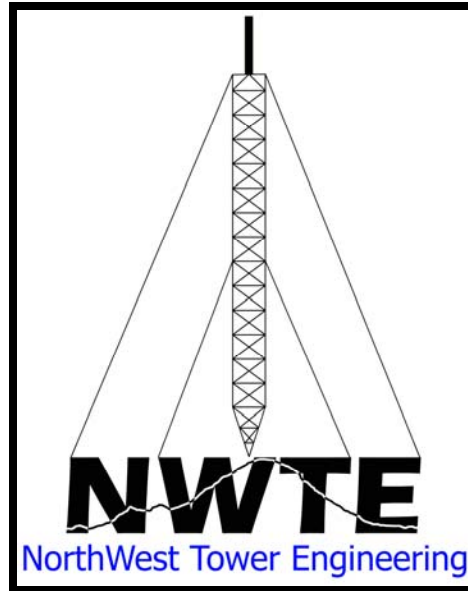




NorthWest Tower Engineering



SE02629A Mercer Island WT, WA **100-ft Self-Supporting Tower** **TAEC / T-Mobile**

Structural Analysis Report No. 251538.11 **January 13, 2025**

Analysis and Report by: Harvey Carlisle, S.E.

Checked by: Steven Diamond, P.E.

Approved by: Harvey Carlisle, S.E.





NorthWest Tower Engineering

Mercer Island WT

Report No. 251538.11

January 13, 2025

Introduction

NorthWest Tower Engineering (NWTE) has completed a structural analysis of the 100-foot self-supporting tower at the water tank site on Mercer Island, Washington. The analysis was performed at the request of Technology Associates EC (TAEC) to determine the ability of the tower to support proposed T-Mobile equipment.

Tower Information

NWTE visited the site on 06-16-15. The tower is a Rohn Industries model SSV-100ft. Tower and foundation drawings were not provided. A Subsurface Exploration Report dated 04-05-12 and a Nondestructive Foundation Mapping report dated 04-17-12 by Tower Engineering Professionals (TEP) were provided. The tower has been structurally modified multiple times. Construction drawings for the original modifications were not provided. Original modifications include the installation of mid bay horizontals at one bay above 40ft and completing the "X" bracing above 80ft for 5 bays. The tower was structurally modified again per NWTE construction drawings dated 05-20-21 (Project No. 211538.09). Modifications consist of installation of mid-bay horizontal bracing between 0'-20' (3 bays) and between 44'-60' (4 bays). NWTE visited the site again on 03-09-22 to make observations of the structural modifications.

Assessed Condition

This analysis was performed to determine the ability of the tower to support the following load conditions:

Existing Appurtenance Configuration

Elev.	Location	Appurtenance	Tx Line	Tx Line No.
26'	Leg A	(2) GPS	1/2" Coax	# 26
63'	Leg A	Empty Mount	N/A	N/A
66'	Leg C	10' Omni on 3-ft Stand-off Mount	7/8" Coax	# 20
84'	Leg A,B,C	T-Mobile (3) Commscope FFVV-65C-R3-V1 Panels (3) Nokia AHFIG RRU (3) Nokia AHLOA RRU (1) HCS 2.0 Pendant (3) Site Pro 1 TAM-2U Universal Sliding Tapered Pipe Mount with 8' Pipe	HCS 2.0 Hybrid	# 30
99'	Face C	10ft Face Frame 10ft 2-bay Single Dipole 10ft 4-bay Dual Dipole 4ft Yagi Antenna	(2) 7/8" Coax 1/4" coax	# 16,17 #25
99'	Leg B	18" Standoff Mount 10ft 4-bay Dual Dipole	7/8" Coax	# 18
110'	Leg C	10ft Omni Antenna	7/8" Coax	# 19



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Proposed Appurtenance Configuration

All existing antennas and the following:

Elev.	Location	Appurtenance	Tx Line	Tx Line No.
84'	Leg A,B,C	Remove		
		(3) Site Pro 1 TAM-2U Universal Sliding Tapered Pipe Mount with 8' Pipe		
		Retain		
		(3) Commscope FFVV-65C-R3-V1 Panels	Retain	# 30
		(3) Nokia AHFIG RRU	HCS 2.0 Hybrid	
		(3) Nokia AHLOA RRU	Proposed	
		(1) HCS 2.0 Pendant	6x24 Hybrid	# 31
		Proposed		
		(3) Nokia AEHC Panels (86.4')		
		(3) Site Pro 1 VFA8-HD Sector Frames		

Antenna center elevations are listed for microwave, yagi, and panel type antennas. Base elevations are listed for other antenna types.

Information on tower geometry, structural member sizes, and existing appurtenances was gathered during NWTE's site visit. Information on proposed appurtenances was provided by TAEC in preliminary construction drawings dated 01-09-25 and in T-Mobile's RFDS dated 12-20-24.

Steel yield strengths for structural members are assumed standard Rohn as follows:

- Pipe Legs 50 ksi
- Angle Bracing 36 ksi

The attached drawing shows tower geometry, structural member sizes, existing and proposed antennas, feed lines, and other supported appurtenances.

Wind Load Specifications

A comprehensive structural analysis was performed using the provisions of the current design standard, TIA-222-H, "Structural Standard for Antenna Supporting Structures, Antennas, and Small Wind Turbine Support Structures." This standard is referenced in the 2021 International Building Code (IBC). The minimum basic wind speed of **109 mph** (V_{ult} , 3-second gust) as listed in the standard for Risk Category IV structures at this location was used. A basic wind speed of 30 mph in combination with a design ice thickness of 1" as listed in the TIA-222-H standard was also considered. Exposure Category B (suburban area) was considered. The rigorous topographic factor procedure was used (flat topped hill with crest height, $H=365'$; slope distance, $L=3300'$; and distance from crest, $x=760'$). A base elevation above sea level of 380' was considered.



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Analysis Method

A three-dimensional finite element model of the tower was created using *tnxTower Version 8.2.1.0 (Tower Numerics, 2023)*. This computer software program calculates and distributes wind and ice loads in the model. It calculates the resulting forces (required strength) in all structural members and determines tower deflections and foundation loads. Required strength of each structural member is compared to each member's design strength determined using the TIA-222-H standard.

Analysis Results

The following ratios of required strength to design strength for the tower's structural members were found:

MEMBER DEMAND-CAPACITY RATIO

Elevation (ft)	Member	Existing Configuration Maximum % Capacity	Proposed Configuration Maximum % Capacity
100 - 0	Leg	70	87
	Diagonal	43	67
	Horizontal	13	16

The attached tables contain more detailed lists of member forces and capacities. Capacities of all structural members were found to be adequate.

Calculations show anchor bolts and bolts in leg splice and bracing connections to be adequate. Welds, plates, and other elements of the connections are assumed to develop the full strengths of the members.

According to the TEP foundation mapping report, each leg of the tower rests on a concrete pier. Pier dimensions are listed as approximately 2'-6" square at top and 3'-6" square at bottom with a depth of 11'-6". Calculations confirm that the foundations are adequate.

Seismic calculations were performed using the equivalent lateral force procedure in accordance with the TIA-222-H standard. Seismic forces were distributed over the height of the tower in accordance with the TIA-222-H standard. Resulting values for shear forces in the tower were then calculated at multiple levels and compared with shear forces generated from wind loads. Wind load was found to govern over the full height of the structure.

Conclusion

The tower meets the requirements of the TIA-222-H standard for the antenna configurations considered. Structural modifications are not required.



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Conditions of Analysis

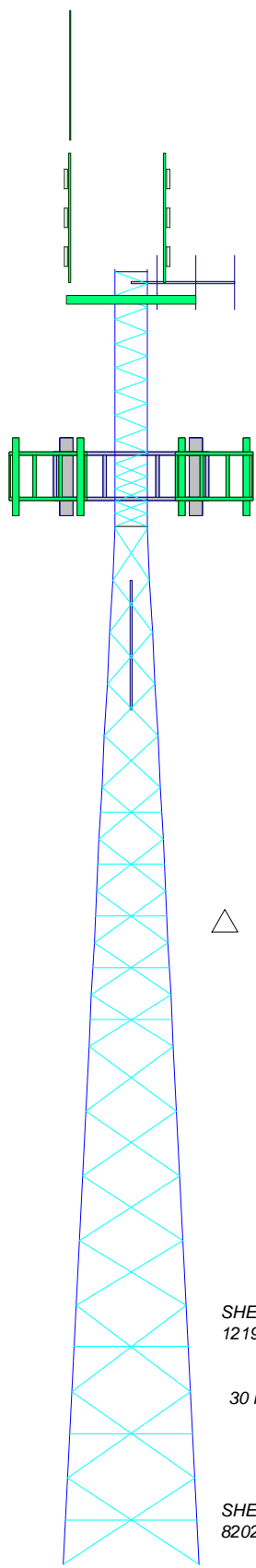
The analysis performed and the conclusions contained herein are based on the following assumptions:

- The tower has been properly installed and maintained.
- Steel grades for structural members are as listed above.
- Any deficiencies noted during the field visit have been or will be corrected.
- No x-ray, subsurface excavation, or other similar examination of the tower, foundation system, or welded connections was conducted. For portions of the tower and foundation system that were not visually accessible, no determination regarding the condition or adequacy was made.
- All structural components of the tower including, but not limited to, structural members (legs, bracing, etc.), connection components (gusset plates, welds, bolts), and foundations are in good condition.
- Feed lines are arranged as shown in the attached cross section.
- Existing and proposed T-Mobile antennas and equipment will be installed on new sector frames.

Deviations to these assumptions may affect the analysis results.

Section	T14	T13	T12	T11	T10	T9	T8	T7	T6	T5	T4	T3	T2	T1																																								
Legs	ROHN 2.5 X-STR (2.875"x.276)				ROHN 2 STD (2.375"x.154)										SR 1 7/16																																							
Leg Grade					A572-50																																																	
Diagonals	L1 3/4x1 3/4x3/16				L1 1/2x1 1/2x3/16				L1 1/2x1 1/2x1/8				SR 5/8																																									
Diagonal Grade					A36																																																	
Top Girts					N.A.										SR 5/8																																							
Bottom Girts					N.A.										SR 5/8																																							
Sec. Horizontals	L2x2x1/4				N.A.				L2x2x1/4				N.A.																																									
Face Width (ft)	8.55208				6.54167				5.73438				5.32812				4.92448				4.52083				4.11719				3.71354				3.30729				2.90365				2.5													
# Panels @ (ft)	3 @ 6.66667				4 @ 5				10 @ 4				A										16 @ 0.927083																															
Weight (lb)	3890.6				1203.9				876.3				194.7				158.3				152.0				145.7				139.6				92.2				90.1				86.1				84.4				194.1				415.2	

100.0 ft
85.0 ft
80.0 ft
76.0 ft
72.0 ft
68.0 ft
64.0 ft
60.0 ft
56.0 ft
52.0 ft
48.0 ft
44.0 ft
40.0 ft
20.0 ft
0.0 ft



DESIGNED APPURTENANCE LOADING

TYPE	ELEVATION	TYPE	ELEVATION
Mast 10'x1"	110	Commscope FFVV-65C-R3 (T-Mobile)	84
Small Yagi	99	Commscope FFVV-65C-R3 (T-Mobile)	84
Face Frame	99	Commscope FFVV-65C-R3 (T-Mobile)	84
10' Dipole Antenna with Mount	99	AHLOA RRU (T-Mobile)	84
10' Dipole Antenna with Mount	99	AHLOA RRU (T-Mobile)	84
10' Dipole Antenna with Mount	99	AHLOA RRU (T-Mobile)	84
Nokia AEHC (T-Mobile)	86	Nokia AHFIG (T-Mobile)	84
Nokia AEHC (T-Mobile)	86	Nokia AHFIG (T-Mobile)	84
Nokia AEHC (T-Mobile)	86	Nokia AHFIG (T-Mobile)	84
Site Pro 1 VFA8-HD V-Frame (T-Mobile)	84	HCS 2.0 Pendant (T-Mobile)	84
Site Pro 1 VFA8-HD V-Frame (T-Mobile)	84	Mast 10'x1"	66
Site Pro 1 VFA8-HD V-Frame (T-Mobile)	84	3-ft Stand-Off Mount	66
Site Pro 1 VFA8-HD V-Frame (T-Mobile)	84	3-ft Stand-Off Mount	63
Site Pro 1 VFA8-HD V-Frame (T-Mobile)	84	GPS	21 - 11

SYMBOL LIST

MARK	SIZE	MARK	SIZE
A	5 @ 0.966667		

MATERIAL STRENGTH

GRADE	Fy	Fu	GRADE	Fy	Fu
A572-50	50 ksi	65 ksi	A36	36 ksi	58 ksi

TOWER DESIGN NOTES

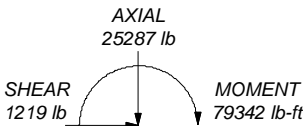
1. Tower is located in King County, Washington.
2. Tower designed for Exposure B to the TIA-222-H Standard.
3. Tower designed for a 109 mph basic wind in accordance with the TIA-222-H Standard.
4. Tower is also designed for a 30 mph basic wind with 1.00 inch ice. Ice is considered to increase in thickness with height.
5. Deflections are based upon a 60 mph wind.
6. Tower Risk Category IV.
7. Topographic Category 5 with Crest Height of 365'
8. TOWER RATING: 86.5%

ALL REACTIONS
ARE FACTORED

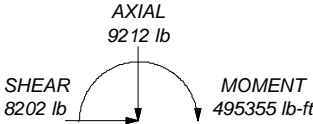
MAX. CORNER REACTIONS AT BASE:

DOWN: 57223 lb
SHEAR: 5419 lb

UPLIFT: -48900 lb
SHEAR: 4605 lb



TORQUE 322 lb-ft
30 mph WIND - 1.000 in ICE



TORQUE 2597 lb-ft
REACTIONS - 109 mph WIND

NorthWest Tower Engineering

3426 Broadway Suite 302

Everett, WA 98201

Phone: 425 258 4248

FAX: 425 258 4289

NWTE

Job: 100-ft SS Mercer Island, WA 251538.11

Project: Proposed, V=109 mph & 30 mph with 1" Ice

Client: TAEC/ T-Mobile Drawn by: Steven Diamond App'd:

Code: TIA-222-H Date: 01/13/25 Scale: NTS

Path: Dwg No. E-1



NorthWest Tower Engineering
3426 Broadway Suite 302
Everett, WA 98201
Phone: 425-258-4248

Job Name:

100-ft SS, Mercer Island

Page: A-1

Project Number:

251538.11

Date: 1/8/2025

Client Name:

TAEC / T-Mobile

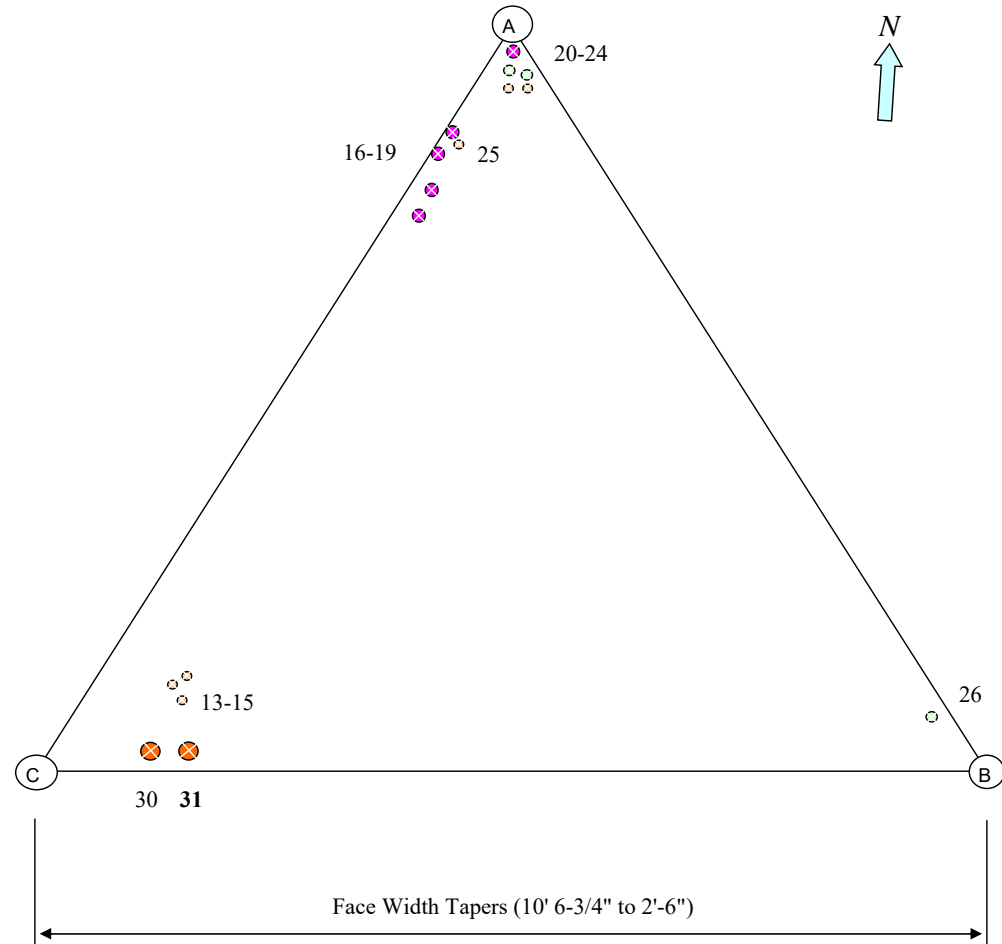
By: SD/HC

EXISTING FEEDLINES

Coax Number	Coax Description	Termination Elevation	Coax Key
1-12	removed	N/A	N/A
13-15	(3) 1/4" Coax (Dead)	80'	⊗
16-19	(4) 7/8" Coax	99', 110'	⊗
20	7/8" Coax	66'	⊗
21-22	(2) 1/2" Coax (Dead)	98', 62'	⊗
23-24	(2) 3/8" Coax (Dead)	62'	⊗
25	1/4" Coax	99'	⊗
26	1/2" Coax	21'	⊗
27-29	removed	N/A	N/A
30	HCS 2.0 Hybrid Cable	84'	⊗

PROPOSED FEEDLINES T-Mobile

31	6x24 Hybrid Cable	84'	⊗



<i>tnxTower</i> <i>NorthWest Tower Engineering</i> 3426 Broadway Suite 302 Everett, WA 98201 Phone: 425 258 4248 FAX: 425 258 4289	Job	100-ft SS Mercer Island, WA 251538.11	Page	2 of 2
	Project	Existing, V =109 mph & 30 mph with 1" Ice	Date	15:04:48 01/13/25
	Client	TAEC/ T-Mobile	Designed by	Steven Diamond

<i>Section No.</i>	<i>Elevation ft</i>	<i>Component Type</i>	<i>Size</i>	<i>Critical Element</i>	<i>P lb</i>	<i>ϕP_{allow} lb</i>	<i>% Capacity</i>	<i>Pass Fail</i>
						(T3) Secondary Horizontal	13.2	Pass
						(T14) Top Girt	3.5	Pass
						(T1) Bottom Girt	5.2	Pass
						(T2) Bolt Checks	43.2	Pass
						RATING =	70.4	Pass

Program Version 8.2.1.0 - 9/11/2023 File:P:/Projects 2025/251538.11 100ft SSV Mercer Island, WA TAEC, T-Mobile AN/Analysis/100-ft SS Mercer Island, WA Existing 251538.11.eri

<i>tnxTower</i> <i>NorthWest Tower Engineering</i> 3426 Broadway Suite 302 Everett, WA 98201 Phone: 425 258 4248 FAX: 425 258 4289	Job	100-ft SS Mercer Island, WA 251538.11	Page	2 of 2
	Project	Proposed, V =109 mph & 30 mph with 1" Ice	Date	15:00:24 01/13/25
	Client	TAEC/ T-Mobile	Designed by	Steven Diamond

<i>Section No.</i>	<i>Elevation ft</i>	<i>Component Type</i>	<i>Size</i>	<i>Critical Element</i>	<i>P lb</i>	<i>ϕP_{allow} lb</i>	<i>% Capacity</i>	<i>Pass Fail</i>
						(T3) Secondary Horizontal	15.6	Pass
						(T14) Top Girt	3.5	Pass
						(T1) Bottom Girt	6.2	Pass
						(T2) Bolt Checks	66.7	Pass
						RATING =	86.5	Pass

Program Version 8.2.1.0 - 9/11/2023 File:P:/Projects 2025/251538.11 100ft SSV Mercer Island, WA TAEC, T-Mobile AN/Analysis/100-ft SS Mercer Island, WA Proposed 251538.11.eri