Robinson+Cole

KENNETH C. BALDWIN

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Also admitted in Massachusetts

November 24, 2014

Via Hand Delivery

Melanie A. Bachman
Acting Executive Director
Connecticut Siting Council
10 Franklin Square
New Britain, CT 06051

Re: **Notice of Exempt Modification – Facility Modifications**
53 Gallup Road and 422 Rockville Road, Voluntown, Connecticut

Dear Ms. Bachman:

Cellco Partnership d/b/a Verizon Wireless ("Cellco") currently maintains wireless telecommunications facilities at 422 Rockville Road and 53 Gallup Road in Voluntown, Connecticut. The Rockville Road facility was approved by the Council in Docket No. 405 on January 20, 2011, and was activated in December of 2013. The Gallup Road facility was approved by the Council in Docket No. 438 on September 5, 2013, and has not yet been activated.

Cellco recently learned that its backhaul service provider will not be able to install fiber service to the Gallup Road site until April of 2015. To avoid any further delay in the activation of the Gallup Road facility, Cellco intends to provide temporary backhaul service through the use of a "microwave hop" from the Gallup Road tower to the Rockville Road tower. To do so, Cellco will install a single microwave dish antenna on its existing antenna platforms at the 150-foot level on the Gallup Road tower and the 160-foot level on the Rockville Road tower. Included in Attachment 1 are specifications for the Model MA0528-28AN microwave dish antenna that Cellco intends to install at each tower location. Once permanent backhaul service is established at the Gallup Road tower site, Cellco will notify the Council and remove the dish antennas from both towers.

13270445-v1

Please accept this letter as notification pursuant to R.C.S.A. § 16-50j-73, for construction that constitutes an exempt modification pursuant to R.C.S.A. § 16-50j-72(b)(2). In accordance with R.C.S.A. § 16-50j-73, a copy of this letter is being sent to Robert A. Sirpenski, First Selectman of the Town of Voluntown. A copy of this notice is also being sent to Benjamin and Byron D. Gallup and Cheryl Marcinko, the owners of the Gallup Road and Rockville Road properties, respectively.

The planned modifications to the facilities fall squarely within those activities explicitly provided for in R.C.S.A. § 16-50j-72(b)(2).

1. The proposed modifications will not result in an increase in the height of either of the existing towers. Cellco will install a single dish antenna on the existing antenna platform at the top of each tower.

2. The proposed modifications will not involve any change to ground-mounted equipment and, therefore, will not require the extension of the site boundary.

3. The proposed modifications will not increase noise levels at the facility by six decibels or more, or to levels that exceed state and local criteria.

4. The operation of the microwave dish antennas will not increase radio frequency (RF) emissions at either facility to levels that are at or above the Federal Communications Commission (FCC) safety standard. Calculated Radio Frequency Emissions Reports for both the Gallup Road and Rockville Road facilities are included in Attachment 2.

5. The proposed modifications will not cause a change or alteration in the physical or environmental characteristics of the site.

6. The Gallup Road and Rockville Road towers and their foundations can support Cellco's proposed modifications. Structural Analysis Reports for the Gallup Road and the Rockville Road towers are included in Attachment 3.

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For the foregoing reasons, Cellco respectfully submits that the proposed modifications to the above-referenced telecommunications facility constitutes an exempt modification under R.C.S.A. § 16-50j-72(b)(2).

Sincerely,

Kenneth C. Baldwin

Enclosures
Copy to:
Robert A. Sirpenski, Voluntown First Selectman
Benjamin and Byron D. Gallup
Cheryl Marcinko
Sandy M. Carter

ATTACHMENT 1

Flat Panel Antenna, Single Polarized, 2 ft, 28 dBi

Product Description
(Only available in North America)

Radio Frequency Systems? new flat panel antennas are especially designed to serve license-free ISM, Spread Spectrum and UNII band applications in 2.4 GHz and 5.2-5.8 GHz.Because of their new, simpler, lightweight construction, these antennas meet the need for an aesthetically pleasing antenna with superior pattern characteristics. New flat panel antennas are lower in profile and weigh significantly less, for easier handling, reduced tower loading and lower shipping cost, and are an attractive solution for both point to point and point to multi point applications.Ideal for point-to-point and point-to-multipoint applications, these new antennas have been rigorously tested to meet extremely stringent environmental specifications for safe and reliable long-term operation. Their cost effective design translates into an outstanding value for the user.

Antenna

Features/Benefits

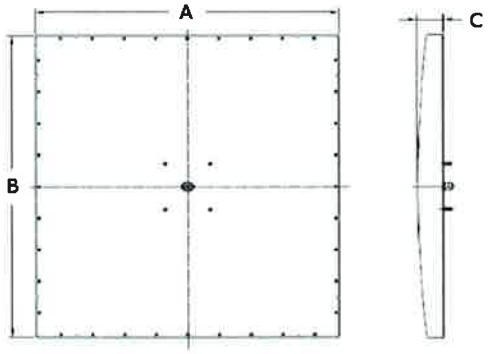
Technical Features

Product Type	Point to point antennas, Broadband Wireless Antennas
Frequency, GHz	5.15 - 5.35, 5.725 - 5.875
Profile	Flat Panel
Antenna color	White
Swaybar	0: (not applicable)
optional Swaybar	0: (not applicable)
Performance	Standard
Polarization	Single
Regulatory Compliance	ETSI EN 302085 V1.1.2 TS1-TS5
3dB beamwidth, (degrees)	4.5
Antenna Input	N Female
Mid Band Gain, dBi	28
F/B Ratio, dB	45
XPD, dB	28
Max VSWR / R L, dB	1.5 (14) @5.15 - 5.35 GHz, 1.7 (12) @5.725 - 5.85 GHz
Elevation Adjustment, degrees	-10
Azimuth Adjustment, degrees	360
Radome	rigid
Radome Material	Plastic
Mounting Pipe Diameter minimum, mm (in)	68 (2.75)
Mounting Pipe Diameter maximum, mm (in)	100 (4)
Approximate Weight, kg (lb)	5 (11)

All information contained in the present datasheet is subject to confirmation at time of ordering

Flat Panel Antenna, Single Polarized, 2 ft, 28 dBi

Dimensions	mm (in)
A	600 (23.6)
B	600 (23.6)
C	35 (1.4)



Notes

no notes

Documentation

Radiation pattern: (ADF)
Radiation pattern: (NSMA format)
Radiation pattern: (PDF format)

All information contained in the present datasheet is subject to confirmation at time of ordering

ATTACHMENT 2

C Squared Systems, LLC
65 Dartmouth Drive
Auburn, NH 03032
(603) 644-2800
support@csquaredsystems.com

Calculated Radio Frequency Emissions

Palmer Pond CT

53 Gallup Road, Voluntown, CT 06384

November 21, 2014

Table of Contents

1. Introduction 1
2. FCC Guidelines for Evaluating RF Radiation Exposure Limits 1
3. RF Exposure Prediction Methods 2
4. Calculation Results 3
5. Conclusion 4
6. Statement of Certification 4
Attachment A: References 5
Attachment B: FCC Limits for Maximum Permissible Exposure (MPE) 6
Attachment C: Verizon Wireless' Antenna Model Data Sheets and Electrical Patterns 8

List of Tables

Table 1: Carrier Information 3
Table 2: FCC Limits for Maximum Permissible Exposure (MPE) 6

List of Figures

Figure 1: Graph of FCC Limits for Maximum Permissible Exposure (MPE) 7

1. Introduction

The purpose of this report is to investigate compliance with applicable FCC regulations for the modifications to the Verizon Wireless antennas on the monopole tower located at 53 Gallup Road in Voluntown, CT. The coordinates of the tower are 41° 32' 12.1" N, 71° 49' 45.7" W.

Verizon Wireless is proposing the following modifications:

1) Install one Microwave panel antenna.

2. FCC Guidelines for Evaluating RF Radiation Exposure Limits

In 1985, the FCC established rules to regulate radio frequency (RF) exposure from FCC licensed antenna facilities. In 1996, the FCC updated these rules, which were further amended in August 1997 by OET Bulletin 65 Edition 97-01. These new rules include Maximum Permissible Exposure (MPE) limits for transmitters operating between 300 kHz and 100 GHz. The FCC MPE limits are based upon those recommended by the National Council on Radiation Protection and Measurements (NCRP), developed by the Institute of Electrical and Electronics Engineers, Inc., (IEEE) and adopted by the American National Standards Institute (ANSI).

The FCC general population/uncontrolled limits set the maximum exposure to which most people may be subjected. General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

Public exposure to radio frequencies is regulated and enforced in units of milliwatts per square centimeter (mW/cm^2). The general population exposure limits for the various frequency ranges are defined in the attached "FCC Limits for Maximum Permissible Exposure (MPE)" in Attachment B of this report.

Higher exposure limits are permitted under the occupational/controlled exposure category, but only for persons who are exposed as a consequence of their employment and who have been made fully aware of the potential for exposure, and they must be able to exercise control over their exposure. General population/uncontrolled limits are five times more stringent than the levels that are acceptable for occupational, or radio frequency trained individuals. Attachment B contains excerpts from OET Bulletin 65 and defines the Maximum Exposure Limit.

Finally, it should be noted that the MPE limits adopted by the FCC for both general population/uncontrolled exposure and for occupational/controlled exposure incorporate a substantial margin of safety and have been established to be well below levels generally accepted as having the potential to cause adverse health effects.

3. RF Exposure Prediction Methods

The emission field calculation results displayed in the following figures were generated using the following formula as outlined in FCC bulletin OET 65:

$$\text{Power Density} = \left(\frac{1.6^2 \times EIRP}{4\pi \times R^2} \right) \times OffBeamLoss$$

Where:

EIRP = Effective Isotropic Radiated Power

R = Radial Distance = $\sqrt{(H^2 + V^2)}$

H = Horizontal Distance from antenna in meters

V = Vertical Distance from radiation center of antenna in meters

Ground reflection factor of 1.6

Off Beam Loss is determined by the selected antenna patterns

These calculations assume that the antennas are operating at 100 percent capacity, that all antenna channels are transmitting simultaneously, and that the radio transmitters are operating at full power. As a result, the predicted signal levels reported below are much higher than the actual signal levels will be from the final site configuration.

4. Calculation Results

Table 1 below outlines the power density information for the site. Due to the directional nature of Verizon Wireless' existing panel antennas and proposed microwave antenna, the majority of the RF power will be focused out towards the horizon. As a result, there will be less RF power directed below the antennas relative to the horizon, and consequently lower power density levels around the base of the tower. Please refer to Attachment C for the vertical patterns of Verizon Wireless' proposed microwave (MW) antenna and existing panel antennas. The calculated results shown in Table 1 include a nominal 10 dB off-beam pattern loss to account for the lower relative gain below the antenna.

Carrier	Antenna Height (Feet)	Operating Frequency (MHz)	Number of Trans.	ERP Per Transmitter (Watts)	Power Density (mW/cm^2)	Limit	%MPE
Verizon LTE	150	698	1	1050	0.0017	0.4653	0.36%
Verizon Cellular	150	869	9	249	0.0036	0.5793	0.62%
Verizon PCS	150	1970	11	238	0.0042	1.0000	0.42%
Verizon AWS	150	2145	1	1750	0.0028	1.0000	0.28%
Verizon MW	**150**	**5800**	**1**	**47.14**	**0.0001**	**1.0000**	**0.01%**
						Total	**1.68%**

Table 1: Carrier Information[1] [2]

[1] Power density calculations for Verizon's existing configuration are based on the CSC database dated 9/5/2014. Antennas heights are based on the Centek Engineering, Inc Structural Analysis dated 11/20/2014.

[2] Please note that %MPE values listed are rounded to two decimal points. The total %MPE listed is a summation of each unrounded contribution. Therefore, summing each rounded value may not reflect the total value listed in the table.

5. Conclusion

The above analysis verifies that emissions from the final site configuration will be well below the maximum power density levels as outlined by the FCC in the OET Bulletin 65 Ed. 97-01. The highest expected percent of Maximum Permissible Exposure at the base of the tower is **1.68% of the FCC Uncontrolled/General Population limit.**

6. Statement of Certification

I certify to the best of my knowledge that the statements in this report are true and accurate. The calculations follow guidelines set forth in ANSI/IEEE Std. C95.3, ANSI/IEE Std. C95.1 and FCC OET Bulletin 65 Edition 97-01.

Daniel L. Goulet
C Squared Systems, LLC

November 21, 2014
Date

Attachment A: References

OET Bulletin 65 - Edition 97-01 - August 1997 Federal Communications Commission Office of Engineering & Technology

ANSI C95.1-1982, American National Standard Safety Levels With Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz to 100 GHz IEEE-SA Standards Board

IEEE Std C95.3-1991 (Reaff 1997), IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave IEEE-SA Standards Board

Attachment B: FCC Limits for Maximum Permissible Exposure (MPE)

(A) Limits for Occupational/Controlled Exposure[3]

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (E) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	($900/f^2$)*	6
30-300	61.4	0.163	1.0	6
300-1500	-	-	f/300	6
1500-100,000	-	-	5	6

(B) Limits for General Population/Uncontrolled Exposure[4]

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (E) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	($180/f^2$)*	30
30-300	27.5	0.073	0.2	30
300-1500	-	-	f/1500	30
1500-100,000	-	-	1.0	30

f = frequency in MHz * Plane-wave equivalent power density

Table 2: FCC Limits for Maximum Permissible Exposure (MPE)

[3] Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

[4] General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

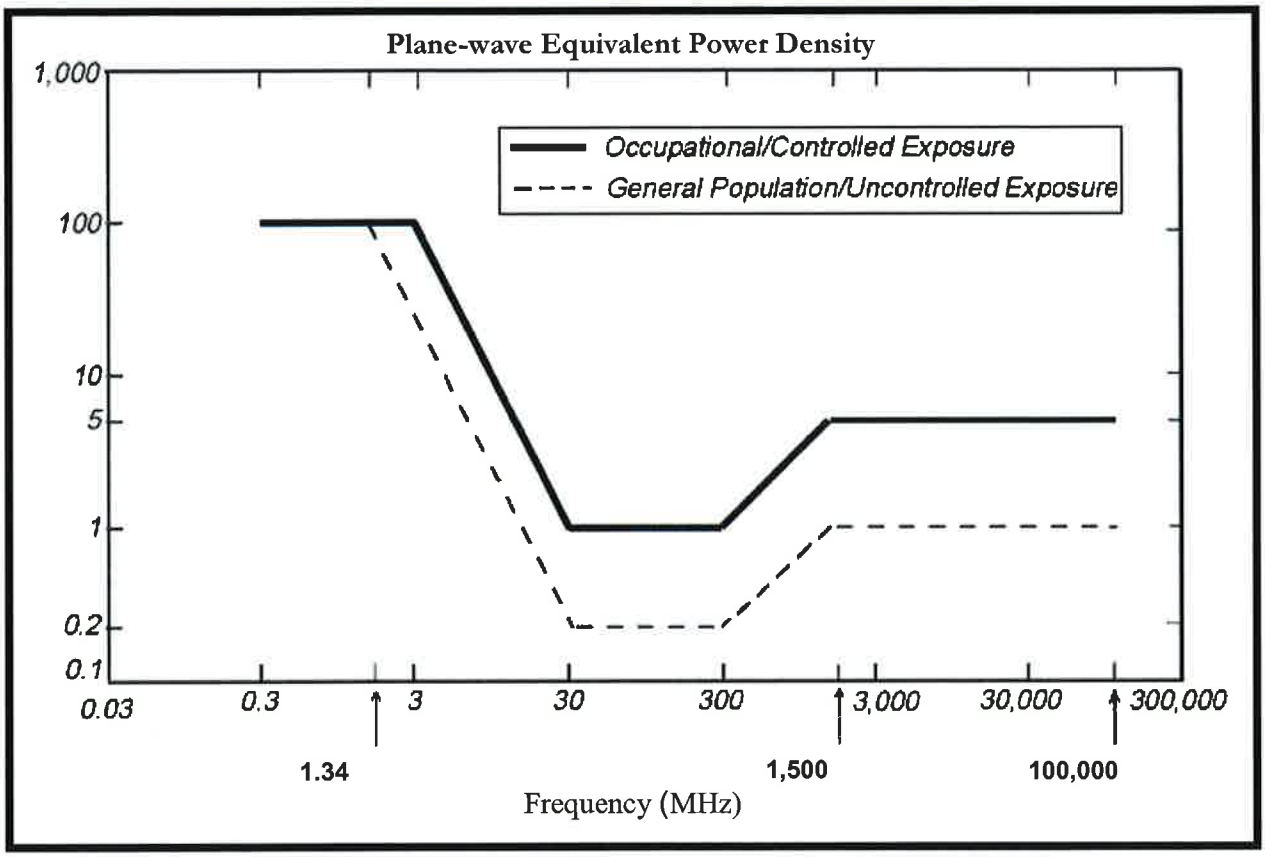
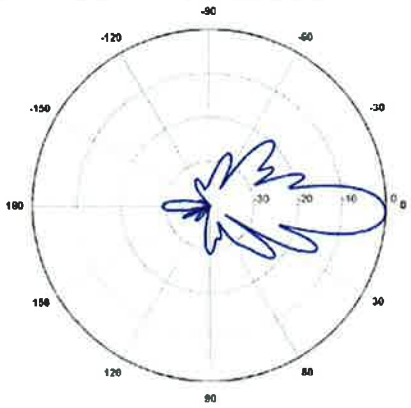


Figure 1: Graph of FCC Limits for Maximum Permissible Exposure (MPE)

Attachment C: Verizon Wireless' Antenna Model Data Sheets and Electrical Patterns

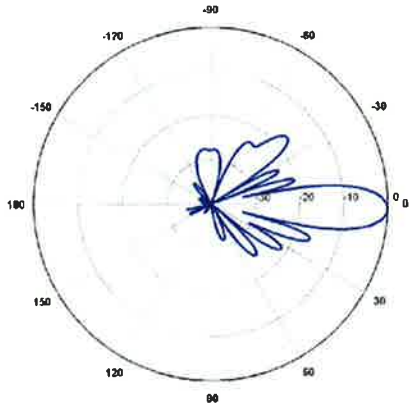
750 MHz

Manufacturer:	Amphenol
Model #:	BXA-70063-6CF
Frequency Band:	696-806 MHz
Gain:	14.0 dBd
Vertical Beamwidth:	13°
Horizontal Beamwidth:	65°
Polarization:	±45
Size L x W x D:	71.0" x 11.2" x 5.2"



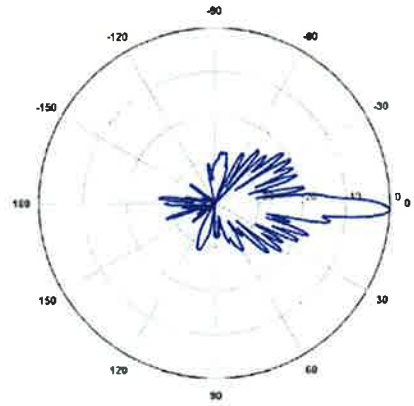
850 MHz

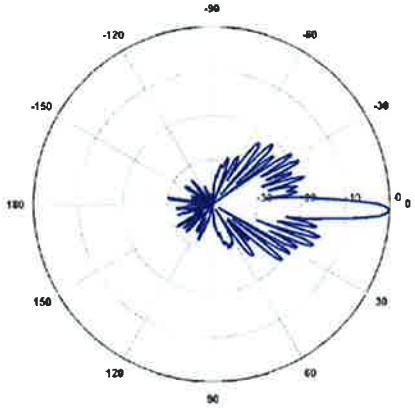
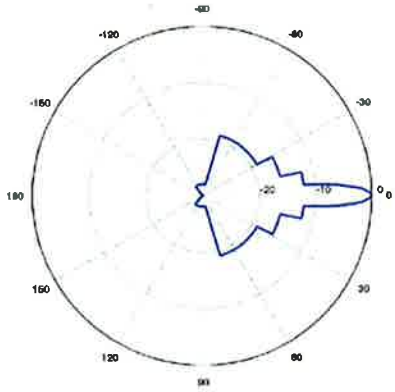
Manufacturer:	Amphenol
Model #:	BXA-70063-6CF
Frequency Band:	806-900 MHz
Gain:	14.5 dBd
Vertical Beamwidth:	11°
Horizontal Beamwidth:	63°
Polarization:	±45
Size L x W x D:	71.0" x 11.2" x 5.2"



1900 MHz

Manufacturer:	Amphenol
Model #:	BXA-171063-12CF
Frequency Band:	1850-1990 MHz
Gain:	16.5 dBd
Vertical Beamwidth:	4.5°
Horizontal Beamwidth:	65°
Polarization:	±45
Size L x W x D:	72.4" x 6.1" x 4.1"



2100 MHz Manufacturer: Amphenol Model #: BXA-171063-12CF Frequency Band: 1920-2170 MHz Gain: 16.9 dBd Vertical Beamwidth: 4.5° Horizontal Beamwidth: 60° Polarization: ±45 Size L x W x D: 72.4" x 6.1" x 4.1"	
5800 MHz Manufacturer: RFS Model #: MA0528-28AN Frequency Band: 5725-5875 MHz Gain: 25.85 dBd Vertical Beamwidth: 4.5° Horizontal Beamwidth: 4.5° Polarization: Single Size L x W x D: 23.6" x 23.6" x 1.4"	

C Squared Systems, LLC
65 Dartmouth Drive
Auburn, NH 03032
(603) 644-2800
support@csquaredsystems.com

Calculated Radio Frequency Emissions

Voluntown CT

422 Rockville Road, Voluntown, CT 06384

November 21, 2014

Table of Contents

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4. Calculation Results 3
5. Conclusion 4
6. Statement of Certification 4
Attachment A: References 5
Attachment B: FCC Limits for Maximum Permissible Exposure (MPE) 6
Attachment C: Verizon Wireless' Antenna Model Data Sheets and Electrical Patterns 8

List of Tables

Table 1: Carrier Information 3
Table 2: FCC Limits for Maximum Permissible Exposure (MPE) 6

List of Figures

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1. Introduction

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Verizon Wireless is proposing the following modifications:

1) Install one Microwave panel antenna.

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In 1985, the FCC established rules to regulate radio frequency (RF) exposure from FCC licensed antenna facilities. In 1996, the FCC updated these rules, which were further amended in August 1997 by OET Bulletin 65 Edition 97-01. These new rules include Maximum Permissible Exposure (MPE) limits for transmitters operating between 300 kHz and 100 GHz. The FCC MPE limits are based upon those recommended by the National Council on Radiation Protection and Measurements (NCRP), developed by the Institute of Electrical and Electronics Engineers, Inc., (IEEE) and adopted by the American National Standards Institute (ANSI).

The FCC general population/uncontrolled limits set the maximum exposure to which most people may be subjected. General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

Public exposure to radio frequencies is regulated and enforced in units of milliwatts per square centimeter (mW/cm^2). The general population exposure limits for the various frequency ranges are defined in the attached "FCC Limits for Maximum Permissible Exposure (MPE)" in Attachment B of this report.

Higher exposure limits are permitted under the occupational/controlled exposure category, but only for persons who are exposed as a consequence of their employment and who have been made fully aware of the potential for exposure, and they must be able to exercise control over their exposure. General population/uncontrolled limits are five times more stringent than the levels that are acceptable for occupational, or radio frequency trained individuals. Attachment B contains excerpts from OET Bulletin 65 and defines the Maximum Exposure Limit.

Finally, it should be noted that the MPE limits adopted by the FCC for both general population/uncontrolled exposure and for occupational/controlled exposure incorporate a substantial margin of safety and have been established to be well below levels generally accepted as having the potential to cause adverse health effects.

3. RF Exposure Prediction Methods

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$$\text{Power Density} = \left(\frac{1.6^2 \times EIRP}{4\pi \times R^2} \right) \times OffBeamLoss$$

Where:

EIRP = Effective Isotropic Radiated Power

R = Radial Distance = $\sqrt{(H^2 + V^2)}$

H = Horizontal Distance from antenna in meters

V = Vertical Distance from radiation center of antenna in meters

Ground reflection factor of 1.6

Off Beam Loss is determined by the selected antenna patterns

These calculations assume that the antennas are operating at 100 percent capacity, that all antenna channels are transmitting simultaneously, and that the radio transmitters are operating at full power. As a result, the predicted signal levels reported below are much higher than the actual signal levels will be from the final site configuration.

4. Calculation Results

Table 1 below outlines the power density information for the site. Due to the directional nature of Verizon Wireless' existing panel antennas and proposed microwave antenna, the majority of the RF power will be focused out towards the horizon. As a result, there will be less RF power directed below the antennas relative to the horizon, and consequently lower power density levels around the base of the tower. Please refer to Attachment C for the vertical patterns of Verizon Wireless' proposed microwave (MW) antenna and existing panel antennas. The calculated results shown in Table 1 include a nominal 10 dB off-beam pattern loss to account for the lower relative gain below the antenna.

Carrier	Antenna Height (Feet)	Operating Frequency (MHz)	Number of Trans.	ERP Per Transmitter (Watts)	Power Density (mw/cm^2)	Limit	%MPE
Verizon LTE	160	698	1	810	0.0011	0.4653	0.24%
Verizon Cellular	160	869	9	246	0.0031	0.5793	0.54%
Verizon PCS	160	1970	11	233	0.0036	1.0000	0.36%
Verizon AWS	160	2145	1	1750	0.0025	1.0000	0.25%
Verizon MW	**160**	**5800**	**1**	**47.14**	**0.0001**	**1.0000**	**0.01%**
Unknown	**160**	**40**	**1**	**110**	**0.0015**	**0.2000**	**0.77%**
Unknown	**160**	**460**	**1**	**100**	**0.0014**	**0.3067**	**0.46%**
						Total	**2.62%**

Table 1: Carrier Information[1 2 3]

[1] Power density calculations for Verizon's existing configuration comes from the CSC database dated 9/5/2014. Antennas heights are based on the Centek Engineering, Inc Structural Analysis dated 11/20/2014.

[2] Please note that %MPE values listed are rounded to two decimal points. The total %MPE listed is a summation of each unrounded contribution. Therefore, summing each rounded value may not reflect the total value listed in the table.

[3] The unknown carriers are not included in the current CSC database, but have been added for completeness based upon information listed in the Structural Analysis provided by Verizon Wireless. Power assumptions are based upon conservative values associated with typical FCC licenses in each band. Calculations for these antennas do not include 10 dB off-beam pattern loss factor.

5. Conclusion

The above analysis verifies that emissions from the final site configuration will be below the maximum power density levels as outlined by the FCC in the OET Bulletin 65 Ed. 97-01. The highest expected percent of Maximum Permissible Exposure at the base of the tower is **2.62% of the FCC Uncontrolled/General Population limit.**

6. Statement of Certification

I certify to the best of my knowledge that the statements in this report are true and accurate. The calculations follow guidelines set forth in ANSI/IEEE Std. C95.3, ANSI/IEE Std. C95.1 and FCC OET Bulletin 65 Edition 97-01.

Daniel L. Goulet
C Squared Systems, LLC

November 21, 2014
Date

Attachment A: References

OET Bulletin 65 - Edition 97-01 - August 1997 Federal Communications Commission Office of Engineering & Technology

ANSI C95.1-1982, American National Standard Safety Levels With Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz to 100 GHz IEEE-SA Standards Board

IEEE Std C95.3-1991 (Reaff 1997), IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave IEEE-SA Standards Board

Attachment B: FCC Limits for Maximum Permissible Exposure (MPE)

(A) Limits for Occupational/Controlled Exposure[4]

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (E) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	($900/f^2$)*	6
30-300	61.4	0.163	1.0	6
300-1500	-	-	f/300	6
1500-100,000	-	-	5	6

(B) Limits for General Population/Uncontrolled Exposure[5]

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (E) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	($180/f^2$)*	30
30-300	27.5	0.073	0.2	30
300-1500	-	-	f/1500	30
1500-100,000	-	-	1.0	30

f = frequency in MHz * Plane-wave equivalent power density

Table 2: FCC Limits for Maximum Permissible Exposure (MPE)

[4] Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

[5] General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

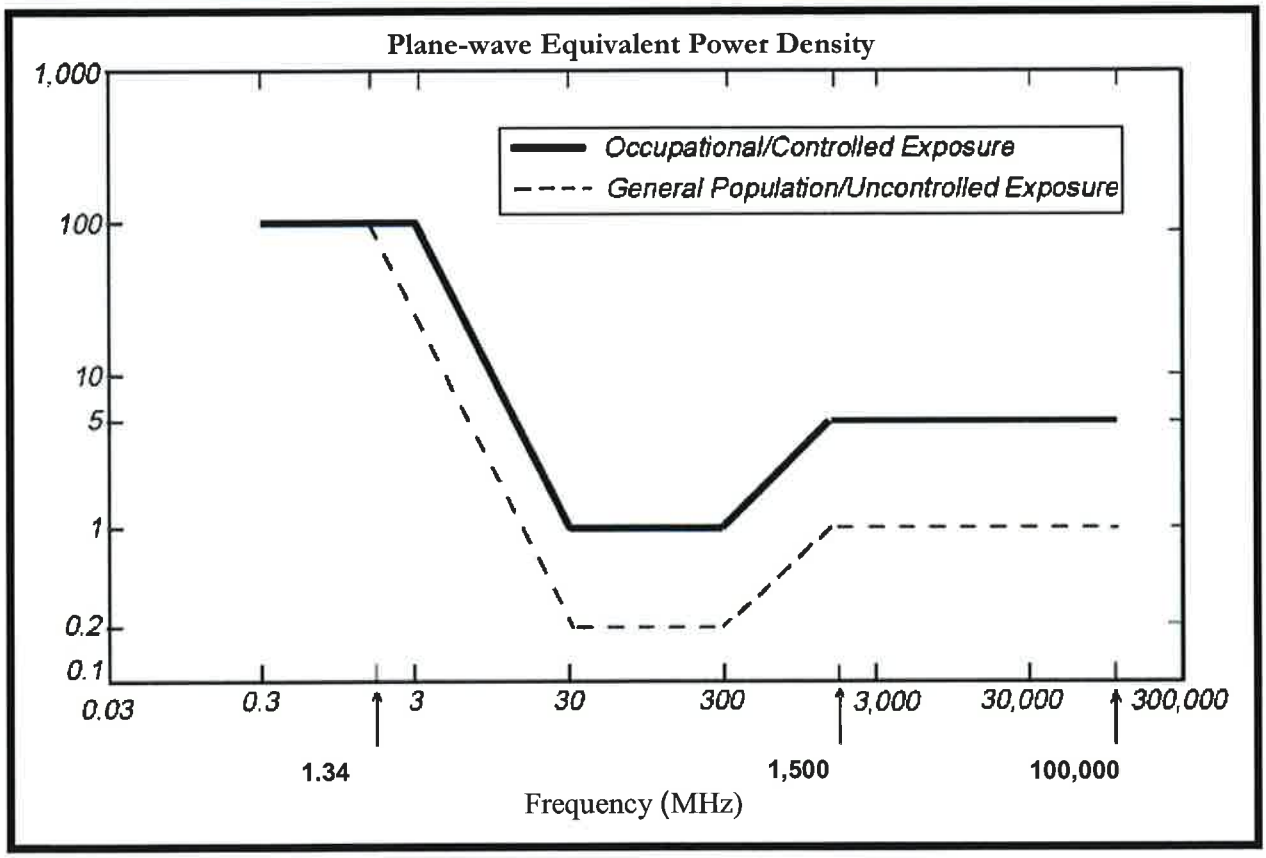
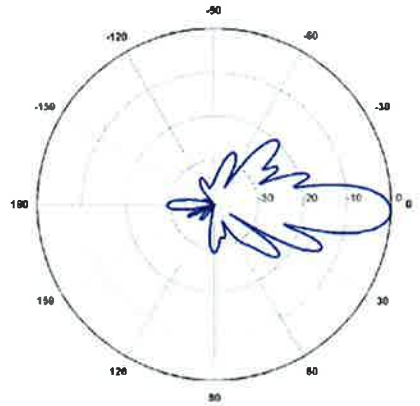


Figure 1: Graph of FCC Limits for Maximum Permissible Exposure (MPE)

Attachment C: Verizon Wireless' Antenna Model Data Sheets and Electrical Patterns

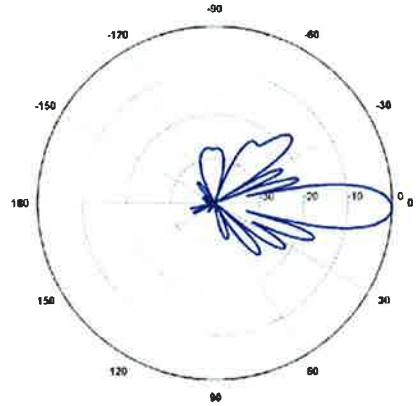
750 MHz

Manufacturer:	Amphenol
Model #:	BXA-70063-6CF
Frequency Band:	696-806 MHz
Gain:	14.0 dBd
Vertical Beamwidth:	13°
Horizontal Beamwidth:	65°
Polarization:	±45
Size L x W x D:	71.0" x 11.2" x 5.2"



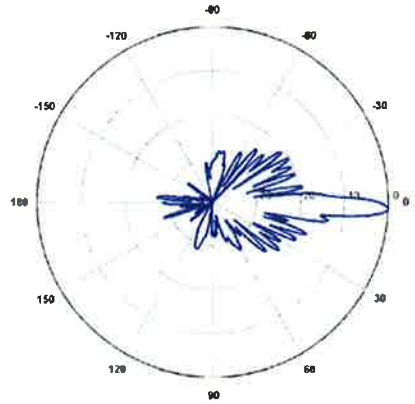
850 MHz

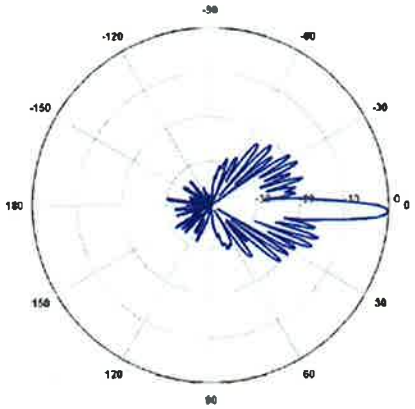
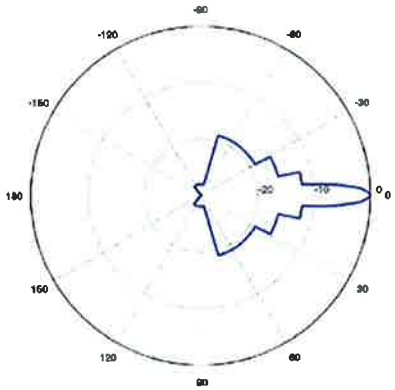
Manufacturer:	Amphenol
Model #:	BXA-70063-6CF
Frequency Band:	806-900 MHz
Gain:	14.5 dBd
Vertical Beamwidth:	11°
Horizontal Beamwidth:	63°
Polarization:	±45
Size L x W x D:	71.0" x 11.2" x 5.2"



1900 MHz

Manufacturer:	Amphenol
Model #:	BXA-171063-12CF
Frequency Band:	1850-1990 MHz
Gain:	16.5 dBd
Vertical Beamwidth:	4.5°
Horizontal Beamwidth:	65°
Polarization:	±45
Size L x W x D:	72.4" x 6.1" x 4.1"



2100 MHz Manufacturer: Amphenol Model #: BXA-171063-12CF Frequency Band: 1920-2170 MHz Gain: 16.9 dBd Vertical Beamwidth: 4.5° Horizontal Beamwidth: 60° Polarization: ±45 Size L x W x D: 72.4" x 6.1" x 4.1"	
5800 MHz Manufacturer: RFS Model #: MA0528-28AN Frequency Band: 5725-5875 MHz Gain: 25.85 dBd Vertical Beamwidth: 4.5° Horizontal Beamwidth: 4.5° Polarization: Single Size L x W x D: 23.6" x 23.6" x 1.4"	

ATTACHMENT 3

CENTEK engineering

Centered on Solutions℠

Structural Analysis Report

150-ft Existing EEI Monopole

Proposed Verizon Wireless
Antenna Upgrade

Verizon Site Ref: Palmer Pond

53 Gallup Road
Voluntown, CT

CENTEK Project No. 14325.001

Date: November 20, 2014

STATE OF CONNECTICUT
TIMOTHY J. LAND
No. 28038
LICENSED
PROFESSIONAL ENGINEER

Prepared for:

Verizon Wireless
99 East River Road, 9th Floor
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63-2 North Branford Road, Branford, CT 06405 203.488.0580 Fax 203.488.8587 www.CentekEng.com

Table of Contents

SECTION 1 - REPORT

- INTRODUCTION
- ANTENNA AND APPURTENANCE SUMMARY
- PRIMARY ASSUMPTIONS USED IN THE ANALYSIS
- ANALYSIS
- TOWER LOADING
- TOWER CAPACITY
- FOUNDATION AND ANCHORS
- CONCLUSION

SECTION 2 – CONDITIONS & SOFTWARE

- STANDARD ENGINEERING CONDITIONS
- GENERAL DESCRIPTION OF STRUCTURAL ANALYSIS PROGRAM

SECTION 3 – CALCULATIONS

- tnxTower INPUT/OUTPUT SUMMARY
- tnxTower DETAILED OUTPUT
- ANCHOR BOLT AND BASE PLATE ANALYSIS
- FOUNDATION ANALYSIS

SECTION 4 – REFERENCE MATERIAL

- EQUIPMENT CUT SHEETS

Introduction

The purpose of this report is to summarize the results of the non-linear, P-Δ structural analysis of the antenna upgrade proposed by Verizon Wireless on the existing monopole (tower) located in Voluntown, CT.

The host tower is a 150-ft tall, three-section, eighteen sided, tapered monopole, originally designed and manufactured by Engineered Endeavors Incorporated (EEI job no; 17125), dated March 27, 2014. The tower geometry, structure member sizes and foundation system information were obtained from a the aforementioned EEI design documents.

Antenna and appurtenance information were obtained from visual verification conducted from grade by Centek personnel on September 16, 2014 and a Verizon RF.

The tower is made up of three (3) tapered vertical sections consisting of A572-65 pole sections. The tower sections are slip joint connected. The diameter of the pole (flat-flat) is 29.5-in at the top and 67.0-in at the base.

Verizon Wireless proposes the installation of one (1) MW panel mounted on the existing low profile platform. Refer to the Antenna and Appurtenance Summary below for a detailed description of the proposed antenna and appurtenance configuration.

Antenna and Appurtenance Summary

The existing, proposed and future loads considered in this analysis consist of the following:

- VERIZON (EXISTING TO REMAIN):
  Antennas: Six (6) Antel BXA-171063-12CF panel antennas, three (3) Antel BXA-80063-6CF panel antennas, three (3) Antel BXA-70063-6CF panel antennas, three (3) Alcatel-Lucent RRH-2x40-07U remote radio heads and two (2) Raycap RC2DC-4750-PF-48 main distribution boxes mounted on a square low profile platform with a RAD center elevation of 150-ft above existing grade.
  Coax Cables: Two (2) 1-5/8" ∅ fiber cables running on the interior of the existing tower.
- VERIZON (RESERVED):
  Antennas: Three (3) Alcatel-Lucent RRH-2x40-AWS remote radio heads mounted on a square low profile platform with a RAD center elevation of 150-ft above existing grade.
- **VERIZON (PROPOSED):**
  Antennas: One (1) RFS MA0528-28AN MW panel mounted on the existing square low profile platform with a RAD center elevation of 150-ft above existing grade.
  Coax Cables: One (1) RFS EP65 cable running on the interior of the existing tower.

Primary Assumptions Used in the Analysis

- The tower structure's theoretical capacity not including any assessment of the condition of the tower.
- The tower carries the horizontal and vertical loads due to the weight of antennas, ice load and wind.
- Tower is properly installed and maintained.
- Tower is in plumb condition.
- Tower loading for antennas and mounts as listed in this report.
- All bolts are appropriately tightened providing the necessary connection continuity.
- All welds are fabricated with ER-70S-6 electrodes.
- All members are assumed to be as specified in the original tower design documents or reinforcement drawings.
- All members are "hot dipped" galvanized in accordance with ASTM A123 and ASTM A153 Standards.
- All member protective coatings are in good condition.
- All tower members were properly designed, detailed, fabricated, installed and have been properly maintained since erection.
- Any deviation from the analyzed antenna loading will require a new analysis for verification of structural adequacy.
- All existing coax cables to be installed as indicated in this report.

Analysis

The existing tower was analyzed using a comprehensive computer program entitled tnxTower. The program analyzes the tower, considering the worst case loading condition. The tower is considered as loaded by concentric forces along the tower shaft, and the model assumes that the shaft members are subjected to bending, axial, and shear forces.

The existing tower was analyzed for the controlling basic wind speed (fastest mile) with no ice and a 75% reduction of wind force with ½ inch accumulative ice to determine stresses in members as per guidelines of TIA/EIA-222-F-96 entitled "Structural Standards for Steel Antenna Towers and Antenna Supporting Structures", the American Institute of Steel Construction (AISC) and the Manual of Steel Construction; Allowable Stress Design (ASD).

The controlling wind speed is determined by evaluating the local available wind speed data as provided in Appendix K of the CSBC[1] and the wind speed data available in the TIA/EIA-222-F-96 Standard. The higher of the two wind speeds is utilized in preparation on the tower analysis.

Tower Loading

Tower loading was determined by the basic wind speed as applied to projected surface areas with modification factors per TIA/EIA-222-F, gravity loads of the tower structure and its components, and the application of ½" radial ice on the tower structure and its components.

Basic Wind Speed:	New London; v = 85 mph (fastest mile)	*[Section 16 of TIA/EIA-222-F-96]*
	Voluntown; v = 110 mph (3 second gust) equivalent to v = 90 mph (fastest mile)	*[Appendix K of the 2005 CT Building Code Supplement]*
	Appendix-K wind speed controls.	
Load Cases:	Load Case 1; 90 mph wind speed w/ no ice plus gravity load – used in calculation of tower stresses and rotation.	*[Section 2.3.16 of TIA/EIA-222-F-96]*
	Load Case 2; 78 mph wind speed w/ ½" radial ice plus gravity load – used in calculation of tower stresses. The 78 mph wind speed velocity represents 75% of the wind pressure generated by the 90 mph wind speed.	*[Section 2.3.16 of TIA/EIA-222-F-96]*
	Load Case 3; Seismic – not checked	*[Section 1614.5 of State Bldg. Code 2005] does not control in the design of this structure type*

[1] The 2005 Connecticut State Building Code as amended by the 2009 CT State Supplement. (CSBC)

Tower Capacity

Tower stresses were calculated utilizing the structural analysis software tnxTower. Allowable stresses were determined based on Table 5 of the TIA/EIA code with a 1/3 increase per Section 3.1.1.1 of the same code.

- Calculated stresses were found to be within allowable limits. In Load Case 1, per tnxTower "Section Capacity Table", this tower was found to be at **29.2%** of its total capacity.

Tower Section	Elevation	Stress Ratio (percentage of capacity)	Result
Pole Shaft (L1)	95.99'-152.00'	18.7%	**PASS**
Pole Shaft (L2)	47.25'-95.99'	25.8%	**PASS**
Pole Shaft (L3)	1.00'-47.25'	29.2%	**PASS**

Foundation and Anchors

The existing foundation consists of a 8.0-ft Ø x 4.0-ft long reinforced concrete pier on a 31.0-ft square x 4.0-ft thick reinforce concrete pad. The sub-grade conditions used in the analysis of the existing foundation were obtained from the geotechnical report prepared by Design Earth Technology; job no. 2013.13 dated November 29, 2013. The base of the tower is connected to the foundation by means of (28) 2.25"Ø, ASTM A615-75 anchor bolts embedded approximately 5-ft into the concrete foundation structure.

- The tower base reactions developed from the governing Load Case 1 were used in the verification of the foundation and its anchors:

Location	Vector	Proposed Reactions
Base	Shear	23 kips
	Compression	42 kips
	Moment	2134 kip-ft

- The foundation was found to be within allowable limits.

Foundation	Design Limit	IBC 2003/2005 CT State Building Code Section 3108.4.2 (FS)(1)	Proposed Loading (FS)(1)	Result
Reinforced Concrete Pad and Pier	OTM(2)	2.0	7.64	**PASS**

Note 1: FS denotes Factor of Safety.
Note 2: OTM denotes Overturning Moment

- The anchor bolts and base plate were found to be within allowable limits.

Tower Component	Design Limit	Stress Ratio (percentage of capacity)	Result
Anchor Bolts	Combined Compression and Bending	25.8%	**PASS**
Base Plate	Bending	19.4%	**PASS**

Conclusion

This analysis shows that the subject tower **is adequate** to support the proposed modified antenna configuration.

The analysis is based, in part, on the information provided to this office by Verizon Wireless. If the existing conditions are different than the information in this report, Centek Engineering, Inc. must be contacted for resolution of any potential issues.

Please feel free to call with any questions or comments.

Respectfully Submitted by:

Timothy J. Lynn, PE
Structural Engineer

STATE OF CONNECTICUT
TIMOTHY J. LYNN
No. 29136
LICENSED
PROFESSIONAL ENGINEER

Standard Conditions for Furnishing of Professional Engineering Services on Existing Structures

All engineering services are performed on the basis that the information used is current and correct. This information may consist of, but is not necessarily limited to:

- Information supplied by the client regarding the structure itself, its foundations, the soil conditions, the antenna and feed line loading on the structure and its components, or other relevant information.
- Information from the field and/or drawings in the possession of CENTEK engineering, Inc. or generated by field inspections or measurements of the structure.
- It is the responsibility of the client to ensure that the information provide to CENTEK engineering, Inc. and used in the performance of our engineering services is correct and complete. In the absence of information to the contrary, we assume that all structures were constructed in accordance with the drawings and specifications and are in an un-corroded condition and have not deteriorated. It is therefore assumed that its capacity has not significantly changed from the "as new" condition.
- All services will be performed to the codes specified by the client, and we do not imply to meet any other codes or requirements unless explicitly agreed in writing. If wind and ice loads or other relevant parameters are to be different from the minimum values recommended by the codes, the client shall specify the exact requirement. In the absence of information to the contrary, all work will be performed in accordance with the latest revision of ANSI/ASCE10 & ANSI/EIA-222
- All services performed, results obtained, and recommendations made are in accordance with generally accepted engineering principles and practices. CENTEK engineering, Inc. is not responsible for the conclusions, opinions and recommendations made by others based on the information we supply.

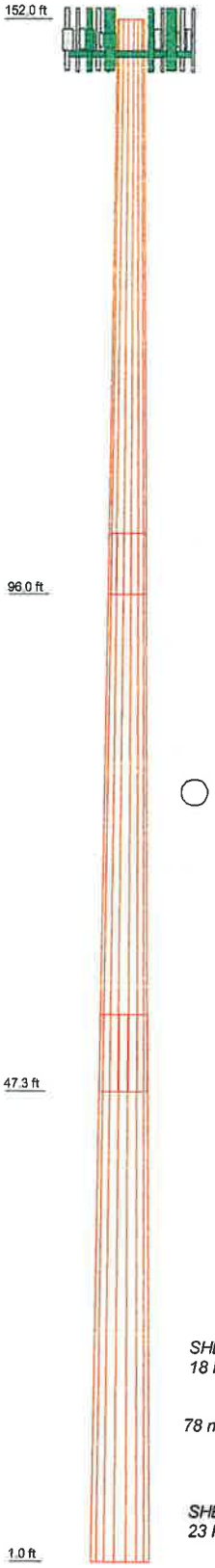
General Description of Structural Analysis Program

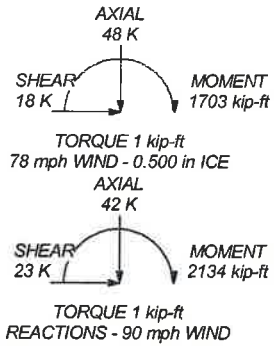
tnxTower, is an integrated structural analysis and design software package for Designed specifically for the telecommunications industry, tnxTower, formerly ERITower, automates much of the tower analysis and design required by the TIA/EIA 222 Standard.

tnxTower Features:

- tnxTower can analyze and design 3- and 4-sided guyed towers, 3- and 4-sided self-supporting towers and either round or tapered ground mounted poles with or without guys.
- The program analyzes towers using the TIA-222-G (2005) standard or any of the previous TIA/EIA standards back to RS-222 (1959). Steel design is checked using the AISC ASD 9th Edition or the AISC LRFD specifications.
- Linear and non-linear (P-delta) analyses can be used in determining displacements and forces in the structure. Wind pressures and forces are automatically calculated.
- Extensive graphics plots include material take-off, shear-moment, leg compression, displacement, twist, feed line, guy anchor and stress plots.
- tnxTower contains unique features such as True Cable behavior, hog rod take-up, foundation stiffness and much more.

Section	Length (ft)	Number of Sides	Thickness (in)	Socket Length (ft)	Top Dia (in)	Bot Dia (in)	Grade	Weight (K)
1	56.010	18	0.375	6.020	29.500	44.120		8.3
2	54.760	18	0.438	7.490	41.799	55.940	A572-65	12.5
3	53.740	18	0.500		53.131	67.000		17.3
								38.1





DESIGNED APPURTENANCE LOADING

TYPE	ELEVATION	TYPE	ELEVATION
BXA-80063-6CF (Verizon - Existing)	150	RRH2x40-07-U (Verizon - Existing)	150
BXA-171063-12CF (Verizon - Existing)	150	RRH2x40-07-U (Verizon - Existing)	150
BXA-70063/6CF (Verizon - Existing)	150	RRH2x40-AWS (Verizon - Reserved)	150
BXA-171063-12CF (Verizon - Existing)	150	RRH2x40-AWS (Verizon - Reserved)	150
BXA-80063-6CF (Verizon - Existing)	150	RRH2x40-AWS (Verizon - Reserved)	150
BXA-171063-12CF (Verizon - Existing)	150	RC2DC-4750-PF-48 (Verizon - Existing)	150
BXA-70063/6CF (Verizon - Existing)	150		
BXA-171063-12CF (Verizon - Existing)	150	RC2DC-4750-PF-48 (Verizon - Existing)	150
BXA-80063-6CF (Verizon - Existing)	150		
BXA-171063-12CF (Verizon - Existing)	150	MA0528-28AN (Verizon - Proposed)	150
BXA-70063/6CF (Verizon - Existing)	150	EEI SQ Low Profile Platform (Verizon - Existing)	149
BXA-171063-12CF (Verizon - Existing)	150		
RRH2x40-07-U (Verizon - Existing)	150		

MATERIAL STRENGTH

GRADE	Fy	Fu	GRADE	Fy	Fu
A572-65	65 ksi	80 ksi			

TOWER DESIGN NOTES

1. Tower designed for a 90 mph basic wind in accordance with the TIA/EIA-222-F Standard.
2. Tower is also designed for a 78 mph basic wind with 0.50 in ice.
3. Deflections are based upon a 50 mph wind.
4. Weld together tower sections have flange connections.
5. Connections use galvanized A325 bolts, nuts and locking devices. Installation per TIA/EIA-222 and AISC Specifications.
6. Tower members are "hot dipped" galvanized in accordance with ASTM A123 and ASTM A153 Standards.
7. Welds are fabricated with ER-70S-6 electrodes.
8. TOWER RATING: 29.2%

Centek Engineering Inc.
63-2 North Branford Rd.
Branford, CT 06405
Phone: (203) 488-0580
FAX: (203) 488-8587

Job: **14325.001 - Voluntown**			
Project: **150-ft EEI Monopole - 53 Gallup Rd., Voluntown, CT**			
Client: Verizon Wireless	Drawn by: TJL	App'd:	
Code: TIA/EIA-222-F	Date: 11/20/14	Scale: NTS	
Path:		Dwg No. E-1	

Tower Input Data

There is a pole section.
This tower is designed using the TIA/EIA-222-F standard.
The following design criteria apply:

Basic wind speed of 90 mph.
Nominal ice thickness of 0.500 in.
Ice density of 56 pcf.
A wind speed of 78 mph is used in combination with ice.
Temperature drop of 50 °F.
Deflections calculated using a wind speed of 50 mph.
Weld together tower sections have flange connections..
Connections use galvanized A325 bolts, nuts and locking devices. Installation per TIA/EIA-222 and AISC Specifications..
Tower members are "hot dipped" galvanized in accordance with ASTM A123 and ASTM A153 Standards..
Welds are fabricated with ER-70S-6 electrodes..
A non-linear (P-delta) analysis was used.
Pressures are calculated at each section.
Stress ratio used in pole design is 1.333.
Local bending stresses due to climbing loads, feedline supports, and appurtenance mounts are not considered.

Options

Consider Moments - Legs
Consider Moments - Horizontals
Consider Moments - Diagonals
Use Moment Magnification
√ Use Code Stress Ratios
Use Code Safety Factors - Guys
Escalate Ice
Always Use Max Kz
Use Special Wind Profile
Include Bolts In Member Capacity
Leg Bolts Are At Top Of Section
Secondary Horizontal Braces Leg
Use Diamond Inner Bracing (4 Sided)
Add IBC .6D+W Combination

Distribute Leg Loads As Uniform
Assume Legs Pinned
√ Assume Rigid Index Plate
Use Clear Spans For Wind Area
Use Clear Spans For KL/r
Retension Guys To Initial Tension
√ Bypass Mast Stability Checks
Use Azimuth Dish Coefficients
√ Project Wind Area of Appurt.
Autocalc Torque Arm Areas
SR Members Have Cut Ends
√ Sort Capacity Reports By Component
Triangulate Diamond Inner Bracing

Treat Feedline Bundles As Cylinder
Use ASCE 10 X-Brace Ly Rules
Calculate Redundant Bracing Forces
Ignore Redundant Members in FEA
SR Leg Bolts Resist Compression
All Leg Panels Have Same Allowable
Offset Girt At Foundation
Consider Feedline Torque
Include Angle Block Shear Check
Poles
√ Include Shear-Torsion Interaction
Always Use Sub-Critical Flow
Use Top Mounted Sockets

Tapered Pole Section Geometry

Section	Elevation ft	Section Length ft	Splice Length ft	Number of Sides	Top Diameter in	Bottom Diameter in	Wall Thickness in	Bend Radius in	Pole Grade
L1	152.000-95.990	56.010	6.020	18	29.500	44.120	0.375	1.500	A572-65 (65 ksi)
L2	95.990-47.250	54.760	7.490	18	41.799	55.940	0.438	1.750	A572-65 (65 ksi)
L3	47.250-1.000	53.740		18	53.131	67.000	0.500	2.000	A572-65 (65 ksi)

Tapered Pole Properties

Section	Tip Dia. in	Area in^2	I in^4	r in	C in	I/C in^3	J in^4	It/Q in^2	w in	w/t
L1	29.955	34.666	3715.125	10.339	14.986	247.906	7435.139	17.336	4.532	12.085
	44.801	52.067	12588.121	15.529	22.413	561.645	25192.805	26.039	7.105	18.947
L2	44.022	57.435	12413.654	14.683	21.234	584.620	24843.643	28.723	6.587	15.055
	56.803	77.072	29995.774	19.703	28.418	1055.538	60031.016	38.543	9.075	20.744
L3	55.913	83.525	29230.305	18.684	26.990	1082.988	58499.072	41.770	8.471	16.942
	68.034	105.536	58962.965	23.608	34.036	1732.371	118003.515	52.778	10.912	21.824

Tower Elevation ft	Gusset Area (per face) ft^2	Gusset Thickness in	Gusset Grade	Adjust. Factor A_f	Adjust. Factor A_r	Weight Mult.	Double Angle Stitch Bolt Spacing Diagonals in	Double Angle Stitch Bolt Spacing Horizontals in
L1 152.000-95.990				1	1	1		
L2 95.990-47.250				1	1	1		
L3 47.250-1.000				1	1	1		

Feed Line/Linear Appurtenances - Entered As Area

Description	Face or Leg	Allow Shield	Component Type	Placement ft	Total Number		C_AA_A ft^2/ft	Weight klf
HYBRIFLEX 1-5/8" (Verizon - Existing)	C	No	Inside Pole	152.000 - 4.000	2	No Ice	0.000	0.002
						1/2" Ice	0.000	0.002
EP65 (ELLIPTICAL AIR) (Verizon - Proposed)	C	No	Inside Pole	152.000 - 4.000	1	No Ice	0.000	0.001
						1/2" Ice	0.000	0.001

Feed Line/Linear Appurtenances Section Areas

Tower Section	Tower Elevation ft	Face	A_R ft^2	A_F ft^2	C_AA_A In Face ft^2	C_AA_A Out Face ft^2	Weight K
L1	152.000-95.990	A	0.000	0.000	0.000	0.000	0.000
		B	0.000	0.000	0.000	0.000	0.000
		C	0.000	0.000	0.000	0.000	0.250
L2	95.990-47.250	A	0.000	0.000	0.000	0.000	0.000
		B	0.000	0.000	0.000	0.000	0.000
		C	0.000	0.000	0.000	0.000	0.218
L3	47.250-1.000	A	0.000	0.000	0.000	0.000	0.000
		B	0.000	0.000	0.000	0.000	0.000
		C	0.000	0.000	0.000	0.000	0.193

Feed Line/Linear Appurtenances Section Areas - With Ice

Tower Section	Tower Elevation ft	Face or Leg	Ice Thickness in	A_R ft^2	A_F ft^2	C_AA_A In Face ft^2	C_AA_A Out Face ft^2	Weight K
L1	152.000-95.990	A	0.500	0.000	0.000	0.000	0.000	0.000
		B		0.000	0.000	0.000	0.000	0.000
		C		0.000	0.000	0.000	0.000	0.250
L2	95.990-47.250	A	0.500	0.000	0.000	0.000	0.000	0.000
		B		0.000	0.000	0.000	0.000	0.000
		C		0.000	0.000	0.000	0.000	0.218
L3	47.250-1.000	A	0.500	0.000	0.000	0.000	0.000	0.000
		B		0.000	0.000	0.000	0.000	0.000
		C		0.000	0.000	0.000	0.000	0.193

Discrete Tower Loads

Description	Face or Leg	Offset Type	Offsets: Horz Lateral Vert ft ft ft	Azimuth Adjustment °	Placement ft		C_AA_A Front ft^2	C_AA_A Side ft^2	Weight K
BXA-80063-6CF	A	From Face	3.500	0.000	150.000	No Ice	7.731	4.158	0.020
(Verizon - Existing)			-4.000			1/2" Ice	8.268	4.595	0.062
			0.000						
BXA-171063-12CF	A	From Face	3.500	0.000	150.000	No Ice	4.791	3.618	0.015
(Verizon - Existing)			-2.000			1/2" Ice	5.242	4.058	0.042
			0.000						
BXA-70063/6CF	A	From Face	3.500	0.000	150.000	No Ice	7.731	4.158	0.012
(Verizon - Existing)			2.000			1/2" Ice	8.268	4.595	0.054
			0.000						
BXA-171063-12CF	A	From Face	3.500	0.000	150.000	No Ice	4.791	3.618	0.015
(Verizon - Existing)			4.000			1/2" Ice	5.242	4.058	0.042
			0.000						
BXA-80063-6CF	B	From Face	3.500	0.000	150.000	No Ice	7.731	4.158	0.020
(Verizon - Existing)			-4.000			1/2" Ice	8.268	4.595	0.062
			0.000						
BXA-171063-12CF	B	From Face	3.500	0.000	150.000	No Ice	4.791	3.618	0.015
(Verizon - Existing)			-2.000			1/2" Ice	5.242	4.058	0.042
			0.000						
BXA-70063/6CF	B	From Face	3.500	0.000	150.000	No Ice	7.731	4.158	0.012
(Verizon - Existing)			2.000			1/2" Ice	8.268	4.595	0.054
			0.000						
BXA-171063-12CF	B	From Face	3.500	0.000	150.000	No Ice	4.791	3.618	0.015
(Verizon - Existing)			4.000			1/2" Ice	5.242	4.058	0.042
			0.000						
BXA-80063-6CF	C	From Face	3.500	0.000	150.000	No Ice	7.731	4.158	0.020
(Verizon - Existing)			-4.000			1/2" Ice	8.268	4.595	0.062
			0.000						
BXA-171063-12CF	C	From Face	3.500	0.000	150.000	No Ice	4.791	3.618	0.015
(Verizon - Existing)			-2.000			1/2" Ice	5.242	4.058	0.042
			0.000						
BXA-70063/6CF	C	From Face	3.500	0.000	150.000	No Ice	7.731	4.158	0.012
(Verizon - Existing)			2.000			1/2" Ice	8.268	4.595	0.054
			0.000						
BXA-171063-12CF	C	From Face	3.500	0.000	150.000	No Ice	4.791	3.618	0.015
(Verizon - Existing)			4.000			1/2" Ice	5.242	4.058	0.042

Description	Face or Leg	Offset Type	Offsets: Horz Lateral Vert ft ft ft	Azimuth Adjustment °	Placement ft		C_AA_A Front ft^2	C_AA_A Side ft^2	Weight K
			0.000						
RRH2x40-07-U	A	From Face	3.000	0.000	150.000	No Ice	2.246	1.228	0.050
(Verizon - Existing)			2.000			1/2" Ice	2.447	1.385	0.067
			0.000						
RRH2x40-07-U	B	From Face	3.000	0.000	150.000	No Ice	2.246	1.228	0.050
(Verizon - Existing)			2.000			1/2" Ice	2.447	1.385	0.067
			0.000						
RRH2x40-07-U	C	From Face	3.000	0.000	150.000	No Ice	2.246	1.228	0.050
(Verizon - Existing)			2.000			1/2" Ice	2.447	1.385	0.067
			0.000						
RRH2x40-AWS	A	From Face	3.000	0.000	150.000	No Ice	2.522	1.589	0.044
(Verizon - Reserved)			4.000			1/2" Ice	2.753	1.795	0.061
			0.000						
RRH2x40-AWS	B	From Face	3.000	0.000	150.000	No Ice	2.522	1.589	0.044
(Verizon - Reserved)			4.000			1/2" Ice	2.753	1.795	0.061
			0.000						
RRH2x40-AWS	C	From Face	3.000	0.000	150.000	No Ice	2.522	1.589	0.044
(Verizon - Reserved)			4.000			1/2" Ice	2.753	1.795	0.061
			0.000						
RC2DC-4750-PF-48	A	From Face	3.000	0.000	150.000	No Ice	3.517	2.292	0.025
(Verizon - Existing)			-2.000			1/2" Ice	3.773	2.512	0.051
			0.000						
RC2DC-4750-PF-48	B	From Face	3.000	0.000	150.000	No Ice	3.517	2.292	0.025
(Verizon - Existing)			-2.000			1/2" Ice	3.773	2.512	0.051
			0.000						
EEI SQ Low Profile Platform	C	None		0.000	149.000	No Ice	28.000	28.000	2.300
(Verizon - Existing)						1/2" Ice	33.000	33.000	3.155
MA0528-28AN	A	From Face	3.500	0.000	150.000	No Ice	5.415	0.397	0.011
(Verizon - Proposed)			-4.000			1/2" Ice	5.725	0.543	0.033
			0.000						

Tower Pressures - No Ice

$G_H = 1.690$

Section Elevation ft	z ft	K_Z	q_z ksf	A_G ft^2	Face	A_F ft^2	A_R ft^2	A_{leg} ft^2	Leg % 	C_AA_A In Face ft^2	C_AA_A Out Face ft^2
L1	122.590	1.455	0.030	171.811	A	0.000	171.811	171.811	100.00	0.000	0.000
152.000-95.990					B	0.000	171.811		100.00	0.000	0.000
					C	0.000	171.811		100.00	0.000	0.000
L2	71.188	1.246	0.026	201.648	A	0.000	201.648	201.648	100.00	0.000	0.000
95.990-47.250					B	0.000	201.648		100.00	0.000	0.000
					C	0.000	201.648		100.00	0.000	0.000
L3	23.491	1	0.021	235.227	A	0.000	235.227	235.227	100.00	0.000	0.000
47.250-1.000					B	0.000	235.227		100.00	0.000	0.000
					C	0.000	235.227		100.00	0.000	0.000

Tower Pressure - With Ice

$G_H = 1.690$

Section Elevation ft	z ft	K_Z	q_z ksf	t_Z in	A_G ft²	Face	A_F ft²	A_R ft²	A_{leg} ft²	Leg %	C_AA_A In Face ft²	C_AA_A Out Face ft²
L1	122.590	1.455	0.023	0.500	176.478	A	0.000	176.478	176.478	100.00	0.000	0.000
152.000-95.990						B	0.000	176.478		100.00	0.000	0.000
						C	0.000	176.478		100.00	0.000	0.000
L2	71.188	1.246	0.019	0.500	205.710	A	0.000	205.710	205.710	100.00	0.000	0.000
95.990-47.250						B	0.000	205.710		100.00	0.000	0.000
						C	0.000	205.710		100.00	0.000	0.000
L3 47.250-1.000	23.491	1	0.016	0.500	239.081	A	0.000	239.081	239.081	100.00	0.000	0.000
						B	0.000	239.081		100.00	0.000	0.000
						C	0.000	239.081		100.00	0.000	0.000

Tower Pressure - Service

$G_H = 1.690$

Section Elevation ft	z ft	K_Z	q_z ksf	A_G ft²	Face	A_F ft²	A_R ft²	A_{leg} ft²	Leg %	C_AA_A In Face ft²	C_AA_A Out Face ft²
L1	122.590	1.455	0.009	171.811	A	0.000	171.811	171.811	100.00	0.000	0.000
152.000-95.99					B	0.000	171.811		100.00	0.000	0.000
0					C	0.000	171.811		100.00	0.000	0.000
L2	71.188	1.246	0.008	201.648	A	0.000	201.648	201.648	100.00	0.000	0.000
95.990-47.250					B	0.000	201.648		100.00	0.000	0.000
					C	0.000	201.648		100.00	0.000	0.000
L3	23.491	1	0.006	235.227	A	0.000	235.227	235.227	100.00	0.000	0.000
47.250-1.000					B	0.000	235.227		100.00	0.000	0.000
					C	0.000	235.227		100.00	0.000	0.000

Tower Forces - No Ice - Wind Normal To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft²	F K	w klf	Ctrl. Face
L1	0.250	8.265	A	1	0.65	1	1	1	171.811	5.681	0.101	C
152.000-95.99			B	1	0.65	1	1	1	171.811			
0			C	1	0.65	1	1	1	171.811			
L2	0.218	12.532	A	1	0.65	1	1	1	201.648	5.691	0.117	C
95.990-47.250			B	1	0.65	1	1	1	201.648			
			C	1	0.65	1	1	1	201.648			
L3	0.193	17.286	A	1	0.65	1	1	1	235.227	5.412	0.117	C
47.250-1.000			B	1	0.65	1	1	1	235.227			
			C	1	0.65	1	1	1	235.227			
Sum Weight:	0.662	38.083						OTM	1211.827 kip-ft	16.783		

Tower Forces - No Ice - Wind 45 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft²	F K	w klf	Ctrl. Face
L1	0.250	8.265	A	1	0.65	1	1	1	171.811	5.681	0.101	C
152.000-95.990			B	1	0.65	1	1	1	171.811			
			C	1	0.65	1	1	1	171.811			
L2	0.218	12.532	A	1	0.65	1	1	1	201.648	5.691	0.117	C
95.990-47.250			B	1	0.65	1	1	1	201.648			
			C	1	0.65	1	1	1	201.648			
L3	0.193	17.286	A	1	0.65	1	1	1	235.227	5.412	0.117	C
47.250-1.000			B	1	0.65	1	1	1	235.227			
			C	1	0.65	1	1	1	235.227			
Sum Weight:	0.662	38.083						OTM	1211.827 kip-ft	16.783		

Tower Forces - No Ice - Wind 60 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft²	F K	w klf	Ctrl. Face
L1	0.250	8.265	A	1	0.65	1	1	1	171.811	5.681	0.101	C
152.000-95.990			B	1	0.65	1	1	1	171.811			
			C	1	0.65	1	1	1	171.811			
L2	0.218	12.532	A	1	0.65	1	1	1	201.648	5.691	0.117	C
95.990-47.250			B	1	0.65	1	1	1	201.648			
			C	1	0.65	1	1	1	201.648			
L3	0.193	17.286	A	1	0.65	1	1	1	235.227	5.412	0.117	C
47.250-1.000			B	1	0.65	1	1	1	235.227			
			C	1	0.65	1	1	1	235.227			
Sum Weight:	0.662	38.083						OTM	1211.827 kip-ft	16.783		

Tower Forces - No Ice - Wind 90 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft²	F K	w klf	Ctrl. Face
L1	0.250	8.265	A	1	0.65	1	1	1	171.811	5.681	0.101	C
152.000-95.990			B	1	0.65	1	1	1	171.811			
			C	1	0.65	1	1	1	171.811			
L2	0.218	12.532	A	1	0.65	1	1	1	201.648	5.691	0.117	C
95.990-47.250			B	1	0.65	1	1	1	201.648			
			C	1	0.65	1	1	1	201.648			
L3	0.193	17.286	A	1	0.65	1	1	1	235.227	5.412	0.117	C
47.250-1.000			B	1	0.65	1	1	1	235.227			
			C	1	0.65	1	1	1	235.227			
Sum Weight:	0.662	38.083						OTM	1211.827	16.783		

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
									kip-ft			

Tower Forces - With Ice - Wind Normal To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L1	0.250	9.555	A	1	0.65	1	1	1	176.478	4.376	0.078	C
152.000-95.99			B	1	0.65	1	1	1	176.478			
0			C	1	0.65	1	1	1	176.478			
L2	0.218	14.040	A	1	0.65	1	1	1	205.710	4.354	0.089	C
95.990-47.250			B	1	0.65	1	1	1	205.710			
			C	1	0.65	1	1	1	205.710			
L3	0.193	19.043	A	1	0.65	1	1	1	239.081	4.125	0.089	C
47.250-1.000			B	1	0.65	1	1	1	239.081			
			C	1	0.65	1	1	1	239.081			
Sum Weight:	0.662	42.638						OTM	930.473 kip-ft	12.855		

Tower Forces - With Ice - Wind 45 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L1	0.250	9.555	A	1	0.65	1	1	1	176.478	4.376	0.078	C
152.000-95.99			B	1	0.65	1	1	1	176.478			
0			C	1	0.65	1	1	1	176.478			
L2	0.218	14.040	A	1	0.65	1	1	1	205.710	4.354	0.089	C
95.990-47.250			B	1	0.65	1	1	1	205.710			
			C	1	0.65	1	1	1	205.710			
L3	0.193	19.043	A	1	0.65	1	1	1	239.081	4.125	0.089	C
47.250-1.000			B	1	0.65	1	1	1	239.081			
			C	1	0.65	1	1	1	239.081			
Sum Weight:	0.662	42.638						OTM	930.473 kip-ft	12.855		

Tower Forces - With Ice - Wind 60 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L1	0.250	9.555	A	1	0.65	1	1	1	176.478	4.376	0.078	C
152.000-95.99			B	1	0.65	1	1	1	176.478			
0			C	1	0.65	1	1	1	176.478			

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L2	0.218	14.040	A	1	0.65	1	1	1	205.710	4.354	0.089	C
95.990-47.250			B	1	0.65	1	1	1	205.710			
			C	1	0.65	1	1	1	205.710			
L3	0.193	19.043	A	1	0.65	1	1	1	239.081	4.125	0.089	C
47.250-1.000			B	1	0.65	1	1	1	239.081			
			C	1	0.65	1	1	1	239.081			
Sum Weight:	0.662	42.638						OTM	930.473 kip-ft	12.855		

Tower Forces - With Ice - Wind 90 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L1	0.250	9.555	A	1	0.65	1	1	1	176.478	4.376	0.078	C
152.000-95.99			B	1	0.65	1	1	1	176.478			
0			C	1	0.65	1	1	1	176.478			
L2	0.218	14.040	A	1	0.65	1	1	1	205.710	4.354	0.089	C
95.990-47.250			B	1	0.65	1	1	1	205.710			
			C	1	0.65	1	1	1	205.710			
L3	0.193	19.043	A	1	0.65	1	1	1	239.081	4.125	0.089	C
47.250-1.000			B	1	0.65	1	1	1	239.081			
			C	1	0.65	1	1	1	239.081			
Sum Weight:	0.662	42.638						OTM	930.473 kip-ft	12.855		

Tower Forces - Service - Wind Normal To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L1	0.250	8.265	A	1	0.65	1	1	1	171.811	1.753	0.031	C
152.000-95.99			B	1	0.65	1	1	1	171.811			
0			C	1	0.65	1	1	1	171.811			
L2	0.218	12.532	A	1	0.65	1	1	1	201.648	1.756	0.036	C
95.990-47.250			B	1	0.65	1	1	1	201.648			
			C	1	0.65	1	1	1	201.648			
L3	0.193	17.286	A	1	0.65	1	1	1	235.227	1.670	0.036	C
47.250-1.000			B	1	0.65	1	1	1	235.227			
			C	1	0.65	1	1	1	235.227			
Sum Weight:	0.662	38.083						OTM	374.021 kip-ft	5.180		

Tower Forces - Service - Wind 45 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L1	0.250	8.265	A	1	0.65	1	1	1	171.811	1.753	0.031	C
152.000-95.99			B	1	0.65	1	1	1	171.811			
0			C	1	0.65	1	1	1	171.811			
L2	0.218	12.532	A	1	0.65	1	1	1	201.648	1.756	0.036	C
95.990-47.250			B	1	0.65	1	1	1	201.648			
			C	1	0.65	1	1	1	201.648			
L3	0.193	17.286	A	1	0.65	1	1	1	235.227	1.670	0.036	C
47.250-1.000			B	1	0.65	1	1	1	235.227			
			C	1	0.65	1	1	1	235.227			
Sum Weight:	0.662	38.083						OTM	374.021 kip-ft	5.180		

Tower Forces - Service - Wind 60 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L1	0.250	8.265	A	1	0.65	1	1	1	171.811	1.753	0.031	C
152.000-95.99			B	1	0.65	1	1	1	171.811			
0			C	1	0.65	1	1	1	171.811			
L2	0.218	12.532	A	1	0.65	1	1	1	201.648	1.756	0.036	C
95.990-47.250			B	1	0.65	1	1	1	201.648			
			C	1	0.65	1	1	1	201.648			
L3	0.193	17.286	A	1	0.65	1	1	1	235.227	1.670	0.036	C
47.250-1.000			B	1	0.65	1	1	1	235.227			
			C	1	0.65	1	1	1	235.227			
Sum Weight:	0.662	38.083						OTM	374.021 kip-ft	5.180		

Tower Forces - Service - Wind 90 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L1	0.250	8.265	A	1	0.65	1	1	1	171.811	1.753	0.031	C
152.000-95.99			B	1	0.65	1	1	1	171.811			
0			C	1	0.65	1	1	1	171.811			
L2	0.218	12.532	A	1	0.65	1	1	1	201.648	1.756	0.036	C
95.990-47.250			B	1	0.65	1	1	1	201.648			
			C	1	0.65	1	1	1	201.648			
L3	0.193	17.286	A	1	0.65	1	1	1	235.227	1.670	0.036	C
47.250-1.000			B	1	0.65	1	1	1	235.227			
			C	1	0.65	1	1	1	235.227			
Sum Weight:	0.662	38.083						OTM	374.021 kip-ft	5.180		

Force Totals

Load Case	Vertical Forces K	Sum of Forces X K	Sum of Forces Z K	Sum of Overturning Moments, M_x kip-ft	Sum of Overturning Moments, M_z kip-ft	Sum of Torques kip-ft
Leg Weight	38.083					
Bracing Weight	0.000					
Total Member Self-Weight	38.083			-0.094	0.117	
Total Weight	41.574			-0.094	0.117	
Wind 0 deg - No Ice		-0.117	-22.566	-2072.077	17.605	-1.053
Wind 30 deg - No Ice		11.282	-19.484	-1785.740	-1035.757	-0.694
Wind 45 deg - No Ice		16.016	-15.873	-1452.842	-1473.882	-0.436
Wind 60 deg - No Ice		19.659	-11.181	-1020.941	-1811.557	-0.149
Wind 90 deg - No Ice		22.767	0.117	17.393	-2101.920	0.436
Wind 120 deg - No Ice		19.776	11.385	1051.042	-1829.045	0.904
Wind 135 deg - No Ice		16.182	16.039	1477.385	-1498.614	1.053
Wind 150 deg - No Ice		11.485	19.601	1803.039	-1066.046	1.130
Wind 180 deg - No Ice		0.117	22.566	2071.889	-17.370	1.053
Wind 210 deg - No Ice		-11.282	19.484	1785.552	1035.991	0.694
Wind 225 deg - No Ice		-16.016	15.873	1452.653	1474.117	0.436
Wind 240 deg - No Ice		-19.659	11.181	1020.752	1811.791	0.149
Wind 270 deg - No Ice		-22.767	-0.117	-17.582	2102.155	-0.436
Wind 300 deg - No Ice		-19.776	-11.385	-1051.231	1829.279	-0.904
Wind 315 deg - No Ice		-16.182	-16.039	-1477.573	1498.848	-1.053
Wind 330 deg - No Ice		-11.485	-19.601	-1803.228	1066.281	-1.130
Member Ice	4.555					
Total Weight Ice	47.580			-0.182	0.303	
Wind 0 deg - Ice		-0.091	-17.696	-1650.533	13.848	-0.860
Wind 30 deg - Ice		8.847	-15.279	-1422.655	-824.768	-0.585
Wind 45 deg - Ice		12.559	-12.448	-1157.578	-1173.534	-0.383
Wind 60 deg - Ice		15.415	-8.769	-813.627	-1442.306	-0.154
Wind 90 deg - Ice		17.852	0.091	13.363	-1673.299	0.319
Wind 120 deg - Ice		15.505	8.927	836.724	-1455.851	0.706
Wind 135 deg - Ice		12.687	12.577	1176.370	-1192.690	0.833
Wind 150 deg - Ice		9.005	15.370	1435.836	-848.228	0.904
Wind 180 deg - Ice		0.091	17.696	1650.169	-13.242	0.860
Wind 210 deg - Ice		-8.847	15.279	1422.291	825.374	0.585
Wind 225 deg - Ice		-12.559	12.448	1157.214	1174.140	0.383
Wind 240 deg - Ice		-15.415	8.769	813.263	1442.912	0.154
Wind 270 deg - Ice		-17.852	-0.091	-13.727	1673.905	-0.319
Wind 300 deg - Ice		-15.505	-8.927	-837.088	1456.457	-0.706
Wind 315 deg - Ice		-12.687	-12.577	-1176.734	1193.296	-0.833
Wind 330 deg - Ice		-9.005	-15.370	-1436.200	848.834	-0.904
Total Weight	41.574			-0.094	0.117	
Wind 0 deg - Service		-0.036	-6.965	-639.595	5.515	-0.325
Wind 30 deg - Service		3.482	-6.014	-551.220	-319.597	-0.214
Wind 45 deg - Service		4.943	-4.899	-448.473	-454.821	-0.135
Wind 60 deg - Service		6.067	-3.451	-315.170	-559.041	-0.046
Wind 90 deg - Service		7.027	0.036	5.303	-648.660	0.135
Wind 120 deg - Service		6.104	3.514	324.330	-564.439	0.279
Wind 135 deg - Service		4.994	4.950	455.918	-462.454	0.325
Wind 150 deg - Service		3.545	6.050	556.428	-328.946	0.349
Wind 180 deg - Service		0.036	6.965	639.407	-5.280	0.325
Wind 210 deg - Service		-3.482	6.014	551.031	319.831	0.214
Wind 225 deg - Service		-4.943	4.899	448.285	455.055	0.135
Wind 240 deg - Service		-6.067	3.451	314.982	559.276	0.046
Wind 270 deg - Service		-7.027	-0.036	-5.492	648.894	-0.135
Wind 300 deg - Service		-6.104	-3.514	-324.519	564.673	-0.279
Wind 315 deg - Service		-4.994	-4.950	-456.106	462.688	-0.325
Wind 330 deg - Service		-3.545	-6.050	-556.617	329.180	-0.349

Load Combinations

Comb. No.	Description
1	Dead Only
2	Dead+Wind 0 deg - No Ice
3	Dead+Wind 30 deg - No Ice
4	Dead+Wind 45 deg - No Ice
5	Dead+Wind 60 deg - No Ice
6	Dead+Wind 90 deg - No Ice
7	Dead+Wind 120 deg - No Ice
8	Dead+Wind 135 deg - No Ice
9	Dead+Wind 150 deg - No Ice
10	Dead+Wind 180 deg - No Ice
11	Dead+Wind 210 deg - No Ice
12	Dead+Wind 225 deg - No Ice
13	Dead+Wind 240 deg - No Ice
14	Dead+Wind 270 deg - No Ice
15	Dead+Wind 300 deg - No Ice
16	Dead+Wind 315 deg - No Ice
17	Dead+Wind 330 deg - No Ice
18	Dead+Ice+Temp
19	Dead+Wind 0 deg+Ice+Temp
20	Dead+Wind 30 deg+Ice+Temp
21	Dead+Wind 45 deg+Ice+Temp
22	Dead+Wind 60 deg+Ice+Temp
23	Dead+Wind 90 deg+Ice+Temp
24	Dead+Wind 120 deg+Ice+Temp
25	Dead+Wind 135 deg+Ice+Temp
26	Dead+Wind 150 deg+Ice+Temp
27	Dead+Wind 180 deg+Ice+Temp
28	Dead+Wind 210 deg+Ice+Temp
29	Dead+Wind 225 deg+Ice+Temp
30	Dead+Wind 240 deg+Ice+Temp
31	Dead+Wind 270 deg+Ice+Temp
32	Dead+Wind 300 deg+Ice+Temp
33	Dead+Wind 315 deg+Ice+Temp
34	Dead+Wind 330 deg+Ice+Temp
35	Dead+Wind 0 deg - Service
36	Dead+Wind 30 deg - Service
37	Dead+Wind 45 deg - Service
38	Dead+Wind 60 deg - Service
39	Dead+Wind 90 deg - Service
40	Dead+Wind 120 deg - Service
41	Dead+Wind 135 deg - Service
42	Dead+Wind 150 deg - Service
43	Dead+Wind 180 deg - Service
44	Dead+Wind 210 deg - Service
45	Dead+Wind 225 deg - Service
46	Dead+Wind 240 deg - Service
47	Dead+Wind 270 deg - Service
48	Dead+Wind 300 deg - Service
49	Dead+Wind 315 deg - Service
50	Dead+Wind 330 deg - Service

Maximum Member Forces

Section No.	Elevation ft	Component Type	Condition	Gov. Load Comb.	Force K	Major Axis Moment kip-ft	Minor Axis Moment kip-ft
L1	152 - 95.99	Pole	Max Tension	1	0.000	0.000	0.000
			Max. Compression	18	-12.849	0.303	0.182
			Max. Mx	14	-10.076	410.975	5.800
			Max. My	2	-10.083	5.811	401.157
			Max. Vy	14	-11.152	410.975	5.800
			Max. Vx	2	-10.947	5.811	401.157
			Max. Torque	17			1.130
L2	95.99 - 47.25	Pole	Max Tension	1	0.000	0.000	0.000
			Max. Compression	18	-26.124	0.303	0.182
			Max. Mx	14	-21.976	1067.431	11.447
			Max. My	2	-21.981	11.468	1047.906
			Max. Vy	14	-16.648	1067.431	11.447
			Max. Vx	2	-16.443	11.468	1047.906
			Max. Torque	17			1.130
L3	47.25 - 1	Pole	Max Tension	1	0.000	0.000	0.000
			Max. Compression	18	-47.580	0.303	0.182
			Max. Mx	14	-41.569	2126.014	17.822
			Max. My	2	-41.569	17.845	2095.533
			Max. Vy	14	-22.777	2126.014	17.822
			Max. Vx	2	-22.575	17.845	2095.533
			Max. Torque	17			1.130

Maximum Reactions

Location	Condition	Gov. Load Comb.	Vertical K	Horizontal, X K	Horizontal, Z K
Pole	Max. Vert	32	47.580	15.505	8.927
	Max. H_x	14	41.574	22.767	0.117
	Max. H_z	2	41.574	0.117	22.566
	Max. M_x	2	2095.533	0.117	22.566
	Max. M_z	6	2125.775	-22.767	-0.117
	Max. Torsion	17	1.130	11.485	19.601
	Min. Vert	48	41.574	6.104	3.514
	Min. H_x	6	41.574	-22.767	-0.117
	Min. H_z	10	41.574	-0.117	-22.566
	Min. M_x	10	-2095.340	-0.117	-22.566
	Min. M_z	14	-2126.014	22.767	0.117
	Min. Torsion	9	-1.128	-11.485	-19.601

Tower Mast Reaction Summary

Load Combination	Vertical K	$Shear_x$ K	$Shear_z$ K	Overturning Moment, M_x kip-ft	Overturning Moment, M_z kip-ft	Torque kip-ft
Dead Only	41.574	0.000	0.000	-0.094	0.117	0.000
Dead+Wind 0 deg - No Ice	41.574	-0.117	-22.566	-2095.533	17.845	-1.053
Dead+Wind 30 deg - No Ice	41.574	11.282	-19.484	-1805.936	-1047.481	-0.693
Dead+Wind 45 deg - No Ice	41.574	16.016	-15.873	-1469.260	-1490.585	-0.435
Dead+Wind 60 deg - No Ice	41.574	19.659	-11.181	-1032.463	-1832.100	-0.148
Dead+Wind 90 deg - No Ice	41.574	22.767	0.117	17.629	-2125.775	0.436
Dead+Wind 120 deg - No Ice	41.574	19.776	11.385	1062.969	-1849.821	0.903
Dead+Wind 135 deg - No Ice	41.574	16.182	16.039	1494.130	-1515.649	1.052

Load Combination	Vertical K	$Shear_x$ K	$Shear_z$ K	Overturning Moment, M_x kip-ft	Overturning Moment, M_z kip-ft	Torque kip-ft
Dead+Wind 150 deg - No Ice	41.574	11.485	19.601	1823.464	-1078.180	1.128
Dead+Wind 180 deg - No Ice	41.574	0.117	22.566	2095.340	-17.606	1.052
Dead+Wind 210 deg - No Ice	41.574	-11.282	19.484	1805.744	1047.720	0.693
Dead+Wind 225 deg - No Ice	41.574	-16.016	15.873	1469.068	1490.825	0.436
Dead+Wind 240 deg - No Ice	41.574	-19.659	11.181	1032.270	1832.339	0.149
Dead+Wind 270 deg - No Ice	41.574	-22.767	-0.117	-17.822	2126.014	-0.435
Dead+Wind 300 deg - No Ice	41.574	-19.776	-11.385	-1063.162	1850.060	-0.904
Dead+Wind 315 deg - No Ice	41.574	-16.182	-16.039	-1494.324	1515.887	-1.053
Dead+Wind 330 deg - No Ice	41.574	-11.485	-19.601	-1823.657	1078.418	-1.130
Dead+Ice+Temp	47.580	0.000	0.000	-0.182	0.303	0.000
Dead+Wind 0 deg+Ice+Temp	47.580	-0.091	-17.696	-1673.589	14.083	-0.859
Dead+Wind 30 deg+Ice+Temp	47.580	8.847	-15.279	-1442.510	-836.284	-0.584
Dead+Wind 45 deg+Ice+Temp	47.580	12.559	-12.448	-1173.722	-1189.941	-0.382
Dead+Wind 60 deg+Ice+Temp	47.580	15.415	-8.769	-824.961	-1462.484	-0.153
Dead+Wind 90 deg+Ice+Temp	47.580	17.852	0.091	13.585	-1696.728	0.319
Dead+Wind 120 deg+Ice+Temp	47.580	15.505	8.927	848.438	-1476.253	0.706
Dead+Wind 135 deg+Ice+Temp	47.580	12.687	12.577	1192.822	-1209.415	0.833
Dead+Wind 150 deg+Ice+Temp	47.580	9.005	15.370	1455.905	-860.136	0.903
Dead+Wind 180 deg+Ice+Temp	47.580	0.091	17.696	1673.215	-13.461	0.859
Dead+Wind 210 deg+Ice+Temp	47.580	-8.847	15.279	1442.136	836.906	0.585
Dead+Wind 225 deg+Ice+Temp	47.580	-12.559	12.448	1173.349	1190.563	0.382
Dead+Wind 240 deg+Ice+Temp	47.580	-15.415	8.769	824.587	1463.106	0.154
Dead+Wind 270 deg+Ice+Temp	47.580	-17.852	-0.091	-13.959	1697.350	-0.319
Dead+Wind 300 deg+Ice+Temp	47.580	-15.505	-8.927	-848.813	1476.875	-0.706
Dead+Wind 315 deg+Ice+Temp	47.580	-12.687	-12.577	-1193.197	1210.037	-0.833
Dead+Wind 330 deg+Ice+Temp	47.580	-9.005	-15.370	-1456.280	860.758	-0.904
Dead+Wind 0 deg - Service	41.574	-0.036	-6.965	-646.872	5.591	-0.325
Dead+Wind 30 deg - Service	41.574	3.482	-6.014	-557.485	-323.231	-0.214
Dead+Wind 45 deg - Service	41.574	4.943	-4.899	-453.567	-460.000	-0.135
Dead+Wind 60 deg - Service	41.574	6.067	-3.451	-318.746	-565.412	-0.046
Dead+Wind 90 deg - Service	41.574	7.027	0.036	5.375	-656.059	0.135
Dead+Wind 120 deg - Service	41.574	6.104	3.514	328.030	-570.884	0.279
Dead+Wind 135 deg - Service	41.574	4.994	4.950	461.112	-467.738	0.325
Dead+Wind 150 deg - Service	41.574	3.545	6.050	562.764	-332.708	0.349
Dead+Wind 180 deg - Service	41.574	0.036	6.965	646.680	-5.352	0.325
Dead+Wind 210 deg - Service	41.574	-3.482	6.014	557.292	323.471	0.214
Dead+Wind 225 deg - Service	41.574	-4.943	4.899	453.375	460.240	0.135
Dead+Wind 240 deg - Service	41.574	-6.067	3.451	318.553	565.652	0.046
Dead+Wind 270 deg - Service	41.574	-7.027	-0.036	-5.568	656.299	-0.135
Dead+Wind 300 deg - Service	41.574	-6.104	-3.514	-328.223	571.123	-0.279
Dead+Wind 315 deg - Service	41.574	-4.994	-4.950	-461.305	467.977	-0.325
Dead+Wind 330 deg - Service	41.574	-3.545	-6.050	-562.956	332.948	-0.349

Solution Summary

	Sum of Applied Forces			Sum of Reactions			
Load Comb.	PX K	PY K	PZ K	PX K	PY K	PZ K	% Error
1	0.000	-41.574	0.000	0.000	41.574	0.000	0.000%
2	-0.117	-41.574	-22.566	0.117	41.574	22.566	0.000%
3	11.282	-41.574	-19.484	-11.282	41.574	19.484	0.000%
4	16.016	-41.574	-15.873	-16.016	41.574	15.873	0.000%
5	19.659	-41.574	-11.181	-19.659	41.574	11.181	0.000%
6	22.767	-41.574	0.117	-22.767	41.574	-0.117	0.000%
7	19.776	-41.574	11.385	-19.776	41.574	-11.385	0.000%
8	16.182	-41.574	16.039	-16.182	41.574	-16.039	0.000%
9	11.485	-41.574	19.601	-11.485	41.574	-19.601	0.000%
10	0.117	-41.574	22.566	-0.117	41.574	-22.566	0.000%

Load Comb.	Sum of Applied Forces PX K	PY K	PZ K	Sum of Reactions PX K	PY K	PZ K	% Error
11	-11.282	-41.574	19.484	11.282	41.574	-19.484	0.000%
12	-16.016	-41.574	15.873	16.016	41.574	-15.873	0.000%
13	-19.659	-41.574	11.181	19.659	41.574	-11.181	0.000%
14	-22.767	-41.574	-0.117	22.767	41.574	0.117	0.000%
15	-19.776	-41.574	-11.385	19.776	41.574	11.385	0.000%
16	-16.182	-41.574	-16.039	16.182	41.574	16.039	0.000%
17	-11.485	-41.574	-19.601	11.485	41.574	19.601	0.000%
18	0.000	-47.580	0.000	0.000	47.580	0.000	0.000%
19	-0.091	-47.580	-17.696	0.091	47.580	17.696	0.000%
20	8.847	-47.580	-15.279	-8.847	47.580	15.279	0.000%
21	12.559	-47.580	-12.448	-12.559	47.580	12.448	0.000%
22	15.415	-47.580	-8.769	-15.415	47.580	8.769	0.000%
23	17.852	-47.580	0.091	-17.852	47.580	-0.091	0.000%
24	15.505	-47.580	8.927	-15.505	47.580	-8.927	0.000%
25	12.687	-47.580	12.577	-12.687	47.580	-12.577	0.000%
26	9.005	-47.580	15.370	-9.005	47.580	-15.370	0.000%
27	0.091	-47.580	17.696	-0.091	47.580	-17.696	0.000%
28	-8.847	-47.580	15.279	8.847	47.580	-15.279	0.000%
29	-12.559	-47.580	12.448	12.559	47.580	-12.448	0.000%
30	-15.415	-47.580	8.769	15.415	47.580	-8.769	0.000%
31	-17.852	-47.580	-0.091	17.852	47.580	0.091	0.000%
32	-15.505	-47.580	-8.927	15.505	47.580	8.927	0.000%
33	-12.687	-47.580	-12.577	12.687	47.580	12.577	0.000%
34	-9.005	-47.580	-15.370	9.005	47.580	15.370	0.000%
35	-0.036	-41.574	-6.965	0.036	41.574	6.965	0.000%
36	3.482	-41.574	-6.014	-3.482	41.574	6.014	0.000%
37	4.943	-41.574	-4.899	-4.943	41.574	4.899	0.000%
38	6.067	-41.574	-3.451	-6.067	41.574	3.451	0.000%
39	7.027	-41.574	0.036	-7.027	41.574	-0.036	0.000%
40	6.104	-41.574	3.514	-6.104	41.574	-3.514	0.000%
41	4.994	-41.574	4.950	-4.994	41.574	-4.950	0.000%
42	3.545	-41.574	6.050	-3.545	41.574	-6.050	0.000%
43	0.036	-41.574	6.965	-0.036	41.574	-6.965	0.000%
44	-3.482	-41.574	6.014	3.482	41.574	-6.014	0.000%
45	-4.943	-41.574	4.899	4.943	41.574	-4.899	0.000%
46	-6.067	-41.574	3.451	6.067	41.574	-3.451	0.000%
47	-7.027	-41.574	-0.036	7.027	41.574	0.036	0.000%
48	-6.104	-41.574	-3.514	6.104	41.574	3.514	0.000%
49	-4.994	-41.574	-4.950	4.994	41.574	4.950	0.000%
50	-3.545	-41.574	-6.050	3.545	41.574	6.050	0.000%

Non-Linear Convergence Results

Load Combination	Converged?	Number of Cycles	Displacement Tolerance	Force Tolerance
1	Yes	4	0.00000001	0.00000001
2	Yes	4	0.00000001	0.00001337
3	Yes	4	0.00000001	0.00005023
4	Yes	4	0.00000001	0.00006195
5	Yes	4	0.00000001	0.00005456
6	Yes	4	0.00000001	0.00000743
7	Yes	4	0.00000001	0.00006249
8	Yes	4	0.00000001	0.00006650
9	Yes	4	0.00000001	0.00005219
10	Yes	4	0.00000001	0.00001115
11	Yes	4	0.00000001	0.00005727

12	Yes	4	0.00000001	0.00006178
13	Yes	4	0.00000001	0.00005294
14	Yes	4	0.00000001	0.00000562
15	Yes	4	0.00000001	0.00005301
16	Yes	4	0.00000001	0.00006613
17	Yes	4	0.00000001	0.00006330
18	Yes	4	0.00000001	0.00000001
19	Yes	4	0.00000001	0.00021900
20	Yes	4	0.00000001	0.00024536
21	Yes	4	0.00000001	0.00025516
22	Yes	4	0.00000001	0.00024736
23	Yes	4	0.00000001	0.00022189
24	Yes	4	0.00000001	0.00025338
25	Yes	4	0.00000001	0.00026129
26	Yes	4	0.00000001	0.00025056
27	Yes	4	0.00000001	0.00021881
28	Yes	4	0.00000001	0.00024645
29	Yes	4	0.00000001	0.00025520
30	Yes	4	0.00000001	0.00024716
31	Yes	4	0.00000001	0.00022204
32	Yes	4	0.00000001	0.00025231
33	Yes	4	0.00000001	0.00026154
34	Yes	4	0.00000001	0.00025248
35	Yes	4	0.00000001	0.00000001
36	Yes	4	0.00000001	0.00000001
37	Yes	4	0.00000001	0.00000001
38	Yes	4	0.00000001	0.00000001
39	Yes	4	0.00000001	0.00000001
40	Yes	4	0.00000001	0.00000001
41	Yes	4	0.00000001	0.00000001
42	Yes	4	0.00000001	0.00000001
43	Yes	4	0.00000001	0.00000001
44	Yes	4	0.00000001	0.00000001
45	Yes	4	0.00000001	0.00000001
46	Yes	4	0.00000001	0.00000001
47	Yes	4	0.00000001	0.00000001
48	Yes	4	0.00000001	0.00000001
49	Yes	4	0.00000001	0.00000001
50	Yes	4	0.00000001	0.00000001

Maximum Tower Deflections - Service Wind

Section No.	Elevation ft	Horz. Deflection in	Gov. Load Comb.	Tilt °	Twist °
L1	152 - 95.99	7.238	48	0.406	0.001
L2	102.01 - 47.25	3.352	48	0.309	0.000
L3	54.74 - 1	0.964	48	0.162	0.000

Critical Deflections and Radius of Curvature - Service Wind

Elevation ft	Appurtenance	Gov. Load Comb.	Deflection in	Tilt °	Twist °	Radius of Curvature ft
150.000	BXA-80063-6CF	48	7.072	0.403	0.001	187041

Elevation ft	Appurtenance	Gov. Load Comb.	Deflection in	Tilt °	Twist °	Radius of Curvature ft
149.000	EEI SQ Low Profile Platform	48	6.989	0.401	0.001	187041

Maximum Tower Deflections - Design Wind

Section No.	Elevation ft	Horz. Deflection in	Gov. Load Comb.	Tilt °	Twist °
L1	152 - 95.99	23.437	15	1.314	0.005
L2	102.01 - 47.25	10.855	15	1.000	0.002
L3	54.74 - 1	3.124	15	0.524	0.000

Critical Deflections and Radius of Curvature - Design Wind

Elevation ft	Appurtenance	Gov. Load Comb.	Deflection in	Tilt °	Twist °	Radius of Curvature ft
150.000	BXA-80063-6CF	15	22.899	1.304	0.004	57871
149.000	EEI SQ Low Profile Platform	15	22.630	1.299	0.004	57871

Compression Checks

Pole Design Data

Section No.	Elevation ft	Size	L ft	L_u ft	Kl/r	F_a ksi	A in^2	Actual P K	Allow. P_a K	Ratio $\frac{P}{P_a}$
L1	152 - 95.99 (1)	TP44.12x29.5x0.375	56.010	0.000	0.0	39.000	50.197	-10.074	1957.690	0.005
L2	95.99 - 47.25 (2)	TP55.94x41.799x0.438	54.760	0.000	0.0	39.000	74.386	-21.975	2901.060	0.008
L3	47.25 - 1 (3)	TP67x53.131x0.5	53.740	0.000	0.0	39.000	105.535	-41.569	4115.880	0.010

Pole Bending Design Data

Section No.	Elevation ft	Size	Actual M_x kip-ft	Actual f_{bx} ksi	Allow. F_{bx} ksi	Ratio $\frac{f_{bx}}{F_{bx}}$	Actual M_y kip-ft	Actual f_{by} ksi	Allow. F_{by} ksi	Ratio $\frac{f_{by}}{F_{by}}$
L1	152 - 95.99 (1)	TP44.12x29.5x0.375	413.496	9.508	39.000	0.244	0.000	0.000	39.000	0.000
L2	95.99 - 47.25 (2)	TP55.94x41.799x0.438	1072.417	13.092	39.000	0.336	0.000	0.000	39.000	0.000
L3	47.25 - 1 (3)	TP67x53.131x0.5	2133.783	14.781	39.000	0.379	0.000	0.000	39.000	0.000

Pole Shear Design Data

Section No.	Elevation ft	Size	Actual V K	Actual f_v ksi	Allow. F_v ksi	Ratio $\frac{f_v}{F_v}$	Actual T kip-ft	Actual f_{vt} ksi	Allow. F_{vt} ksi	Ratio $\frac{f_{vt}}{F_{vt}}$
L1	152 - 95.99 (1)	TP44.12x29.5x0.375	11.204	0.223	26.000	0.017	0.904	0.010	26.000	0.000
L2	95.99 - 47.25 (2)	TP55.94x41.799x0.438	16.700	0.225	26.000	0.017	0.904	0.005	26.000	0.000
L3	47.25 - 1 (3)	TP67x53.131x0.5	22.828	0.216	26.000	0.017	0.904	0.003	26.000	0.000

Pole Interaction Design Data

Section No.	Elevation ft	Ratio $\frac{P}{P_a}$	Ratio $\frac{f_{bx}}{F_{bx}}$	Ratio $\frac{f_{by}}{F_{by}}$	Ratio $\frac{f_v}{F_v}$	Ratio $\frac{f_{vt}}{F_{vt}}$	Comb. Stress Ratio	Allow. Stress Ratio	Criteria
L1	152 - 95.99 (1)	0.005	0.244	0.000	0.017	0.000	0.249 ✔	1.333	H1-3+VT ✔
L2	95.99 - 47.25 (2)	0.008	0.336	0.000	0.017	0.000	0.343 ✔	1.333	H1-3+VT ✔
L3	47.25 - 1 (3)	0.010	0.379	0.000	0.017	0.000	0.389 ✔	1.333	H1-3+VT ✔

Section Capacity Table

Section No.	Elevation ft	Component Type	Size	Critical Element	P K	$SF*P_{allow}$ K	% Capacity	Pass Fail
L1	152 - 95.99	Pole	TP44.12x29.5x0.375	1	-10.074	2609.601	18.7	Pass
L2	95.99 - 47.25	Pole	TP55.94x41.799x0.438	2	-21.975	3867.113	25.8	Pass
L3	47.25 - 1	Pole	TP67x53.131x0.5	3	-41.569	5486.468	29.2	Pass
							Summary	
						Pole (L3)	29.2	Pass
						RATING =	**29.2**	**Pass**

Anchor Bolt and Base Plate Analysis:

Input Data:

Tower Reactions:

Overturning Moment =	$OM := 2134 \cdot ft \cdot kips$	(Input From tnxTower)
Shear Force =	$Shear := 23 \cdot kips$	(Input From tnxTower)
Axial Force =	$Axial := 42 \cdot kips$	(Input From tnxTower)

Anchor Bolt Data:

Use ASTM A615 Grade 75

Number of Anchor Bolts =	$N := 28$	(User Input)
Diameter of Bolt Circle =	$D_{bc} := 75 \cdot in$	(User Input)
Bolt "Column" Distance =	$l := 3.0 \cdot in$	(User Input)
Bolt Ultimate Strength =	$F_u := 100 \cdot ksi$	(User Input)
Bolt Yield Strength =	$F_y := 75 \cdot ksi$	(User Input)
Bolt Modulus =	$E := 29000 \cdot ksi$	(User Input)
Diameter of Anchor Bolts =	$D := 2.25 \cdot in$	(User Input)
Threads per Inch =	$n := 4.5$	(User Input)

Base Plate Data:

Use ASTM A572-GR50

Plate Yield Strength =	$Fy_{bp} := 50 \cdot ksi$	(User Input)
Base Plate Thickness =	$t_{bp} := 3 \cdot in$	(User Input)
Base Plate Diameter =	$D_{bp} := 81 \cdot in$	(User Input)
Outer Pole Diameter =	$D_{pole} := 67 \cdot in$	(User Input)

Geometric Layout Data:

Distance from Bolts to Centroid of Pole:

Radius of Bolt Circle =: $R_{bc} := \frac{D_{bc}}{2} = 37.5 \cdot in$

Distance to Bolts = $i := 1 .. N$

$$d_i := \left| \begin{array}{l} \theta \leftarrow 2 \cdot \pi \cdot \left(\frac{i}{N}\right) \\ d \leftarrow R_{bc} \cdot \sin(\theta) \end{array} \right.$$

$d_1 = 8.34 \cdot in$	$d_7 = 37.50 \cdot in$
$d_2 = 16.27 \cdot in$	$d_8 = 36.56 \cdot in$
$d_3 = 23.38 \cdot in$	$d_9 = 33.79 \cdot in$
$d_4 = 29.32 \cdot in$	$d_{10} = 29.32 \cdot in$
$d_5 = 33.79 \cdot in$	$d_{11} = 23.38 \cdot in$
$d_6 = 36.56 \cdot in$	etc.

Critical Distances For Bending in Plate:

Outer Pole Radius = $R_{pole} := \frac{D_{pole}}{2} = 33.5 \cdot in$

Moment Arms of Bolts about Neutral Axis = $MA_i := if(d_i \geq R_{pole}, d_i - R_{pole}, 0in)$

$MA_1 = 0.00 \cdot in$	$MA_7 = 4.00 \cdot in$
$MA_2 = 0.00 \cdot in$	$MA_8 = 3.06 \cdot in$
$MA_3 = 0.00 \cdot in$	$MA_9 = 0.29 \cdot in$
$MA_4 = 0.00 \cdot in$	$MA_{10} = 0.00 \cdot in$
$MA_5 = 0.29 \cdot in$	$MA_{11} = 0.00 \cdot in$
$MA_6 = 3.06 \cdot in$	etc

Effective Width of Baseplate for Bending = $B_{eff} := .8 \cdot 2 \cdot \sqrt{\left(\frac{D_{bp}}{2}\right)^2 - \left(\frac{D_{pole}}{2}\right)^2} = 36.4 \cdot in$

Anchor Bolt Analysis:

Calculated Anchor Bolt Properties:

Polar Moment of Inertia = $I_p := \sum_i (d_i)^2 = 1.969 \times 10^4 \cdot in^2$

Gross Area of Bolt = $A_g := \frac{\pi}{4} \cdot D^2 = 3.976 \cdot in^2$

Net Area of Bolt = $A_n := \frac{\pi}{4} \cdot \left(D - \frac{0.9743 \cdot in}{n}\right)^2 = 3.248 \cdot in^2$

Net Diameter = $D_n := \frac{2 \cdot \sqrt{A_n}}{\sqrt{\pi}} = 2.033 \cdot in$

Radius of Gyration of Bolt = $r := \frac{D_n}{4} = 0.508 \cdot in$

Section Modulus of Bolt = $S_x := \frac{\pi \cdot D_n^3}{32} = 0.826 \cdot in^3$

Check Anchor Bolt Tension Force:

Maximum Tensile Force = $T_{Max} := OM \cdot \frac{R_{bc}}{I_p} - \frac{Axial}{N} = 47.3 \cdot kips$

Allowable Tensile Force = $T_{ALL.Gross} := 1.333 \cdot (0.33 \cdot A_g \cdot F_u) = 174.9 \cdot kips$ (1.333 increase allowed per TIA/EIA)

$T_{ALL.Net} := 1.333 \cdot (0.60 \cdot A_n \cdot F_y) = 194.812 \cdot kips$ (1.333 increase allowed per TIA/EIA)

Bolt Tension % of Capacity = $\frac{T_{Max}}{T_{ALL.Net}} \cdot 100 = 24$ Bolts are "upset bolts". Use net area per AISC

Condition1 = $Condition1 := if\left(\frac{T_{Max}}{T_{ALL.Net}} \le 1.00, "OK", "Overstressed"\right)$

Condition1 = "OK"

Check Anchor Bolt Bending Stress:

Maximum Bending Moment = $M_x := \left(\frac{Shear}{N}\right) \cdot l = 0.205 \cdot ft \cdot kips$

Maximum Bending Stress = $f_{bx} := \frac{M_x}{S_x} = 3 \cdot ksi$

Allowable Bending Stress = $F_{bx} := 1.333 \cdot 0.6 \cdot F_y = 60 \cdot ksi$ (1.333 increase allowed per TIA/EIA)

Check Combined Stress Requirement:

Per ASCE Manual 72: "If the clearance between the base plate and concrete does not exceed two times the bolt diameter a bending stress analysis of the bolts is NOT normally required.

$$l := \begin{cases} l & \text{if } l > 2 \cdot D_n \\ 0 & \text{otherwise} \end{cases} = 0 \cdot in$$

$$f_{bx} := \begin{cases} f_{bx} & \text{if } l > 2 \cdot D_n \\ 0 & \text{otherwise} \end{cases} = 0 \cdot ksi$$

Check Anchor Bolt Compression/Combined Stress:

Maximum Compressive Force =

$$C_{Max} := OM \cdot \frac{R_{bc}}{l_p} + \frac{Axial}{N} = 50.3 \cdot kips$$

Maximum Compressive Stress =

$$f_a := \frac{C_{Max}}{A_n} = 15.5 \cdot ksi$$

$$K := 0.65$$

$$C_c := \sqrt{\frac{2 \cdot \pi^2 \cdot E}{F_y}} = 87.364$$

$$F_a := \begin{cases} \dfrac{\left[1 - \dfrac{\left(\frac{K \cdot l}{r}\right)^2}{2 \cdot C_c^2}\right] \cdot F_y}{\dfrac{5}{3} + \dfrac{3 \cdot \left(\frac{K \cdot l}{r}\right)}{8 \cdot C_c} - \dfrac{\left(\frac{K \cdot l}{r}\right)^3}{8 \cdot C_c^3}} & \text{if } \dfrac{K \cdot l}{r} \le C_c \\ \dfrac{12 \cdot \pi^2 \cdot E}{23 \cdot \left(\frac{K \cdot l}{r}\right)^2} & \text{if } \dfrac{K \cdot l}{r} > C_c \end{cases} = 45 \cdot ksi$$

Allowable Compressive Stress =

$$F_a := 1.333 \cdot F_a = 60 \cdot ksi$$

(1.333 increase allowed per TIA/EIA)

Combined Stress % of Capacity =

$$\left(\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}}\right) \cdot 100 = 25.8$$

Condition 2 =

$$Condition2 := \text{if}\left(\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} \le 1.00, \text{"OK"}, \text{"Overstressed"}\right)$$

Condition2 = "OK"

Base Plate Analysis:

Force from Bolts = $C_i := \frac{OM \cdot d_i}{I_p} + \frac{Axial}{N}$

$C_1 = 12.4 \cdot kips$ $C_7 = 50.3 \cdot kips$

$C_2 = 22.7 \cdot kips$ $C_8 = 49.1 \cdot kips$

$C_3 = 31.9 \cdot kips$ $C_9 = 45.4 \cdot kips$

$C_4 = 39.6 \cdot kips$ $C_{10} = 39.6 \cdot kips$

$C_5 = 45.4 \cdot kips$ $C_{11} = 31.9 \cdot kips$

$C_6 = 49.1 \cdot kips$ etc.

Maximum Bending Stress in Plate = $f_{bp} := \sum_i \frac{6 \cdot C_i \cdot MA_i}{\left(B_{eff} \cdot t_{bp}^2\right)} = 9.7 \cdot ksi$

Allowable Bending Stress in Plate = $F_{bp} := 1.33 \cdot 0.75 \cdot Fy_{bp} = 49.9 \cdot ksi$

Plate Bending Stress % of Capacity = $\frac{f_{bp}}{F_{bp}} \cdot 100 = 19.4$

Condition3 = $Condition3 := if\left(\frac{f_{bp}}{F_{bp}} < 1.00, "Ok", "Overstressed"\right)$

Condition3 = "Ok"

Standard Monopole Foundation:

Input Data:

Tower Data

Overturning Moment =	$OM := 2134 \cdot ft \cdot kips$	(User Input from tnxTower)	
Shear Force =	$Shear := 23 \cdot kip$	(User Input from tnxTower)	
Axial Force =	$Axial := 42 \cdot kip$	(User Input from tnxTower)	
Tower Height =	$H_t := 150 \cdot ft$	(User Input)	

Footing Data:

Overall Depth of Footing =	$D_f := 7.0 \cdot ft$	(User Input)	
Length of Pier =	$L_p := 4.0 \cdot ft$	(User Input)	
Extension of Pier Above Grade =	$L_{pag} := 1.0 \cdot ft$	(User Input)	
Diameter of Pier =	$d_p := 8.0 \cdot ft$	(User Input)	
Thickness of Footing =	$T_f := 4.0 \cdot ft$	(User Input)	
Width of Footing =	$W_f := 31.0 \cdot ft$	(User Input)	

Anchor Bolt Data:

Length of Anchor Bolts =	$L_{st} := 72 \cdot in$	(User Input)	
Projection of Anchor Bolts Above Pier =	$A_{BP} := 12.0 \cdot in$	(User Input)	
Anchor Bolt Diameter =	$d_{anchor} := 2.25 \cdot in$	(User Input)	
Base Plate Bolt Circle =	$MP := 75.0 \cdot in$	(User Input)	

Material Properties:

Concrete Compressive Strength =	$f_c := 4000 \cdot psi$	(User Input)	
Steel Reinforcment Yield Strength =	$f_y := 60000 \cdot psi$	(User Input)	
Anchor Bolt Yield Strength =	$f_{ya} := 75000 \cdot psi$	(User Input)	
Internal Friction Angle of Soil =	$\Phi_s := 30 \cdot deg$	(User Input)	
Allowable Soil Bearing Capacity =	$q_s := 6000 \cdot psf$	(User Input)	
Unit Weight of Soil =	$\gamma_{soil} := 120 \cdot pcf$	(User Input)	
Unit Weight of Concrete =	$\gamma_{conc} := 150 \cdot pcf$	(User Input)	
Foundation Bouyancy =	$Bouyancy := 0$	(User Input)	(Yes=1 / No=0)
Depth to Neglect =	$n := 0 \cdot ft$	(User Input)	
Cohesion of Clay Type Soil =	$c := 0 \cdot ksf$	(User Input)	(Use 0 for Sandy Soil)
Seismic Zone Factor =	$Z := 2$	(User Input)	(UBC-1997 Fig 23-2)
Coefficient of Friction Between Concrete =	$\mu := 0.45$	(User Input)	

Pier Reinforcement:

Bar Size =	$BS_{pier} := 9$	(User Input)	
Bar Diameter =	$d_{bpier} := 1.128 \cdot in$	(User Input)	
Number of Bars =	$NB_{pier} := 60$	(User Input)	
Clear Cover of Reinforcement =	$Cvr_{pier} := 3 \cdot in$	(User Input)	
Reinforcement Location Factor =	$\alpha_{pier} := 1.0$	(User Input)	(ACI-2008 12.2.4)
Coating Factor =	$\beta_{pier} := 1.0$	(User Input)	(ACI-2008 12.2.4)
Concrete Strength Factor =	$\lambda_{pier} := 1.0$	(User Input)	(ACI-2008 12.2.4)
Reinforcement Size Factor =	$\gamma_{pier} := 1.0$	(User Input)	(ACI-2008 12.2.4)
Diameter of Tie =	$d_{Tie} := 0.5 \cdot in$	(User Input)	

Pad Reinforcement:

Bar Size =	$BS_{top} := 9$	(User Input)	(Top of Pad)
Bar Diameter =	$d_{btop} := 1.128 \cdot in$	(User Input)	(Top of Pad)
Number of Bars =	$NB_{top} := 30$	(User Input)	(Top of Pad)
Bar Size =	$BS_{bot} := 9$	(User Input)	(Bottom of Pad)
Bar Diameter =	$d_{bbot} := 1.128 \cdot in$	(User Input)	(Bottom of Pad)
Number of Bars =	$NB_{bot} := 50$	(User Input)	(Bottom of Pad)
Clear Cover of Reinforcement =	$Cvr_{pad} := 3.0 \cdot in$	(User Input)	
Reinforcement Location Factor =	$\alpha_{pad} := 1.0$	(User Input)	(ACI-2008 12.2.4)
Coating Factor =	$\beta_{pad} := 1.0$	(User Input)	(ACI-2008 12.2.4)
Concrete Strength Factor =	$\lambda_{pad} := 1.0$	(User Input)	(ACI-2008 12.2.4)
Reinforcement Size Factor =	$\gamma_{pad} := 1.0$	(User Input)	(ACI-2008 12.2.4)

Calculated Factors:

Pier Reinforcement Bar Area = $A_{bpier} := \frac{\pi \cdot d_{bpier}^2}{4} = 0.999 \cdot in^2$

Pad Top Reinforcement Bar Area = $A_{btop} := \frac{\pi \cdot d_{btop}^2}{4} = 0.999 \cdot in^2$

Pad Bottom Reinforcement Bar Area = $A_{bbot} := \frac{\pi \cdot d_{bbot}^2}{4} = 0.999 \cdot in^2$

Coefficient of Lateral Soil Pressure = $K_p := \frac{1 + \sin(\Phi_s)}{1 - \sin(\Phi_s)} = 3$

Load Factor = $LF := \begin{cases} 1.333 & \text{if } H_t \le 700 \cdot ft \\ 1.7 & \text{if } H_t \ge 1200 \cdot ft \\ 1.333 + \left(\frac{H_t - 700ft}{1200ft - 700ft}\right) \cdot 0.4 & \text{otherwise} \end{cases} = 1.333$

Stability of Footing:

Adjusted Concrete Unit Weight = $\gamma_c := \text{if}(\text{Bouyancy} = 1, \gamma_{conc} - 62.4\text{pcf}, \gamma_{conc}) = 150 \cdot \text{pcf}$

Adjusted Soil Unit Weight = $\gamma_s := \text{if}(\text{Bouyancy} = 1, \gamma_{soil} - 62.4\text{pcf}, \gamma_{soil}) = 120 \cdot \text{pcf}$

Passive Pressure = $P_{pn} := K_p \cdot \gamma_s \cdot n + c \cdot 2 \cdot \sqrt{K_p} = 0 \cdot \text{ksf}$

$P_{pt} := K_p \cdot \gamma_s \cdot (D_f - T_f) + c \cdot 2 \cdot \sqrt{K_p} = 1.08 \cdot \text{ksf}$

$P_{top} := \text{if}[n < (D_f - T_f), P_{pt}, P_{pn}] = 1.08 \cdot \text{ksf}$

$P_{bot} := K_p \cdot \gamma_s \cdot D_f + c \cdot 2 \cdot \sqrt{K_p} = 2.52 \cdot \text{ksf}$

$P_{ave} := \frac{P_{top} + P_{bot}}{2} = 1.8 \cdot \text{ksf}$

$T_p := \text{if}[n < (D_f - T_f), T_f, (D_f - n)] = 4$

$A_p := W_f \cdot T_p = 124$

Ultimate Shear = $S_u := P_{ave} \cdot A_p = 223.2 \cdot \text{kip}$

Weight of Concrete Pad = $WT_c := \left[\left(W_f^2 \cdot T_f\right) + d_p^2 \cdot L_p\right] \cdot \gamma_c = 615 \cdot \text{kip}$

Weight of Soil Above Footing = $WT_{s1} := \left[\left(W_f^2 - d_p^2\right) \cdot \begin{cases} (L_p - L_{pag} - n) & \text{if } (L_p - L_{pag} - n) \geq 0 \\ 0 & \text{if } (L_p - L_{pag} - n) \leq 0 \end{cases}\right] \cdot \gamma_s = 322.92 \cdot \text{kip}$

Weight of Soil Wedge at Back Face = $WT_{s2} := \left(\frac{D_f^2 \cdot \tan(\Phi_s)}{2} \cdot W_f\right) \cdot \gamma_s = 52.62 \cdot \text{kip}$

Weight of Soil Wedge at back face Corners = $WT_{s3} := 2 \cdot \left[(D_f)^3 \cdot \frac{\tan(\Phi_s)}{3}\right] \cdot \gamma_s = 15.842 \cdot \text{kips}$

Total Weight = $WT_{tot} := WT_c + WT_{s1} + \text{Axial} = 979.92 \cdot \text{kip}$

Resisting Moment = $M_r := (WT_{tot}) \cdot \frac{W_f}{2} + S_u \cdot \frac{T_f}{3} + \left[(WT_{s2} + WT_{s3}) \cdot \left(W_f + \frac{D_f \cdot \tan(\Phi_s)}{3}\right)\right] = 17701 \cdot \text{kip} \cdot \text{ft}$

Overturning Moment = $M_{ot} := OM + \text{Shear} \cdot (L_p + T_f) = 2318 \cdot \text{kip} \cdot \text{ft}$

Factor of Safety Actual = $FS := \frac{M_r}{M_{ot}} = 7.64$

Factor of Safety Required = $FS_{req} := 2$

$\text{OverTurning_Moment_Check} := \text{if}(FS \geq FS_{req}, \text{"Okay"}, \text{"No Good"})$

OverTurning_Moment_Check = "Okay"

Shear Capacity in Pier:

Shear Resistance of Pier = $S_p := \frac{\mu \cdot WT_{tot}}{FS_{req}} = 220.482 \cdot kips$

$Shear_Check := if(S_p > Shear, "Okay", "No Good")$

Shear_Check = "Okay"

Bearing Pressure Caused by Footing:

Area of the Mat = $A_{mat} := W_f^2 = 961$

Section Modulus of Mat = $S := \frac{W_f^3}{6} = 4965.17 \cdot ft^3$

Maximum Pressure in Mat = $P_{max} := \frac{WT_{tot}}{A_{mat}} + \frac{M_{ot}}{S} = 1.487 \cdot ksf$

$Max_Pressure_Check := if(P_{max} < q_s, "Okay", "No Good")$

Max_Pressure_Check = "Okay"

Minimum Pressure in Mat = $P_{min} := \frac{WT_{tot}}{A_{mat}} - \frac{M_{ot}}{S} = 0.553 \cdot ksf$

$Min_Pressure_Check := if[(P_{min} \geq 0) \cdot (P_{min} < q_s), "Okay", "No Good"]$

Min_Pressure_Check = "Okay"

Distance to Resultant of Pressure Distribution = $X_p := \frac{P_{max}}{\frac{P_{max} - P_{min}}{W_f}} \cdot \frac{1}{3} = 16.452$

Distance to Kern = $X_k := \frac{W_f}{6} = 5.167$

Since Resultant Force is Not in Kern, Area to which Pressure is Applied Must be Reduced.

Eccentricity = $e := \frac{M_{ot}}{WT_{tot}} = 2.365$

Adjusted Soil Pressure = $P_a := \frac{2 \cdot WT_{tot}}{3 \cdot W_f \cdot \left(\frac{W_f}{2} - e\right)} = 1.604 \cdot ksf$

$q_{adj} := if(P_{min} < 0, P_a, P_{max}) = 1.487 \cdot ksf$

$Pressure_Check := if(q_{adj} < q_s, "Okay", "No Good")$

Pressure_Check = "Okay"

Concrete Bearing Capacity:

Strength Reduction Factor = $\Phi_c := 0.65$ (ACI-2008 9.3.2.2)

Bearing Strength Between Pier and Pad = $P_b := \Phi_c \cdot 0.85 \cdot f_c \cdot \frac{\pi \cdot d_p^2}{4} = 1.6 \times 10^4 \cdot kips$ (ACI-2008 10.14)

$Bearing_Check := if(P_b > LF \cdot Axial, "Okay", "No Good")$

Bearing_Check = "Okay"

Shear Strength of Concrete:

Beam Shear: (Critical section located at a distance d from the face of Pier) (ACI 11.3.1.1)

$\phi_c := 0.85$ (ACI 9.3.2.5)

$d := T_f - Cvr_{pad} - d_{bbot} = 43.872 \cdot in$

$d_1 := \frac{W_f}{2} - \frac{d_p}{2}$

$d_2 := d_1 - d$

$L := \left(\frac{W_f}{2} - e\right) \cdot 3$

$Slope := if\left(L > W_f, \frac{P_{max} - P_{min}}{W_f}, \frac{q_{adj}}{L}\right)$

$V_{req} := LF \cdot \left[\left(q_{adj} - Slope \cdot d_1\right) + \left(\frac{Slope \cdot d_1}{2}\right)\right] \cdot W_f \cdot d_1$

$V_{Avail} := \phi_c \cdot 2 \cdot \sqrt{f_c \cdot psi} \cdot W_f \cdot d$ (ACI-2008 11.2.1.1)

$Beam_Shear_Check := if(V_{req} < V_{Avail}, "Okay", "No Good")$

Beam_Shear_Check = "Okay"

Punching Shear: (Critical Section Located at a distance of d/2 from the face of pier) (ACI 11.11.1.2)

Critical Perimeter of Punching Shear = $b_o := (d_p + d) \cdot \pi = 36.6$

Area Included Inside Perimeter = $A_{bo} := \frac{\pi \cdot (d_p + d)^2}{4} = 106.7$

Area Outside of Perimeter = $A_{out} := A_{mat} - A_{bo} = 854.3$

Guess Value = $v_u := 1ksf$ (From "Foundation Analysis and design", By Joseph Bowles, Eq. 8-9)

Given $d^2 + d_p \cdot d = \frac{WT_{tot}}{\pi \cdot v_u}$

$v_u := Find(v_u) = 7.3 \cdot ksf$

$V_u := v_u \cdot d \cdot W_f = 829.6 \cdot kips$

Required Shear Strength = $V_{req} := LF \cdot V_u = 1.1 \times 10^3 \cdot kips$

Available Shear Strength = $V_{Avail} := \phi_c \cdot 4 \cdot \sqrt{f_c \cdot psi} \cdot b_o \cdot d = 4145.5 \cdot kip$ (ACI-2008 11.11.2.1)

Punching_Shear_Check := if($V_{req} < V_{Avail}$, "Okay", "No Good")

Punching_Shear_Check = "Okay"

Steel Reinforcement in Pad:

Required Reinforcement for Bending:

Strength Reduction Factor = $\phi_m := .90$ (ACI-2008 9.3.2.1)

$q_b := q_{adj} - d_1 \cdot Slope = 1.14 \cdot ksf$

Maximum Bending at Face of Pier = $M_u := LF \cdot \left[(q_{adj} - q_b) \cdot \frac{d_1^2}{3} + q_b \cdot \frac{d_1^2}{2} \right] \cdot W_f = 3746.5 \cdot kip \cdot ft$

$$\beta := \begin{cases} 0.85 & \text{if } 2500 \cdot psi \le f_c \le 4000 \cdot psi \\ 0.65 & \text{if } f_c > 8000 \cdot psi \\ \left[0.85 - \left[\frac{\left(\frac{f_c}{psi} - 4000 \right)}{1000} \right] \cdot 0.5 \right] & \text{otherwise} \end{cases} = 0.85$$

(ACI-200810.2.7.3)

$$R_n := \frac{M_u}{\phi_m \cdot W_f \cdot d^2} = 69.8 \cdot psi$$

$$\rho := \frac{0.85 \cdot f_c}{f_y} \left(1 - \sqrt{1 - \frac{2 \cdot R_n}{0.85 \cdot f_c}} \right) = 0.0012$$

$\rho_{min} := \rho = 0.00117$

Required Reinforcement for Temperature and Shrinkage:

$$\rho_{sh} := \begin{cases} .0018 & \text{if } f_y \geq 60000 \cdot psi \\ .0020 & \text{otherwise} \end{cases}$$ (ACI -2008 7.12.2.1)

Check Bottom Bars:

$$As := \begin{cases} \rho_{min} \cdot W_f \cdot d & \text{if } \rho_{min} > \frac{\rho_{sh}}{2} \\ \rho_{sh} \cdot W_f \cdot \frac{d}{2} & \text{otherwise} \end{cases} = 19.176 \cdot in^2$$

$$As_{prov} := A_{bbot} \cdot NB_{bot} = 50 \cdot in^2$$

$$Pad_Reinforcement_Bot := if(As_{prov} > As, \text{"Okay"}, \text{"No Good"})$$

Pad_Reinforcement_Bot = "Okay"

Check top Bars:

$$As := \rho_{sh} \cdot \left(W_f \cdot \frac{d}{2}\right) = 14.7 \cdot in^2$$

$$As_{prov} := A_{btop} \cdot NB_{top} = 30 \cdot in^2$$

$$Pad_Reinforcement_Top := if(As_{prov} > As, \text{"Okay"}, \text{"No Good"})$$

Pad_Reinforcement_Top = "Okay"

Developement Length Pad Reinforcement:

Bar Spacing =

$$B_{sPad} := \frac{W_f - 2 \cdot Cvr_{pad} - NB_{bot} \cdot d_{bbot}}{NB_{bot} - 1} = 6.32 \cdot in$$

Spacing or Cover Dimension =

$$c := if\left(Cvr_{pad} < \frac{B_{sPad}}{2}, Cvr_{pad}, \frac{B_{sPad}}{2}\right) = 3 \cdot in$$

Transverse Reinforcement Index =

$$k_{tr} := 0$$ (ACI-2008 12.2.3)

$$L_{dbt} := \frac{3 \cdot f_y \alpha_{pad} \cdot \beta_{pad} \cdot \gamma_{pad} \cdot \lambda_{pad}}{40 \cdot \sqrt{f_c \cdot psi} \cdot \frac{c + k_{tr}}{d_{bbot}}} \cdot d_{bbot} = 30.2 \cdot in$$

Minimum Development Length =

$$L_{dbmin} := 12 \cdot in$$ (ACI-2008 12.2.1)

$$L_{dbtCheck} := if(L_{dbt} \geq L_{dbmin}, \text{"Use L.dbt"}, \text{"Use L.dbmin"})$$

Available Length in Pad =

$$L_{Pad} := \frac{W_f}{2} - \frac{d_p}{2} - Cvr_{pad} = 135 \cdot in$$

$$Lpad_Check := if(L_{Pad} > L_{dbt}, \text{"Okay"}, \text{"No Good"})$$

Lpad_Check = "Okay"

Steel Reinforcement in Pier:

Area of Pier = $A_p := \frac{\pi \cdot d_p^2}{4} = 7238.23 \cdot in^2$

$A_{smin} := 0.01 \cdot 0.5 \cdot A_p = 36.19 \cdot in^2$ (ACI-2008 10.8.4 & 10.9.1)

$A_{sprov} := NB_{pier} \cdot A_{bpier} = 59.96 \cdot in^2$

Steel_Area_Check := if($A_{sprov} > A_{smin}$, "Okay", "No Good")

Steel_Area_Check = "Okay"

Bar Spacing In Pier = $B_{sPier} := \frac{d_p \cdot \pi}{NB_{pier}} - d_{bpier} = 3.899 \cdot in$

Diameter of Reinforcement Cage = $Diam_{cage} := d_p - 2 \cdot Cvr_{pier} = 90 \cdot in$

Maximum Moment in Pier = $M_p := \left[OM + Shear \cdot \left(L_p + \frac{A_{BP}}{2}\right)\right] \cdot LF = 35791 \cdot in \cdot kips$

Pier Check evaluated from outside program and results are listed below;

$$\begin{pmatrix} D & N & n & P_u & M_{xu} \end{pmatrix} := \begin{pmatrix} d_p \cdot 12 & NB_{pier} & BS_{pier} & \frac{Axial \cdot 1.333}{kips} & \frac{M_p}{in \cdot kips} \end{pmatrix}$$

$$\begin{pmatrix} D & N & n & P_u & M_{xu} \end{pmatrix} = \begin{pmatrix} 96 & 60 & 9 & 55.986 & 3.579 \times 10^4 \end{pmatrix}$$

$$\begin{pmatrix} \phi P_n & \phi M_{xn} & f_{sp} & \rho \end{pmatrix} := \begin{pmatrix} 0 & 0 & 0 & 0 \end{pmatrix}$$

$$\begin{pmatrix} \phi P_n & \phi M_{xn} & f_{sp} & \rho \end{pmatrix} := \phi P'_n(D, N, n, P_u, M_{xu})^T$$

$$\begin{pmatrix} \phi P_n & \phi M_{xn} & f_{sp} & \rho \end{pmatrix} = \begin{pmatrix} 205.082 & 1.311 \times 10^5 & -60 & 8.289 \times 10^{-3} \end{pmatrix}$$

Axial_Load_Check := if($\phi P_n \geq P_u$, "Okay", "No Good")

Axial_Load_Check = "Okay"

Bending_Check := if($\phi M_{xn} \geq M_{xu}$, "Okay", "No Good")

Bending_Check = "Okay"

Development Length Pier Reinforcement:

Available Length in Foundation:

$L_{pier} := L_p - Cvr_{pier} = 45 \cdot in$

$L_{pad} := T_f - Cvr_{pad} = 45 \cdot in$

Tension: (ACI-2008 12.2.3)

Spacing or Cover Dimension = $c := if\left(Cvr_{pier} < \frac{B_{sPier}}{2}, Cvr_{pier}, \frac{B_{sPier}}{2}\right) = 1.949 \cdot in$

Transverse Reinforcement = $k_{tr} := 0$ (ACI-2008 12.2.3)

$$L_{dbt} := \frac{3 \cdot f_y \alpha_{pier} \cdot \beta_{pier} \cdot \gamma_{pier} \cdot \lambda_{pier}}{40 \cdot \sqrt{f_c \cdot psi} \cdot \left(\frac{c + k_{tr}}{d_{bpier}}\right)} \cdot d_{bpier} = 46.44 \cdot in$$

Minimum Development Length = $L_{dh} := \frac{1200 \cdot d_{bpier}}{\sqrt{\frac{f_c}{psi}}} \cdot .7 = 14.982 \cdot in$ (ACI 12.2.1)

Pier reinforcement bars are standard 90 degree hooks and therefore developement in the pad is computed as follows:

$L_{db} := max(L_{dbt}, L_{dbmin})$

$L_{tension_Check} := if(L_{pier} + L_{pad} > L_{dbt}, "Okay", "No Good")$

$L_{tension_Check} = "Okay"$

Compression: (ACI-2008 12.3.2)

$$L_{dbc1} := \frac{.02 \cdot d_{bpier} \cdot f_y}{\sqrt{f_c \cdot psi}} = 21.402 \cdot in$$

$$L_{dbmin} := 0.0003 \cdot \frac{in^2}{lb} \cdot (d_{bpier} \cdot f_y) = 20.304 \cdot in$$

$L_{dbc} := if(L_{dbc1} \geq L_{dbmin}, L_{dbc1}, L_{dbmin}) = 21.402 \cdot in$

$L_{compression_Check} := if(L_{pier} + L_{pad} > L_{dbc}, "Okay", "No Good")$

$L_{compression_Check} = "Okay"$

Tie Size and Spacing in Column:

Minimum Tie Size = $Tie_{min} := if(BS_{pier} \le 10, 3, 4) = 3$

Used #4 Ties

Seismic Factor = $z := if(Z \le 2, 1, 0.5) = 1$ (ACI-2008 21.10.5)

$s_{lim1} := 16 \cdot d_{bpier} \cdot z = 18.048 \cdot in$

$s_{lim2} := 48 \cdot d_{Tie} \cdot z = 24 \cdot in$

$s_{lim3} := D_f \cdot z = 84 \cdot in$

$s_{lim4} := 18in$

Maximum Spacing = $s_{tie} := min\begin{pmatrix} s_{lim1} \\ s_{lim2} \\ s_{lim3} \\ s_{lim4} \end{pmatrix} = 18 \cdot in$

Number of Ties Required = $n_{tie} := \frac{L_{pier} - 3 \cdot in}{s_{tie}} + 1 = 3.333$

Check Anchor Steel Embedment:

Depth Available = $D_{ab} := L_{st} - A_{BP} = 5 \cdot ft$

Length of Anchor Bolt = $L_{anchor} := \frac{(0.11 \cdot f_{ya}) \cdot in}{\sqrt{f_c \cdot psi}} = 10.87 \cdot ft$

$Depth_Check := if(D_{ab} \ge L_{anchor}, "Okay", "No Good")$

$Depth_Check = "No Good"$

Note: Anchor plate is provided

Flat Panel Antenna, Single Polarized, 2 ft, 28 dBi

Product Description
(Only available in North America)

Radio Frequency Systems? new flat panel antennas are especially designed to serve license-free ISM, Spread Spectrum and UNII band applications in 2.4 GHz and 5.2-5.8 GHz.Because of their new, simpler, lightweight construction, these antennas meet the need for an aesthetically pleasing antenna with superior pattern characteristics. New flat panel antennas are lower in profile and weigh significantly less, for easier handling, reduced tower loading and lower shipping cost, and are an attractive solution for both point to point and point to multi point applications.Ideal for point-to-point and point-to-multipoint applications, these new antennas have been rigorously tested to meet extremely stringent environmental specifications for safe and reliable long-term operation. Their cost effective design translates into an outstanding value for the user.

Antenna

Features/Benefits

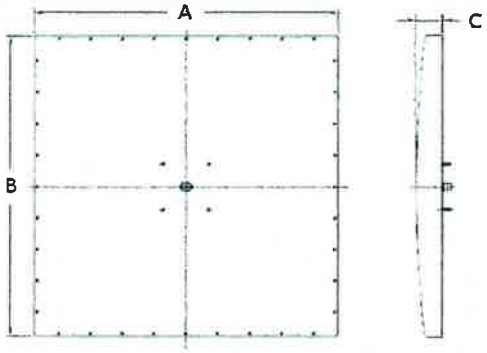
Technical Features

Product Type	Point to point antennas, Broadband Wireless Antennas
Frequency, GHz	5.15 - 5.35, 5.725 - 5.875
Profile	Flat Panel
Antenna color	White
Swaybar	0: (not applicable)
optional Swaybar	0: (not applicable)
Performance	Standard
Polarization	Single
Regulatory Compliance	ETSI EN 302085 V1.1.2 TS1-TS5
3dB beamwidth, (degrees)	4.5
Antenna Input	N Female
Mid Band Gain, dBi	28
F/B Ratio, dB	45
XPD, dB	28
Max VSWR / R L, dB	1.5 (14) @5.15 - 5.35 GHz, 1.7 (12) @5.725 - 5.85 GHz
Elevation Adjustment, degrees	-10
Azimuth Adjustment, degrees	360
Radome	rigid
Radome Material	Plastic
Mounting Pipe Diameter minimum, mm (in)	68 (2.75)
Mounting Pipe Diameter maximum, mm (in)	100 (4)
Approximate Weight, kg (lb)	5 (11)

All information contained in the present datasheet is subject to confirmation at time of ordering

Flat Panel Antenna, Single Polarized, 2 ft, 28 dBi

Dimensions	mm (in)
A	600 (23.6)
B	600 (23.6)
C	35 (1.4)



Notes

no notes

Documentation

Radiation pattern: (ADF)
Radiation pattern: (NSMA format)
Radiation pattern: (PDF format)

All information contained in the present datasheet is subject to confirmation at time of ordering

Product Data Sheet EP65

FLEXWELL® Premium Elliptical Waveguide

Product Description

FLEXWELL® elliptical waveguide is constructed of longitudinally continuous seam welded, highly conductive copper tube, corrugated and precision formed into an elliptical cross section. It is manufactured in continuous lengths using a special seam welding process developed by the RFS organization.

The corrugation design achieves high transverse stability, flexibility and crush strength for superior handling and forming at an installation. The inherent strength and flexibility of FLEXWELL waveguide allows on location, a continuous length of waveguide to be run directly from a tower-mounted antenna to the equipment building, eliminating flange joint discontinuities and the use of bends, twists and flex sections associated with a rigid rectangular waveguide system. Because of its flexibility, FLEXWELL elliptical waveguide can be easily transported to an installation site in coils or on reels and then uncoiled as required during installation.

FLEXWELL elliptical waveguide has set an industry standard for excellent electrical performance. Each waveguide has been carefully designed for low loss and low VSWR in specific frequency bands. For optimum system performance, there is no substitute for FLEXWELL waveguide.

As part of the RFS manufacturing process, all elliptical waveguides undergo several different electrical tests. Prior to shipping, every length is 100% tested again for input VSWR, and undergoes a twenty-four hour pressure test. This additional testing is performed to guarantee conformance with published specifications and to avoid any problems in the field.

A FLEXWELL elliptical waveguide feeder requires less planning and reduces installation costs when compared to a feeder system using a rigid rectangular waveguide. FLEXWELL waveguide is available cut to length with factory attached connectors or in continuous lengths for termination in the field.

Features/Benefits

Technical Specifications

Typical Operating Band, GHz	5.9 - 7.125
Performance	Premium
Dimension over Jacket, mm (in)	51 x 30 (2.0 x 1.2)
Weight, kg/m (lb/ft)	0.75 (0.50)
Minimum Bending Radius E Plane, without rebending, mm (in)	200 (8)
Minimum Bending Radius H Plane, without rebending, mm (in)	500 (20)
Minimum Bending Radius E Plane, with rebending, mm (in)	300 (12)
Minimum Bending Radius H Plane, with rebending, mm (in)	600 (24)
Maximum Twist, degree/m (degree/ft)	5 (1.5)
Max. Operating Pressure, bar (psi)	0.5 (7)
Max. Pulling Length per Hoisting Grip, m (ft)	100 (305)
Standard Hanger Spacing, m (ft)	0.9 (3)
Recommended Installation Temperature Range, °C (°F)	-40 to +60 (-40 to +140)
Max. VSWR / Return Loss, dB	1.062 / 30.5
Cut-off Frequency, GHz	4.01

Notes

VSWR values include connectors and are valid for frequency band of connectors.

Max. Operating Band: 5.00 - 7.125 GHz

Other Documentation

All information contained in the present datasheet is subject to confirmation at time of ordering

FLEXWELL® Premium Elliptical Waveguide

E65/EP65

ATTENUATION, AVERAGE POWER, GROUP VELOCITY, GROUP DELAY

Frequency GHz	Attenuation dB / 100 m (ft)	Avg. Pow. kW	Group Vel. %c	Group Delay ns/100 m (ft)
5.90	4.92 (1.50)	4.82	73.4	454.7 (138.6)
6.00	4.84 (1.47)	4.90	74.4	448.4 (136.7)
6.10	4.76 (1.45)	4.98	75.4	442.6 (134.9)
6.20	4.69 (1.43)	5.06	76.3	437.4 (133.3)
6.30	4.62 (1.41)	5.13	77.1	432.5 (131.8)
6.40	4.56 (1.39)	5.19	77.9	428.0 (130.5)
6.50	4.51 (1.37)	5.26	78.7	423.8 (129.2)
6.60	4.46 (1.36)	5.32	79.4	420.0 (128.0)
6.70	4.41 (1.34)	5.37	80.1	416.4 (126.9)
6.80	4.37 (1.33)	5.42	80.8	413.0 (125.9)
6.90	4.33 (1.32)	5.47	81.4	409.9 (124.9)
7.00	4.29 (1.31)	5.52	82.0	407.0 (124.0)
7.125	4.25 (1.30)	5.58	82.7	403.5 (123.0)

For attenuation: VSWR 1.0, ambient temperature 20° C (68° F).

For average power: VSWR 1.0 and 42° C (76° F) temperature rise over 40° C (104° F) ambient.

Attenuation, Average Power, Group Velocity, Group Delay

All information contained in the present datasheet is subject to confirmation at time of ordering

CENTEK engineering

Centered on Solutions™

Structural Analysis Report

160-ft Existing EEI Monopole

Proposed Verizon Wireless
Antenna Upgrade

Verizon Site Ref: Voluntown

422 Rockville Road
Voluntown, CT

CENTEK Project No. 14325.002

~~Date: November 20, 2014~~
Rev 1: November 21, 2014

STATE OF CONNECTICUT
TIMOTHY J. LAND
No. 28306
LICENSED
PROFESSIONAL ENGINEER

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Table of Contents

SECTION 1 - REPORT

- INTRODUCTION
- ANTENNA AND APPURTENANCE SUMMARY
- PRIMARY ASSUMPTIONS USED IN THE ANALYSIS
- ANALYSIS
- TOWER LOADING
- TOWER CAPACITY
- FOUNDATION AND ANCHORS
- CONCLUSION

SECTION 2 – CONDITIONS & SOFTWARE

- STANDARD ENGINEERING CONDITIONS
- GENERAL DESCRIPTION OF STRUCTURAL ANALYSIS PROGRAM

SECTION 3 – CALCULATIONS

- tnxTower INPUT/OUTPUT SUMMARY
- tnxTower DETAILED OUTPUT
- ANCHOR BOLT AND BASE PLATE ANALYSIS
- FOUNDATION ANALYSIS

SECTION 4 – REFERENCE MATERIAL

- EQUIPMENT CUT SHEETS

Introduction

The purpose of this report is to summarize the results of the non-linear, P-Δ structural analysis of the antenna upgrade proposed by Verizon Wireless on the existing monopole (tower) located in Voluntown, CT.

The host tower is a 160-ft tall, four-section, eighteen sided, tapered monopole, originally designed and manufactured by Engineered Endeavors Incorporated (EEI job no; 16941), dated October 4, 2012. The tower geometry and structure member sizes were obtained from the aforementioned EEI design documents. The foundation information was obtained from the original design drawing prepared by Centek Engineering job no 09086 dated May 9, 2013.

Antenna and appurtenance information were obtained from visual verification conducted from grade by Centek personnel on October 22, 2013 and a Verizon RF sheet.

The tower is made up of four (4) tapered vertical sections consisting of A572-65 pole sections. The tower sections are slip joint connected. The diameter of the pole (flat-flat) is 29.35-in at the top and 69.0-in at the base.

Verizon Wireless proposes the installation of one (1) MW panel mounted on the existing low profile platform. Refer to the Antenna and Appurtenance Summary below for a detailed description of the proposed antenna and appurtenance configuration.

Antenna and Appurtenance Summary

The existing, proposed and future loads considered in this analysis consist of the following:

- UNKNOWN (EXISTING/RESERVED):
  Antennas: One (1) Kreco CO-40A whip and one (1) Decibel DB-436 yagi mounted on the existing low profile platform with an elevation of 160-ft above existing grade.
  Coax Cables: Two (2) 7/8" ∅ cables running on the interior of the existing tower.
- VERIZON (EXISTING TO REMAIN):
  Antennas: Four (4) Antel BXA-171063-12CF panel antennas, five (5) Antel BXA-70063-6CF panel antennas, one (1) Swedcom SLCP 2x6015 panel antenna, two (2) Swedcom SACP 2x5516 panel antennas, three (3) Alcatel-Lucent RRH-2x40-07U remote radio heads and two (2) Raycap RC2DC-4750-PF-48 main distribution boxes mounted on a square low profile platform with a RAD center elevation of 160-ft above existing grade.
  Coax Cables: Two (2) 1-5/8" ∅ fiber cables running on the interior of the existing tower.
- **VERIZON (PROPOSED):**
  Antennas: One (1) RFS MA0528-28AN MW panel mounted on the existing square low profile platform with a RAD center elevation of 160-ft above existing grade.
  Coax Cables: One (1) RFS EP65 cable running on the interior of the existing tower.

Primary Assumptions Used in the Analysis

- The tower structure's theoretical capacity not including any assessment of the condition of the tower.
- The tower carries the horizontal and vertical loads due to the weight of antennas, ice load and wind.
- Tower is properly installed and maintained.
- Tower is in plumb condition.
- Tower loading for antennas and mounts as listed in this report.
- All bolts are appropriately tightened providing the necessary connection continuity.
- All welds are fabricated with ER-70S-6 electrodes.
- All members are assumed to be as specified in the original tower design documents or reinforcement drawings.
- All members are "hot dipped" galvanized in accordance with ASTM A123 and ASTM A153 Standards.
- All member protective coatings are in good condition.
- All tower members were properly designed, detailed, fabricated, installed and have been properly maintained since erection.
- Any deviation from the analyzed antenna loading will require a new analysis for verification of structural adequacy.
- All existing coax cables to be installed as indicated in this report.

Analysis

The existing tower was analyzed using a comprehensive computer program entitled tnxTower. The program analyzes the tower, considering the worst case loading condition. The tower is considered as loaded by concentric forces along the tower shaft, and the model assumes that the shaft members are subjected to bending, axial, and shear forces.

The existing tower was analyzed for the controlling basic wind speed (fastest mile) with no ice and a 75% reduction of wind force with ½ inch accumulative ice to determine stresses in members as per guidelines of TIA/EIA-222-F-96 entitled "Structural Standards for Steel Antenna Towers and Antenna Supporting Structures", the American Institute of Steel Construction (AISC) and the Manual of Steel Construction; Allowable Stress Design (ASD).

The controlling wind speed is determined by evaluating the local available wind speed data as provided in Appendix K of the CSBC[1] and the wind speed data available in the TIA/EIA-222-F-96 Standard. The higher of the two wind speeds is utilized in preparation on the tower analysis.

Tower Loading

Tower loading was determined by the basic wind speed as applied to projected surface areas with modification factors per TIA/EIA-222-F, gravity loads of the tower structure and its components, and the application of ½" radial ice on the tower structure and its components.

Basic Wind Speed:	New London; v = 85 mph (fastest mile)	*[Section 16 of TIA/EIA-222-F-96]*
	Voluntown; v = 110 mph (3 second gust) equivalent to v = 90 mph (fastest mile)	*[Appendix K of the 2005 CT Building Code Supplement]*
	Appendix-K wind speed controls.	
Load Cases:	Load Case 1; 90 mph wind speed w/ no ice plus gravity load – used in calculation of tower stresses and rotation.	*[Section 2.3.16 of TIA/EIA-222-F-96]*
	Load Case 2; 78 mph wind speed w/ ½" radial ice plus gravity load – used in calculation of tower stresses. The 78 mph wind speed velocity represents 75% of the wind pressure generated by the 90 mph wind speed.	*[Section 2.3.16 of TIA/EIA-222-F-96]*
	Load Case 3; Seismic – not checked	*[Section 1614.5 of State Bldg. Code 2005] does not control in the design of this structure type*

[1] The 2005 Connecticut State Building Code as amended by the 2009 CT State Supplement. (CSBC)

Tower Capacity

Tower stresses were calculated utilizing the structural analysis software tnxTower. Allowable stresses were determined based on Table 5 of the TIA/EIA code with a 1/3 increase per Section 3.1.1.1 of the same code.

- Calculated stresses were found to be within allowable limits. In Load Case 1, per tnxTower "Section Capacity Table", this tower was found to be at **27.5%** of its total capacity.

Tower Section	Elevation	Stress Ratio (percentage of capacity)	Result
Pole Shaft (L1)	133.46'-160.00'	12.3%	**PASS**
Pole Shaft (L2)	88.75'-133.46'	20.5%	**PASS**
Pole Shaft (L3)	44.08'-88.75'	25.0%	**PASS**
Pole Shaft (L4)	1.00'-44.08'	27.5%	**PASS**

Foundation and Anchors

The existing foundation consists of a 8.0-ft square x 2.0-ft long reinforced concrete pier on a 22.0-ft square x 4.0-ft thick reinforce concrete pad with (12) 1-3/4" ∅ rock anchors. The sub-grade conditions used in the analysis of the existing foundation were obtained from the geotechnical report prepared by Design Earth Technology; job no. 2012.09 dated August 23, 2012. The base of the tower is connected to the foundation by means of (28) 2.25"∅, ASTM A615-75 anchor bolts embedded approximately 5-ft into the concrete foundation structure.

- The tower base reactions developed from the governing Load Case 1 were used in the verification of the foundation and its anchors:

Location	Vector	Proposed Reactions
Base	Shear	24 kips
	Compression	49 kips
	Moment	2385 kip-ft

- The foundation was found to be within allowable limits.

Foundation	Design Limit	IBC 2003/2005 CT State Building Code Section 3108.4.2 (FS)[1]	Proposed Loading (FS)[1]	Result
Reinforced Concrete Pad and Pier	Uplift	2.0	26.1	**PASS**

Note 1: FS denotes Factor of Safety.

- The anchor bolts and base plate were found to be within allowable limits.

Tower Component	Design Limit	Stress Ratio (percentage of capacity)	Result
Anchor Bolts	Combined Compression and Bending	28.2%	**PASS**
Base Plate	Bending	20.4%	**PASS**

Conclusion

This analysis shows that the subject tower **is adequate** to support the proposed modified antenna configuration.

The analysis is based, in part, on the information provided to this office by Verizon Wireless. If the existing conditions are different than the information in this report, Centek Engineering, Inc. must be contacted for resolution of any potential issues.

Please feel free to call with any questions or comments.

Respectfully Submitted by:

Timothy J. Lynn, PE
Structural Engineer

STATE OF CONNECTICUT
TIMOTHY J. LYNN
No. 29336
LICENSED
PROFESSIONAL ENGINEER

Standard Conditions for Furnishing of Professional Engineering Services on Existing Structures

All engineering services are performed on the basis that the information used is current and correct. This information may consist of, but is not necessarily limited to:

- Information supplied by the client regarding the structure itself, its foundations, the soil conditions, the antenna and feed line loading on the structure and its components, or other relevant information.
- Information from the field and/or drawings in the possession of CENTEK engineering, Inc. or generated by field inspections or measurements of the structure.
- It is the responsibility of the client to ensure that the information provide to CENTEK engineering, Inc. and used in the performance of our engineering services is correct and complete. In the absence of information to the contrary, we assume that all structures were constructed in accordance with the drawings and specifications and are in an un-corroded condition and have not deteriorated. It is therefore assumed that its capacity has not significantly changed from the "as new" condition.
- All services will be performed to the codes specified by the client, and we do not imply to meet any other codes or requirements unless explicitly agreed in writing. If wind and ice loads or other relevant parameters are to be different from the minimum values recommended by the codes, the client shall specify the exact requirement. In the absence of information to the contrary, all work will be performed in accordance with the latest revision of ANSI/ASCE10 & ANSI/EIA-222
- All services performed, results obtained, and recommendations made are in accordance with generally accepted engineering principles and practices. CENTEK engineering, Inc. is not responsible for the conclusions, opinions and recommendations made by others based on the information we supply.

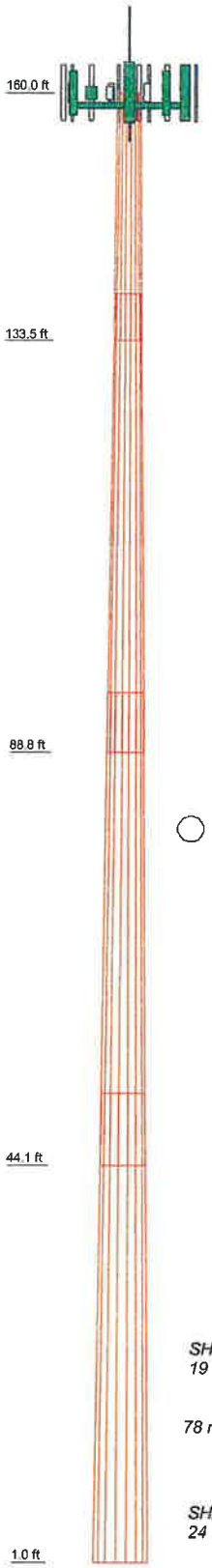
General Description of Structural Analysis Program

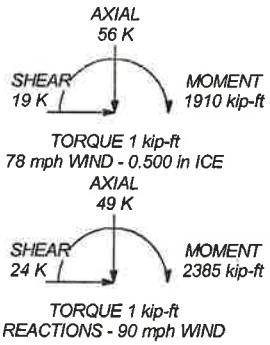
tnxTower, is an integrated structural analysis and design software package for Designed specifically for the telecommunications industry, tnxTower, formerly ERITower, automates much of the tower analysis and design required by the TIA/EIA 222 Standard.

tnxTower Features:

- tnxTower can analyze and design 3- and 4-sided guyed towers, 3- and 4-sided self-supporting towers and either round or tapered ground mounted poles with or without guys.
- The program analyzes towers using the TIA-222-G (2005) standard or any of the previous TIA/EIA standards back to RS-222 (1959). Steel design is checked using the AISC ASD 9th Edition or the AISC LRFD specifications.
- Linear and non-linear (P-delta) analyses can be used in determining displacements and forces in the structure. Wind pressures and forces are automatically calculated.
- Extensive graphics plots include material take-off, shear-moment, leg compression, displacement, twist, feed line, guy anchor and stress plots.
- tnxTower contains unique features such as True Cable behavior, hog rod take-up, foundation stiffness and much more.

Section	Length (ft)	Number of Sides	Thickness (in)	Socket Length (ft)	Top Dia (in)	Bot Dia (in)	Grade	Weight (K)
1	26.540	18	0.313	5.084	29.350	36.450	A572-65	2.9
2	49.790	18	0.438	6.500	34.465	47.660		9.6
3	51.170	18	0.500	7.834	45.062	58.600		14.2
4	50.918	18	0.563		55.527	69.000		19.1
								45.7





DESIGNED APPURTENANCE LOADING

TYPE	ELEVATION	TYPE	ELEVATION
BXA-171063-12CF (Verizon - Existing)	160	RRH2x40-07-U (Verizon - Existing)	160
BXA-70063/6CF (Verizon - Existing)	160	RRH2x40-07-U (Verizon - Existing)	160
BXA-171063-12CF (Verizon - Existing)	160	RRH2x40-07-U (Verizon - Existing)	160
BXA-70063/6CF (Verizon - Existing)	160	RC2DC-4750-PF-48 (Verizon - Existing)	160
BXA-171063-12CF (Verizon - Existing)	160	RC2DC-4750-PF-48 (Verizon - Existing)	160
BXA-70063/6CF (Verizon - Existing)	160	MA0528-28AN (Verizon - Proposed)	160
BXA-171063-12CF (Verizon - Existing)	160	CO-40A	160
BXA-70063/6CF (Verizon - Existing)	160	DB436-C	160
SACP 2X5516 (Verizon - Existing)	160	EEI SQ Low Profile Platform (Verizon - Existing)	159
SLCP 2x6015 (Verizon - Existing)	160		
SACP 2X5516 (Verizon - Existing)	160		
BXA-70063/6CF (Verizon - Existing)	160		

MATERIAL STRENGTH

GRADE	Fy	Fu	GRADE	Fy	Fu
A572-65	65 ksi	80 ksi			

TOWER DESIGN NOTES

1. Tower designed for a 90 mph basic wind in accordance with the TIA/EIA-222-F Standard.
2. Tower is also designed for a 78 mph basic wind with 0.50 in ice.
3. Deflections are based upon a 50 mph wind.
4. Weld together tower sections have flange connections.
5. Connections use galvanized A325 bolts, nuts and locking devices. Installation per TIA/EIA-222 and AISC Specifications.
6. Tower members are "hot dipped" galvanized in accordance with ASTM A123 and ASTM A153 Standards.
7. Welds are fabricated with ER-70S-6 electrodes.
8. TOWER RATING: 27.5%

Centek Engineering Inc.
63-2 North Branford Rd.
Branford, CT 06405
Phone: (203) 488-0580
FAX: (203) 488-8587

Job: 14325.002 - Voluntown			
Project: 160-ft EEI Monopole - 422 Rockville Rd., Voluntown, CT			
Client: Verizon Wireless	Drawn by: TJL	App'd:	
Code: TIA/EIA-222-F	Date: 11/21/14	Scale: NTS	
Path:		Dwg No. E-1	

Tower Input Data

There is a pole section.
This tower is designed using the TIA/EIA-222-F standard.
The following design criteria apply:

Basic wind speed of 90 mph.
Nominal ice thickness of 0.500 in.
Ice density of 56 pcf.
A wind speed of 78 mph is used in combination with ice.
Temperature drop of 50 °F.
Deflections calculated using a wind speed of 50 mph.
Weld together tower sections have flange connections..
Connections use galvanized A325 bolts, nuts and locking devices. Installation per TIA/EIA-222 and AISC Specifications..
Tower members are "hot dipped" galvanized in accordance with ASTM A123 and ASTM A153 Standards..
Welds are fabricated with ER-70S-6 electrodes..
A non-linear (P-delta) analysis was used.
Pressures are calculated at each section.
Stress ratio used in pole design is 1.333.
Local bending stresses due to climbing loads, feedline supports, and appurtenance mounts are not considered.

Options

Consider Moments - Legs
Consider Moments - Horizontals
Consider Moments - Diagonals
Use Moment Magnification
√ Use Code Stress Ratios
Use Code Safety Factors - Guys
Escalate Ice
Always Use Max Kz
Use Special Wind Profile
Include Bolts In Member Capacity
Leg Bolts Are At Top Of Section
Secondary Horizontal Braces Leg
Use Diamond Inner Bracing (4 Sided)
Add IBC .6D+W Combination

Distribute Leg Loads As Uniform
Assume Legs Pinned
√ Assume Rigid Index Plate
Use Clear Spans For Wind Area
Use Clear Spans For KL/r
Retension Guys To Initial Tension
√ Bypass Mast Stability Checks
Use Azimuth Dish Coefficients
√ Project Wind Area of Appurt.
Autocalc Torque Arm Areas
SR Members Have Cut Ends
√ Sort Capacity Reports By Component
Triangulate Diamond Inner Bracing

Treat Feedline Bundles As Cylinder
Use ASCE 10 X-Brace Ly Rules
Calculate Redundant Bracing Forces
Ignore Redundant Members in FEA
SR Leg Bolts Resist Compression
All Leg Panels Have Same Allowable
Offset Girt At Foundation
Consider Feedline Torque
Include Angle Block Shear Check
Poles
√ Include Shear-Torsion Interaction
Always Use Sub-Critical Flow
Use Top Mounted Sockets

Tapered Pole Section Geometry

Section	Elevation ft	Section Length ft	Splice Length ft	Number of Sides	Top Diameter in	Bottom Diameter in	Wall Thickness in	Bend Radius in	Pole Grade
L1	160.000-133.460	26.540	5.084	18	29.350	36.450	0.313	1.250	A572-65 (65 ksi)
L2	133.460-88.754	49.790	6.500	18	34.465	47.660	0.438	1.750	A572-65 (65 ksi)
L3	88.754-44.084	51.170	7.834	18	45.062	58.600	0.500	2.000	A572-65 (65 ksi)

Section	Elevation ft	Section Length ft	Splice Length ft	Number of Sides	Top Diameter in	Bottom Diameter in	Wall Thickness in	Bend Radius in	Pole Grade
L4	44.084-1.000	50.918		18	55.527	69.000	0.563	2.250	A572-65 (65 ksi)

Tapered Pole Properties

Section	Tip Dia. in	Area in^2	I in^4	r in	C in	I/C in^3	J in^4	It/Q in^2	w in	w/t
L1	29.803	28.802	3068.118	10.308	14.910	205.779	6140.273	14.404	4.616	14.77
	37.012	35.844	5913.828	12.829	18.517	319.380	11835.438	17.925	5.865	18.769
L2	36.365	47.251	6912.095	12.080	17.508	394.792	13833.285	23.630	5.296	12.105
	48.395	65.574	18474.358	16.764	24.211	763.048	36973.025	32.793	7.618	17.413
L3	47.504	70.721	17742.722	15.820	22.892	775.072	35508.790	35.367	7.051	14.102
	59.504	92.205	39322.650	20.625	29.769	1320.935	78697.041	46.111	9.434	18.867
L4	58.489	98.133	37456.215	19.513	28.208	1327.861	74961.716	49.076	8.783	15.614
	70.064	122.187	72301.833	24.295	35.052	2062.702	144698.803	61.105	11.154	19.829

Tower Elevation ft	Gusset Area (per face) ft^2	Gusset Thickness in	Gusset Grade	Adjust. Factor A_f	Adjust. Factor A_r	Weight Mult.	Double Angle Stitch Bolt Spacing Diagonals in	Double Angle Stitch Bolt Spacing Horizontals in
L1 160.000-133.460				1	1	1		
L2 133.460-88.754				1	1	1		
L3 88.754-44.084				1	1	1		
L4 44.084-1.000				1	1	1		

Feed Line/Linear Appurtenances - Entered As Area

Description	Face or Leg	Allow Shield	Component Type	Placement ft	Total Number		C_AA_A ft^2/ft	Weight klf
HYBRIFLEX 1-5/8" (Verizon - Existing)	C	No	Inside Pole	160.000 - 4.000	2	No Ice	0.000	0.002
						1/2" Ice	0.000	0.002
EP65 (ELLIPTICAL AIR) (Verizon - Proposed)	C	No	Inside Pole	160.000 - 4.000	1	No Ice	0.000	0.001
						1/2" Ice	0.000	0.001
7/8	C	No	Inside Pole	160.000 - 4.000	2	No Ice	0.000	0.001
						1/2" Ice	0.000	0.001

Feed Line/Linear Appurtenances Section Areas

Tower Section	Tower Elevation ft	Face	A_R ft^2	A_F ft^2	C_AA_A In Face ft^2	C_AA_A Out Face ft^2	Weight K
L1	160.000-133.460	A	0.000	0.000	0.000	0.000	0.000
		B	0.000	0.000	0.000	0.000	0.000
		C	0.000	0.000	0.000	0.000	0.147
L2	133.460-88.754	A	0.000	0.000	0.000	0.000	0.000
		B	0.000	0.000	0.000	0.000	0.000
		C	0.000	0.000	0.000	0.000	0.248
L3	88.754-44.084	A	0.000	0.000	0.000	0.000	0.000
		B	0.000	0.000	0.000	0.000	0.000
		C	0.000	0.000	0.000	0.000	0.248
L4	44.084-1.000	A	0.000	0.000	0.000	0.000	0.000
		B	0.000	0.000	0.000	0.000	0.000
		C	0.000	0.000	0.000	0.000	0.222

Feed Line/Linear Appurtenances Section Areas - With Ice

Tower Section	Tower Elevation ft	Face or Leg	Ice Thickness in	A_R ft^2	A_F ft^2	C_AA_A In Face ft^2	C_AA_A Out Face ft^2	Weight K
L1	160.000-133.460	A	0.500	0.000	0.000	0.000	0.000	0.000
		B		0.000	0.000	0.000	0.000	0.000
		C		0.000	0.000	0.000	0.000	0.147
L2	133.460-88.754	A	0.500	0.000	0.000	0.000	0.000	0.000
		B		0.000	0.000	0.000	0.000	0.000
		C		0.000	0.000	0.000	0.000	0.248
L3	88.754-44.084	A	0.500	0.000	0.000	0.000	0.000	0.000
		B		0.000	0.000	0.000	0.000	0.000
		C		0.000	0.000	0.000	0.000	0.248
L4	44.084-1.000	A	0.500	0.000	0.000	0.000	0.000	0.000
		B		0.000	0.000	0.000	0.000	0.000
		C		0.000	0.000	0.000	0.000	0.222

Discrete Tower Loads

Description	Face or Leg	Offset Type	Offsets: Horz Lateral Vert ft ft ft	Azimuth Adjustment °	Placement ft		C_AA_A Front ft^2	C_AA_A Side ft^2	Weight K
BXA-171063-12CF	A	From Face	3.500	0.000	160.000	No Ice	4.791	3.618	0.015
(Verizon - Existing)			6.000			1/2" Ice	5.242	4.058	0.042
			0.000						
BXA-70063/6CF	A	From Face	3.500	0.000	160.000	No Ice	7.731	4.158	0.012
(Verizon - Existing)			0.000			1/2" Ice	8.268	4.595	0.054
			0.000						
BXA-171063-12CF	A	From Face	3.500	0.000	160.000	No Ice	4.791	3.618	0.015
(Verizon - Existing)			-4.000			1/2" Ice	5.242	4.058	0.042
			0.000						
BXA-70063/6CF	A	From Face	3.500	0.000	160.000	No Ice	7.731	4.158	0.012
(Verizon - Existing)			-6.000			1/2" Ice	8.268	4.595	0.054
			0.000						
BXA-171063-12CF	B	From Face	3.500	0.000	160.000	No Ice	4.791	3.618	0.015
(Verizon - Existing)			6.000			1/2" Ice	5.242	4.058	0.042

Description	Face or Leg	Offset Type	Offsets: Horz Lateral Vert ft ft ft	Azimuth Adjustment °	Placement ft		C_AA_A Front ft^2	C_AA_A Side ft^2	Weight K
			0.000						
BXA-70063/6CF	B	From Face	3.500	0.000	160.000	No Ice	7.731	4.158	0.012
(Verizon - Existing)			0.000			1/2" Ice	8.268	4.595	0.054
			0.000						
BXA-171063-12CF	B	From Face	3.500	0.000	160.000	No Ice	4.791	3.618	0.015
(Verizon - Existing)			-4.000			1/2" Ice	5.242	4.058	0.042
			0.000						
BXA-70063/6CF	B	From Face	3.500	0.000	160.000	No Ice	7.731	4.158	0.012
(Verizon - Existing)			-6.000			1/2" Ice	8.268	4.595	0.054
			0.000						
SACP 2X5516	C	From Face	3.500	0.000	160.000	No Ice	5.281	3.675	0.016
(Verizon - Existing)			6.000			1/2" Ice	5.711	4.034	0.050
			0.000						
SLCP 2x6015	C	From Face	3.500	0.000	160.000	No Ice	10.481	8.235	0.030
(Verizon - Existing)			0.000			1/2" Ice	11.075	8.809	0.101
			0.000						
SACP 2X5516	C	From Face	3.500	0.000	160.000	No Ice	5.281	3.675	0.016
(Verizon - Existing)			-4.000			1/2" Ice	5.711	4.034	0.050
			0.000						
BXA-70063/6CF	C	From Face	3.500	0.000	160.000	No Ice	7.731	4.158	0.012
(Verizon - Existing)			-6.000			1/2" Ice	8.268	4.595	0.054
			0.000						
RRH2x40-07-U	A	From Face	3.500	0.000	160.000	No Ice	2.246	1.228	0.050
(Verizon - Existing)			4.000			1/2" Ice	2.447	1.385	0.067
			0.000						
RRH2x40-07-U	B	From Face	3.500	0.000	160.000	No Ice	2.246	1.228	0.050
(Verizon - Existing)			4.000			1/2" Ice	2.447	1.385	0.067
			0.000						
RRH2x40-07-U	C	From Face	3.500	0.000	160.000	No Ice	2.246	1.228	0.050
(Verizon - Existing)			4.000			1/2" Ice	2.447	1.385	0.067
			0.000						
RC2DC-4750-PF-48	A	From Face	1.000	0.000	160.000	No Ice	3.517	2.292	0.025
(Verizon - Existing)			0.000			1/2" Ice	3.773	2.512	0.051
			0.000						
RC2DC-4750-PF-48	B	From Face	1.000	0.000	160.000	No Ice	3.517	2.292	0.025
(Verizon - Existing)			0.000			1/2" Ice	3.773	2.512	0.051
			0.000						
EEI SQ Low Profile Platform	C	None		0.000	159.000	No Ice	28.000	28.000	2.300
(Verizon - Existing)						1/2" Ice	33.000	33.000	3.155
MA0528-28AN	A	From Face	3.500	0.000	160.000	No Ice	5.415	0.397	0.011
(Verizon - Proposed)			-4.000			1/2" Ice	5.725	0.543	0.033
			0.000						
CO-40A	A	From Leg	3.500	0.000	160.000	No Ice	2.267	2.267	0.014
			0.000			1/2" Ice	3.705	3.705	0.032
			2.000						
DB436-C	B	From Leg	3.500	0.000	160.000	No Ice	0.450	0.450	0.007
			0.000			1/2" Ice	0.810	0.810	0.009
			2.000						

Tower Pressures - No Ice

$G_H = 1.690$

Section Elevation ft	z ft	K_Z	q_z ksf	A_G ft²	Face	A_F ft²	A_R ft²	A_{leg} ft²	Leg %	C_AA_A In Face ft²	C_AA_A Out Face ft²
L1	146.253	1.53	0.032	72.764	A	0.000	72.764	72.764	100.00	0.000	0.000
160.000-133.460					B	0.000	72.764		100.00	0.000	0.000
					C	0.000	72.764		100.00	0.000	0.000
L2	110.370	1.412	0.029	155.488	A	0.000	155.488	155.488	100.00	0.000	0.000
133.460-88.754					B	0.000	155.488		100.00	0.000	0.000
					C	0.000	155.488		100.00	0.000	0.000
L3	66.126	1.22	0.025	196.142	A	0.000	196.142	196.142	100.00	0.000	0.000
88.754-44.084					B	0.000	196.142		100.00	0.000	0.000
					C	0.000	196.142		100.00	0.000	0.000
L4	21.902	1	0.021	227.269	A	0.000	227.269	227.269	100.00	0.000	0.000
44.084-1.000					B	0.000	227.269		100.00	0.000	0.000
					C	0.000	227.269		100.00	0.000	0.000

Tower Pressure - With Ice

$G_H = 1.690$

Section Elevation ft	z ft	K_Z	q_z ksf	t_Z in	A_G ft²	Face	A_F ft²	A_R ft²	A_{leg} ft²	Leg %	C_AA_A In Face ft²	C_AA_A Out Face ft²
L1	146.253	1.53	0.024	0.500	74.975	A	0.000	74.975	74.975	100.00	0.000	0.000
160.000-133.460						B	0.000	74.975		100.00	0.000	0.000
						C	0.000	74.975		100.00	0.000	0.000
L2	110.370	1.412	0.022	0.500	159.213	A	0.000	159.213	159.213	100.00	0.000	0.000
133.460-88.754						B	0.000	159.213		100.00	0.000	0.000
						C	0.000	159.213		100.00	0.000	0.000
L3	66.126	1.22	0.019	0.500	199.865	A	0.000	199.865	199.865	100.00	0.000	0.000
88.754-44.084						B	0.000	199.865		100.00	0.000	0.000
						C	0.000	199.865		100.00	0.000	0.000
L4 44.084-1.000	21.902	1	0.016	0.500	230.859	A	0.000	230.859	230.859	100.00	0.000	0.000
						B	0.000	230.859		100.00	0.000	0.000
						C	0.000	230.859		100.00	0.000	0.000

Tower Pressure - Service

$G_H = 1.690$

Section Elevation ft	z ft	K_Z	q_z ksf	A_G ft²	Face	A_F ft²	A_R ft²	A_{leg} ft²	Leg %	C_AA_A In Face ft²	C_AA_A Out Face ft²
L1	146.253	1.53	0.010	72.764	A	0.000	72.764	72.764	100.00	0.000	0.000
160.000-133.460					B	0.000	72.764		100.00	0.000	0.000
					C	0.000	72.764		100.00	0.000	0.000
L2	110.370	1.412	0.009	155.488	A	0.000	155.488	155.488	100.00	0.000	0.000
133.460-88.754					B	0.000	155.488		100.00	0.000	0.000
					C	0.000	155.488		100.00	0.000	0.000
L3	66.126	1.22	0.008	196.142	A	0.000	196.142	196.142	100.00	0.000	0.000

Section Elevation ft	z ft	K_Z	q_z ksf	A_G ft²	Face	A_F ft²	A_R ft²	A_{leg} ft²	Leg %	C_AA_A In Face ft²	C_AA_A Out Face ft²
88.754-44.084					B	0.000	196.142		100.00	0.000	0.000
					C	0.000	196.142		100.00	0.000	0.000
L4	21.902	1	0.006	227.269	A	0.000	227.269	227.269	100.00	0.000	0.000
44.084-1.000					B	0.000	227.269		100.00	0.000	0.000
					C	0.000	227.269		100.00	0.000	0.000

Tower Forces - No Ice - Wind Normal To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft²	F K	w klf	Ctrl. Face
L1	0.147	2.919	A	1	0.65	1	1	1	72.764	2.536	0.096	C
160.000-133.4			B	1	0.65	1	1	1	72.764			
60			C	1	0.65	1	1	1	72.764			
L2	0.248	9.558	A	1	0.65	1	1	1	155.488	4.991	0.112	C
133.460-88.75			B	1	0.65	1	1	1	155.488			
4			C	1	0.65	1	1	1	155.488			
L3	0.248	14.184	A	1	0.65	1	1	1	196.142	5.421	0.121	C
88.754-44.084			B	1	0.65	1	1	1	196.142			
			C	1	0.65	1	1	1	196.142			
L4	0.222	19.087	A	1	0.65	1	1	1	227.269	5.180	0.120	C
44.084-1.000			B	1	0.65	1	1	1	227.269			
			C	1	0.65	1	1	1	227.269			
Sum Weight:	0.866	45.748						OTM	1375.581 kip-ft	18.128		

Tower Forces - No Ice - Wind 45 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft²	F K	w klf	Ctrl. Face
L1	0.147	2.919	A	1	0.65	1	1	1	72.764	2.536	0.096	C
160.000-133.4			B	1	0.65	1	1	1	72.764			
60			C	1	0.65	1	1	1	72.764			
L2	0.248	9.558	A	1	0.65	1	1	1	155.488	4.991	0.112	C
133.460-88.75			B	1	0.65	1	1	1	155.488			
4			C	1	0.65	1	1	1	155.488			
L3	0.248	14.184	A	1	0.65	1	1	1	196.142	5.421	0.121	C
88.754-44.084			B	1	0.65	1	1	1	196.142			
			C	1	0.65	1	1	1	196.142			
L4	0.222	19.087	A	1	0.65	1	1	1	227.269	5.180	0.120	C
44.084-1.000			B	1	0.65	1	1	1	227.269			
			C	1	0.65	1	1	1	227.269			
Sum Weight:	0.866	45.748						OTM	1375.581 kip-ft	18.128		

Tower Forces - No Ice - Wind 60 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L1	0.147	2.919	A	1	0.65	1	1	1	72.764	2.536	0.096	C
160.000-133.4			B	1	0.65	1	1	1	72.764			
60			C	1	0.65	1	1	1	72.764			
L2	0.248	9.558	A	1	0.65	1	1	1	155.488	4.991	0.112	C
133.460-88.75			B	1	0.65	1	1	1	155.488			
4			C	1	0.65	1	1	1	155.488			
L3	0.248	14.184	A	1	0.65	1	1	1	196.142	5.421	0.121	C
88.754-44.084			B	1	0.65	1	1	1	196.142			
			C	1	0.65	1	1	1	196.142			
L4	0.222	19.087	A	1	0.65	1	1	1	227.269	5.180	0.120	C
44.084-1.000			B	1	0.65	1	1	1	227.269			
			C	1	0.65	1	1	1	227.269			
Sum Weight:	0.866	45.748						OTM	1375.581 kip-ft	18.128		

Tower Forces - No Ice - Wind 90 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L1	0.147	2.919	A	1	0.65	1	1	1	72.764	2.536	0.096	C
160.000-133.4			B	1	0.65	1	1	1	72.764			
60			C	1	0.65	1	1	1	72.764			
L2	0.248	9.558	A	1	0.65	1	1	1	155.488	4.991	0.112	C
133.460-88.75			B	1	0.65	1	1	1	155.488			
4			C	1	0.65	1	1	1	155.488			
L3	0.248	14.184	A	1	0.65	1	1	1	196.142	5.421	0.121	C
88.754-44.084			B	1	0.65	1	1	1	196.142			
			C	1	0.65	1	1	1	196.142			
L4	0.222	19.087	A	1	0.65	1	1	1	227.269	5.180	0.120	C
44.084-1.000			B	1	0.65	1	1	1	227.269			
			C	1	0.65	1	1	1	227.269			
Sum Weight:	0.866	45.748						OTM	1375.581 kip-ft	18.128		

Tower Forces - With Ice - Wind Normal To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L1	0.147	3.466	A	1	0.65	1	1	1	74.975	1.960	0.074	C
160.000-133.4			B	1	0.65	1	1	1	74.975			
60			C	1	0.65	1	1	1	74.975			
L2	0.248	10.723	A	1	0.65	1	1	1	159.213	3.833	0.086	C
133.460-88.75			B	1	0.65	1	1	1	159.213			
4			C	1	0.65	1	1	1	159.213			
L3	0.248	15.651	A	1	0.65	1	1	1	199.865	4.143	0.093	C
88.754-44.084			B	1	0.65	1	1	1	199.865			

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
			C	1	0.65	1	1	1	199.865			
L4	0.222	20.783	A	1	0.65	1	1	1	230.859	3.946	0.092	C
44.084-1.000			B	1	0.65	1	1	1	230.859			
			C	1	0.65	1	1	1	230.859			
Sum Weight:	0.866	50.623						OTM	1056.201 kip-ft	13.882		

Tower Forces - With Ice - Wind 45 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L1	0.147	3.466	A	1	0.65	1	1	1	74.975	1.960	0.074	C
160.000-133.4			B	1	0.65	1	1	1	74.975			
60			C	1	0.65	1	1	1	74.975			
L2	0.248	10.723	A	1	0.65	1	1	1	159.213	3.833	0.086	C
133.460-88.75			B	1	0.65	1	1	1	159.213			
4			C	1	0.65	1	1	1	159.213			
L3	0.248	15.651	A	1	0.65	1	1	1	199.865	4.143	0.093	C
88.754-44.084			B	1	0.65	1	1	1	199.865			
			C	1	0.65	1	1	1	199.865			
L4	0.222	20.783	A	1	0.65	1	1	1	230.859	3.946	0.092	C
44.084-1.000			B	1	0.65	1	1	1	230.859			
			C	1	0.65	1	1	1	230.859			
Sum Weight:	0.866	50.623						OTM	1056.201 kip-ft	13.882		

Tower Forces - With Ice - Wind 60 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L1	0.147	3.466	A	1	0.65	1	1	1	74.975	1.960	0.074	C
160.000-133.4			B	1	0.65	1	1	1	74.975			
60			C	1	0.65	1	1	1	74.975			
L2	0.248	10.723	A	1	0.65	1	1	1	159.213	3.833	0.086	C
133.460-88.75			B	1	0.65	1	1	1	159.213			
4			C	1	0.65	1	1	1	159.213			
L3	0.248	15.651	A	1	0.65	1	1	1	199.865	4.143	0.093	C
88.754-44.084			B	1	0.65	1	1	1	199.865			
			C	1	0.65	1	1	1	199.865			
L4	0.222	20.783	A	1	0.65	1	1	1	230.859	3.946	0.092	C
44.084-1.000			B	1	0.65	1	1	1	230.859			
			C	1	0.65	1	1	1	230.859			
Sum Weight:	0.866	50.623						OTM	1056.201 kip-ft	13.882		

Tower Forces - With Ice - Wind 90 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft²	F K	w klf	Ctrl. Face
L1	0.147	3.466	A	1	0.65	1	1	1	74.975	1.960	0.074	C
160.000-133.4			B	1	0.65	1	1	1	74.975			
60			C	1	0.65	1	1	1	74.975			
L2	0.248	10.723	A	1	0.65	1	1	1	159.213	3.833	0.086	C
133.460-88.75			B	1	0.65	1	1	1	159.213			
4			C	1	0.65	1	1	1	159.213			
L3	0.248	15.651	A	1	0.65	1	1	1	199.865	4.143	0.093	C
88.754-44.084			B	1	0.65	1	1	1	199.865			
			C	1	0.65	1	1	1	199.865			
L4	0.222	20.783	A	1	0.65	1	1	1	230.859	3.946	0.092	C
44.084-1.000			B	1	0.65	1	1	1	230.859			
			C	1	0.65	1	1	1	230.859			
Sum Weight:	0.866	50.623						OTM	1056.201 kip-ft	13.882		

Tower Forces - Service - Wind Normal To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft²	F K	w klf	Ctrl. Face
L1	0.147	2.919	A	1	0.65	1	1	1	72.764	0.783	0.029	C
160.000-133.4			B	1	0.65	1	1	1	72.764			
60			C	1	0.65	1	1	1	72.764			
L2	0.248	9.558	A	1	0.65	1	1	1	155.488	1.541	0.034	C
133.460-88.75			B	1	0.65	1	1	1	155.488			
4			C	1	0.65	1	1	1	155.488			
L3	0.248	14.184	A	1	0.65	1	1	1	196.142	1.673	0.037	C
88.754-44.084			B	1	0.65	1	1	1	196.142			
			C	1	0.65	1	1	1	196.142			
L4	0.222	19.087	A	1	0.65	1	1	1	227.269	1.599	0.037	C
44.084-1.000			B	1	0.65	1	1	1	227.269			
			C	1	0.65	1	1	1	227.269			
Sum Weight:	0.866	45.748						OTM	424.562 kip-ft	5.595		

Tower Forces - Service - Wind 45 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft²	F K	w klf	Ctrl. Face
L1	0.147	2.919	A	1	0.65	1	1	1	72.764	0.783	0.029	C
160.000-133.4			B	1	0.65	1	1	1	72.764			
60			C	1	0.65	1	1	1	72.764			
L2	0.248	9.558	A	1	0.65	1	1	1	155.488	1.541	0.034	C
133.460-88.75			B	1	0.65	1	1	1	155.488			
4			C	1	0.65	1	1	1	155.488			

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L3	0.248	14.184	A	1	0.65	1	1	1	196.142	1.673	0.037	C
88.754-44.084			B	1	0.65	1	1	1	196.142			
			C	1	0.65	1	1	1	196.142			
L4	0.222	19.087	A	1	0.65	1	1	1	227.269	1.599	0.037	C
44.084-1.000			B	1	0.65	1	1	1	227.269			
			C	1	0.65	1	1	1	227.269			
Sum Weight:	0.866	45.748						OTM	424.562 kip-ft	5.595		

Tower Forces - Service - Wind 60 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L1	0.147	2.919	A	1	0.65	1	1	1	72.764	0.783	0.029	C
160.000-133.4			B	1	0.65	1	1	1	72.764			
60			C	1	0.65	1	1	1	72.764			
L2	0.248	9.558	A	1	0.65	1	1	1	155.488	1.541	0.034	C
133.460-88.75			B	1	0.65	1	1	1	155.488			
4			C	1	0.65	1	1	1	155.488			
L3	0.248	14.184	A	1	0.65	1	1	1	196.142	1.673	0.037	C
88.754-44.084			B	1	0.65	1	1	1	196.142			
			C	1	0.65	1	1	1	196.142			
L4	0.222	19.087	A	1	0.65	1	1	1	227.269	1.599	0.037	C
44.084-1.000			B	1	0.65	1	1	1	227.269			
			C	1	0.65	1	1	1	227.269			
Sum Weight:	0.866	45.748						OTM	424.562 kip-ft	5.595		

Tower Forces - Service - Wind 90 To Face

Section Elevation ft	Add Weight K	Self Weight K	Face	e	C_F	R_R	D_F	D_R	A_E ft^2	F K	w klf	Ctrl. Face
L1	0.147	2.919	A	1	0.65	1	1	1	72.764	0.783	0.029	C
160.000-133.4			B	1	0.65	1	1	1	72.764			
60			C	1	0.65	1	1	1	72.764			
L2	0.248	9.558	A	1	0.65	1	1	1	155.488	1.541	0.034	C
133.460-88.75			B	1	0.65	1	1	1	155.488			
4			C	1	0.65	1	1	1	155.488			
L3	0.248	14.184	A	1	0.65	1	1	1	196.142	1.673	0.037	C
88.754-44.084			B	1	0.65	1	1	1	196.142			
			C	1	0.65	1	1	1	196.142			
L4	0.222	19.087	A	1	0.65	1	1	1	227.269	1.599	0.037	C
44.084-1.000			B	1	0.65	1	1	1	227.269			
			C	1	0.65	1	1	1	227.269			
Sum Weight:	0.866	45.748						OTM	424.562 kip-ft	5.595		

Force Totals

Load Case	Vertical Forces K	Sum of Forces X K	Sum of Forces Z K	Sum of Overturning Moments, M_x kip-ft	Sum of Overturning Moments, M_z kip-ft	Sum of Torques kip-ft
Leg Weight	45.748					
Bracing Weight	0.000					
Total Member Self-Weight	45.748			0.001	0.040	
Total Weight	49.328			0.001	0.040	
Wind 0 deg - No Ice		-0.120	-24.035	-2313.502	19.049	-0.637
Wind 30 deg - No Ice		12.029	-20.755	-1994.047	-1158.601	0.076
Wind 45 deg - No Ice		17.074	-16.911	-1622.451	-1648.365	0.438
Wind 60 deg - No Ice		20.955	-11.914	-1140.288	-2025.794	0.769
Wind 90 deg - No Ice		24.265	0.120	19.010	-2350.166	1.256
Wind 120 deg - No Ice		21.074	12.121	1173.215	-2044.803	1.407
Wind 135 deg - No Ice		17.243	17.080	1649.336	-1675.248	1.339
Wind 150 deg - No Ice		12.236	20.874	2013.058	-1191.525	1.180
Wind 180 deg - No Ice		0.120	24.035	2313.504	-18.968	0.637
Wind 210 deg - No Ice		-12.029	20.755	1994.049	1158.682	-0.076
Wind 225 deg - No Ice		-17.074	16.911	1622.454	1648.446	-0.438
Wind 240 deg - No Ice		-20.955	11.914	1140.291	2025.875	-0.769
Wind 270 deg - No Ice		-24.265	-0.120	-19.007	2350.247	-1.256
Wind 300 deg - No Ice		-21.074	-12.121	-1173.212	2044.883	-1.407
Wind 315 deg - No Ice		-17.243	-17.080	-1649.333	1675.328	-1.339
Wind 330 deg - No Ice		-12.236	-20.874	-2013.055	1191.606	-1.180
Member Ice	4.875					
Total Weight Ice	55.664			0.079	0.177	
Wind 0 deg - Ice		-0.093	-18.873	-1848.644	14.900	-0.466
Wind 30 deg - Ice		9.444	-16.298	-1593.601	-925.449	-0.052
Wind 45 deg - Ice		13.404	-13.279	-1296.755	-1316.477	0.167
Wind 60 deg - Ice		16.451	-9.356	-911.532	-1617.777	0.375
Wind 90 deg - Ice		19.049	0.093	14.802	-1876.576	0.702
Wind 120 deg - Ice		16.543	9.517	937.191	-1632.500	0.840
Wind 135 deg - Ice		13.535	13.410	1317.734	-1337.298	0.825
Wind 150 deg - Ice		9.605	16.390	1608.482	-950.950	0.754
Wind 180 deg - Ice		0.093	18.873	1848.802	-14.546	0.466
Wind 210 deg - Ice		-9.444	16.298	1593.758	925.803	0.052
Wind 225 deg - Ice		-13.404	13.279	1296.913	1316.831	-0.167
Wind 240 deg - Ice		-16.451	9.356	911.690	1618.131	-0.375
Wind 270 deg - Ice		-19.049	-0.093	-14.644	1876.930	-0.702
Wind 300 deg - Ice		-16.543	-9.517	-937.033	1632.854	-0.840
Wind 315 deg - Ice		-13.535	-13.410	-1317.576	1337.653	-0.825
Wind 330 deg - Ice		-9.605	-16.390	-1608.324	951.304	-0.754
Total Weight	49.328			0.001	0.040	
Wind 0 deg - Service		-0.037	-7.418	-714.043	5.907	-0.197
Wind 30 deg - Service		3.713	-6.406	-615.445	-357.565	0.024
Wind 45 deg - Service		5.270	-5.219	-500.756	-508.727	0.135
Wind 60 deg - Service		6.468	-3.677	-351.940	-625.217	0.237
Wind 90 deg - Service		7.489	0.037	5.868	-725.332	0.388
Wind 120 deg - Service		6.504	3.741	362.104	-631.084	0.434
Wind 135 deg - Service		5.322	5.271	509.055	-517.024	0.413
Wind 150 deg - Service		3.777	6.443	621.315	-367.727	0.364
Wind 180 deg - Service		0.037	7.418	714.046	-5.827	0.197
Wind 210 deg - Service		-3.713	6.406	615.448	357.646	-0.024
Wind 225 deg - Service		-5.270	5.219	500.758	508.808	-0.135
Wind 240 deg - Service		-6.468	3.677	351.943	625.298	-0.237
Wind 270 deg - Service		-7.489	-0.037	-5.865	725.413	-0.388
Wind 300 deg - Service		-6.504	-3.741	-362.101	631.165	-0.434
Wind 315 deg - Service		-5.322	-5.271	-509.053	517.105	-0.413

Load Case	Vertical Forces K	Sum of Forces X K	Sum of Forces Z K	Sum of Overturning Moments, M_x kip-ft	Sum of Overturning Moments, M_z kip-ft	Sum of Torques kip-ft
Wind 330 deg - Service		-3.777	-6.443	-621.312	367.807	-0.364

Load Combinations

Comb. No.	Description
1	Dead Only
2	Dead+Wind 0 deg - No Ice
3	Dead+Wind 30 deg - No Ice
4	Dead+Wind 45 deg - No Ice
5	Dead+Wind 60 deg - No Ice
6	Dead+Wind 90 deg - No Ice
7	Dead+Wind 120 deg - No Ice
8	Dead+Wind 135 deg - No Ice
9	Dead+Wind 150 deg - No Ice
10	Dead+Wind 180 deg - No Ice
11	Dead+Wind 210 deg - No Ice
12	Dead+Wind 225 deg - No Ice
13	Dead+Wind 240 deg - No Ice
14	Dead+Wind 270 deg - No Ice
15	Dead+Wind 300 deg - No Ice
16	Dead+Wind 315 deg - No Ice
17	Dead+Wind 330 deg - No Ice
18	Dead+Ice+Temp
19	Dead+Wind 0 deg+Ice+Temp
20	Dead+Wind 30 deg+Ice+Temp
21	Dead+Wind 45 deg+Ice+Temp
22	Dead+Wind 60 deg+Ice+Temp
23	Dead+Wind 90 deg+Ice+Temp
24	Dead+Wind 120 deg+Ice+Temp
25	Dead+Wind 135 deg+Ice+Temp
26	Dead+Wind 150 deg+Ice+Temp
27	Dead+Wind 180 deg+Ice+Temp
28	Dead+Wind 210 deg+Ice+Temp
29	Dead+Wind 225 deg+Ice+Temp
30	Dead+Wind 240 deg+Ice+Temp
31	Dead+Wind 270 deg+Ice+Temp
32	Dead+Wind 300 deg+Ice+Temp
33	Dead+Wind 315 deg+Ice+Temp
34	Dead+Wind 330 deg+Ice+Temp
35	Dead+Wind 0 deg - Service
36	Dead+Wind 30 deg - Service
37	Dead+Wind 45 deg - Service
38	Dead+Wind 60 deg - Service
39	Dead+Wind 90 deg - Service
40	Dead+Wind 120 deg - Service
41	Dead+Wind 135 deg - Service
42	Dead+Wind 150 deg - Service
43	Dead+Wind 180 deg - Service
44	Dead+Wind 210 deg - Service
45	Dead+Wind 225 deg - Service
46	Dead+Wind 240 deg - Service
47	Dead+Wind 270 deg - Service
48	Dead+Wind 300 deg - Service
49	Dead+Wind 315 deg - Service

Comb. No.	Description
50	Dead+Wind 330 deg - Service

Maximum Member Forces

Section No.	Elevation ft	Component Type	Condition	Gov. Load Comb.	Force K	Major Axis Moment kip-ft	Minor Axis Moment kip-ft
L1	160 - 133.46	Pole	Max Tension	1	0.000	0.000	0.000
			Max. Compression	18	-7.038	0.177	-0.079
			Max. Mx	14	-4.966	153.192	2.604
			Max. My	10	-4.974	-2.555	-148.162
			Max. Vy	14	-8.255	153.192	2.604
			Max. Vx	10	8.022	-2.555	-148.162
			Max. Torque	7			-1.407
L2	133.46 - 88.754	Pole	Max Tension	1	0.000	0.000	0.000
			Max. Compression	18	-17.110	0.177	-0.079
			Max. Mx	14	-13.927	612.940	7.848
			Max. My	10	-13.935	-7.806	-597.762
			Max. Vy	14	-13.093	612.940	7.848
			Max. Vx	10	12.858	-7.806	-597.762
			Max. Torque	7			-1.407
L3	88.754 - 44.084	Pole	Max Tension	1	0.000	0.000	0.000
			Max. Compression	18	-31.920	0.177	-0.079
			Max. Mx	14	-27.413	1293.881	13.123
			Max. My	10	-27.418	-13.083	-1268.508
			Max. Vy	14	-18.327	1293.881	13.123
			Max. Vx	10	18.092	-13.083	-1268.508
			Max. Torque	7			-1.407
L4	44.084 - 1	Pole	Max Tension	1	0.000	0.000	0.000
			Max. Compression	18	-55.664	0.177	-0.079
			Max. Mx	14	-49.323	2377.734	19.276
			Max. My	10	-49.323	-19.236	-2340.479
			Max. Vy	14	-24.275	2377.734	19.276
			Max. Vx	10	24.044	-19.236	-2340.479
			Max. Torque	7			-1.406

Maximum Reactions

Location	Condition	Gov. Load Comb.	Vertical K	Horizontal, X K	Horizontal, Z K
Pole	Max. Vert	32	55.664	16.543	9.517
	Max. H_x	14	49.328	24.265	0.120
	Max. H_z	2	49.328	0.120	24.035
	Max. M_x	2	2340.477	0.120	24.035
	Max. M_z	6	2377.652	-24.265	-0.120
	Max. Torsion	15	1.406	21.074	12.121
	Min. Vert	48	49.328	6.504	3.741
	Min. H_x	6	49.328	-24.265	-0.120
	Min. H_z	10	49.328	-0.120	-24.035
	Min. M_x	10	-2340.479	-0.120	-24.035
	Min. M_z	14	-2377.734	24.265	0.120
	Min. Torsion	7	-1.406	-21.074	-12.121

Location	Condition	Gov. Load Comb.	Vertical K	Horizontal, X K	Horizontal, Z K

Tower Mast Reaction Summary

Load Combination	Vertical K	$Shear_x$ K	$Shear_z$ K	Overturning Moment, M_x kip-ft	Overturning Moment, M_z kip-ft	Torque kip-ft
Dead Only	49.328	0.000	0.011	0.014	0.040	0.000
Dead+Wind 0 deg - No Ice	49.328	-0.120	-24.035	-2340.477	19.318	-0.638
Dead+Wind 30 deg - No Ice	49.328	12.029	-20.755	-2017.275	-1172.115	0.075
Dead+Wind 45 deg - No Ice	49.328	17.074	-16.911	-1641.336	-1667.615	0.437
Dead+Wind 60 deg - No Ice	49.328	20.955	-11.914	-1153.542	-2049.467	0.768
Dead+Wind 90 deg - No Ice	49.328	24.265	0.120	19.278	-2377.652	1.256
Dead+Wind 120 deg - No Ice	49.328	21.074	12.121	1186.930	-2068.739	1.406
Dead+Wind 135 deg - No Ice	49.328	17.243	17.080	1668.595	-1694.873	1.339
Dead+Wind 150 deg - No Ice	49.328	12.236	20.874	2036.549	-1205.501	1.180
Dead+Wind 180 deg - No Ice	49.328	0.120	24.035	2340.479	-19.236	0.638
Dead+Wind 210 deg - No Ice	49.328	-12.029	20.755	2017.277	1172.198	-0.076
Dead+Wind 225 deg - No Ice	49.328	-17.074	16.911	1641.338	1667.698	-0.437
Dead+Wind 240 deg - No Ice	49.328	-20.955	11.914	1153.544	2049.550	-0.769
Dead+Wind 270 deg - No Ice	49.328	-24.265	-0.120	-19.276	2377.734	-1.256
Dead+Wind 300 deg - No Ice	49.328	-21.074	-12.121	-1186.929	2068.821	-1.406
Dead+Wind 315 deg - No Ice	49.328	-17.243	-17.080	-1668.593	1694.954	-1.339
Dead+Wind 330 deg - No Ice	49.328	-12.236	-20.874	-2036.547	1205.583	-1.180
Dead+Ice+Temp	55.664	0.000	0.000	0.079	0.177	0.000
Dead+Wind 0 deg+Ice+Temp	55.664	-0.093	-18.873	-1874.975	15.159	-0.469
Dead+Wind 30 deg+Ice+Temp	55.664	9.444	-16.298	-1616.278	-938.632	-0.055
Dead+Wind 45 deg+Ice+Temp	55.664	13.404	-13.279	-1315.194	-1335.254	0.165
Dead+Wind 60 deg+Ice+Temp	55.664	16.451	-9.356	-924.477	-1640.867	0.374
Dead+Wind 90 deg+Ice+Temp	55.664	19.049	0.093	15.057	-1903.383	0.703
Dead+Wind 120 deg+Ice+Temp	55.664	16.543	9.517	950.577	-1655.841	0.843
Dead+Wind 135 deg+Ice+Temp	55.664	13.535	13.410	1336.533	-1356.432	0.828
Dead+Wind 150 deg+Ice+Temp	55.664	9.605	16.390	1631.413	-964.571	0.757
Dead+Wind 180 deg+Ice+Temp	55.664	0.093	18.873	1875.137	-14.795	0.469
Dead+Wind 210 deg+Ice+Temp	55.664	-9.444	16.298	1616.440	938.997	0.055
Dead+Wind 225 deg+Ice+Temp	55.664	-13.404	13.279	1315.356	1335.619	-0.166
Dead+Wind 240 deg+Ice+Temp	55.664	-16.451	9.356	924.638	1641.232	-0.374
Dead+Wind 270 deg+Ice+Temp	55.664	-19.049	-0.093	-14.896	1903.747	-0.703
Dead+Wind 300 deg+Ice+Temp	55.664	-16.543	-9.517	-950.415	1656.205	-0.843
Dead+Wind 315 deg+Ice+Temp	55.664	-13.535	-13.410	-1336.372	1356.795	-0.828
Dead+Wind 330 deg+Ice+Temp	55.664	-9.605	-16.390	-1631.251	964.935	-0.757
Dead+Wind 0 deg - Service	49.328	-0.037	-7.418	-722.409	5.992	-0.197
Dead+Wind 30 deg - Service	49.328	3.713	-6.406	-622.649	-361.756	0.023
Dead+Wind 45 deg - Service	49.328	5.270	-5.219	-506.612	-514.697	0.135
Dead+Wind 60 deg - Service	49.328	6.468	-3.677	-356.051	-632.559	0.237
Dead+Wind 90 deg - Service	49.328	7.489	0.037	5.952	-733.858	0.388
Dead+Wind 120 deg - Service	49.328	6.504	3.741	366.360	-638.510	0.434
Dead+Wind 135 deg - Service	49.328	5.322	5.271	515.030	-523.112	0.414
Dead+Wind 150 deg - Service	49.328	3.777	6.443	628.602	-372.062	0.365
Dead+Wind 180 deg - Service	49.328	0.037	7.418	722.412	-5.909	0.197
Dead+Wind 210 deg - Service	49.328	-3.713	6.406	622.652	361.838	-0.023
Dead+Wind 225 deg - Service	49.328	-5.270	5.219	506.615	514.779	-0.135
Dead+Wind 240 deg - Service	49.328	-6.468	3.677	356.054	632.642	-0.237
Dead+Wind 270 deg - Service	49.328	-7.489	-0.037	-5.949	733.941	-0.388
Dead+Wind 300 deg - Service	49.328	-6.504	-3.741	-366.357	638.592	-0.434
Dead+Wind 315 deg - Service	49.328	-5.322	-5.271	-515.027	523.194	-0.413
Dead+Wind 330 deg - Service	49.328	-3.777	-6.443	-628.599	372.144	-0.364

Solution Summary

Load Comb.	Sum of Applied Forces PX K	PY K	PZ K	Sum of Reactions PX K	PY K	PZ K	% Error
1	0.000	-49.328	0.000	0.000	49.328	-0.011	0.023%
2	-0.120	-49.328	-24.035	0.120	49.328	24.035	0.000%
3	12.029	-49.328	-20.755	-12.029	49.328	20.755	0.000%
4	17.074	-49.328	-16.911	-17.074	49.328	16.911	0.000%
5	20.955	-49.328	-11.914	-20.955	49.328	11.914	0.000%
6	24.265	-49.328	0.120	-24.265	49.328	-0.120	0.000%
7	21.074	-49.328	12.121	-21.074	49.328	-12.121	0.000%
8	17.243	-49.328	17.080	-17.243	49.328	-17.080	0.000%
9	12.236	-49.328	20.874	-12.236	49.328	-20.874	0.000%
10	0.120	-49.328	24.035	-0.120	49.328	-24.035	0.000%
11	-12.029	-49.328	20.755	12.029	49.328	-20.755	0.000%
12	-17.074	-49.328	16.911	17.074	49.328	-16.911	0.000%
13	-20.955	-49.328	11.914	20.955	49.328	-11.914	0.000%
14	-24.265	-49.328	-0.120	24.265	49.328	0.120	0.000%
15	-21.074	-49.328	-12.121	21.074	49.328	12.121	0.000%
16	-17.243	-49.328	-17.080	17.243	49.328	17.080	0.000%
17	-12.236	-49.328	-20.874	12.236	49.328	20.874	0.000%
18	0.000	-55.664	0.000	0.000	55.664	0.000	0.000%
19	-0.093	-55.664	-18.873	0.093	55.664	18.873	0.000%
20	9.444	-55.664	-16.298	-9.444	55.664	16.298	0.000%
21	13.404	-55.664	-13.279	-13.404	55.664	13.279	0.000%
22	16.451	-55.664	-9.356	-16.451	55.664	9.356	0.000%
23	19.049	-55.664	0.093	-19.049	55.664	-0.093	0.000%
24	16.543	-55.664	9.517	-16.543	55.664	-9.517	0.000%
25	13.535	-55.664	13.410	-13.535	55.664	-13.410	0.000%
26	9.605	-55.664	16.390	-9.605	55.664	-16.390	0.000%
27	0.093	-55.664	18.873	-0.093	55.664	-18.873	0.000%
28	-9.444	-55.664	16.298	9.444	55.664	-16.298	0.000%
29	-13.404	-55.664	13.279	13.404	55.664	-13.279	0.000%
30	-16.451	-55.664	9.356	16.451	55.664	-9.356	0.000%
31	-19.049	-55.664	-0.093	19.049	55.664	0.093	0.000%
32	-16.543	-55.664	-9.517	16.543	55.664	9.517	0.000%
33	-13.535	-55.664	-13.410	13.535	55.664	13.410	0.000%
34	-9.605	-55.664	-16.390	9.605	55.664	16.390	0.000%
35	-0.037	-49.328	-7.418	0.037	49.328	7.418	0.000%
36	3.713	-49.328	-6.406	-3.713	49.328	6.406	0.000%
37	5.270	-49.328	-5.219	-5.270	49.328	5.219	0.000%
38	6.468	-49.328	-3.677	-6.468	49.328	3.677	0.000%
39	7.489	-49.328	0.037	-7.489	49.328	-0.037	0.000%
40	6.504	-49.328	3.741	-6.504	49.328	-3.741	0.000%
41	5.322	-49.328	5.271	-5.322	49.328	-5.271	0.000%
42	3.777	-49.328	6.443	-3.777	49.328	-6.443	0.000%
43	0.037	-49.328	7.418	-0.037	49.328	-7.418	0.000%
44	-3.713	-49.328	6.406	3.713	49.328	-6.406	0.000%
45	-5.270	-49.328	5.219	5.270	49.328	-5.219	0.000%
46	-6.468	-49.328	3.677	6.468	49.328	-3.677	0.000%
47	-7.489	-49.328	-0.037	7.489	49.328	0.037	0.000%
48	-6.504	-49.328	-3.741	6.504	49.328	3.741	0.000%
49	-5.322	-49.328	-5.271	5.322	49.328	5.271	0.000%
50	-3.777	-49.328	-6.443	3.777	49.328	6.443	0.000%

Non-Linear Convergence Results

Load Combination	Converged?	Number of Cycles	Displacement Tolerance	Force Tolerance
1	Yes	4	0.00000001	0.00012810
2	Yes	4	0.00000001	0.00002695
3	Yes	4	0.00000001	0.00014859
4	Yes	4	0.00000001	0.00017079
5	Yes	4	0.00000001	0.00013675
6	Yes	4	0.00000001	0.00004944
7	Yes	4	0.00000001	0.00018932
8	Yes	4	0.00000001	0.00018864
9	Yes	4	0.00000001	0.00014260
10	Yes	4	0.00000001	0.00002033
11	Yes	4	0.00000001	0.00014604
12	Yes	4	0.00000001	0.00017155
13	Yes	4	0.00000001	0.00016476
14	Yes	4	0.00000001	0.00004236
15	Yes	4	0.00000001	0.00014074
16	Yes	4	0.00000001	0.00018659
17	Yes	4	0.00000001	0.00018075
18	Yes	4	0.00000001	0.00000001
19	Yes	4	0.00000001	0.00037196
20	Yes	4	0.00000001	0.00045669
21	Yes	4	0.00000001	0.00048394
22	Yes	4	0.00000001	0.00045790
23	Yes	4	0.00000001	0.00037878
24	Yes	4	0.00000001	0.00047776
25	Yes	4	0.00000001	0.00049914
26	Yes	4	0.00000001	0.00046696
27	Yes	4	0.00000001	0.00037178
28	Yes	4	0.00000001	0.00045757
29	Yes	4	0.00000001	0.00048442
30	Yes	4	0.00000001	0.00046207
31	Yes	4	0.00000001	0.00037855
32	Yes	4	0.00000001	0.00046921
33	Yes	4	0.00000001	0.00049890
34	Yes	4	0.00000001	0.00047432
35	Yes	4	0.00000001	0.00000351
36	Yes	4	0.00000001	0.00000663
37	Yes	4	0.00000001	0.00000762
38	Yes	4	0.00000001	0.00000603
39	Yes	4	0.00000001	0.00000573
40	Yes	4	0.00000001	0.00001062
41	Yes	4	0.00000001	0.00000966
42	Yes	4	0.00000001	0.00000682
43	Yes	4	0.00000001	0.00000333
44	Yes	4	0.00000001	0.00000641
45	Yes	4	0.00000001	0.00000768
46	Yes	4	0.00000001	0.00000831
47	Yes	4	0.00000001	0.00000550
48	Yes	4	0.00000001	0.00000709
49	Yes	4	0.00000001	0.00000950
50	Yes	4	0.00000001	0.00000972

Maximum Tower Deflections - Service Wind

Section No.	Elevation ft	Horz. Deflection in	Gov. Load Comb.	Tilt °	Twist °
L1	160 - 133.46	7.531	48	0.415	0.002
L2	138.544 - 88.754	5.714	48	0.384	0.001
L3	95.254 - 44.084	2.694	48	0.269	0.000
L4	51.918 - 1	0.794	48	0.140	0.000

Critical Deflections and Radius of Curvature - Service Wind

Elevation ft	Appurtenance	Gov. Load Comb.	Deflection in	Tilt °	Twist °	Radius of Curvature ft
160.000	BXA-171063-12CF	48	7.531	0.415	0.002	103453
159.000	EEI SQ Low Profile Platform	48	7.445	0.414	0.002	103453

Maximum Tower Deflections - Design Wind

Section No.	Elevation ft	Horz. Deflection in	Gov. Load Comb.	Tilt °	Twist °
L1	160 - 133.46	24.394	15	1.345	0.006
L2	138.544 - 88.754	18.508	15	1.245	0.003
L3	95.254 - 44.084	8.726	15	0.870	0.001
L4	51.918 - 1	2.573	15	0.455	0.000

Critical Deflections and Radius of Curvature - Design Wind

Elevation ft	Appurtenance	Gov. Load Comb.	Deflection in	Tilt °	Twist °	Radius of Curvature ft
160.000	BXA-171063-12CF	15	24.394	1.345	0.006	31991
159.000	EEI SQ Low Profile Platform	15	24.114	1.341	0.006	31991

Compression Checks

Pole Design Data

Section No.	Elevation ft	Size	L ft	L_u ft	Kl/r	F_a ksi	A in^2	Actual P K	Allow. P_a K	Ratio $\frac{P}{P_a}$
L1	160 - 133.46 (1)	TP36.45x29.35x0.313	26.540	0.000	0.0	39.000	34.495	-4.964	1345.300	0.004
L2	133.46 - 88.754 (2)	TP47.66x34.465x0.438	49.790	0.000	0.0	39.000	63.182	-13.926	2464.110	0.006
L3	88.754 - 44.084	TP58.6x45.062x0.5	51.170	0.000	0.0	39.000	88.915	-27.413	3467.710	0.008

Section No.	Elevation ft	Size	L ft	L_u ft	Kl/r	F_a ksi	A in^2	Actual P K	Allow. P_a K	Ratio $\frac{P}{P_a}$
L4	(3) 44.084 - 1 (4)	TP69x55.527x0.563	50.918	0.000	0.0	39.000	122.187	-49.323	4765.280	0.010

Pole Bending Design Data

Section No.	Elevation ft	Size	Actual M_x kip-ft	Actual f_{bx} ksi	Allow. F_{bx} ksi	Ratio $\frac{f_{bx}}{F_{bx}}$	Actual M_y kip-ft	Actual f_{by} ksi	Allow. F_{by} ksi	Ratio $\frac{f_{by}}{F_{by}}$
L1	160 - 133.46 (1)	TP36.45x29.35x0.313	154.179	6.257	39.000	0.160	0.000	0.000	39.000	0.000
L2	133.46 - 88.754 (2)	TP47.66x34.465x0.438	615.944	10.438	39.000	0.268	0.000	0.000	39.000	0.000
L3	88.754 - 44.084 (3)	TP58.6x45.062x0.5	1298.908	12.693	39.000	0.325	0.000	0.000	39.000	0.000
L4	44.084 - 1 (4)	TP69x55.527x0.563	2385.125	13.876	39.000	0.356	0.000	0.000	39.000	0.000

Pole Shear Design Data

Section No.	Elevation ft	Size	Actual V K	Actual f_v ksi	Allow. F_v ksi	Ratio $\frac{f_v}{F_v}$	Actual T kip-ft	Actual f_{vt} ksi	Allow. F_{vt} ksi	Ratio $\frac{f_{vt}}{F_{vt}}$
L1	160 - 133.46 (1)	TP36.45x29.35x0.313	8.302	0.241	26.000	0.019	1.407	0.028	26.000	0.001
L2	133.46 - 88.754 (2)	TP47.66x34.465x0.438	13.140	0.208	26.000	0.016	1.407	0.012	26.000	0.000
L3	88.754 - 44.084 (3)	TP58.6x45.062x0.5	18.373	0.207	26.000	0.016	1.406	0.007	26.000	0.000
L4	44.084 - 1 (4)	TP69x55.527x0.563	24.320	0.199	26.000	0.015	1.406	0.004	26.000	0.000

Pole Interaction Design Data

Section No.	Elevation ft	Ratio $\frac{P}{P_a}$	Ratio $\frac{f_{bx}}{F_{bx}}$	Ratio $\frac{f_{by}}{F_{by}}$	Ratio $\frac{f_v}{F_v}$	Ratio $\frac{f_{vt}}{F_{vt}}$	Comb. Stress Ratio	Allow. Stress Ratio	Criteria
L1	160 - 133.46 (1)	0.004	0.160	0.000	0.019	0.001	0.164 ✔	1.333	H1-3+VT ✔
L2	133.46 - 88.754 (2)	0.006	0.268	0.000	0.016	0.000	0.273 ✔	1.333	H1-3+VT ✔
L3	88.754 - 44.084 (3)	0.008	0.325	0.000	0.016	0.000	0.333 ✔	1.333	H1-3+VT ✔
L4	44.084 - 1 (4)	0.010	0.356	0.000	0.015	0.000	0.366 ✔	1.333	H1-3+VT ✔

Section Capacity Table

Section No.	Elevation ft	Component Type	Size	Critical Element	P K	$SF*P_{allow}$ K	% Capacity	Pass Fail
L1	160 - 133.46	Pole	TP36.45x29.35x0.313	1	-4.964	1793.285	12.3	Pass
L2	133.46 - 88.754	Pole	TP47.66x34.465x0.438	2	-13.926	3284.658	20.5	Pass
L3	88.754 - 44.084	Pole	TP58.6x45.062x0.5	3	-27.413	4622.457	25.0	Pass
L4	44.084 - 1	Pole	TP69x55.527x0.563	4	-49.323	6352.118	27.5	Pass
							Summary	
						Pole (L4)	27.5	Pass
						RATING =	**27.5**	**Pass**

Anchor Bolt and Base Plate Analysis:

Input Data:

Tower Reactions:

Overturning Moment =	$OM := 2385 \cdot ft \cdot kips$	(Input From tnxTower)
Shear Force =	$Shear := 24 \cdot kips$	(Input From tnxTower)
Axial Force =	$Axial := 49 \cdot kips$	(Input From tnxTower)

Anchor Bolt Data:

Use ASTM A615 Grade 75

Number of Anchor Bolts =	$N := 28$	(User Input)
Diameter of Bolt Circle =	$D_{bc} := 77 \cdot in$	(User Input)
Bolt "Column" Distance =	$l := 3.0 \cdot in$	(User Input)
Bolt Ultimate Strength =	$F_u := 100 \cdot ksi$	(User Input)
Bolt Yield Strength =	$F_y := 75 \cdot ksi$	(User Input)
Bolt Modulus =	$E := 29000 \cdot ksi$	(User Input)
Diameter of Anchor Bolts =	$D := 2.25 \cdot in$	(User Input)
Threads per Inch =	$n := 4.5$	(User Input)

Base Plate Data:

Use ASTM A572-GR50

Plate Yield Strength =	$Fy_{bp} := 50 \cdot ksi$	(User Input)
Base Plate Thickness =	$t_{bp} := 3 \cdot in$	(User Input)
Base Plate Diameter =	$D_{bp} := 83 \cdot in$	(User Input)
Outer Pole Diameter =	$D_{pole} := 69 \cdot in$	(User Input)

Geometric Layout Data:

Distance from Bolts to Centroid of Pole:

Radius of Bolt Circle =: $R_{bc} := \frac{D_{bc}}{2} = 38.5 \cdot in$

Distance to Bolts = $i := 1 .. N$

$$d_i := \left| \begin{array}{l} \theta \leftarrow 2 \cdot \pi \cdot \left(\frac{i}{N}\right) \\ d \leftarrow R_{bc} \cdot \sin(\theta) \end{array} \right.$$

$d_1 = 8.57 \cdot in$	$d_7 = 38.50 \cdot in$
$d_2 = 16.70 \cdot in$	$d_8 = 37.53 \cdot in$
$d_3 = 24.00 \cdot in$	$d_9 = 34.69 \cdot in$
$d_4 = 30.10 \cdot in$	$d_{10} = 30.10 \cdot in$
$d_5 = 34.69 \cdot in$	$d_{11} = 24.00 \cdot in$
$d_6 = 37.53 \cdot in$	etc.

Critical Distances For Bending in Plate:

Outer Pole Radius = $R_{pole} := \frac{D_{pole}}{2} = 34.5 \cdot in$

Moment Arms of Bolts about Neutral Axis = $MA_i := if\left(d_i \geq R_{pole}, d_i - R_{pole}, 0in\right)$

$MA_1 = 0.00 \cdot in$	$MA_7 = 4.00 \cdot in$
$MA_2 = 0.00 \cdot in$	$MA_8 = 3.03 \cdot in$
$MA_3 = 0.00 \cdot in$	$MA_9 = 0.19 \cdot in$
$MA_4 = 0.00 \cdot in$	$MA_{10} = 0.00 \cdot in$
$MA_5 = 0.19 \cdot in$	$MA_{11} = 0.00 \cdot in$
$MA_6 = 3.03 \cdot in$	etc

Effective Width of Baseplate for Bending = $B_{eff} := .8 \cdot 2 \cdot \sqrt{\left(\frac{D_{bp}}{2}\right)^2 - \left(\frac{D_{pole}}{2}\right)^2} = 36.9 \cdot in$

Anchor Bolt Analysis:

Calculated Anchor Bolt Properties:

Polar Moment of Inertia = $I_p := \sum_i (d_i)^2 = 2.075 \times 10^4 \cdot in^2$

Gross Area of Bolt = $A_g := \frac{\pi}{4} \cdot D^2 = 3.976 \cdot in^2$

Net Area of Bolt = $A_n := \frac{\pi}{4} \cdot \left(D - \frac{0.9743 \cdot in}{n}\right)^2 = 3.248 \cdot in^2$

Net Diameter = $D_n := \frac{2 \cdot \sqrt{A_n}}{\sqrt{\pi}} = 2.033 \cdot in$

Radius of Gyration of Bolt = $r := \frac{D_n}{4} = 0.508 \cdot in$

Section Modulus of Bolt = $S_x := \frac{\pi \cdot D_n^3}{32} = 0.826 \cdot in^3$

Check Anchor Bolt Tension Force:

Maximum Tensile Force = $T_{Max} := OM \cdot \frac{R_{bc}}{I_p} - \frac{Axial}{N} = 51.3 \cdot kips$

Allowable Tensile Force = $T_{ALL.Gross} := 1.333 \cdot (0.33 \cdot A_g \cdot F_u) = 174.9 \cdot kips$ (1.333 increase allowed per TIA/EIA)

$T_{ALL.Net} := 1.333 \cdot (0.60 \cdot A_n \cdot F_y) = 194.812 \cdot kips$ (1.333 increase allowed per TIA/EIA)

Bolt Tension % of Capacity = $\frac{T_{Max}}{T_{ALL.Net}} \cdot 100 = 26$ Bolts are "upset bolts". Use net area per AISC

Condition1 = $Condition1 := if\left(\frac{T_{Max}}{T_{ALL.Net}} \le 1.00, "OK", "Overstressed"\right)$

Condition1 = "OK"

Check Anchor Bolt Bending Stress:

Maximum Bending Moment = $M_x := \left(\frac{Shear}{N}\right) \cdot l = 0.214 \cdot ft \cdot kips$

Maximum Bending Stress = $f_{bx} := \frac{M_x}{S_x} = 3.1 \cdot ksi$

Allowable Bending Stress = $F_{bx} := 1.333 \cdot 0.6 \cdot F_y = 60 \cdot ksi$ (1.333 increase allowed per TIA/EIA)

Check Combined Stress Requirement:

Per ASCE Manual 72: "If the clearance between the base plate and concrete does not exceed two times the bolt diameter a bending stress analysis of the bolts is NOT normally required.

$$l := \begin{cases} l & \text{if } l > 2 \cdot D_n \\ 0 & \text{otherwise} \end{cases} = 0 \cdot in$$

$$f_{bx} := \begin{cases} f_{bx} & \text{if } l > 2 \cdot D_n \\ 0 & \text{otherwise} \end{cases} = 0 \cdot ksi$$

Check Anchor Bolt Compression/Combined Stress:

Maximum Compressive Force =

$$C_{Max} := OM \cdot \frac{R_{bc}}{I_p} + \frac{Axial}{N} = 54.8 \cdot kips$$

Maximum Compressive Stress =

$$f_a := \frac{C_{Max}}{A_n} = 16.9 \cdot ksi$$

$$K := 0.65$$

$$C_c := \sqrt{\frac{2 \cdot \pi^2 \cdot E}{F_y}} = 87.364$$

$$F_a := \begin{cases} \dfrac{\left[1 - \dfrac{\left(\frac{K \cdot l}{r}\right)^2}{2 \cdot C_c^2}\right] \cdot F_y}{\dfrac{5}{3} + \dfrac{3 \cdot \left(\frac{K \cdot l}{r}\right)}{8 \cdot C_c} - \dfrac{\left(\frac{K \cdot l}{r}\right)^3}{8 \cdot C_c^3}} & \text{if } \dfrac{K \cdot l}{r} \le C_c \\ \dfrac{12 \cdot \pi^2 \cdot E}{23 \cdot \left(\frac{K \cdot l}{r}\right)^2} & \text{if } \dfrac{K \cdot l}{r} > C_c \end{cases} = 45 \cdot ksi$$

Allowable Compressive Stress =

$$F_a := 1.333 \cdot F_a = 60 \cdot ksi$$

(1.333 increase allowed per TIA/EIA)

Combined Stress % of Capacity =

$$\left(\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}}\right) \cdot 100 = 28.2$$

Condition 2 =

$$Condition2 := \text{if}\left(\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} \le 1.00, \text{"OK"}, \text{"Overstressed"}\right)$$

Condition2 = "OK"

Base Plate Analysis:

Force from Bolts = $C_i := \frac{OM \cdot d_i}{I_p} + \frac{Axial}{N}$

$C_1 = 13.6 \cdot kips$	$C_7 = 54.8 \cdot kips$
$C_2 = 24.8 \cdot kips$	$C_8 = 53.5 \cdot kips$
$C_3 = 34.9 \cdot kips$	$C_9 = 49.6 \cdot kips$
$C_4 = 43.3 \cdot kips$	$C_{10} = 43.3 \cdot kips$
$C_5 = 49.6 \cdot kips$	$C_{11} = 34.9 \cdot kips$
$C_6 = 53.5 \cdot kips$	etc.

Maximum Bending Stress in Plate = $f_{bp} := \sum_i \frac{6 \cdot C_i \cdot MA_i}{\left(B_{eff} \cdot t_{bp}^2\right)} = 10.2 \cdot ksi$

Allowable Bending Stress in Plate = $F_{bp} := 1.33 \cdot 0.75 \cdot Fy_{bp} = 49.9 \cdot ksi$

Plate Bending Stress % of Capacity = $\frac{f_{bp}}{F_{bp}} \cdot 100 = 20.4$

Condition3 = $Condition3 := if\left(\frac{f_{bp}}{F_{bp}} < 1.00, "Ok", "Overstressed"\right)$

Condition3 = "Ok"

Rock Anchor Design:

Input Data:

Max Pier Reactions:

Moment =	$Moment := 2385 \cdot ft \cdot kips$	*user input*	
Shear =	$Shear := 24 \cdot kips$	*user input*	
Compression =	$Axial := 49 \cdot kips$	*user input*	

Structure:

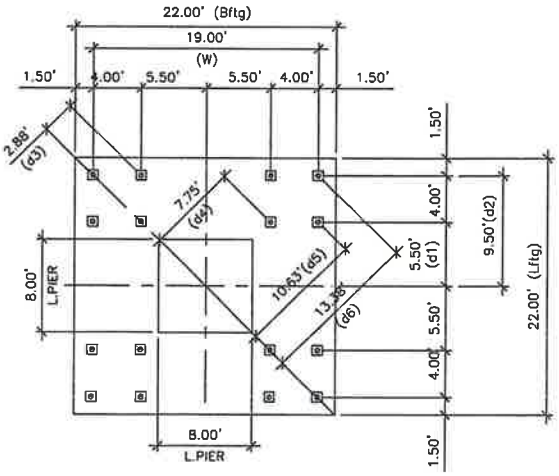
Footing Width =	$W_{ftg} := 22.0ft$	*user input*	
Footing Length =	$L_{ftg} := 22.0ft$	*user input*	
Footing Thickness =	$T_{ftg} := 4.0ft$	*user input*	
Pier Length=	$L_{pier} := 8.0ft$	*user input*	
Pier Depth =	$T_{pier} := 2.0ft$	*user input*	
Pier Projection Above Grade =	$P_p := 1.0 \cdot ft$	*user input*	

Depths:

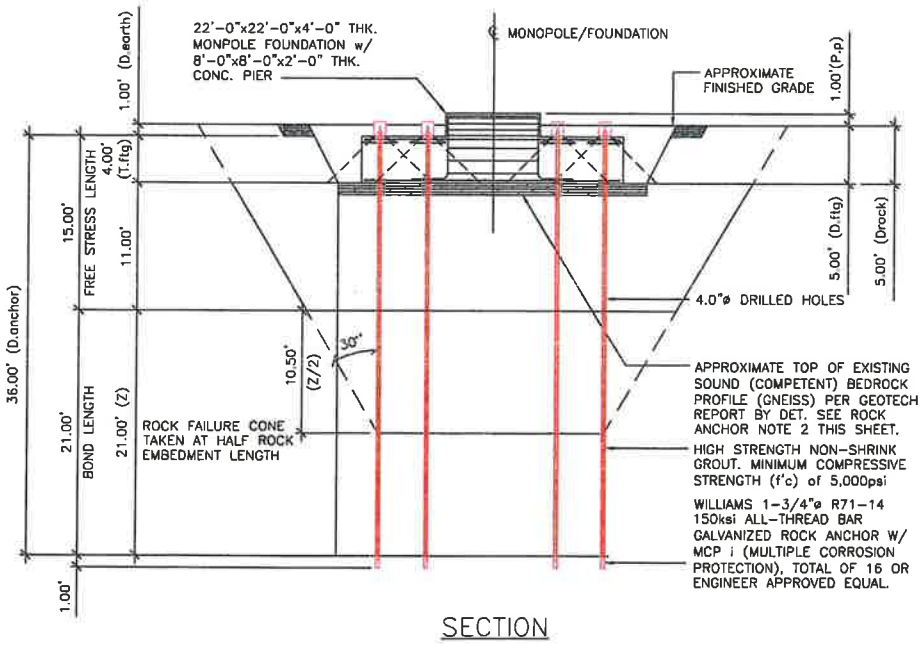
Depth to Bottom of Footing =	$D_{ftg} := 5.0ft$	*user input*	(from grade line)
Depth to Sound (Competent) Rock Per Geo-tech Report =	$D_{rock} := 5.0ft$	*user input*	(from grade line)
Depth to Suitable Earth =	$D_{earth} := 1.0ft$	*user input*	(from grade line)
Anchor Depth =	$D_{anchor} := 31.0ft$	*user input*	(from grade line)

Subgrade Properties:

Internal Friction Angle =	$\phi := 30deg$	*user input*	
Unit Weight of Earth =	$\gamma_{earth} := 120 \frac{lb}{ft^3}$	*user input*	
Unit Weight of Rock =	$\gamma_{rock} := 165 \frac{lb}{ft^3}$	*user input*	(RQD = 75% at -22.0ft BGL).
Unit Weight of Conc =	$\gamma_{conc} := 150 \frac{lb}{ft^3}$	*user input*	*(Based on Geo-technical Report prepared by Design Earth Technology (DET), dated August 23, 2012. Gneiss Bedrock with average RQD of 68% and average Uniaxial Compressive Strength of 12225psi at boring B-1.*
Ultimate Bearing =	$q_u := 90000 \cdot psf$	*user input*	
Allowable Bearing =	$q_s := \frac{q_u}{3.0} = 30000 \cdot psf$	*user input*	



PLAN (22'x22')



SECTION

Rock Anchor Foundation Geometry:

Rock Anchor Properties:

Number of Anchors (along width) =	$N_{anchor} := 4$	*user input*	
Hole Diameter =	$hole_d := 3.0in$	*user input*	
Ultimate Bond Stress Between Rock and Grout =	$\sigma_{bond} := 150 \cdot psi$	*user input*	
Allowable Bond Stress Between Rock and Grout =	$\sigma_{allbond} := \sigma_{bond} \cdot 0.5 = 75 psi$	*user input*	
Grout Allowable Compressive Stress =	$fc_g := 5000 \cdot psi$	*user input*	
Anchor Spacing* (along length) =	$S_{anchor} := 19.0ft$	*user input*	
Required Factor of Safety =	$F_S := 2.0$	*user input*	
Rock Anchor Ultimate Strength =	$Fu_{anchor} := 150.0ksi$	*user input*	Williams R71-14 1.75" dia. 150ksi
Rock Anchor Yield Strength =	$Fy_{anchor} := 127.7ksi$	*user input*	Per Recommendation of PTI For Prestressed Rock Soil and Soil Anchors Section 6.6 Design Load Should Be Designed so that the design load is not more than 60% of Specified Minimum Tensile Strength per Recommendation per PTI Section 6.6
Rock Anchor Diameter =	$d_{ra} := 1.375in$	*user input*	
Rock Anchor Area per Group =	$A_g := 1.580in^2$	*user input*	
Rock Anchor Ultimate Tensile Strength =	$P_u := 237kips$	*user input*	
Rock Anchor Allowable Tension =	$P_{all} := 0.60 \cdot P_u = 142.2 \cdot kips$		
Rock Anchor Maximum Working Load to Yield =	$T_y := 0.80 \cdot P_u = 189.6 \cdot kips$		
Rock Anchor Shear Capacity =	$Sh := 0.4 \cdot T_y = 75.84 \cdot kips$		
Number of Rock Anchors =	$n_{anchor} := 16$	*user input*	

Rock Anchor Tension/Shear Check:

Overturning Moment =	$OM := Moment + Shear \cdot (T_{ftg} + T_{pier}) = 2529 \cdot ft \cdot kips$
Weight of Pad =	$W_{pad} := (W_{ftg} \cdot L_{ftg} \cdot T_{ftg}) \cdot \gamma_{conc} = 290.4 \cdot kips$
Weight of Pier =	$W_{pier} := (L_{pier}^2 \cdot T_{pier}) \cdot \gamma_{conc} = 19.2 \cdot kips$
Weight of Soil =	$W_{soil} := \left[\left[(W_{ftg} \cdot L_{ftg}) - L_{pier}^2\right] \cdot D_{earth}\right] \cdot \gamma_{earth} = 50.4 \cdot kips$
Total Weight =	$W_{conc} := W_{pad} + W_{pier} + W_{soil} = 360 \cdot kips$
Total Weight of Foundation =	$W_{tot} := W_{conc} + Axial = 409 \cdot kips$
Resisting Moment =	$M_r := W_{tot} \cdot \left(\frac{W_{ftg}}{2}\right) = 4499 ft \cdot kips$
Moment Required w/ F.O.S of 2.0 =	$M_{reqd} := OM \cdot (F_S) = 5058 ft \cdot kips$
Net Moment Required =	$M_{net} := M_{reqd} - M_r = 559 ft \cdot kips$

Check Perpendicular About Foundation Toe

Rock Anchor Distance 1 = $d_1 := 5.50 \cdot ft$ *user input*

Rock Anchor Distance 2 = $d_2 := 9.50 \cdot ft$ *user input*

Number of Rock Anchors in Group 1 = $n_1 := 8$ *user input*

Number of Rock Anchors in Group 2 = $n_2 := 8$ *user input*

Polar Moment of Inertia = $I_{p1} := d_1^2 \cdot n_1 + d_2^2 \cdot n_2 = 964 ft^2$

Tension Force per Anchor = $P_{design.perp} := \frac{d_2}{I_{p1}} \cdot (M_{net}) = 5.5 \cdot kips$

Check @ 45 Degree Angle About Foundation Toe

Rock Anchor Distance 1 = $d_3 := 2.88 \cdot ft$ *user input*

Rock Anchor Distance 2 = $d_4 := 7.75 \cdot ft$ *user input*

Rock Anchor Distance 2 = $d_5 := 10.63 \cdot ft$ *user input*

$d_6 := 13.38 \cdot ft$ *user input*

Number of Rock Anchors in Group = $n_3 := 4$ *user input*

$n_4 := 2$ *user input*

$n_5 := 4$ *user input*

$n_6 := 2$ *user input*

Polar Moment of Inertia = $I_{p2} := d_3^2 \cdot n_3 + d_4^2 \cdot n_4 + d_5^2 \cdot n_5 + d_6^2 \cdot n_6 = 963.34 ft^2$

Tension Force per Anchor = $P_{design.diag} := \frac{d_6}{I_{p2}} \cdot (M_{net}) = 7.8 \cdot kips$

Design Tension Force per Anchor = $P_{design} := (P_{design.perp}) = 5.5 \cdot kips$

Proof Load Rock Anchors To 1.33x Design Load for Working Loads or Maximum of 0.8x Ultimate Design Load =

$P_{Lreqd} := P_{design} \cdot 1.33 = 7.3 \cdot kips$ $L_{Lreqd} := P_{design} \cdot 1.10 = 6.1 \cdot kips$

$P_{Lmax} := P_u \cdot 0.80 = 189.6 \cdot kips$ $L_{Lmax} := P_u \cdot 0.60 = 142.2 \cdot kips$

Check Anchor Design Load Against Max Allowable Tensile Load =

$TensionCheck1 := \max(P_{Lmax}, P_{Lreqd}) = 189.6 \cdot kips$

$TensionCheck2 := \max(L_{Lmax}, L_{Lreqd}) = 142.2 \cdot kips$

$TensionCondition1 := if(P_{Lreqd} \le P_{Lmax}, "OK", "IncreaseAnchorDia") = "OK"$

$TensionCondition2 := if(L_{Lreqd} \le L_{Lmax}, "OK", "IncreaseAnchorDia") = "OK"$

Provided Safety Factor = $\frac{P_{design}}{P_{all}} = 0.04$

$SafetyFactor := if\left(\frac{P_{design}}{P_{all}} \le 1.0, "OK", "Overstressed"\right)$

$SafetyFactor = "OK"$

Rock Anchor Req'd Development Length in Rock:

Minimum Free Stress Length Required = $F_{stressreqd} := 10.0ft$ *user input*

Minimum Free Stress Length Provided = $F_{stressprov} := 15.0ft$ *user input*

Controlling Free Stress Length: $L_f := if(F_{stressprov} > F_{stressreqd}, F_{stressprov}, F_{stressreqd})$ $L_f = 15ft$

Rock Anchor/Grout Bond Length: $L_d := \frac{\left(\frac{0.04}{in} P_u\right)}{\sqrt{fc_g \cdot psi}}$ $L_d = 11.17 \cdot ft$

Rock/Grout Bond Length: $L_b := \frac{P_u}{\pi \cdot hole_d \cdot \sigma_{bond}} = 13.97ft$

Controlling Length: $L_a := if(L_b < L_d, L_d, L_b)$ $L_a = 13.97ft$

$L_{bprov} := D_{anchor} - T_{ftg} = 27ft$

$Bond_Length_Check := if\left(\frac{L_a}{L_{bprov}} \le 1.00, "OK", "Increase\ Length"\right)$

$\frac{L_a}{L_{bprov}} = 0.52$ $\boxed{Bond_Length_Check = "OK"}$

Resistance Calculations:

Intermediate Dimension:

Total Anchor Width = $W := S_{anchor} = 19ft$

Volumes:

Base Area 1 of Resisting Pyramid = $B_1 := W^2 = 361ft^2$

Base Area 2 of Resisting Pyramid = $B_2 := \left[\tan(\phi) \cdot \left(L_{bprov} \cdot 0.5 + L_f - T_{ftg}\right) \cdot 2 + W\right]^2 = 2236.4ft^2$

Base Area 3 of Resisting Pyramid = $B_3 := \left[\tan(\phi) \cdot \left(L_{bprov} \cdot 0.5 + L_f\right) \cdot 2 + W\right]^2 = 2694.5ft^2$

Total Volume of Resisting Material = $V_{tot} := \frac{\left[\left[L_f + \left(L_{bprov} \cdot 0.5\right)\right] \cdot \left(B_1 + B_3 + \sqrt{B_1 \cdot B_3}\right)\right]}{3} = 38397.2 \cdot ft^3$

Volume of Rock = $V_{rock} := \frac{\left[\left(L_{bprov} \cdot 0.5 + L_f - T_{ftg}\right) \cdot \left(B_1 + B_2 + \sqrt{B_1 \cdot B_2}\right)\right]}{3} = 28549.6 \cdot ft^3$

Volume of Concrete = $V_{conc} := \left(W_{ftg} \cdot L_{ftg} \cdot T_{ftg}\right) + \left(L_{pier}^2 \cdot T_{pier}\right) = 2064 \cdot ft^3$

Volume of Earth = $V_{earth} := V_{tot} - V_{rock} - V_{conc} = 7783.6 \cdot ft^3$

Resisting Forces:

Resisting Rock Force = $W_{rock} := V_{rock} \cdot \gamma_{rock} = 4710.7 \cdot kips$

Resisting Earth Force = $W_{earth} := V_{earth} \cdot \gamma_{earth} = 934 \cdot kips$

Resisting Concrete Force = $W_{conc} = 360 \cdot kips$

Total Resisting Force = $W_{total} := W_{rock} + W_{earth} + W_{conc} = 6004.7 \cdot kips$

Foundation Uplift Check:

Check Perpendicular to Foundation =

Uplift Force = $Uplift_{perp} := \dfrac{OM}{\left(\dfrac{W_{ftg}}{2}\right)} = 229.9 \cdot kips$

Factor of Safety = $\dfrac{W_{total}}{Uplift_{perp}} = 26.12$

$Uplift_Perp_Check := if\left(\dfrac{W_{total}}{Uplift_{perp}} \geq F_S, "OK", "Overstressed"\right)$

Uplift_Perp_Check = "OK"

Check @ 45 Degree Angle to Foundation =

Uplift Force = $Uplift_{Diag} := \dfrac{OM}{\dfrac{\left(\sqrt{2} \cdot L_{ftg}\right)}{2}} = 162.6 \cdot kips$

Factor of Safety = $\dfrac{W_{total}}{Uplift_{Diag}} = 36.94$

$Uplift_Diag_Check := if\left(\dfrac{W_{total}}{Uplift_{Diag}} \geq F_S, "OK", "Overstressed"\right)$

Uplift_Diag_Check = "OK"

Rock Bearing Capacity Check:

Bearing Force = $MaxBearing := \left[\dfrac{\left(Axial + W_{conc}\right) + \left(n_{anchor} L_{Lreqd}\right)}{W_{ftg} \cdot L_{ftg}}\right] + \dfrac{OM}{\left(\dfrac{W_{ftg}^3}{6}\right)}$

$MaxBearing = 2.47 \cdot ksf$

$\dfrac{MaxBearing}{q_s} = 0.08$

$Rock_Bearing_Check := if\left(\dfrac{MaxBearing}{q_s} \leq 1.00, "OK", "Overstressed"\right)$

Rock_Bearing_Check = "OK"

Technical Data Sheet **MA0528-28AN**

Flat Panel Antenna, Single Polarized, 2 ft, 28 dBi

Product Description
(Only available in North America)

Radio Frequency Systems? new flat panel antennas are especially designed to serve license-free ISM, Spread Spectrum and UNII band applications in 2.4 GHz and 5.2-5.8 GHz.Because of their new, simpler, lightweight construction, these antennas meet the need for an aesthetically pleasing antenna with superior pattern characteristics. New flat panel antennas are lower in profile and weigh significantly less, for easier handling, reduced tower loading and lower shipping cost, and are an attractive solution for both point to point and point to multi point applications.Ideal for point-to-point and point-to-multipoint applications, these new antennas have been rigorously tested to meet extremely stringent environmental specifications for safe and reliable long-term operation. Their cost effective design translates into an outstanding value for the user.

Antenna

Features/Benefits

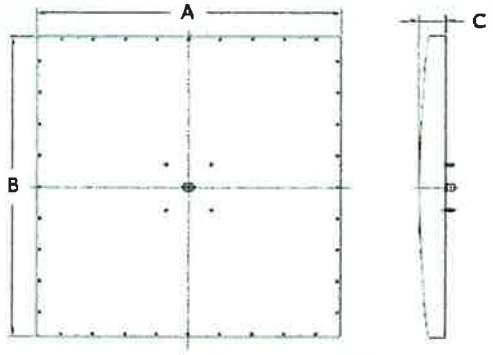
Technical Features

Product Type	Point to point antennas, Broadband Wireless Antennas
Frequency, GHz	5.15 - 5.35, 5.725 - 5.875
Profile	Flat Panel
Antenna color	White
Swaybar	0: (not applicable)
optional Swaybar	0: (not applicable)
Performance	Standard
Polarization	Single
Regulatory Compliance	ETSI EN 302085 V1.1.2 TS1-TS5
3dB beamwidth, (degrees)	4.5
Antenna Input	N Female
Mid Band Gain, dBi	28
F/B Ratio, dB	45
XPD, dB	28
Max VSWR / R L, dB	1.5 (14) @5.15 - 5.35 GHz, 1.7 (12) @5.725 - 5.85 GHz
Elevation Adjustment, degrees	-10
Azimuth Adjustment, degrees	360
Radome	rigid
Radome Material	Plastic
Mounting Pipe Diameter minimum, mm (in)	68 (2.75)
Mounting Pipe Diameter maximum, mm (in)	100 (4)
Approximate Weight, kg (lb)	5 (11)

All information contained in the present datasheet is subject to confirmation at time of ordering

Flat Panel Antenna, Single Polarized, 2 ft, 28 dBi

Dimensions	mm (in)
A	600 (23.6)
B	600 (23.6)
C	35 (1.4)



Notes

no notes

Documentation

Radiation pattern: (ADF)
Radiation pattern: (NSMA format)
Radiation pattern: (PDF format)

All information contained in the present datasheet is subject to confirmation at time of ordering

FLEXWELL® Premium Elliptical Waveguide

Product Description

FLEXWELL® elliptical waveguide is constructed of longitudinally continuous seam welded, highly conductive copper tube, corrugated and precision formed into an elliptical cross section. It is manufactured in continuous lengths using a special seam welding process developed by the RFS organization.

The corrugation design achieves high transverse stability, flexibility and crush strength for superior handling and forming at an installation. The inherent strength and flexibility of FLEXWELL waveguide allows on location, a continuous length of waveguide to be run directly from a tower-mounted antenna to the equipment building, eliminating flange joint discontinuities and the use of bends, twists and flex sections associated with a rigid rectangular waveguide system. Because of its flexibility, FLEXWELL elliptical waveguide can be easily transported to an installation site in coils or on reels and then uncoiled as required during installation.

FLEXWELL elliptical waveguide has set an industry standard for excellent electrical performance. Each waveguide has been carefully designed for low loss and low VSWR in specific frequency bands. For optimum system performance, there is no substitute for FLEXWELL waveguide.

As part of the RFS manufacturing process, all elliptical waveguides undergo several different electrical tests. Prior to shipping, every length is 100% tested again for input VSWR, and undergoes a twenty-four hour pressure test. This additional testing is performed to guarantee conformance with published specifications and to avoid any problems in the field.

A FLEXWELL elliptical waveguide feeder requires less planning and reduces installation costs when compared to a feeder system using a rigid rectangular waveguide. FLEXWELL waveguide is available cut to length with factory attached connectors or in continuous lengths for termination in the field.

Features/Benefits

Technical Specifications

Typical Operating Band, GHz	5.9 - 7.125
Performance	Premium
Dimension over Jacket, mm (in)	51 x 30 (2.0 x 1.2)
Weight, kg/m (lb/ft)	0.75 (0.50)
Minimum Bending Radius E Plane, without rebending, mm (in)	200 (8)
Minimum Bending Radius H Plane, without rebending, mm (in)	500 (20)
Minimum Bending Radius E Plane, with rebending, mm (in)	300 (12)
Minimum Bending Radius H Plane, with rebending, mm (in)	600 (24)
Maximum Twist, degree/m (degree/ft)	5 (1.5)
Max. Operating Pressure, bar (psi)	0.5 (7)
Max. Pulling Length per Hoisting Grip, m (ft)	100 (305)
Standard Hanger Spacing, m (ft)	0.9 (3)
Recommended Installation Temperature Range, °C (°F)	-40 to +60 (-40 to +140)
Max. VSWR / Return Loss, dB	1.062 / 30.5
Cut-off Frequency, GHz	4.01

Notes

VSWR values include connectors and are valid for frequency band of connectors.

Max. Operating Band: 5.00 - 7.125 GHz

Other Documentation

All information contained in the present datasheet is subject to confirmation at time of ordering

FLEXWELL® Premium Elliptical Waveguide

E65/EP65

ATTENUATION, AVERAGE POWER, GROUP VELOCITY, GROUP DELAY

Frequency GHz	Attenuation dB / 100 m (ft)	Avg. Pow. kW	Group Vel. %c	Group Delay ns/100 m (ft)
5.90	4.92 (1.50)	4.82	73.4	454.7 (138.6)
6.00	4.84 (1.47)	4.90	74.4	448.4 (136.7)
6.10	4.76 (1.45)	4.99	75.4	442.6 (134.9)
6.20	4.69 (1.43)	5.06	76.3	437.4 (133.3)
6.30	4.62 (1.41)	5.13	77.1	432.5 (131.8)
6.40	4.56 (1.39)	5.19	77.9	428.0 (130.5)
6.50	4.51 (1.37)	5.26	78.7	423.8 (129.2)
6.60	4.46 (1.36)	5.32	79.4	420.0 (128.0)
6.70	4.41 (1.34)	5.37	80.1	416.4 (126.9)
6.80	4.37 (1.33)	5.42	80.8	413.0 (125.9)
6.90	4.33 (1.32)	5.47	81.4	409.9 (124.9)
7.00	4.29 (1.31)	5.52	82.0	407.0 (124.0)
7.125	4.25 (1.30)	5.59	82.7	403.5 (123.0)

For attenuation: VSWR 1.0, ambient temperature 20° C (68° F).

For average power: VSWR 1.0 and 42° C (76° F) temperature rise over 40° C (104° F) ambient.

Attenuation, Average Power, Group Velocity, Group Delay

All information contained in the present datasheet is subject to confirmation at time of ordering