

Structural Design Calculations

A handwritten signature in black ink, appearing to read "MARC R. CHRETIEN".

Site No.: 4BS0539A - Cedar Street WT
Project: Anchor
Client: Centerline Communications
Date: August 8, 2023

Synopsis:

The final T-Mobile Anchor equipment installation will consists of:

- Three (3) RFS APXVAARR24 antennas (1 per sector)
- Three (3) Ericsson AIR6449 antennas (1 per sector)
- Two (2) Commscope HBXX-6516DS antennas (sector B & C)
- Three (3) Ericsson RRUS-4460 remote radio heads (RRHs)(1 per sector)
- Three (3) Ericsson RRUS-4449 RRHs (1 per sector)

Material Properties:

Structural steel yield stress,

$$F_{ys} := 36 \cdot \text{ksi}$$

Steel yield stress (pipe),

$$F_{yp} := 35 \cdot \text{ksi}$$

Modulus of elasticity of steel,

$$E_s := 29 \cdot 10^6 \cdot \text{psi}$$

Steel unit weight,

$$\gamma_s := 490 \cdot \text{pcf}$$

Loads:

Environmental Loads:

Wind Load:

Exposure category,



(ASCE 7-10 Sec 26.7.3)

Risk Category, Category IV (Water tank)

(ASCE 7-10 Table 1.5-1)

Basic Wind Velocity, $V_w := 137 \text{ mph}$

(MSBC Table 1604.11)

Antenna Height, Height := 73ft

Exposure coefficient, $K_z = 0.9$

(ASCE 7-10 Table 29.3-1)

Wind Directionality Factor, $K_d := 0.9$

(ASCE 7-10 Table 26.6-1)

Velocity wind pressure, $q_z := .00256 \cdot V_w^2 \cdot K_z \cdot K_d \cdot \text{psf} = 39.03 \cdot \text{psf}$

(ASCE 7-10 Sec. 27.3.2)

Force coeff: Flat, $C_f := 1.4$

(ASCE 7-10 Fig. 29.5-1)

Wind Load factor, LF := .6

(ASCE 7-10 Sect 2.4)

Wind load pressure, $WL_f := q_z \cdot C_f = 54.64 \cdot \text{psf}$

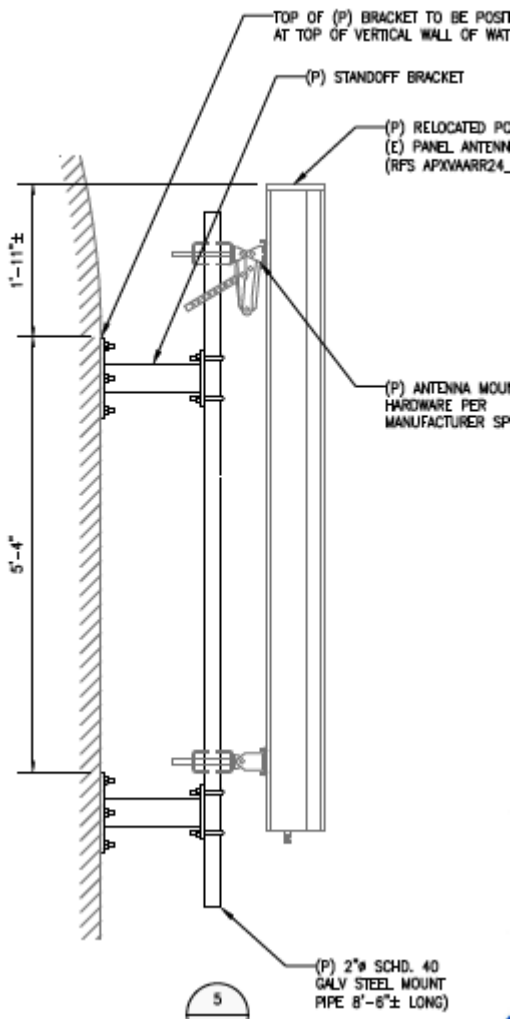
(ASCE 7-10 C26.5-1)

Radial ice thickness, $t_{ice} := .75 \cdot \text{in}$

Density of ice, $\gamma_{ice} := 56 \cdot \text{pcf}$

Analysis:

Figure 1: Proposed Antenna Installation (from drawings)



Antenna (APXVAARR24) - Governs

Width, $w_{a1} := 24 \cdot \text{in}$

Depth, $t_{a1} := 7.1 \cdot \text{in}$

Length, $l_{a1} := 96 \cdot \text{in}$

Weight, $W_{a1} := 155 \cdot \text{lb}$

RRH (NA)

Width, $w_{r1} := 0 \cdot \text{in}$

Depth, $t_{r1} := 0 \cdot \text{in}$

Length, $l_{r1} := 0 \cdot \text{in}$

Weight, $W_{r1} := 0 \cdot \text{lb}$

RRH separation, $d_{rrh} := 0 \cdot \text{in}$

Pipe

Diameter, $\phi_p := 2.375 \cdot \text{in}$

Length, $l_p := 8.5 \cdot \text{ft}$

Weight, $w_p := 3.65 \cdot \text{plf}$

Weight of ice:

$$W_{\text{ant_ice}} := \left[\left[w_{a1} + (2 \cdot t_{\text{ice}}) \right] \cdot \left[t_{a1} + (2 \cdot t_{\text{ice}}) \right] \cdot \left[l_{a1} + (2 \cdot t_{\text{ice}}) \right] - w_{a1} \cdot t_{a1} \cdot l_{a1} \right] \cdot \gamma_{\text{ice}} = 162.79 \text{ lb}$$

$$W_{\text{rrh_ice}} := \left[\left[w_{r1} + (2 \cdot t_{\text{ice}}) \right] \cdot \left[t_{r1} + (2 \cdot t_{\text{ice}}) \right] \cdot \left[l_{r1} + (2 \cdot t_{\text{ice}}) \right] - w_{r1} \cdot t_{r1} \cdot l_{r1} \right] \cdot \gamma_{\text{ice}} = 0.11 \text{ lb}$$

Side Wind Loading:

Effective depth of equipment, $D_{\text{eff}} := \max(t_{r1}, t_{a1}) + 4 \cdot \text{in} + \phi_p = 1.12 \text{ ft}$

Effective length of equipment, $L_{\text{eff}} := l_{a1} + d_{\text{rrh}} + l_{r1} = 8 \text{ ft}$

Wind force on equipment, $P_{\text{wind_eq}} := D_{\text{eff}} \cdot L_{\text{eff}} \cdot W_L \cdot LF = 294.51 \text{ lb}$

Weight of pipe, brackets, $W_{\text{misc}} := l_p \cdot w_p + 50 \cdot \text{lb} = 81.02 \text{ lb}$

Distance of assembly from wall, $d_1 := 12 \cdot \text{in}$

Number of mounts, $n_s := 2$

Mount separation, $d_2 := 5.33 \cdot \text{ft}$

Moment at each mount, $M := \frac{P_{\text{wind_eq}} \cdot d_1}{n_s} = 147.26 \text{ lb} \cdot \text{ft}$

Number of studs per mount, $n_b := 8$

Spacing of studs, $s_{\text{stud}} := 9 \cdot \text{in}$

Maximum tensile force on stud, $T_{\text{bolt_side}} := \frac{\frac{M}{s_{\text{stud}}}}{\frac{(n_b - 2)}{2}} = 65.45 \text{ lb}$

Front Wind Loading:

Effective width of equipment, $W_{\text{eff}} := \max(w_{a1}, w_{r1}) = 2 \text{ ft}$

Effective length of equipment, $L_{\text{eff}} = 8 \text{ ft}$

Wind force on equipment, $w_{\text{wind_eq}} := W_{\text{eff}} \cdot W_L \cdot LF = 65.57 \cdot \text{plf}$

Weight of pipe, brackets, $W_{\text{misc}} = 81.02 \text{ lb}$

Number of mounts, $n_s = 2$

Distance from top of antenna to top mount, $d_3 := 2 \cdot \text{ft}$

Mount separation, $d_2 = 5.33 \text{ ft}$

Gravity load from equipment, $P_{g_eq} := W_{\text{ant_ice}} + W_{\text{rrh_ice}} + W_{a1} + W_{r1} + W_{\text{misc}} = 398.93 \text{ lb}$

Mount Reactions:

$$\text{Top, } R_t := \frac{P_{\text{wind_eq}} \cdot \left[d_2 - \left(\frac{L_{\text{eff}}}{2} - d_3 \right) \right] + P_{g_eq} \cdot d_1}{d_2} = 258.85 \text{ lb}$$

$$\text{Bottom, } R_b := P_{\text{wind_eq}} - R_t = 35.67 \text{ lb}$$

Number of studs per mount, $n_b = 8$

Maximum tensile force on stud, $T_{\text{bolt_front}} := \frac{\max(R_t, R_b)}{n_b} = 32.36 \text{ lb}$

Maximum tensile force on bolt
(from either side or front loading), $T_{\text{stud}} := \max(T_{\text{bolt_front}}, T_{\text{bolt_side}}) = 65.45 \text{ lb}$

Allowable tensile load on 5/16" C-D stud, $T_{\text{allow}} := \frac{2900 \cdot \text{lb}}{4} = 725 \text{ lb}$

StudWeldTensileCheck := $\begin{cases} \text{"OK"} & \text{if } T_{\text{allow}} \geq T_{\text{stud}} \\ \text{"NG"} & \text{otherwise} \end{cases}$

StudWeldTensileCheck = "OK"

Shear force on stud, $V_s := \frac{\frac{P_{g_eq}}{n_s}}{n_b} = 24.93 \text{ lb}$

Allowable shear load for 5/16" C-D stud, $V_{\text{allow}} := \frac{2200 \cdot \text{lb}}{4} = 550 \text{ lb}$

StudWeldShearCheck := $\begin{cases} \text{"OK"} & \text{if } V_{\text{allow}} \geq V_s \\ \text{"NG"} & \text{otherwise} \end{cases}$

StudWeldShearCheck = "OK"

Conclusion:

Based on the results of the analysis, the proposed T-Mobile Anchor installation is structurally sound, as designed and depicted on plans by this office dated 2/22/23, Rev 3. The standpipe water tank is considered structurally adequate by inspection. The analysis was conducted in accordance with the Massachusetts State Building Code, 9th Edition, and ASCE 7-10.

References:

1. American Society of Civil Engineers (2010), Minimum Design Loads for Buildings and Other Structures (7-10), American Society of Civil Engineers, New York, NY
2. Massachusetts State Building Code, 9th Edition.

Client: Centerline
Subject: Structural Analysis, 396 Cedar
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Sheet: 5
Date: 8/8/23
Calculated by: MRC

C-D Stud Load Strengths

STUD MATERIAL	STUD SIZE	MAXIMUM FASTENING TORQUE (INCH LBS.)*	ULTIMATE TENSILE LOAD (LBS.)	MAXIMUM SHEAR LOAD (LBS.)
Low-Carbon, Copper-Flashed Steel	6-32	6	500	375
	8-32	12	765	575
	10-24	14	960	720
	1/4-20	43	1750	1300
	5/16-18	72	2900	2200
	3/8-16	106	4300	3250
Stainless Steel	6-32	10	790	590
	8-32	20	1260	940
	10-24	23	1530	1150
	1/4-20	75	2880	2160
	5/16-18	126	3750	5350
	3/8-16	186	4850	7150
Aluminum Alloy 6061	6-32	6.5	350	160
	8-32	13	560	229
	10-24	19	670	310
	1/4-20	40	1240	679
	5/16-18	70.5	2025	1210
	3/8-16	100	2985	1750