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Report of Structural Engineering and Safety Considerations
Application for Wireless Communications Facility

TO: Bourbon County Joint Planning Commission

RE: Applicant: New Cingular Wireless PCS. LLC d/b/a AT&T Mobility
Site Name: Cane Ridge
Proposal: New Wireless Communication Facility
Location: Roseberry Road; Carlisle KY 40311

Dear Commissioners:

My name is Bill Grigsby. I am a Structural Engineer, licensed in the Commonwealth of Kentucky. My qualifications are outlined in the resume attached as a part of this report. As set out below, I have reviewed the engineering drawings for the above referenced proposed new tower. The Structural Engineer of Record (SER) has certified that this tower meets or exceeds all building code requirements and engineering standards for a structure of this type. In my opinion, it does not pose a threat to public health or safety for the following reasons:

Tower Description:

195' Tall Monopole with a 4' tall (approximate) lightning arrestor.

An eighteen-sided, tapered steel tower with approximate 18.25" and 67.57" (across the flats) diameters at the top and base respectively.

Designed to support antennae at the 193', 181', 169' and 157' elevations.

The SER has provided a mat foundation design for this tower. The drawings indicate a 31'-0" square x 2'-0" thick reinforced concrete mat bearing on ROCK (LIMESTONE with thin SHALE partings – moderately hard to hard, moderately to slightly weathered, very light gray to light gray) at 6'-0" below finish grade. There is an 9'-0" diameter reinforced concrete pier centered under the tower. All concrete elements will be reinforced in accordance with applicable codes and standards.

The structural steel material specified for the construction of this tower is ASTM A572, Grade 65 material.

Blasting will not be used in any way in the construction of the foundation of this tower.

Design Standards:

The 2012 International Building Code (IBC) governs construction within the Commonwealth of Kentucky. The IBC references ANSI Standard TIA/EIA-222 as the controlling standard for the design of these types of structures.

This tower was designed to conform to the requirements of ANSI Standard TIA/EIA-222-G, "Structural Standards for Steel Antenna Towers and Antenna Supporting Structures". (ANSI is the American

National Standards Institute; EIA is the Electronic Industries Association; TIA is the Telecommunications Industry Association.) Revision G is the current revision of TIA/EIA-222.

This communication tower was designed by a Professional Engineer, registered in the Commonwealth of Kentucky. The SER has certified that the tower design conforms to the requirements of TIA/EIA-222-G.

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The design wind speed specified for Kentucky in EIA/TIA-222-G is a wind speed of 89 miles per hour (mph) for a 3-second gust.

The “design wind speed” must not be construed as a “collapse wind speed”. That is; saying that the tower is designed for 89-mph wind does not mean that the tower will collapse if subjected to a 90-mph wind. It can be demonstrated that towers of this nature can withstand wind speeds far more than 90-mph. In fact, some monopole cell towers have survived, intact, a direct hit from a tornado.

In addition to the wind load, the design of this tower assumes that the entire structure along with the antennae and other miscellaneous attachments are covered with a 0.75”-thick layer of ice along with a 30-mph wind. EIA/TIA-222 allows for this reduction of the design wind speed in combination with this radial ice loading.

Construction Procedures and Standards:

Power of Design Group, LLC (POD) prepared a geotechnical report for this project (Re: Report No. 17-12791 dated 08/18/17). The geotechnical report provides foundation design data and criteria along with recommendations for foundation construction. The geotechnical report was based on testing performed and samples taken at the tower site. The report was prepared by a Licensed Professional Engineer registered in the Commonwealth of Kentucky.

The tower foundation design was based on the criteria and recommendations contained in the geotechnical engineer’s report as well as recognized engineering principles. The tower foundation was designed by a Licensed Professional Engineer registered in the Commonwealth of Kentucky.

When the tower foundation is constructed, a representative of the geotechnical engineering firm will be on site for inspections to ensure that the findings outlined in the geotechnical report are consistent with the subsurface conditions encountered during construction and that the recommendations set forth in the geotechnical report are followed. Again, the geotechnical engineer is a Licensed Professional Engineer.

Construction of the tower foundation and erection of the tower are monitored by a “Special Inspector” under the provisions Chapter 17 of the International Building Code (2012 IBC).

All these levels of inspection and engineering control give the construction of cell towers a high level of quality assurance in the commercial construction industry.

Discussion of Structural Integrity:

There are conservatisms inherent in all tower construction regardless of the tower height. For example, wind is a “dynamic load”. However, the analysis of the tower is based on an “equivalent static force” that is calculated to model the dynamic load of the wind. The conversion of the dynamic load of the wind into an equivalent static force is very conservative. In other words, the calculation of the equivalent static force significantly ***overestimates*** the actual wind forces on the tower.

There are additional conservatisms involved in the analysis of the tower to distribute the equivalent static wind forces to the individual tower structural members. There are also conservatisms involved in the calculation of stress in the individual tower structural members.

There are factors of safety and conservatisms involved in determining the allowable stress levels in each individual tower structural member. For example, the code allows the engineer to utilize only 60% of the specified elastic strength or "yield strength" of a structural member in tension. The "elastic limit" for a structural member is defined as the point beyond which a member deflecting under a load will not rebound to its original shape when a load is removed. This is distinguished from the "ultimate strength", where the structural member breaks under the load.

The specified elastic limit for the types of steel used to fabricate these types of structures is generally very conservative. For example, A572, Grade 65 steel is specified for the tower and base plate on this project. This is a common grade of steel used to fabricate structural elements in the construction industry. The yield strength for grade 65 material is a stress of 65,000 pounds per square inch (psi). The actual yield strength for Grade 65 material is almost always greater than 65,000 psi and sometimes greater than 70,000 psi. Limiting the calculated stress to 70% of the specified yield strength of 65,000 psi for Grade 65 material can underestimate the actual capacity of a steel member by as much as fifty percent or more.

The specified ultimate strength of A572, Grade 65 material is typically around 80,000 psi or 1.24 times the specified yield strength. Again, the engineer is limited to about 70% of the yield strength when designing structural members. In other words, if the engineer pushed the stress levels right to the code allowable limit (which few engineers will do), the stress levels in the structural members subjected to a 90-mph wind will be less than 50% of the stress that would fracture that member.

There are twenty-six (26) anchor bolts specified for this tower that are to be fabricated using 2.25" diameter ASTM A615, Grade 75 material. Anchor bolts are designed utilizing the "ultimate strength" of the anchor bolt material. The engineer is limited to about sixty-five percent (65%) of the "ultimate strength" (breaking strength) or eighty-five percent (85%) of the yield strength the anchor bolt material. And, just like the specified yield strength of Grade 50 material discussed above, the specified value for the breaking strength of the anchor bolt is conservative.

The accumulated effect of all these conservatisms and factors of safety (and others not discussed here) is that the actual wind speed at which this tower will "fail" is significantly higher than 90 mph. It is important to understand that the use of the word "fail" in the paragraphs above does not imply that the tower will fall over. The tower foundation is designed to ensure that it is not the weak link. In other words, the tower foundation is much stronger than the tower itself. The code prescribes a factor of safety against overturning of 1.67. The methodology used by engineers to calculate this factor of safety is conservative. The "allowable" design parameters provided by the geotechnical engineer and used in the foundation design typically have a factor of safety of at least 3.

The tower geometry assures that the tower is stronger at the base than at higher elevations. A structural failure of the tower will manifest itself in the top of the tower bending over, not breaking off and falling to the ground. It is my understanding that towers "failed" in exactly this fashion during Hurricane Andrew in Florida (wind speeds exceeded 140-mph during Hurricane Andrew). That is, the tops of the towers bent over, but did not break off and did not become wind-generated missiles.

"Failure" of the communication tower does not imply that the tower will break of at the base and fall over. Any discussion of "fall radius" is misleading because the tower will not simply fall over except in circumstances of sabotage, human misadventure, faulty construction practices or faulty materials.

Because of the levels of control and inspection, the probability of faulty construction materials or faulty workmanship resulting in a catastrophic failure is minimal. Any failure in the tower will occur only under a very high wind and will manifest itself in the top of the tower bending over, not in the tower breaking off at the base and falling over.

In large cities around the country, there are buildings that are as tall as or taller than this proposed communication tower. I am unaware of any discussion of "fall radius" relative to any of these buildings. The design and construction of a monopole communication tower is much less complex than that of a so-called "skyscraper" and yet the communication tower is designed and constructed with levels of control and inspections like those for a skyscraper. It is safe to say that a heavily occupied skyscraper "falling" over in a large city, would be a far greater catastrophic disaster than a falling communication tower.

Extreme Winds (Tornadoes):

Building codes do not address designing for tornado level winds except for certain special structures, such as nuclear power plants. There are several reasons for this, the primary one being the very low probability of occurrence of a tornado at any given location. Another reason is that the cost to "tornado proof" a structure would exceed the cost to re-build a conventional structure in the aftermath of a tornado.

It is not clear that this tower would withstand a "direct hit" from a tornado. However, since the engineering controls over the design and construction of cell towers far exceeds that of any of the residential structures in the vicinity, it is almost certain that a communication tower will be the "last structure standing" in the aftermath of a tornado.

A major concern with respect to tornadoes is the issue of "tornado-generated missiles". A tornado-generated missile is any object picked up by the tornado and thrown great distances at fantastic speeds by the tremendous force of the wind. In the design of nuclear power plants, one of the more devastating design scenario is a tornado-generated missile consisting of a telephone pole hitting the structure at 300-mph.

The communication tower will likely survive a "near-miss" by a tornado in one piece. The top of it may "bend over" but the tower will not break apart. If this communication tower takes a "direct hit" by a tornado, there is the possibility that pieces of the antennae assembly may become tornado-generated missiles. However, there are literally thousands of other objects near this communication site, most notably utility poles, which would be just as potentially devastating as tornado-generated missiles. To the extent that this communication tower is "one more potential missile", it does represent a minuscule increase in the risk of tornado related damage. However, this increase in risk is so small as to be zero for all practical purposes.

Below is photographic evidence of a monopole communication tower surviving an F2/F3 tornado near Dunwoody, Georgia. An F2 tornado has wind speeds of 113 to 157-mph. An F3 tornado has wind speeds of 158 to 206-mph. This storm occurred at about 10:30pm on April 8, 1998. Records from the Climatic Data Center in Asheville, North Carolina indicate wind speeds up to 175-mph in this storm system. As can be seen in the photograph, the tower structure is undamaged. Dunwoody, Georgia is in DeKalb County. According to the EIA/TIA-222 standard the design wind speed for DeKalb County, Georgia is the same as that for Kentucky. Yet, this tower withstood a wind speed of 175-mph. This is a very powerful illustration of the conservatism inherent in the design of these types of structures.

ATLANTA TORNADO AFTERMATH

In conclusion, the proposed communication tower meets or exceeds all of the building and engineering standards for a tower of this type and does not pose a threat to public health or safety.

Respectfully Submitted,

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