

Analysis of Antenna Mast Strength

The bending stress on an antenna mast is dependant on the following items:

- The wind load area of the antennas mounted on the mast;
- The position of the antennas mounted on the mast;
- The cross sectional area of the mast;
- The velocity of the wind.

The strength of the mast is determined by the following mast properties:

- The yield strength of the mast material;
- The cross-sectional dimensions of the mast.

Common antenna tower and mast configurations consist of a rotatable round hollow tubular mast protruding from the top section of a fixed tower. This analysis deals with the portion of the mast that protrudes above the top of the tower.

The calculations are based on equations stated in the 2004 ARRL Antenna Book, Chapter 22 as follows.

The basic formula for wind pressure is:

$$P = .00256 V^2$$

where

P = the wind pressure (pounds per square foot)
V = wind speed (miles per hour)

The force created by the wind on a structure is:

$$F = P \times A \times Cd$$

where

P = the wind pressure
A = the flat projected area of the structure (square feet)
Cd = drag coefficient for the shape of the structure's members.
The commonly accepted *drag coefficient* for long cylindrical members like the tubing used for the mast and antenna is 1.20. The coefficient for a flat plate is 2.0.

The *bending stress* in a simple beam like a mast is:

$$\sigma = (M \times C) / I$$

where

σ = the stress in pounds per square inch (psi)
M = *bending moment* at the base of the mast (inch-pounds)
C = $\frac{1}{2}$ of the mast outside diameter (inches)
I = *moment of inertia* of the mast section (inches⁴)

The moment of inertia for the round tubing mast section is:

$$I = (\pi/4) \times (R^4 - r^4)$$

where

I = Moment of Inertia of the section (inches⁴)
R = Radius of tube outside diameter (inches)
r = Radius of tube inside diameter (inches.) Zero for solid rod.

The equation used to compute the *bending moment* at the base of the mast (where it is supported by the tower) is:

$$M = (F_M \times L_M) + (F_A \times L_A)$$

where

F_M = wind force from the mast (pounds)
F_M = (Mast OD in feet) × (Length of mast above the tower in feet) × P × Cd
L_M = Distance from tower top to center of mast (inches)
F_A = Wind force from the antenna (pounds)
F_A = (Surface area of antenna in feet²) × P × Cd
L_A = Distance from tower top to antenna attachment (inches)
L_M is the distance to the center of the portion of the mast extending above the tower top.
Additional antennas can be added to this formula by including their F × L terms.