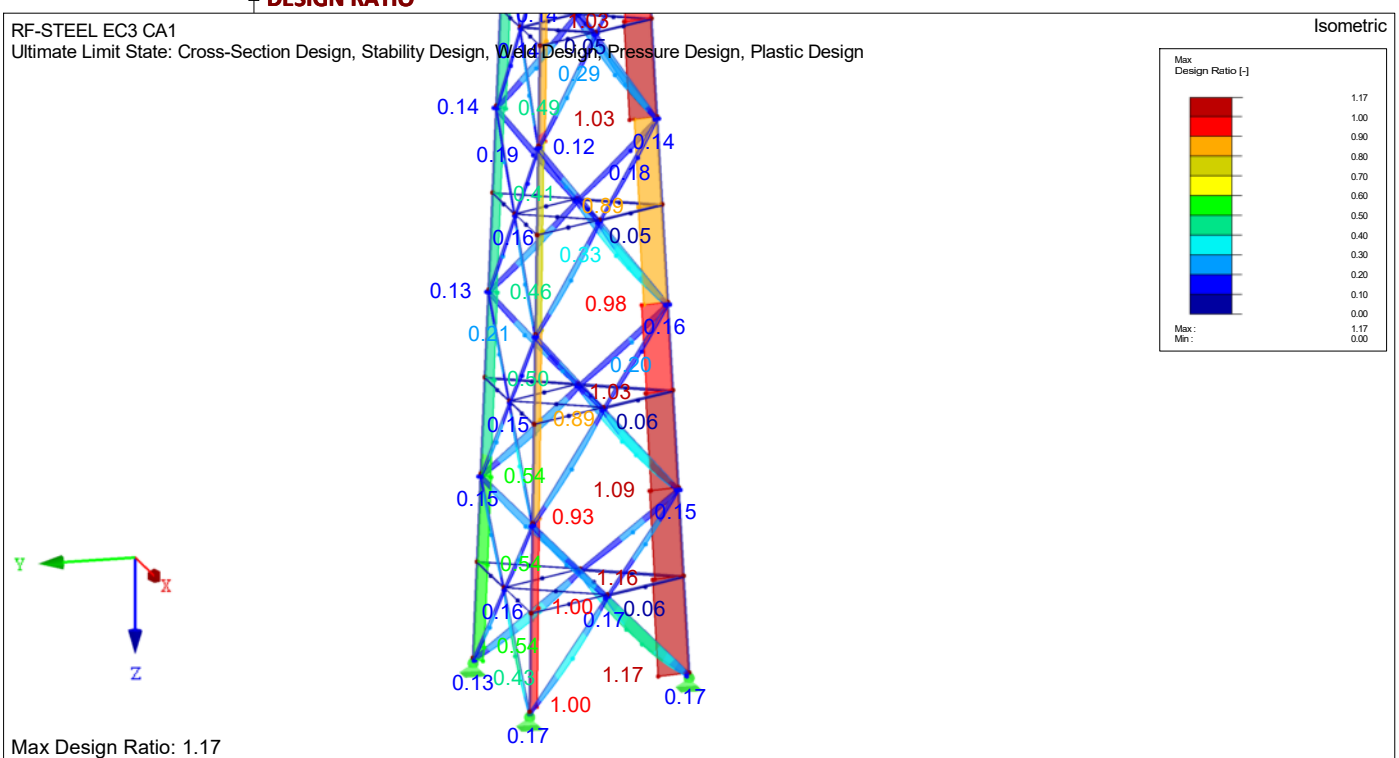
Sect. No.	Membe No.	Location x [m]	LC/CO/ RC	Design		Equation No.	Description
	199	0.000	CO5	0.00	≤ 1	CS100)	Negligible internal forces
	24	4.489	CO7	0.14	≤ 1	CS101)	Cross-section check - Tension acc. to 6.2.3
	28	0.000	CO6	0.17	≤ 1	CS102)	Cross-section check - Compression acc. to 6.2.4
	39	2.148	CO10	0.12	≤ 1	CS112)	Cross-section check - Bending about y-axis acc. to 6.2.5 - Class 3
	28	4.699	CO6	0.01	≤ 1	CS122)	Cross-section check - Shear force in z-axis acc. to 6.2.6(4) - Class 3 or 4
	16	0.000	CO4	0.00	≤ 1	CS124)	Cross-section check - Shear force in y-axis acc. to 6.2.6(4) - Class 3 or 4
	19	0.000	CO6	0.01	≤ 1	CS129)	Cross-section check - Resulting shear force acc. to 6.2.6(4)
	39	2.148	CO10	0.12	≤ 1	CS144)	Cross-section check - Bending and shear force acc. to 6.2.9.2 and 6.2.10 - Class 3 - Pipe
	91	1.542	CO6	0.14	≤ 1	CS164)	Cross-section check - Biaxial bending and shear force acc. to 6.2.9.2 and 6.2.10 - Class 3 - Pipe
	23	3.759	CO1	0.25	≤ 1	CS184)	Cross-section check - Bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	71	2.146	CO8	0.20	≤ 1	CS204)	Cross-section check - Bending about z-axis, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	28	2.350	CO6	0.48	≤ 1	CS224)	Cross-section check - Biaxial bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	204	0.000	CO2	0.04	≤ 1	ST301)	Stability analysis - Flexural buckling about y-axis acc. to 6.3.1.1 and 6.3.1.2(4)
	200	0.000	CO2	0.45	≤ 1	ST302)	Stability analysis - Flexural buckling about y-axis acc. to 6.3.1.1 and 6.3.1.2
	204	0.000	CO2	0.04	≤ 1	ST311)	Stability analysis - Flexural buckling about z-axis acc. to 6.3.1.1 and 6.3.1.2(4)
	200	0.000	CO2	0.45	≤ 1	ST312)	Stability analysis - Flexural buckling about z-axis acc. to 6.3.1.1 and 6.3.1.2
7	**RO 60x3.8 | GOST 10704-91**						
	61	0.000	CO1	0.00	≤ 1	CS100)	Negligible internal forces
	146	3.811	CO2	0.16	≤ 1	CS101)	Cross-section check - Tension acc. to 6.2.3
	170	0.000	CO2	0.20	≤ 1	CS102)	Cross-section check - Compression acc. to 6.2.4
	195	1.250	CO10	0.14	≤ 1	CS112)	Cross-section check - Bending about y-axis acc. to 6.2.5 - Class 3
	170	3.705	CO2	0.01	≤ 1	CS122)	Cross-section check - Shear force in z-axis acc. to 6.2.6(4) - Class 3 or 4
	145	0.000	CO2	0.00	≤ 1	CS124)	Cross-section check - Shear force in y-axis acc. to 6.2.6(4) - Class 3 or 4
	177	0.000	CO6	0.02	≤ 1	CS129)	Cross-section check - Resulting shear force acc. to 6.2.6(4)
	195	1.250	CO10	0.14	≤ 1	CS144)	Cross-section check - Bending and shear force acc. to 6.2.9.2 and 6.2.10 - Class 3 - Pipe
	156	2.025	CO6	0.12	≤ 1	CS164)	Cross-section check - Biaxial bending and shear force acc. to 6.2.9.2 and 6.2.10 - Class 3 - Pipe
	152	1.906	CO6	0.23	≤ 1	CS184)	Cross-section check - Bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	149	2.382	CO8	0.26	≤ 1	CS204)	Cross-section check - Bending about z-axis, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	177	1.852	CO6	0.60	≤ 1	CS224)	Cross-section check - Biaxial bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	61	0.000	CO8	0.05	≤ 1	ST301)	Stability analysis - Flexural buckling about y-axis acc. to 6.3.1.1 and 6.3.1.2(4)
	230	0.000	CO2	0.71	≤ 1	ST302)	Stability analysis - Flexural buckling about y-axis acc. to 6.3.1.1 and 6.3.1.2
	61	0.000	CO8	0.05	≤ 1	ST311)	Stability analysis - Flexural buckling about z-axis acc. to 6.3.1.1 and 6.3.1.2(4)
	230	0.000	CO2	0.71	≤ 1	ST312)	Stability analysis - Flexural buckling about z-axis acc. to 6.3.1.1 and 6.3.1.2
	195	0.833	CO5	0.12	≤ 1	ST364)	Stability analysis - Bending and compression acc. to 6.3.3, Method 2
8	**RO 48x3.5 | GOST 10704-91**						
	304	0.000	CO3	0.00	≤ 1	CS100)	Negligible internal forces
	246	2.561	CO6	0.17	≤ 1	CS101)	Cross-section check - Tension acc. to 6.2.3

2.2 DESIGN BY CROSS-SECTION

Sect. No.	Membe No.	Location x [m]	LC/CO/ RC	Design		Equation No.	Description
	244	0.000	CO2	0.20	≤ 1	CS102)	Cross-section check - Compression acc. to 6.2.4
	218	0.950	CO10	0.12	≤ 1	CS112)	Cross-section check - Bending about y-axis acc. to 6.2.5 - Class 3
	219	0.000	CO1	0.01	≤ 1	CS122)	Cross-section check - Shear force in z-axis acc. to 6.2.6(4) - Class 3 or 4
	217	0.475	CO6	0.00	≤ 1	CS124)	Cross-section check - Shear force in y-axis acc. to 6.2.6(4) - Class 3 or 4
	218	0.950	CO10	0.12	≤ 1	CS144)	Cross-section check - Bending and shear force acc. to 6.2.9.2 and 6.2.10 - Class 3 - Pipe
	218	0.950	CO3	0.13	≤ 1	CS184)	Cross-section check - Bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	218	0.950	CO1	0.15	≤ 1	CS224)	Cross-section check - Biaxial bending, shear and axial force acc. to 6.2.10 and 6.2.9 - Class 3 - Pipe
	226	0.000	CO6	0.05	≤ 1	ST301)	Stability analysis - Flexural buckling about y-axis acc. to 6.3.1.1 and 6.3.1.2(4)
	244	0.000	CO2	0.79	≤ 1	ST302)	Stability analysis - Flexural buckling about y-axis acc. to 6.3.1.1 and 6.3.1.2
	226	0.000	CO6	0.05	≤ 1	ST311)	Stability analysis - Flexural buckling about z-axis acc. to 6.3.1.1 and 6.3.1.2(4)
	244	0.000	CO2	0.79	≤ 1	ST312)	Stability analysis - Flexural buckling about z-axis acc. to 6.3.1.1 and 6.3.1.2
	218	0.475	CO2	0.11	≤ 1	ST364)	Stability analysis - Bending and compression acc. to 6.3.3, Method 2

DESIGN RATIO

RF-STEEL EC3 CA1
Ultimate Limit State: Cross-Section Design, Stability Design, Weld Design, Pressure Design, Plastic Design



Max Design Ratio: 1.17

Project: 11 Model: Tower 70 Date: 09.03.2026

RF-STABILITY
with selection
Stability
analysis

1.1 GENERAL DATA

Number of lowest eigenvalues (eigenvectors for buckling):	3
Normalization of eigenvectors:	Such that max $\{u_X,u_Y,u_Z\}=1$
Import axial forces from RFEM from:	CO10 - 1.4*LC1 + 1.6*LC2
Consider favorable effect due to tension:	☒
Consider axial forces as prestress:	☒
Import axial forces from RFEM from:	LC1 - Self-weight
Eigenvalue calculation method:	☒ Method by Lanczos ☐ Roots of the characteristic polynomial ☐ Subspace Iteration Method ☐ ICG Iteration Method
Stability analysis of LC/CO results	☒
Stability analysis for load increased to structural failure:	☐
Type of matrix:	Standard
Activate Stiffness Modification from RFEM	☒

2.1 CRITICAL LOAD FACTORS

E-Value No.	Critical Load Factor f	Magnification Factor α	
1	17.904	1.059	
2	17.904	1.059	
3	17.904	1.059	

1.1 GUST-EFFECT FACTOR

Wind Directions	Manually defined directions	:	0.00;90.00;270.00°
Turbulence Properties	Consider turbulence ☒	:	k-epsilon
Wind Profile	According to standard ☒	:	EN 1991-1-4
	National Annex	:	CEN European Union
	Wind Zone	:	
	Category	:	Category Category II
	Altitude **H_s**	:	0.000 [m]
	Fundamental Wind Velocity **v_b,0**	:	28.300 [m/s]
	Density **p**	:	1.250 [kg/m³]

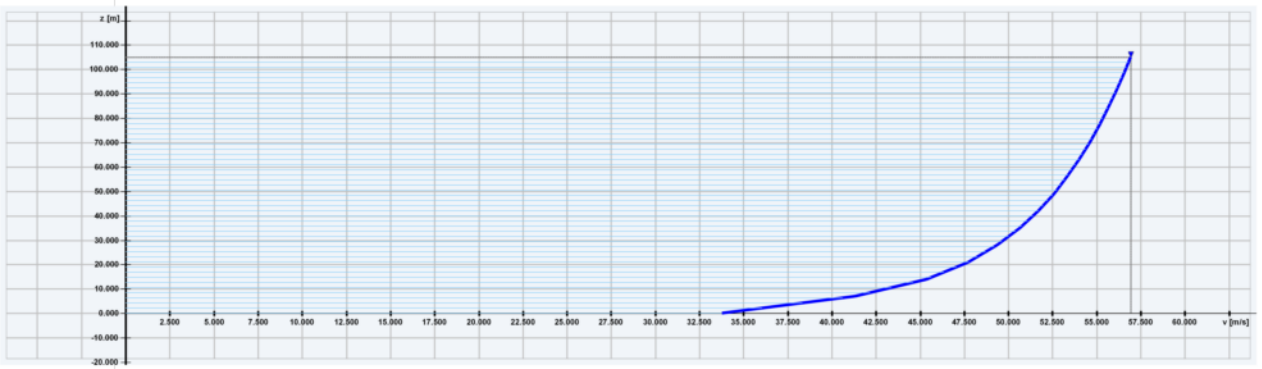
1.1.1 TURBULENCE PROPERTIES

No.	Level z [m]	Wind Velocit v [m/s]	Comment
1	0.000	33.764	
2	7.003	41.308	
3	14.006	45.372	
4	21.009	47.724	
5	28.012	49.383	
6	35.015	50.665	
7	42.018	51.709	
8	49.021	52.590	
9	56.024	53.352	
10	63.027	54.023	
11	70.030	54.623	
12	77.033	55.165	
13	84.036	55.659	
14	91.039	56.113	
15	98.042	56.533	
16	105.045	56.924	

1.2 RWIND SIMULATION PROBES - ORIGINAL MODEL RESULTS

Flow Parameters	Kinematic Viscosity **v**	:	0.000015 [m²/s]
Calculation Parameters	Density of mesh for fluid dynamic calculation	:	20.000000 [kg/m³]
	Maximum number of iterations	:	500
	Convergence criterion (P-residual)	:	0.001
	Level of detail	:	2
Generated Load Case Properties	Number of first load case	:	13
Model Properties	Close openings smaller than Absolute size	:	0.000 [m]
Turbulence Model Properties	Calculate turbulence parameters from the intensity of turbulence	:	☒
Member Load Distribution	Concentrated		
Export to RWIND Simulation	RFEM/RSTAB Model	:	☒Export optimized member topology
		:	☐Export active objects only

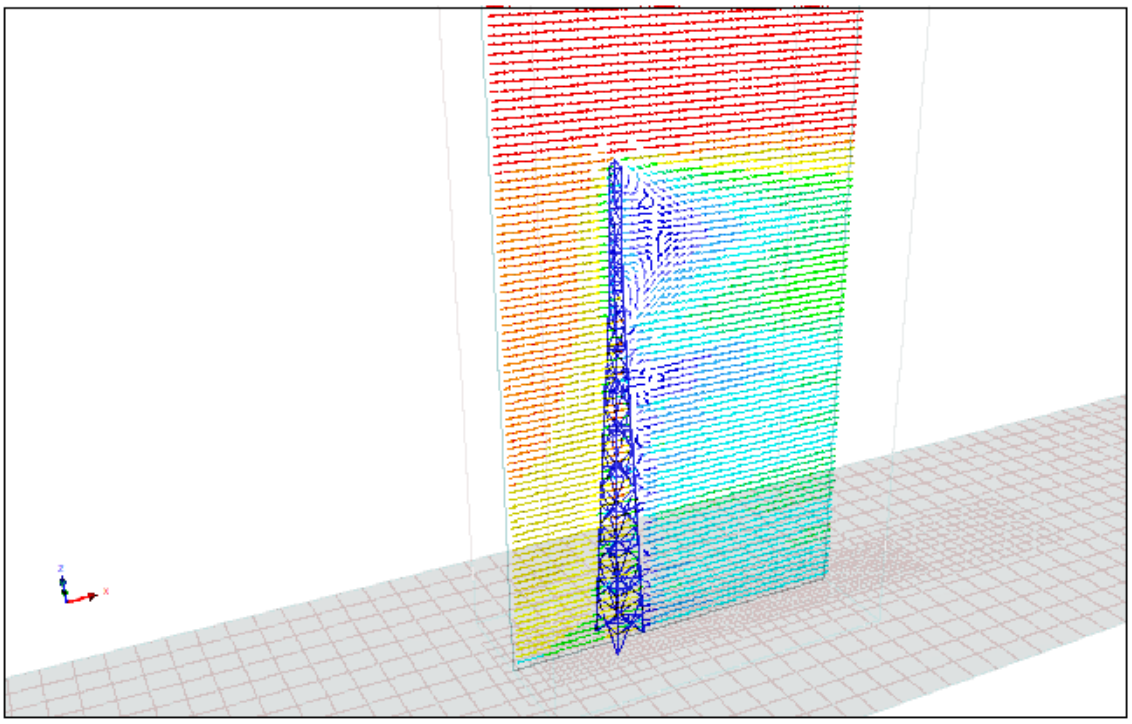
1.1.2 WIND TURBULENCE - GRAPH

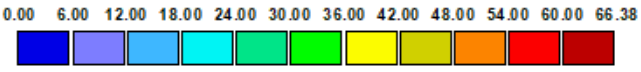


2.1 IMPORTANCE FACTOR

No.	Load Case - Description	Calculated	Drag Force [kN] F_X	F_Y	F_Z	Projected Area [m²]	Comment
LC13	Wind 0 °	☐					
LC14	Wind 90 °	☐					
LC15	Wind 270	☐					

WIND VELOCITY VECTORS

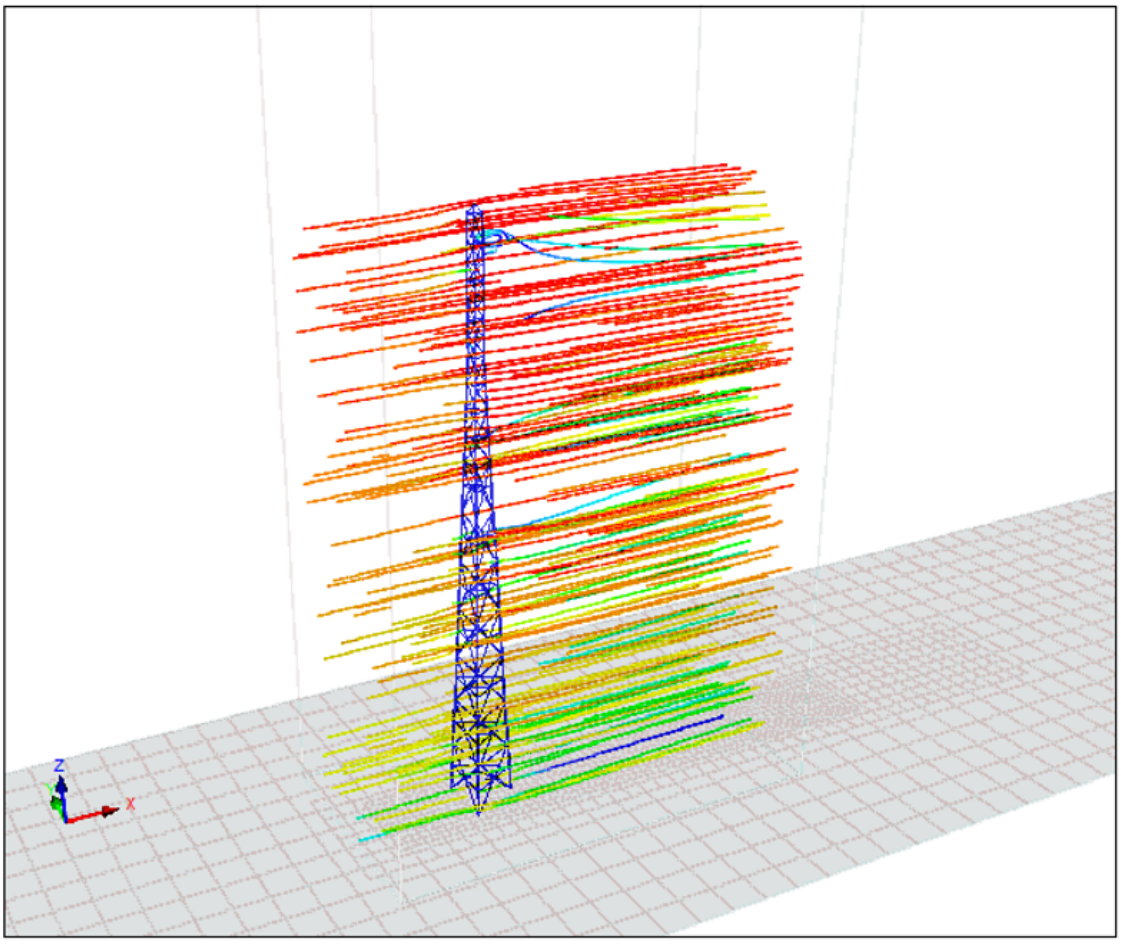


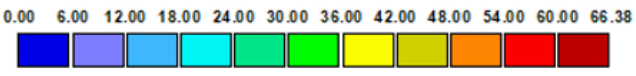


Velocity Vectors - Velocity Vectors[m/s], Min=0.00, Max=66.38

Project Tower 65_LC15_25CDF7AC-C718-4FE2-A078-119BE284F752 - Wind 270
Free Stream Velocity: 54.62 m/s
Results, Velocity Vectors

WIND STREAMLINES





Streamlines - Streamlines [m/s], Min=0.00, Max=66.38

Project Tower 65_LC15_25CDF7AC-C718-4FE2-A078-119BE284F752 - Wind 270
Free Stream Velocity: 54.62 m/s
Results, Streamlines

VECTORS OF FORCES FROM WIND LOADS