STRUCTURAL ANALYSIS REPORT
WATER TANK

Prepared For:

T-Mobile

One Ravinia Drive, Suite 1000
Atlanta, GA 30346

T-Mobile Site Name: Roswell Water Tower
Site No: 9AT0058A
808 Community Circle
Roswell, GA 30075
Lat: 34.020605°, Long:-84.360053°

Compass Job No.: 100396AE September 12, 2012

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1.0 SUBJECT AND REFERENCES

The purpose of this analysis is to evaluate the structural capacity of the existing water tank located at 808 Community Circle, Roswell, GA, 30075 for the additions proposed by T-Mobile.

1.1 STRUCTURE

The 122,000 gallon tank is elevated by (4) braced legs. The overall height of the tank is 170 feet above the ground line (AGL). The tank diameter is approximately 25 feet and the reservoir is approximately 50 feet high. There are (9) T-Mobile Panel Antennas and (15) existing antennas attached to the handrail. There are also (2) Microwaves on the leg of the structure.

2.0 PROPOSED ADDITIONS

T-Mobile proposed configuration is as following

RAD CENTER (FT) CARRIER	ANTENNA, RRU, TMA & OVP	MOUNT	FEED LINES
138 T-Mobile	(6) RFS – APX17DWV (3) RFS – APXV18 *(3) Nokia – FXFB *(3) Nokia – FRIG *(3) RFS – ATMAA1412D-1A20 **(3) Nokia – ASU9338TYP01	(9) Existing Railing Pipe Mounts	(12) 1-5/8” Coax Cables + (3) 1.58” Hybrid Cable

*RRUs and TMAs to be placed behind the antennas to minimize the wind loads
** COVPs to be placed on vertical members of the existing handrail, adjacent to antennas.

3.0 CODES AND LOADING

The analysis and design is in accordance with:

- IBC 2006, with 2010 Georgia Amendments.
- ASCE 7-05, Minimum Design Loads for Building and Other Structures.
- AISC 360-05

The following load parameters were applied:

- V=90 mph, Exposure C, I=1.15
- Ss=0.30 g, S_1=0.10 g, I=1.5
- L=200 lbs, point load (on handrail)
- L=50 plf, distributed load (on handrail)

4.0 STANDARD CONDITIONS FOR ENGINEERING SERVICES ON EXISTING STRUCTURES

The analysis is based on the information provided to Compass and is assumed to be current and correct. Unless otherwise noted, the structure and the foundation system are assumed to be in good condition, free of defects and can achieve theoretical strength.

It is assumed that the structure has been maintained and shall be maintained during its service. The superstructure and the foundation system are assumed to be designed with proper engineering practice and fabricated, constructed and erected in accordance with the design documents. Compass will accept no liability which may arise due to any existing deficiency in design, material, fabrication, erection, construction, etc. or lack of maintenance.

The analysis results presented in this report are only applicable for the previously mentioned existing and proposed additions and alterations. Any deviation of the proposed equipment and placement, etc., will require Compass to generate an additional structural analysis.

5.0 ANALYSIS AND ASSUMPTIONS

The structure is considered to have adequate strength for the proposed loading, if the existing structural members used to support the proposed equipment are structurally adequate per the current code criteria or the additions or alterations to the existing structure do not increase the force in any structural element by more than 5%.

6.0 RESULTS AND CONCLUSION

Water Tank: The existing water tank is found to have **adequate** structural capacity for the proposed additions by T-Mobile. Utilizing a conservative approach, seismic shear and moment are calculated to be 1.01 and 1.49 times larger than the wind shear and moment respectively, thus tank structural design is governed by the seismic loads. The combined mass of existing equipment and T-Mobile additions is approximately 0.779% of the tank mass, less than 5%. Therefore, further analysis of the tank is not required per Section 3403.2 of the 2006 IBC and the structure is considered to have adequate capacity.

Antenna Mounts: The existing handrail is found to have **adequate** structural capacity for the proposed additions by T-Mobile. **The proposed OVPs should be mounted on the vertical member of the handrail.** Utilizing a conservative approach, the maximum point load on the handrail, due to the proposed additions, is 164 lbs, which is less than the 2006 IBC's 200 lb maximum (IBC 2006 Section 1607.7.1.1). The total distributed load on the handrail per sector, due to the proposed additions, is 50 plf, which is equal to the allowable 2006 IBC's 50 plf maximum (IBC 2006 Section 1607.7.1). **However, the existing bolts that connect the antenna pipe mount with the railing are extended beyond proper length, causing excessive bending stress. Therefore, the bolt extension should be eliminated.**

Therefore, the additions proposed by T-Mobile **can be implemented as intended**, once the railing mounts are modified, within the conditions outlined in this report.

Should you have any questions about this report, please contact Ahmet Colakoglu at (856) 313-7183 or acolakoglu@compassts.com.

Sincerely,
For Compass Technology Services
9-12-2012

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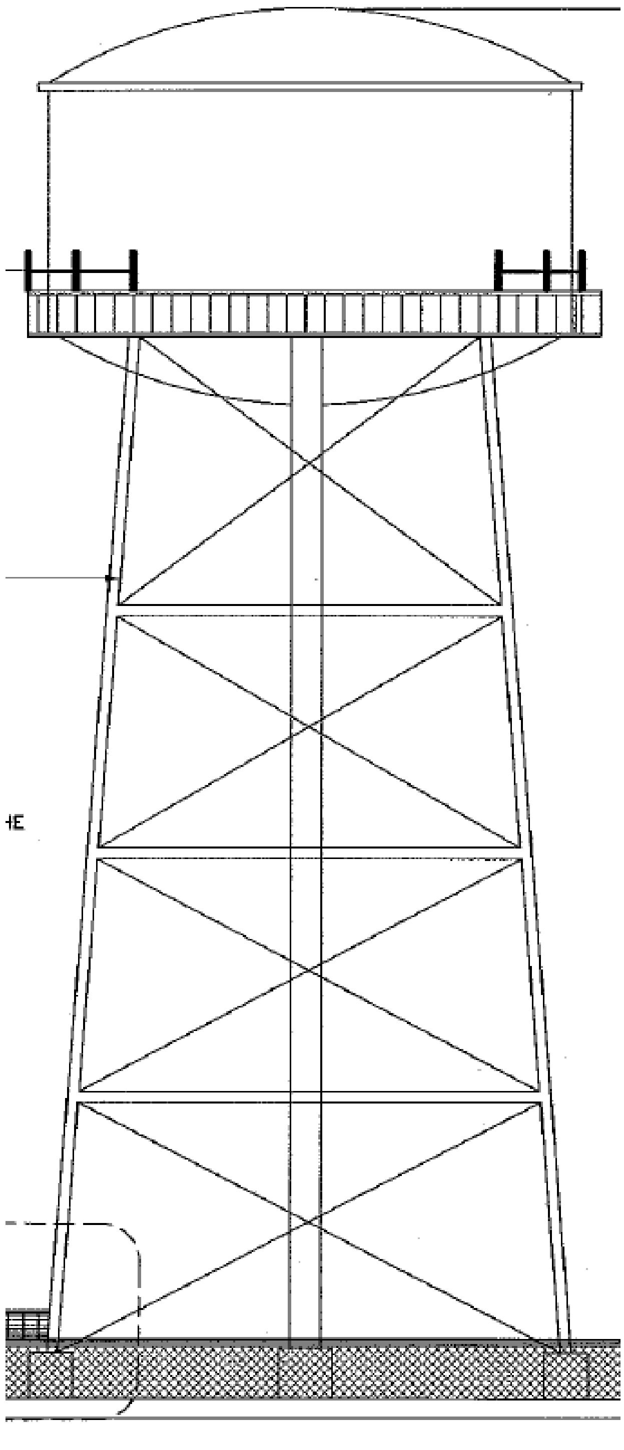
APPENDIX A
CALCULATIONS

Structural Analysis of Existing Water Tank: 808 Community Circle, Roswell, GA 30075

Standards: ASCE 7-05 Minimum Design Loads for Buildings & Other Structures
IBC 2006 with 2010 Georgia Amendments



Water Tank and Equipment Properties

$TankElevation_{MidpointAGL} := 150ft$

$TankDiameter := 25ft$

$TankCylinderHeight := 15ft$

$TankCapHeight := 5ft$

$RiserHeight := 120ft$

$RiserWidth := 3.25ft$

$LegHeight := 135ft$

$NumberOfLegs := 4$

$LegWidth := 1.5ft$

$HandrailHeight := 138ft$

$HeightOfTankCurve := 10ft$

Water Tank Leg Bracing Type 1 are 2" Solid Rods (Assumed Conservative Length)

$LegBracingType1_W := 1in$

$LegBracingType1_{TotalLength} := 1500ft$

Water Tank Leg Bracing Type 2 are 6" Truss Members (Assumed Conservative Length)

$LegBracingType2_W := 6in$

$LegBracingType2_{TotalLength} := 500ft$

Proposed Antenna 1 is an RFS APX17DWV (2 per sector, 3 sectors)

$PropAntenna1_H := 75.8in$

$PropAntenna1_W := 13in$

$PropAntenna1_D := 3.15in$

$PropAntenna1_{Weight} := 0.055kip$

$NumberOfPropAntenna1 := 6$

Proposed Antenna 2 is an RFS APXV18 (1 per sector, 3 sectors)

$PropAntenna2_H := 72in$

$PropAntenna2_W := 6.8in$

$PropAntenna2_D := 3.15in$

$PropAntenna2_{Weight} := 0.0264kip$

$NumberOfPropAntenna2 := 3$

Proposed TMA 1 is an RFS ATMAA1412D (1 per sector, 3 sectors)

$PropTMA1_H := 12in$

$PropTMA1_W := 10in$

$PropTMA1_D := 4in$

$PropTMA1_{Weight} := 0.013kip$

$NumberOfPropTMA1 := 3$

Proposed RRU 1 is a Nokia FXFB (1 per sector, 3 sectors)

$PropRRU1_H := 5.2in$

$PropRRU1_W := 19.4in$

$PropRRU1_D := 22.1in$

$PropRRU1_{Weight} := 0.0551kip$

$NumberOfPropRRU1 := 3$

Proposed RRU 2 is a Nokia FRIG (1 per sector, 3 sectors)

$PropRRU2_H := 23.8in$

$PropRRU2_W := 17.2in$

$PropRRU2_D := 7.6in$

$PropRRU2_{Weight} := 0.0572kip$

$NumberOfPropRRU2 := 3$

Proposed OVP 1 is a Nokia ASU9338TYP01
(1 per sector, 1 sector)

$PropOVP1_{H} := 20.3in$

$PropOVP1_{W} := 17in$

$PropOVP1_{D} := 5.83in$

$PropOVP1_{Weight} := 0.019kip$

$NumberOfPropOVP1 := 3$

Proposed Cable 1 is a 1-5/8" Hybrid Lines
(Wind is (1) due to shielding effects)

$PropCable1_{H} := HandrailHeight$

$PropCable1_{W} := 1.625in$ (Conservative sizing)

$PropCable1_{D} := 1.625in$

$PropCable1_{Weight} := 0.001 \frac{kip}{ft} \cdot PropCable1_{H}$

$NumberOfPropCable1 := 3$ $NumberOfPropCable1_{wind} := 1$

Unknown existing Microwaves are assumed to be a conservative size and weight (on leg)

$ExistMW1_{H} := 36in$

$ExistMW1_{W} := 36in$

$ExistMW1_{D} := 12in$

$ExistMW1_{Weight} := 0.1kip$

$NumberOfExistMW1 := 2$

Existing Cable 1 is a 1-5/8" Coax
(Wind is (4) due to shielding effects)

$ExistCable1_{H} := HandrailHeight$

$ExistCable1_{W} := 1.625in$

$ExistCable1_{D} := 1.625in$

$ExistCable1_{Weight} := 0.001 \frac{kip}{ft} \cdot PropCable1_{H}$

$NumberOfExistCable1 := 12$ $NumberOfExistCable1_{wind} := 4$

Unknown existing antennas are assumed to be a conservative size and weight

$ExistAntenna1_{H} := 84in$

$ExistAntenna1_{W} := 14in$

$ExistAntenna1_{D} := 6in$

$ExistAntenna1_{Weight} := 0.1kip$

$NumberOfExistAntenna1 := 15$

Existing Mount 1 is a 2.0 STD Pipe (Assumed)
(6 per sector, 3 sectors + 6 Tank Side Mounts)

$ExistMount1_{H} := 72in$

$ExistMount1_{W} := 2.38in$

$ExistMount1_{D} := 2.38in$

$ExistMount1_{Weight} := 0.00366 \frac{kip}{ft} \cdot ExistMount1_{H}$

$NumberOfExistMount1 := 24$

1. Wind Load

(reference ASCE 7-05 section 6.5.15)

Input:

Location:	Roswell, GA		ASCE 7 Reference
Classification:	IV		table 1-1 pg 3
Exposure category:	$Exp := C$	(Conservative)	section 6.5.6.2 pg. 25
$z_g := 900$	$\alpha := 9.5$	Exposure C used due to openings larger than 600 ft, in 3200 ft surrounding. From Table 6-2	
	$z := \frac{TankElevation_{MidpointAGL}}{1ft} = 150$		Height of tank above ground level at mid point of tank
Velocity pressure exposure coefficient:	$K_z := 2.01 \cdot \left(\frac{z}{z_g}\right)^{\frac{2}{\alpha}} = 1.378$		table 6-3 pg 79
Topographic factor:	$K_{zt} := 1.0$		section 6.5.7.2 pg. 26. Does not meet all the conditions specified in Section 6.5.7.1
Wind directional factor:	$K_d := 0.95$		table 6-4 pg. 80. Round Tank
Basic wind speed:	$V := 90$	mph	figure 6-1B pg. 35. Cherokee County
Importance factor:	$I := 1.15$		table 6-1 pg 77

Velocity Pressure: $q_z := 0.00256 \cdot K_{zt} \cdot V^2 \cdot I \cdot psf$ $\quad q_z = 23.85 \cdot psf$ equation (6-15), pg 27

Calculate Wind Forces on Water Tank

Tank:

Gust effect factor: $G := 0.85$ — section 6.5.8.1 pg 26

Force coefficient: $D := \frac{TankDiameter}{1ft} = 25$ — diameter of tank (ft.)

$H := \frac{TankCylinderHeight + 2 \cdot TankCapHeight}{1ft} = 25$ — height of tank (ft.)

$qz := \frac{q_z}{1psf} = 23.846$ — velocity pressure (psf)

$\frac{H}{D} = 1 \quad D \cdot \sqrt{qz} = 122.082 \quad C_f := 0.5$ — figure 6-21 pg. 74

$z := \frac{TankElevation_{MidpointAGL}}{1ft}$ — Height of tank above ground level at mid point of tank

$K_z := 2.01 \cdot \left(\frac{z}{z_g}\right)^{\frac{2}{\alpha}} = 1.378$ — table 6-3 pg 79

Area of tank: $A_{nettank} := \frac{TankDiameter}{2} \cdot \frac{2TankCapHeight}{2} \pi \ldots + TankCylinderHeight \cdot TankDiameter = 571\,ft^2$

Wind load on water tank: $F_{tank} := A_{nettank} \cdot C_f \cdot q_z \cdot G \cdot K_z \cdot K_d = 7.582 \cdot kip$

Calculate Wind Forces on Riser

Riser:

Gust effect factor: $G := 0.85$ — section 6.5.8.1 pg 26

Force coefficient: $C_f := 0.7$ — figure 6-21 pg. 74

Area : $A_{netriser} := RiserHeight \cdot RiserWidth = 390\,ft^2$

$z := \frac{RiserHeight}{1ft} \cdot \left(\frac{2}{3}\right)$ — 2/3 based on triangular increase in wind pressure as elevation increases

$K_z := 2.01 \cdot \left(\frac{z}{z_g}\right)^{\frac{2}{\alpha}} = 1.208$

Wind load: $F_{riser} := A_{netriser} \cdot C_f \cdot q_z \cdot G \cdot K_z \cdot K_d = 6.348 \cdot kip$

Calculate Wind Forces on Legs

Legs:

Gust effect factor: $G := 0.85$ — section 6.5.8.1 pg 26

Force coefficient: $C_f := 2.0$ — figure 6-21 pg. 74

Area: $A_{netlegs} := LegHeight \cdot LegWidth \cdot NumberOfLegs = 810\,ft^2$

$$z := \frac{LegHeight}{1ft} \cdot \left(\frac{2}{3}\right)$$

2/3 based on triangular increase in wind pressure as elevation increases

$$K_z := 2.01 \cdot \left(\frac{z}{z_g}\right)^{\frac{2}{\alpha}} = 1.238$$

Wind load: $F_{legs} := A_{netlegs} \cdot C_f \cdot q_z \cdot G \cdot K_z \cdot K_d = 38.614 \cdot kip$

Calculate Wind Forces on Leg Bracing

Leg Bracing:
Assumed to be 2" Solid Rods and 6" Truss Members

Gust effect factor: $G := 0.85$ — section 6.5.8.1 pg 26

Force coefficient: $C_{f1} := 1.2$ Solid Rods — figure 6-21 pg. 74, 2 because of different shaped bracing

$C_{f2} := 2.0$ Truss

Area: $A_{netlegbracing1} := LegBracingType1_W \cdot LegBracingType1_{TotalLength} = 125\,ft^2$

$A_{netlegbracing2} := LegBracingType2_W \cdot LegBracingType2_{TotalLength} = 250\,ft^2$

$$z := \frac{LegHeight}{1ft} \cdot \left(\frac{2}{3}\right)$$

2/3 based on triangular increase in wind pressure as elevation increases

$$K_z := 2.01 \cdot \left(\frac{z}{z_g}\right)^{\frac{2}{\alpha}} = 1.238$$

Wind Load:

$$F_{legbracing} := A_{netlegbracing1} \cdot C_{f1} \cdot q_z \cdot G \cdot K_z \cdot K_d \ldots + A_{netlegbracing2} \cdot C_{f2} \cdot q_z \cdot G \cdot K_z \cdot K_d = 15.493 \cdot kip$$

Wind Forces on Existing Equipment

Existing Equipment:

Gust effect factor: $G := 0.85$ section 6.5.8.1 pg 26

Force coefficient:

$C_{f1} := 1.4$ Antennas

$C_{f2} := 2.0$ MW

$C_{f3} := 1.2$ Mount Pole

figure 6-21 pg. 74, 3 because of different shaped equipment

Area:

$$A_{netexistantennas} := \max\left(ExistAntenna1_W, ExistAntenna1_D\right) \cdot ExistAntenna1_H \cdot NumberOfExistAntenna1 = 122.5\ ft^2$$

$$A_{netexistMW} := \max\left[\left(ExistMW1_H \cdot ExistMW1_D\right), \pi \cdot \left(\frac{ExistMW1_H}{2}\right)^2\right] \cdot NumberOfExistMW1 = 14.137\ ft^2$$

$$A_{netexistmounts} := \max\left(ExistMount1_W, ExistMount1_D\right) \cdot ExistMount1_H \cdot NumberOfExistMount1 = 28.56\ ft^2$$

$$A_{netexistcables} := \max\left(ExistCable1_W, ExistCable1_D\right) \cdot ExistCable1_H \cdot NumberOfExistCable1_{wind} = 74.75\ ft^2$$

$$z := \frac{HandrailHeight}{1ft}$$

$$K_z := 2.01 \cdot \left(\frac{z}{z_g}\right)^{\frac{2}{\alpha}} = 1.354$$

Wind Load:

$$F_{existingequipment} := A_{netexistantennas} \cdot C_{f1} \cdot q_z \cdot G \cdot K_z \cdot K_d + A_{netexistMW} \cdot C_{f2} \cdot q_z \cdot G \cdot K_z \cdot K_d + A_{netexistmounts} \cdot C_{f3} \cdot q_z \cdot G \cdot K_z \cdot K_d + A_{netexistcables} \cdot C_{f3} \cdot q_z \cdot G \cdot K_z \cdot K_d = 8.443 \cdot kip$$

Calculate Wind Forces on Proposed Antennas

Proposed Antennas:

Gust effect factor: $G := 0.85$ section 6.5.8.1 pg 26

Force coefficient: $C_f := 1.4$ figure 6-21 pg. 74

Area:

$$A_{netpropantenna1} := \max(PropAntenna1_W, PropAntenna1_D) \cdot PropAntenna1_H \cdot NumberOfPropAntenna1 = 41.058\ ft^2$$

$$A_{netpropantenna2} := \max(PropAntenna2_W, PropAntenna2_D) \cdot PropAntenna2_H \cdot NumberOfPropAntenna2 = 10.2\ ft^2$$

$$z := \frac{HandrailHeight}{1ft}$$

$$K_z := 2.01 \cdot \left(\frac{z}{z_g}\right)^{\frac{2}{\alpha}} = 1.354$$

Wind Load:

$$F_{propantennas} := A_{netpropantenna1} \cdot C_f \cdot q_z \cdot G \cdot K_z \cdot K_d + A_{netpropantenna2} \cdot C_f \cdot q_z \cdot G \cdot K_z \cdot K_d = 1.872 \cdot kip$$

Calculate Wind Forces on Proposed TMAs

Proposed TMAs:

Gust effect factor: $G := 0.85$ section 6.5.8.1 pg 26

Force coefficient: $C_f := 2.0$ figure 6-21 pg. 74

Area:

$$A_{netpropTMA1} := \max(PropTMA1_W, PropTMA1_D) \cdot PropTMA1_H \cdot NumberOfPropTMA1 = 2.5\ ft^2$$

$$z := \frac{HandrailHeight}{1ft}$$

$$K_z := 2.01 \cdot \left(\frac{z}{z_g}\right)^{\frac{2}{\alpha}} = 1.354$$

Wind Load:

$$F_{propTMAs} := A_{netpropTMA1} \cdot C_f \cdot q_z \cdot G \cdot K_z \cdot K_d = 0.13 \cdot kip$$

Calculate Wind Forces on Proposed RRU's

Proposed RRUs:

Gust effect factor: $G := 0.85$ section 6.5.8.1 pg 26

Force coefficient: $C_f := 2.0$ figure 6-21 pg. 74

Area:

$$A_{netpropRRU1} := \max(PropRRU1_W, PropRRU1_D) \cdot PropRRU1_H \cdot NumberOfPropRRU1 = 2.394\,ft^2$$

$$A_{netpropRRU2} := \max(PropRRU2_W, PropRRU2_D) \cdot PropRRU2_H \cdot NumberOfPropRRU2 = 8.528\,ft^2$$

$$z := \frac{HandrailHeight}{1ft}$$

$$K_z := 2.01 \cdot \left(\frac{z}{z_g}\right)^{\frac{2}{\alpha}} = 1.354$$

Wind Load:

$$F_{propRRUs} := A_{netpropRRU1} \cdot C_f \cdot q_z \cdot G \cdot K_z \cdot K_d \ldots + A_{netpropRRU2} \cdot C_f \cdot q_z \cdot G \cdot K_z \cdot K_d = 0.57 \cdot kip$$

Calculate Wind Forces on Proposed OVPs

Proposed OVPs:

Gust effect factor: $G := 0.85$ section 6.5.8.1 pg 26

Force coefficient: $C_f := 2.0$ figure 6-21 pg. 74

Area:

$$A_{netpropOVP1} := \max(PropOVP1_W, PropOVP1_D) \cdot PropOVP1_H \cdot NumberOfPropOVP1 = 7.19\,ft^2$$

$$z := \frac{HandrailHeight}{1ft}$$

$$K_z := 2.01 \cdot \left(\frac{z}{z_g}\right)^{\frac{2}{\alpha}} = 1.354$$

Wind Load:

$$F_{propOVPs} := A_{netpropOVP1} \cdot C_f \cdot q_z \cdot G \cdot K_z \cdot K_d = 0.375 \cdot kip$$

Calculate Wind Forces on Proposed Hybrid Lines

Cables:

Gust effect factor: $G := 0.85$ — section 6.5.8.1 pg 26

Force coefficient: $C_f := 0.7$ — figure 6-21 pg. 74

Area: $A_{netcables} := PropCable1_H \cdot PropCable1_W \cdot NumberOfPropCable1_{wind} = 19\,ft^2$

$$z := \frac{HandrailHeight}{1ft} \cdot \frac{2}{3}$$

2/3 based on triangular increase in wind pressure as elevation increases

$$K_z := 2.01 \cdot \left(\frac{z}{z_g}\right)^{\frac{2}{\alpha}} = 1.244$$

Wind load: $F_{cables} := A_{netcables} \cdot C_f \cdot q_z \cdot G \cdot K_z \cdot K_d = 0.313 \cdot kip$

SUMMARY OF WIND LOADS

$$F_{wind} := F_{tank} + F_{riser} + F_{legs} + F_{legbracing} + F_{existingequipment} + F_{propantennas} + F_{propTMAs} \ldots + F_{propRRUs} + F_{propOVPs} + F_{cables} = 79.742 \cdot kip$$

$$M_{wind} := (F_{tank}) \cdot TankElevation_{MidpointAGL} \ldots + (F_{riser}) \cdot \left(\frac{2}{3}\right) \cdot RiserHeight \ldots + (F_{legs} + F_{legbracing}) \cdot \left(\frac{2}{3}\right) \cdot LegHeight \ldots + (F_{existingequipment} + F_{propantennas} + F_{propTMAs} + F_{propRRUs} + F_{propOVPs}) \cdot HandrailHeight \ldots + (F_{cables}) \cdot \left(\frac{2}{3}\right) \cdot HandrailHeight = 8116 \cdot kip \cdot ft$$

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2. Seismic Load (per IBC 2006 References ASCE 7-05)

Occupancy Category:	IV	Table 1-1
Importance Factor:	$I := 1.5$	Table 11.5-1

Spectral Parameters

$S_s := 30\%$		Figure 22-1
$S_1 := 10\%$		Figure 22-2
$F_a := 1.40$	Site Class D assumed per code	Table 11.4-1
$F_v := 2.40$		Table 11.4-2
$S_{MS} := F_a \cdot S_s$	$S_{MS} = 0.42$	Eq 11.4-1
$S_{M1} := F_v \cdot S_1$	$S_{M1} = 0.24$	Eq 11.4.2
$S_{DS} := \frac{2}{3} \cdot S_{MS}$	$S_{DS} = 0.28$	Eq. 11.4-3
$S_{D1} := \frac{2}{3} \cdot S_{M1}$	$S_{D1} = 0.16$	Eq. 11.4-4
$R := 3$		Table 15.4-2

$C_s := \dfrac{S_{DS}}{\frac{R}{I}}$ $\quad C_s = 0.1400$ Computed from Equation 12.8-2 and must be compared to max. and min. values.

Period Determination, T: Section 12.8.2

$C_T := 0.02$ per Table 12.8-2

$x := 0.75$ per Table 12.8-2

Water Tank Height: $h_n := \frac{TankElevation_{MidpointAGL}}{1ft}$

$T_a := C_T \cdot h_n^{\,x}$ $T_a = 0.857$ sec

$C_u := 1.5$ Table 12.8-1

$T_{max} := C_u \cdot T_a$ $T_{max} = 1.286$ sec The fundamental period should not exceed this. Section 12.8.2

$T := T_a$ $T = 0.85$ sec

$C_s := \frac{S_{D1}}{T \cdot \left(\frac{R}{I}\right)}$ Eq. 12.8-3 Maximum value of Cs need not be greater than: $C_s = S_{D1}/T(R/I)$

$C_s = 0.0933$ Max C.s value

Minimum value for C_s:

Minimum value of Cs should not be taken less than:

$C_{smin} := 0.01$ Eq. 15.4-1

Therefore, use $C_s := 0.0933$ Maximum Value Controls

Seismic Base Shear:

$$Tank\_Volume := \frac{4}{3}\cdot\pi\cdot\left(\frac{TankDiameter}{2}\right)^2\cdot\left(\frac{2\cdot TankCapHeight}{2}\right) + \pi\cdot\left(\frac{TankDiameter}{2}\right)^2\cdot TankCylinderHeight = 79560\,gal$$

Manual conservative approximation

$$Tank\_Weight := Tank\_Volume\cdot 62\cdot pcf = 659.407\cdot kip$$

$$Riser\_Volume := RiserHeight\cdot\left[\pi\cdot\left(\frac{RiserWidth}{2}\right)^2\right] = 7447\,gal$$

$$Riser\_Weight := Riser\_Volume\cdot 62pcf = 61.721\cdot kip$$

$$Steel\_Density := 0.4899\frac{kip}{ft^3} = 0.49\cdot\frac{kip}{ft^3}$$

$$Steel\_Weight := Steel\_Density\cdot 0.5in\cdot\left[\begin{array}{l}(\pi\cdot TankDiameter\cdot TankCylinderHeight)\ \ldots\\ +\left(\pi\cdot TankCapHeight\cdot\frac{TankDiameter}{2}\right)\ \ldots\\ +(\pi\cdot RiserWidth\cdot RiserHeight)\ \ldots\\ +(4\cdot LegWidth\cdot LegHeight\cdot NumberOfLegs)\ \ldots\\ +(4LegBracingType2_W\cdot LegBracingType2_{TotalLength})\end{array}\right]\ \ldots = 143.623\cdot kip$$
$$+\ Steel\_Density\cdot\left[\left[\pi\cdot\left(\frac{LegBracingType1_W}{2}\right)^2\cdot LegBracingType1_{TotalLength}\right]\right]$$

$$F_{seismic} := C_s\cdot(Tank\_Weight + Riser\_Weight + Steel\_Weight) = 81\cdot kip$$

$$M_{seismic} := F_{seismic}\cdot TankElevation_{MidpointAGL} = 12102\cdot kip\cdot ft$$

3. Determine Governing Load

$\frac{F_{wind}}{F_{seismic}} = 99 \cdot \%$

$\frac{M_{wind}}{M_{seismic}} = 67 \cdot \%$

====>>> SEISMIC SHEAR AND MOMENT GOVERN THE DESIGN

4. Compare Proposed Loads with Existing Tank

$$W_{additional} := PropAntenna1_{Weight} \cdot NumberOfPropAntenna1 \; ... \\ + PropAntenna2_{Weight} \cdot NumberOfPropAntenna2 \; ... \\ + PropTMA1_{Weight} \cdot NumberOfPropTMA1 \; ... \\ + PropRRU1_{Weight} \cdot NumberOfPropRRU1 + ExistMW1_{Weight} \cdot NumberOfExistMW1 \; ... \\ + PropRRU2_{Weight} \cdot NumberOfPropRRU2 + PropOVP1_{Weight} \cdot NumberOfPropOVP1 \; ... \\ + PropCable1_{Weight} \cdot NumberOfPropCable1 \; ... \\ + ExistAntenna1_{Weight} \cdot NumberOfExistAntenna1 \; ... \\ + ExistMount1_{Weight} \cdot NumberOfExistMount1 + ExistCable1_{Weight} \cdot NumberOfExistCable1 \quad = 5.139 \cdot kip$$

Compare the tank mass to the proposed mass:

$\frac{W_{additional}}{Tank\_Weight} = 0.779 \cdot \%$ < 5.0 % ==> Further analysis not required

The total mass with the existing and proposed antennas is increased by less than 5%, thus lateral seismic load and gravity load increase is less than 5%.

5. Check Antenna Support - Handrail

Loads on Proposed Antenna 1

$G := 0.85$

$C_f := 1.4$ Antenna Shape Factor

$Area_{perp} := PropAntenna1_H \cdot PropAntenna1_W = 6.843\ ft^2$

$FAnt1_{perp} := q_z \cdot G \cdot C_f \cdot Area_{perp} = 0.194 \cdot kip$

$PropAntenna1_{Weight} = 0.055 \cdot kip$

$Area_{para} := PropAntenna1_H \cdot PropAntenna1_D = 1.658\ ft^2$

$FAnt1_{para} := q_z \cdot G \cdot C_f \cdot Area_{para} = 0.047 \cdot kip$

Loads on Proposed Antenna 2

$G := 0.85$

$C_f := 1.4$ Antenna Shape Factor

$Area_{perp} := PropAntenna2_H \cdot PropAntenna2_W = 3.4\ ft^2$

$FAnt2_{perp} := q_z \cdot G \cdot C_f \cdot Area_{perp} = 0.096 \cdot kip$

$PropAntenna2_{Weight} = 0.026 \cdot kip$

$Area_{para} := PropAntenna2_H \cdot PropAntenna2_D = 1.575\ ft^2$

$FAnt2_{para} := q_z \cdot G \cdot C_f \cdot Area_{para} = 0.045 \cdot kip$

Loads on Proposed/Existing Mount

$G := 0.85$

$C_f := 1.2$ Pipe Shape Factor

$F_{Pipe} := q_z \cdot G \cdot C_f \cdot ExistMount1_H \cdot ExistMount1_W = 0.029 \cdot kip$

Loads on RRU Mount

$G := 0.85$

$C_f := 2.0$ Flat Equipment Shape Factor

$Area_{perp} := PropRRU1_H \cdot PropRRU1_W = 0.701\ ft^2$

$FRRU1_{perp} := q_z \cdot G \cdot C_f \cdot Area_{perp} = 0.028 \cdot kip$

$Area_{para} := PropRRU1_H \cdot PropRRU1_D = 0.798\ ft^2$

$FRRU1_{para} := q_z \cdot G \cdot C_f \cdot Area_{para} = 0.032 \cdot kip$

$Area_{perp} := PropRRU2_H \cdot PropRRU2_W = 2.843\ ft^2$

$FRRU2_{perp} := q_z \cdot G \cdot C_f \cdot Area_{perp} = 0.115 \cdot kip$

$Area_{para} := PropRRU2_H \cdot PropRRU2_D = 1.256\ ft^2$

$FRRU2_{para} := q_z \cdot G \cdot C_f \cdot Area_{para} = 0.051 \cdot kip$

Loads on OVP/TMA Mount

$G := 0.85$

$C_f := 2.0$ Flat Equipment Shape Factor

$Area_{perp} := PropOVP1_H \cdot PropOVP1_W = 2.397\ ft^2$

$FOVP1_{perp} := q_z \cdot G \cdot C_f \cdot Area_{perp} = 0.097 \cdot kip$

$Area_{para} := PropOVP1_H \cdot PropOVP1_D = 0.822\ ft^2$

$FOVP1_{para} := q_z \cdot G \cdot C_f \cdot Area_{para} = 0.033 \cdot kip$

$Area_{perp} := PropTMA1_H \cdot PropTMA1_W = 0.833\ ft^2$

$FTMA1_{perp} := q_z \cdot G \cdot C_f \cdot Area_{perp} = 0.034 \cdot kip$

$Area_{para} := PropTMA1_H \cdot PropTMA1_D = 0.333\ ft^2$

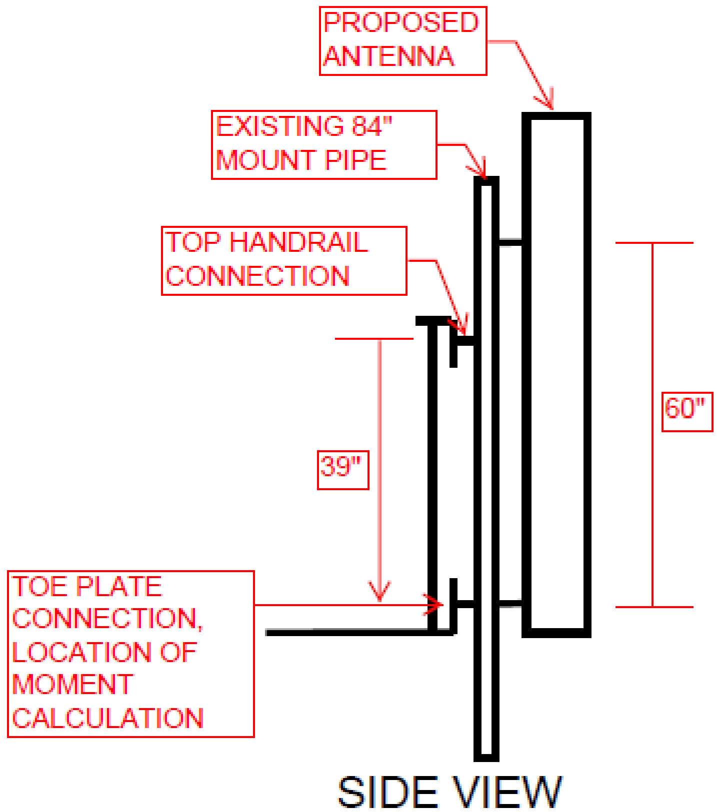
$FTMA1_{para} := q_z \cdot G \cdot C_f \cdot Area_{para} = 0.014 \cdot kip$

Point Load Capacity Check for Handrail

All mounts have (2) handrail connections, (1) at the top handrail member and (1) at the toe plate. The COVPs should be mounted on the vertical member of the handrail.

Existing antenna mount 1 & 3 configuration

Sketch of existing antenna mount 1 & 3 configuration



Weight Load of Mount 1 on top of Handrail

$$AntennaMount1Weight := \frac{(PropAntenna1_{Weight} + ExistMount1_{Weight} + PropRRU1_{Weight})}{2} = 0.066 \cdot kip$$

Wind Load of Mount 1 on Front of Handrail

$$FAnt1_{perp} := \frac{FAnt1_{perp}}{kip} = 0.194$$

Given $$0 = \frac{1}{2} \cdot FAnt1_{perp} \cdot 60 - X \cdot 39$$

$$X := Find(X) \rightarrow 0.14937451199999994615$$

Moment calculation about bottom mount connection to solve for the reaction at the top handrail connection

$$F_{TopHandrailPerp1} := X \cdot kip = 0.149 \cdot kip$$

Wind Load of Mount 1 on Side of Handrail

$FRRU1_{para} := \frac{FRRU1_{para}}{kip} = 0.032$ $FAnt1_{para} := \frac{FAnt1_{para}}{kip} = 0.047$ $F_{Pipe} := \frac{F_{Pipe}}{kip} = 0.029$

Given $0 = \frac{1}{2} \cdot (FAnt1_{para} + F_{Pipe} + FRRU1_{para}) \cdot 60 - Y \cdot 39$

Moment calculation about bottom mount connection to solve for the reaction at the top handrail connection

$Y := Find(Y) \rightarrow 0.083346161538461506923$

$F_{TopHandrailPara1} := Y \cdot kip = 0.083 \cdot kip$

Resultant Mount 1 Load of Weight and Wind on Handrail (Using Max Wind Direction)

$F_{Ant1Wind} := max(F_{TopHandrailPerp1}, F_{TopHandrailPara1}) = 0.149 \cdot kip$

$Resultant_{Mount1Load} := \sqrt{AntennaMount1Weight^2 + F_{Ant1Wind}^2} = 0.163 \cdot kip$ < 0.200 kip CHECK

Weight Load of Mount 3 on top of Handrail

$AntennaMount3Weight := \frac{(PropAntenna1_{Weight} + ExistMount1_{Weight} + PropRRU2_{Weight})}{2} = 0.067 \cdot kip$

Wind Load of Mount 3 on Front of Handrail

Given $0 = \frac{1}{2} \cdot FAnt1_{perp} \cdot 60 - X \cdot 39$

Moment calculation about bottom mount connection to solve for the reaction at the top handrail connection

$X := Find(X) \rightarrow 0.14937451199999994615$

$F_{TopHandrailPerp3} := X \cdot kip = 0.149 \cdot kip$

Wind Load of Mount 3 on Side of Handrail

$FRRU2_{para} := \frac{FRRU2_{para}}{kip} = 0.051$

Given $0 = \frac{1}{2} \cdot (FAnt1_{para} + F_{Pipe} + FRRU2_{para}) \cdot 60 - Y \cdot 39$

Moment calculation about bottom mount connection to solve for the reaction at the top handrail connection

$Y := Find(Y) \rightarrow 0.097630053230769194615$

$F_{TopHandrailPara3} := Y \cdot kip = 0.098 \cdot kip$

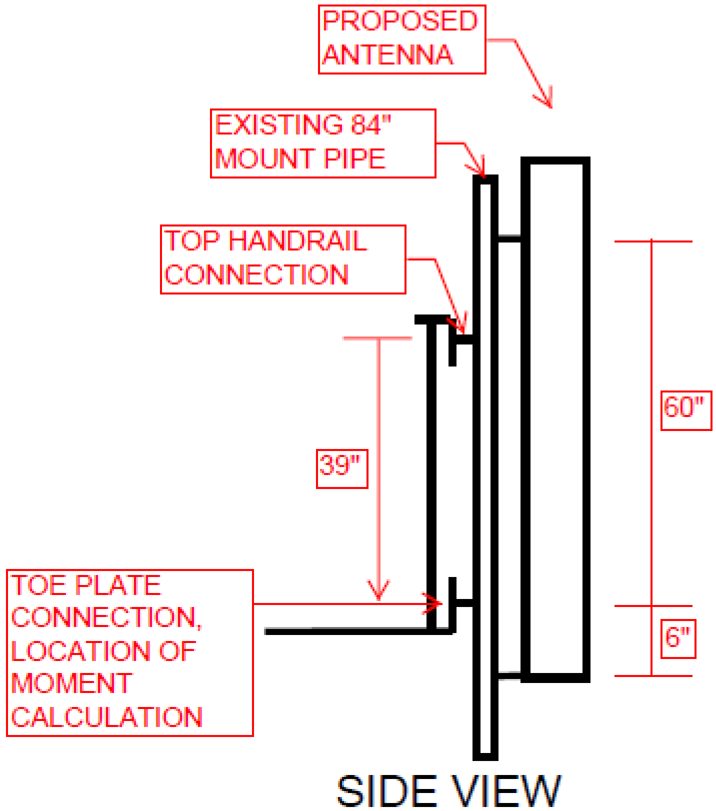
Resultant Mount 3 Load of Weight and Wind on Handrail (Using Max Wind Direction)

$F_{Ant3Wind} := max(F_{TopHandrailPerp3}, F_{TopHandrailPara3}) = 0.149 \cdot kip$

$Resultant_{Mount3Load} := \sqrt{AntennaMount3Weight^2 + F_{Ant3Wind}^2} = 0.164 \cdot kip$ < 0.200 kip CHECK

Existing antenna mount 2 configuration

Sketch of existing mount pipe 2 with proposed antenna



Weight Load of Mount 2 on top of Handrail

$$AntennaMount2Weight := \frac{(PropAntenna2_{Weight} + ExistMount1_{Weight} + 2PropTMA1_{Weight})}{2} = 0.037 \cdot kip$$

Wind Load of Mount 2 on Front of Handrail

$$FAnt2_{perp} := \frac{FAnt2_{perp}}{kip} = 0.096$$

Given $0 = \frac{1}{2} \cdot FAnt2_{perp} \cdot 60 - X \cdot 39 - \frac{1}{2} \cdot FAnt2_{perp} \cdot 6$

Moment calculation about bottom mount connection to solve for the reaction at the top handrail connection

$X := Find(X) \rightarrow 0.066795600738461510077$

$F_{TopHandrailPerp2} := X \cdot kip = 0.067 \cdot kip$

Wind Load of Mount 2 on Side of Handrail

$FTMA1_{para} := \frac{FTMA1_{para}}{1kip} = 0.014 \quad FAnt2_{para} := \frac{FAnt2_{para}}{kip} = 0.045$

Given $0 = \frac{1}{2}\cdot(FAnt2_{para} + F_{Pipe} + FTMA1_{para})\cdot 60 - Y\cdot 39 - \frac{1}{2}\cdot(FAnt2_{para} + F_{Pipe} + FTMA1_{para})\cdot 6$

Moment calculation about bottom mount connection to solve for the reaction at the top handrail connection

$Y := Find(Y) \rightarrow 0.060335886129230745$

$F_{TopHandrailPara2} := Y\cdot kip = 0.06\cdot kip$

Resultant Mount 2 Load of Weight and Wind on Handrail (Using Max Wind Direction)

$F_{Ant2Wind} := max(F_{TopHandrailPerp2}, F_{TopHandrailPara2}) = 0.067\cdot kip$

$Resultant_{Mount2Load} := \sqrt{AntennaMount2Weight^2 + F_{Ant2Wind}^2} = 0.076\cdot kip$

< 0.200 kip CHECK

Distributed Load Capacity Check for Handrail

Load calculated using conservative minimum spacing between antennas of 48 inches.

Distributed Weight Loads of all Equipment and Mount Pipes on Top of Handrail.

$CombinedWeight := AntennaMount1Weight + AntennaMount2Weight + AntennaMount3Weight = 0.17\cdot kip$

$CombinedWindPerp := F_{TopHandrailPerp1} + F_{TopHandrailPerp2} + F_{TopHandrailPerp3} = 0.366\cdot kip$

$CombinedWindPara := F_{TopHandrailPara1} + F_{TopHandrailPara2} + F_{TopHandrailPerp3} = 0.293\cdot kip$

$CombinedLength := 2\cdot 48in = 8\,ft$

Use worst case wind load to calculate resultant

$$Resultant_{DistributedLoad} := \frac{\sqrt{CombinedWeight^2 + max(CombinedWindPerp, CombinedWindPara)^2}}{CombinedLength} = 0.05\cdot\frac{kip}{ft}$$

<= 0.050 kip/ft CHECK

The maximum resultant point load on the handrail is due to the proposed antenna 3 mount and is 164 lbs, which is above the code maximum of 200 lbs. The resultant distributed load from all proposed equipment and mount pipes per sector is 50 lbs/ft, which is equal to the allowable code maximum of 50 lbs/ft.