Structural Analysis of 200 ft Brick Smokestack

Site Number:

Site Name:
County:
Location:

Checked By:

Jeff Triezenberg
Structural Engineer

Wireless Company

1234 1st Street
Town Name, State

April 2010

1 N. Main St., Suite 312, Cortland, NY 13045 607.591.5381 Fax 866.870.0840 www.armortower.com

March 16, 2010

John Doe
Wireless Company
1234 1st Street.
Town Name, State

RE: Wireless Company, Site Number, Site Location

Mr. Doe,

We have completed the structural analysis of the subject site and **have found it to be adequate within the scope of this analysis to support the proposed antenna loading**. The structure was analyzed according to the requirements of TIA 222-G standard for County, PA for 90 mph wind speed with no ice and 40 mph wind with ¾" ice. The structure was analyzed using Topographic Category 1, Exposure C, and Structure Class III.

The structure we analyzed is a 200' tall smokestack adjacent to an old industrial building. The smokestack is composed of brick with a concrete shell of varying thickness. Foundation details have not been provided to us and are therefore considered unknown.

The loading used in the analysis consisted of the existing antennas/lines as well as the following:

- (3) Argus TLLPX310R (4 ea LMR-400-1-1) @ 140'
- (6) ODU-2483-2690-000N-38-4x2-N-0 @ 140'
- (2) Andrew VHLP2-18 microwave dishes (assumed 2 ea LMR-400-1-1) @ 140'

Proposed feed lines are to be stacked 16x1or 8x2 and may be installed outside of the smokestack.

The results of the analysis showed the smokestack will be adequately loaded after the addition of the proposed equipment. As this is an older structure, we recommend that it be inspected regularly for deterioration and caution be exercised during construction.

The acceptability of the analyzed antenna loading is the responsibility of Wireless Company and its affiliates to confirm with the respective carriers or structure owner. Smoke stack foundation loading could not be checked therefore this certification does not include the foundation. Note that this analysis assumes that no change to the antenna configuration has happened since April 2009.

No conclusions, expressed or implied, shall indicate that Armor Tower has made an evaluation of the original design, materials, fabrication, or potential erection deficiencies. Any information contrary to that assumed for the purpose of preparing this analysis could alter the findings and conclusions as stated.

We appreciate the opportunity to provide our services to Wireless Company and if you have any questions concerning this analysis, please contact us.

Sincerely,

ARMOR TOWER, INC.

Alexander Smirnov
Structural Engineer

Site Photo

Client: Adesta Group
Project: PA0014
Calculated By: AAS
Date: 4/12/2010

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PA0019 PlymouthPA Smoke Stack Analysis

Transfer values from April 2009 analysis

Base_Dia := 20ft Top_Dia := 9.5ft Stack_Ht := 200ft

Use TIA/EIA-222-G Code

Incr := 20ft

Define Global Values

$V_o := 90mph$	(Basic wind speed without ice for Luzerne County, PA)
$V_i := 40mph$	(Basic wind speed with ice for Luzerne County, PA)
$G_h := 1.10$	(Tubular pole structure)
$I := 1.15$ $I_{ice} := 1.00$	(Structure class III)
$K_d := 0.95$	(Tubular pole structure)
$K_{zt} := 1.0$	(Topographic Category 1)
$z_g := 900ft$	(Exposure Category C)
$K_{zmin} := 0.85$	(Exposure Category C)
$\alpha := 9.5$	(Exposure Category C)
$t_{iz} := 0.75in$	(Ice thickness)

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Proposed Antenna Configuration:

Proposed equipment: $Z_{ant} := 140ft$ (Antennas elevation)

- (3) Argus TLLPX310R panel antennas
- (6) ODU-2483-2690-000N-38-4x2-N-0
- (2) 2' diameter microwave dishes
- (12) LMR-400-1-1 feed lines

Panel antenna:

$Pan\_Ht := 1070mm = 42.126 \cdot in$

$Pan\_Wd := 300mm = 11.811 \cdot in$

$Pan\_Dpt := 115mm = 4.528 \cdot in$

$Pan\_Qty := 3$

$Pan\_Wght := 28.66lbf$

Microwave Dish:

$Dish\_Dia := 26.1in$

$Dish\_Dpt := 13.2in$

$Dish\_Qty := 2$

$Dish\_Wght := 31lbf$

ODU units:

$ODU\_Ht := 420mm = 16.535 \cdot in$

$ODU\_Wd := 340mm = 13.386 \cdot in$

$ODU\_Dpt := 270mm = 10.63 \cdot in$

$ODU\_Qty := 6$

$ODU\_Wght := 33.07lbf$

Determine Wind Force on the Structure

Height 0-20ft (Increment 1)

Without Ice

$EPA_1 := C_{F1} \cdot D_1 \cdot Incr = 233.7 \cdot ft^2$

$F_1 := q_{z1} \cdot G_h \cdot EPA_1 = 4950.13 \cdot lbf \quad F_1 = 4.95 \cdot kip$

With Ice

$EPA_{1\_ice} := C_{F1\_ice} \cdot (D_1 + 2 \cdot t_{iz}) \cdot Incr = 235.2 \cdot ft^2$

$F_{1\_ice} := q_{z1\_ice} \cdot G_h \cdot EPA_{1\_ice} = 855.72 \cdot lbf \quad F_{1\_ice} = 0.86 \cdot kip$

Height 20-40ft (Increment 2)

Without Ice

$EPA_2 := C_{F2} \cdot D_2 \cdot Incr = 221.1 \cdot ft^2$

$F_2 := q_{z2} \cdot G_h \cdot EPA_2 = 5411.92 \cdot lbf \quad F_2 = 5.41 \cdot kip$

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With Ice

$EPA_{2\_ice} := C_{F2\_ice} \cdot \left(D_2 + 2 \cdot t_{iz}\right) \cdot Incr = 222.6 \cdot ft^2$

$F_{2\_ice} := q_{z2\_ice} \cdot G_h \cdot EPA_{2\_ice} = 935.89 \cdot lbf \qquad F_{2\_ice} = 0.94 \cdot kip$

Height 40-60ft (Increment 3)

Without Ice

$EPA_3 := C_{F3} \cdot D_3 \cdot Incr = 208.5 \cdot ft^2$

$F_3 := q_{z3} \cdot G_h \cdot EPA_3 = 5682.94 \cdot lbf \quad F_3 = 5.68 \cdot kip$

With Ice

$EPA_{3\_ice} := C_{F3\_ice} \cdot \left(D_3 + 2 \cdot t_{iz}\right) \cdot Incr = 210 \cdot ft^2$

$F_{3\_ice} := q_{z3\_ice} \cdot G_h \cdot EPA_{3\_ice} = 983.16 \cdot lbf \qquad F_{3\_ice} = 0.98 \cdot kip$

Height 60-80ft (Increment 4)

Without Ice

$EPA_4 := C_{F4} \cdot D_4 \cdot Incr = 195.9 \cdot ft^2$

$F_4 := q_{z4} \cdot G_h \cdot EPA_4 = 5731.46 \cdot lbf \quad F_4 = 5.73 \cdot kip$

With Ice

$EPA_{4\_ice} := C_{F4\_ice} \cdot \left(D_4 + 2 \cdot t_{iz}\right) \cdot Incr = 197.4 \cdot ft^2$

$F_{4\_ice} := q_{z4\_ice} \cdot G_h \cdot EPA_{4\_ice} = 992.01 \cdot lbf \qquad F_{4\_ice} = 0.99 \cdot kip$

Height 80-100ft (Increment 5)

Without Ice

$EPA_5 := C_{F5} \cdot D_5 \cdot Incr = 183.3 \cdot ft^2$

$F_5 := q_{z5} \cdot G_h \cdot EPA_5 = 5654.2 \cdot lbf \quad F_5 = 5.65 \cdot kip$

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With Ice

$EPA_{5\_ice} := C_{F5\_ice} \cdot \left(D_5 + 2 \cdot t_{iz}\right) \cdot Incr = 184.8 \cdot ft^2$

$F_{5\_ice} := q_{z5\_ice} \cdot G_h \cdot EPA_{5\_ice} = 979.15 \cdot lbf \qquad F_{5\_ice} = 0.98 \cdot kip$

Height 100-120ft (Increment 6)

Without Ice

$EPA_6 := C_{F6} \cdot D_6 \cdot Incr = 170.7 \cdot ft^2$

$F_6 := q_{z6} \cdot G_h \cdot EPA_6 = 5492.75 \cdot lbf \quad F_6 = 5.49 \cdot kip$

With Ice

$EPA_{6\_ice} := C_{F6\_ice} \cdot \left(D_6 + 2 \cdot t_{iz}\right) \cdot Incr = 172.2 \cdot ft^2$

$F_{6\_ice} := q_{z6\_ice} \cdot G_h \cdot EPA_{6\_ice} = 951.76 \cdot lbf \qquad F_{6\_ice} = 0.95 \cdot kip$

Height 120-140ft (Increment 7)

Without Ice

$EPA_7 := C_{F7} \cdot D_7 \cdot Incr = 158.1 \cdot ft^2$

$F_7 := q_{z7} \cdot G_h \cdot EPA_7 = 5269.41 \cdot lbf \quad F_7 = 5.27 \cdot kip$

With Ice

$EPA_{7\_ice} := C_{F7\_ice} \cdot \left(D_7 + 2 \cdot t_{iz}\right) \cdot Incr = 159.6 \cdot ft^2$

$F_{7\_ice} := q_{z7\_ice} \cdot G_h \cdot EPA_{7\_ice} = 913.69 \cdot lbf \qquad F_{7\_ice} = 0.91 \cdot kip$

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Height 140-160ft (Increment 8)

Without Ice

$EPA_8 := C_{F8} \cdot D_8 \cdot Incr = 145.5 \cdot ft^2$

$F_8 := q_{z8} \cdot G_h \cdot EPA_8 = 4997.78 \cdot lbf \quad F_8 = 5 \cdot kip$

With Ice

$EPA_{8\_ice} := C_{F8\_ice} \cdot (D_8 + 2 \cdot t_{iz}) \cdot Incr = 147 \cdot ft^2$

$F_{8\_ice} := q_{z8\_ice} \cdot G_h \cdot EPA_{8\_ice} = 867.3 \cdot lbf \qquad F_{8\_ice} = 0.87 \cdot kip$

Height 160-180ft (Increment 9)

Without Ice

$EPA_9 := C_{F9} \cdot D_9 \cdot Incr = 132.9 \cdot ft^2$

$F_9 := q_{z9} \cdot G_h \cdot EPA_9 = 4686.87 \cdot lbf \quad F_9 = 4.69 \cdot kip$

With Ice

$EPA_{9\_ice} := C_{F9\_ice} \cdot (D_9 + 2 \cdot t_{iz}) \cdot Incr = 134.4 \cdot ft^2$

$F_{9\_ice} := q_{z9\_ice} \cdot G_h \cdot EPA_{9\_ice} = 814.13 \cdot lbf \qquad F_{9\_ice} = 0.81 \cdot kip$

Height 180-200ft (Increment 10)

Without Ice

$EPA_{10} := C_{F10} \cdot D_{10} \cdot Incr = 120.3 \cdot ft^2$

$F_{10} := q_{z10} \cdot G_h \cdot EPA_{10} = 4343.03 \cdot lbf \qquad F_{10} = 4.34 \cdot kip$

With Ice

$EPA_{10\_ice} := C_{F10\_ice} \cdot (D_{10} + 2 \cdot t_{iz}) \cdot Incr = 121.8 \cdot ft^2$

$F_{10\_ice} := q_{z10\_ice} \cdot G_h \cdot EPA_{10\_ice} = 755.29 \cdot lbf \qquad F_{10\_ice} = 0.76 \cdot kip$

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CALCULATE EXISTING EQUIPMENT WIND FORCE

Existing equipment includes:

1) Platform at 120'
2) Platform at 150'
3) Platform on top
4) at@t antennas at 120'
5) Sprint antennas at 150'
6) Nextel antennas at 165'
7) T-Mobile antennas at 180'
8) Verizon antennas at 210'

$z_{att} := 120ft$ $Qty_{att} := 12$ $Pan\_ex\_Ht := 72in$

$z_{spr} := 150ft$ $Qty_{spr} := 6$ $Pan\_ex\_Wd := 8in$

$z_{nex} := 165ft$ $Qty_{nex} := 9$ $Pan\_ex\_Wght := 28lbf$

$z_{tmob} := 180ft$ $Qty_{tmob} := 6$ $Plat\_Wght := 2.4kip$

$z_{ver} := 210ft$ $Qty_{ver} := 12$

at@t antennas

$F_{att} := q_{z\_att} \cdot G_h \cdot EPA_{att} = 961.33 \cdot lbf$ $F_{att\_ice} := q_{z\_att\_ice} \cdot G_h \cdot EPA_{att\_ice} = 200.17 \cdot lbf$

Sprint antennas

$F_{spr} := q_{z\_spr} \cdot G_h \cdot EPA_{spr} = 806.06 \cdot lbf$ $F_{spr\_ice} := q_{z\_spr\_ice} \cdot G_h \cdot EPA_{spr\_ice} = 167.838 \cdot lbf$

Nextel antennas

$F_{nex} := q_{z\_nex} \cdot G_h \cdot EPA_{nex} = 205.6 \cdot lbf$ $F_{nex\_ice} := q_{z\_nex\_ice} \cdot G_h \cdot EPA_{nex\_ice} = 41.96 \cdot lbf$

T-Mobile antennas

$F_{tmob} := q_{z\_tmob} \cdot G_h \cdot EPA_{tmob} = 209.4 \cdot lbf$ $F_{tmob\_ice} := q_{z\_tmob\_ice} \cdot G_h \cdot EPA_{tmob\_ice} = 43.601 \cdot lbf$

Verizon antennas

$F_{ver} := q_{z\_ver} \cdot G_h \cdot EPA_{ver} = 2512.79 \cdot lbf$ $F_{ver\_ice} := q_{z\_ver\_ice} \cdot G_h \cdot EPA_{ver\_ice} = 523.217 \cdot lbf$

Platform @ 120'

$z_{120} := z_{att} = 120 \cdot ft$ $K_{z\_120} := K_z(z_{120}) = 1.315$

$F_{plat120} := F_{plat120\_rail} + F_{plat120\_post} + F_{plat120\_toe} + F_{plat120\_brace} = 1692.42 \cdot lbf$

$F_{plat120\_ice} := F_{plat120\_railice} + F_{plat120\_postice} + F_{plat120\_toeice} + F_{plat120\_braceice} = 457.35 \cdot lbf$

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Platform @ 150'

$z_{150} := z_{spr} = 150 \cdot ft$ $K_{z\_150} := K_z(z_{150}) = 1.378$

$F_{plat150} := F_{plat150\_rail} + F_{plat150\_post} + F_{plat150\_toe} + F_{plat150\_brace} = 1670.78 \cdot lbf$

$F_{plat150\_ice} := F_{plat150\_railice} + F_{plat150\_postice} + F_{plat150\_toeice} + F_{plat150\_braceice} = 458.63 \cdot lbf$

Top Platform

$z_{top} := 205ft$ $K_{z\ top} := K_z(z_{top}) = 1.472$

$F_{plat\_top} := F_{top\_beac} + F_{top\_rail} + F_{top\_base} + F_{top\_diag} + F_{top\_post} = 1737.19 \cdot lbf$

$F_{plat\_topice} := F_{top\_beacice} + F_{top\_railice} + F_{top\_baseice} + F_{top\_diagice} + F_{top\_postice} = 434.88 \cdot lbf$

CALCULATE PROPOSED EQIUIPMENT WIND FORCE

$Pan\_Qty\_exp := 1$ $Dish\_Qty\_exp := 1$ $ODU\_Qty\_exp := 2$

$Z_{ant} = 140 \cdot ft$ $K_{z\_ant} := K_z(Z_{ant}) = 1.359$

$q_{z\_ant} := q_z(K_{z\_ant}, V_o, I) = 30.776 \cdot psf$

$q_{z\_ant\_ice} := q_z(K_{z\_ant}, V_i, I_{ice}) = 5.286 \cdot psf$

Panel Antennas:

$F_{pan} := q_{z\_ant} \cdot G_h \cdot EPA_{pan} = 145.91 \cdot lbf$ $F_{pan\_ice} := q_{z\_ant\_ice} \cdot G_h \cdot EPA_{pan\_ice} = 29.251 \cdot lbf$

Microwave Dishes:

$F_{dish} := q_{z\_ant} \cdot G_h \cdot EPA_{dish} = 150.94 \cdot lbf$ $F_{dish\_ice} := q_{z\_ant\_ice} \cdot G_h \cdot EPA_{dish\_ice} = 28.991 \cdot lbf$

ODU Units:

$F_{odu} := q_{z\_ant} \cdot G_h \cdot EPA_{odu} = 124.89 \cdot lbf$ $F_{odu\_ice} := q_{z\_ant\_ice} \cdot G_h \cdot EPA_{odu\_ice} = 26.019 \cdot lbf$

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CALCULATE FEED LINE IMPACT

Most feed lines are shielded. Consider 2 rows of feed lines on each side of the stack.

$Feed\_Dia := 1.625in$ $Feed\_Qty\_exp := 4$

$R_a := \frac{Feed\_Area_{10}}{Area_{10}} = 0.054$ **< 0.1** **Projected feed line area may be ignored. (ANSI/TIA-222-G Table 2-7)**

CALCULATE OVERTURNING MOMENT OF THE SMOKE STACK

Stack Structure:

$M_{stack} = 5066.92 \cdot kip \cdot ft$

$M_{stack\_ice} = 878.83 \cdot kip \cdot ft$

Existing Equipment:

$M_{exist} := M_{ant\_ex} + M_{plat} = 1645.4 \cdot kip \cdot ft$

$M_{exist\_ice} := M_{ant\_ex\_ice} + M_{plat\_ice} = 386.67 \cdot kip \cdot ft$

Proposed Equipment:

$M_{driving} := M_{stack} + M_{exist} + M_{prop} = 6771.36 \cdot kip \cdot ft$

$M_{driving\_ice} := M_{stack\_ice} + M_{exist\_ice} + M_{prop\_ice} = 1277.3 \cdot kip \cdot ft$

CALCULATE RESISTING MOMENT OF THE SMOKE STACK

Stack Structure:

Structure consist of brick with the concrete shell. (From April 2009 analysis)

$Conc\_Dens := 150 \frac{lbf}{ft^3}$ $Brick\_Dens := 135 \frac{lbf}{ft^3}$ $z_{mid} := \frac{Stack\_Ht}{2} = 100 \cdot ft$

$Conc\_Thick := 8.5in$ $Brick\_Thick := 8in$

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Conc_Wght = 937.41·kip Brick_Wght = 716.28·kip

R_{struct} = 16536.89·kip·ft

Existing Equipment:

Exist_Wght = 8460·lbf R_{exist} = 84.6·kip·ft

Proposed Equipment:

Proposed_Wght = 346.4·lbf $R_{proposed}$ = 3.464·kip·ft

$R_{resisting} := R_{struct} + R_{exist} + R_{proposed}$ = 16624.95·kip·ft

CALCULATE LOADING ON STRUCTURE

Factors:

$Factor_{dead} := 0.9$

$Factor_{wind} := 1.6$

$Factor_{wind\_ice} := 1.0$

Stresses:

σ_{max} = 504.07·psi

σ_{min} = 33.79·psi

Without Ice:

$$Load := \frac{Factor_{wind} M_{driving}}{Factor_{dead} R_{resisting}} = 72.41 \cdot \%$$

With Ice:

$$Load\_ice := \frac{Factor_{wind\_ice} \cdot M_{driving\_ice}}{Factor_{dead} R_{resisting}} = 8.54 \cdot \%$$

CONCLUSION:

PROPOSED LOADING IS ACCEPTABLE