Fact Sheet 4.4: Communication Towers, Masts and Antennas

The mitigation objective of this Fact Sheet is to improve the resilience of communications towers, masts and antennas that support vital communications functions at critical facilities so they can continue to operate safely.

Communications antennas often are mounted on towers or masts at heights where they can send and receive radio waves. Towers are self-supporting structures or supported on one side, while masts are held up by stays or guy wires. Towers and masts can be ground-based or mounted on rooftops. Hurricane winds can collapse towers and masts that support antennas, damaging roofing systems by puncturing roof membranes (Figure 4.4.1). Falling trees and limbs also can damage communications towers and masts, but this Fact Sheet only addresses direct damage from wind and flood.

Figure 4.4.1. The collapse of a tower with antennas can damage the roof membrane, causing it to peel.

Table 4.4.1 summarizes some standard mitigation solutions for reducing the risk of damage to communication systems from hurricanes and floods. These strategies are discussed in the sections that follow.

Table 4.4.1. Common Mitigation Solutions for Communications Systems

Solutions and Options	***Wind***	***Pluvial Flooding***	***Riverine (Fluvial) Flooding***	***Coastal Erosion***	***Storm Surge***
Mitigation Solution: Anchor					
Option 1: Add Bracing and Guy Wires	✓				
Option 2: Replace Gravity Supports with Structural Anchors	✓				
Mitigation Solution: Strengthen					
Option 1: Strengthen the Design	✓	✓	✓	✓	✓
Option 2: Use Appropriate Materials	✓	✓	✓	✓	✓
Option 3: Strengthen the Equipment Shelter	✓	✓	✓	✓	✓
Option 4: Strengthen Poles and Lines	✓	✓	✓	✓	✓
Option 5: Add System Redundancy	✓	✓	✓	✓	✓
Mitigation Solution: Elevate or Relocate					
Option 1: Increase the Equipment Elevation	✓	✓	✓	✓	✓
Option 2: Elevate or Change the Site Grading	✓	✓	✓	✓	✓

Mitigation Solution: Anchor

Option 1: Add Bracing and Guy Wires

In high winds, towers and masts frequently become dislodged from the building or the surface on which they are mounted. Antennas mounted on rooftop towers or masts often use only ballast to hold them in place, which quickly can become dislodged during strong winds. Anchoring using guy wires or bracing can improve the performance of towers and masts during high winds. Some things to consider when evaluating this option include:

- Attach guy wires on the towers or masts in a way that is consistent with structural and manufacturer recommendations.
- Anchor towers and masts to solid structures using corrosion-resistant through-bolts and backing plates below the roof.
- Ensure that mast and guy-wire design can resist the potential wind forces and meet design criteria for the jurisdiction. Building codes require that the antenna supports be designed for wind forces based on location, exposure and other factors.
- Consider the building's primary use, e.g., public safety, when determining the correct design level.
- Replace or modify support structures and connections to towers and masts to increase the design strength of the whole system.
- Evaluate the building or structure to which the mast and guy wires are being attached to ensure that it is structurally capable of supporting the additional loads imposed by the tower or mast.
- Develop and implement a regular tower or mast inspection and maintenance plan. Address deficiencies soon after they are discovered to keep the building and equipment in good condition.

CONSIDERATIONS:

Option 2: Replace Gravity Supports with Structural Anchors

Rooftop equipment that is gravity self-supported is vulnerable to high winds because usually it is not anchored to the structure. Instead, antennas often are mounted on towers or masts using ballast sleds and ballast blocks (mounts that rely on the weight of the blocks to keep the tower or mast in place) (Figure 4.4.2). In high-wind areas, antennas subjected to uplift from wind forces may rotate the tower, knocking ballast off the sled. A ballast sled can be replaced with a structural frame that connects directly to the building (Figure 4.2.3). A structural engineer should evaluate the roof before using structural frames to make sure the roof can provide enough support.

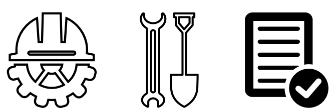
Figure 4.4.2. Rooftop antennas often are mounted using ballast sleds.

Figure 4.4.3. Antennas can be secured to the building structure to improve wind resistance.

When evaluating this option, consider the following items:

- On gravel ballast roofs, the gravel ballast should be removed from under the ballast frame if this approach is used.
- Antennas can be mounted on a tower or mast attached to chimneys, parapets, or other structural parts of the building using straps or anchors (Figure 4.4.3).
    - Anchors and straps should be galvanized or stainless steel to resist corrosion.
    - Anchors require holes to be drilled in the building where the attachment occurs.
    - Straps can be secured to free-standing structural building components, such as chimneys and secured to brackets mounted on the antenna.
    - Chimneys, parapets and other structures must be structurally capable of supporting the forces imposed on them by the antenna as well as their intended functions.

CONSIDERATIONS:



Mitigation Solution: Strengthen

Communications sites can include towers, masts and equipment shelters. Towers and masts can be designed to improve their performance under the forces of wind and flood at the site. Equipment shelters built at the base of large communications towers or masts to house communication equipment (Figure 4.4.4) also can be strengthened to increase the level of protection against damage from floods and hurricanes.

Figure 4.4.4. Exterior and interior of an equipment shelter.

Option 1: Strengthen the Design

Towers, masts, their components and their structural supports should be checked regularly and maintained per code recommendations. Strengthen or replace any of these components if they are not strong enough to withstand the forces of wind or water.

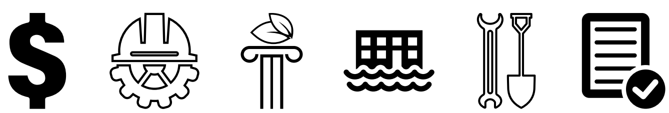
- Evaluate tower or mast strength as part of an assessment.
- Design according to the most recent editions of relevant codes and standards, such as ANSI-TIA-222 and ASCE 7, for expected wind and water forces or even ice loads in the geographic area where the tower is located.
- Design the tower or mast for the appropriate type of use. For example, towers and masts supporting public communications equipment have more strict design requirements than those that support equipment for commercial uses.

- Guy wires and anchors supporting towers should be designed to withstand the wind forces caused by hurricanes. These elements must be properly inspected and maintained through the life cycle of the tower to prevent any section loss from occurring. If the anchor is not strong enough to withstand the wind forces, then additional anchors should be added. These anchors would start within the existing foundation and connect to the tower leg to increase the overall anchorage ability of the tower.
- Evaluate internal bracing within the tower to ensure it can withstand the maximum wind forces for the geographic area. Bracing can be added to improve tower or mast performance in high winds.

Note

ANSI-TIA-222, *Maintenance and Condition Assessment of Telecommunications Towers*, Annex J (Normative), paragraph H outlines a recommended schedule for tower inspections. TIA recommends annual inspections for towers located along the coast subject to corrosive salt air and high winds.

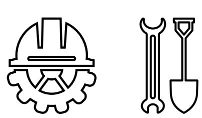
CONSIDERATIONS:



Option 2: Use Appropriate Materials

Use materials suitable for the environment where the tower or mast is located, e.g., galvanized or stainless steel, best resist corrosion in outdoor locations. Metals made of different materials that are in direct contact with each other can result in galvanic corrosion. Ensure that connector metals and the tower or mast structure metals are compatible.

CONSIDERATIONS:

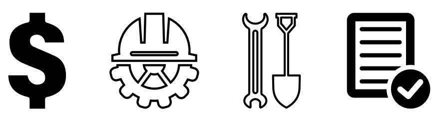


Option 3: Strengthen the Equipment Shelter

Equipment inside a shelter may be mounted to the floor, walls or ceiling via mounting racks. Cables are run through a cable port in the shelter wall and connected to the tower via the underside of a bridging structure known as an ice bridge. Depending on the elevation and location of the equipment shelter, hurricane winds and flooding both may impact the shelter. Improve the equipment shelter's ability to withstand wind and flood damage by implementing the following measures:

- Strengthen the walls and roof of the shelter by using more wind- and flood-resistant materials such as reinforced concrete.
- Improve and seal exterior doors and windows to resist debris impacts and water intrusion.
- See Fact Sheet 3.2, *Walls and Openings,* Fact Sheet 3.3.1, *Sloped Roof Systems*, and Fact Sheet 3.3.2, *Low-Slope Roof Systems*, for additional information.

CONSIDERATIONS:

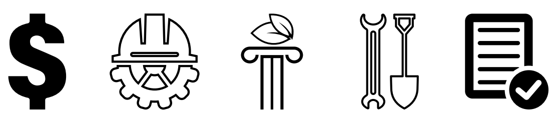


Option 4: Strengthen Poles and Lines

In some cases, antennas are mounted directly on poles rather than on towers or masts. Power and communications lines may be attached directly to the pole. To improve the resilience of communications poles and lines, consider the following:

- Use higher-strength materials for this type of pole. Ensure the pole is structurally able to withstand wind forces in the geographic area, plus the antennas mounted on the poles.
- Use guy wires with extra anchors.
- Improve the pole foundation design by using special fill materials and setting the pole deeper in the ground.
- Evaluate incoming and outgoing communications lines for sufficient strength.
    - Install dampers or de-tuners to dampen some of the vibrations.
    - Install interphase spacers to reduce galloping.
    - Increase tension in the line. This approach can be costly and may be difficult after the line has been constructed.
- See Fact Sheet 4.3, *Electric Power Systems*, for additional information about strengthening lines and poles.

CONSIDERATIONS:



Option 5: Add System Redundancy

Communications systems can stop functioning temporarily when electric power is lost or when data systems go offline. Adding redundancy to power and data systems will help ensure that the communication system continues to function during hurricanes and floods.

Secondary data systems should be in place to back up primary systems if the primary data systems go down. Processes to start the secondary systems should be well-known and practiced in advance of an emergency. Some secondary systems that may be needed include:

- Additional satellite dishes
- Additional microwave dishes
- Additional relay switches

A standby power supply is essential for keeping communications equipment on towers and masts functioning during storms. All standby power supply systems should be elevated out of the floodplain. Communications towers typically have standby generators on-site; however, they must be reachable and maintained regularly to ensure they function when most needed. Below are some key considerations:

- Standby generators must have enough fuel to keep running. Keep fuel tanks filled. If there are concerns about getting to the standby generator because of downed trees or other blockades, consider installing an additional fuel tank.
- Install a quick-connect on the tower or mast to allow a portable backup generator to be used if the primary standby generator fails.
- Consider installing a dual fuel or bi-fuel generator. This will allow continued use of the generator if supplies of one fuel type are temporarily disrupted.
- Add remote monitoring to generators to determine if automatic tests regularly occur and the duration of these tests.
- Communication systems also can use uninterruptable power supply (UPS) systems. These are generally battery systems that can provide 8 to 12 hours of continuous backup to extend connectivity.
- Renewable energy sources such as solar power can be used to provide an additional source of power and may be good options in remote areas that are not easily accessible. They can be connected to UPSs to extend battery life.
- Additional information about backup generators and fuel tanks can be found in Fact Sheet 3.4.2, *Building Utility Systems—Electrical*, and Fact Sheet 3.4.3, *Building Utility Systems—Plumbing*.

CONSIDERATIONS:

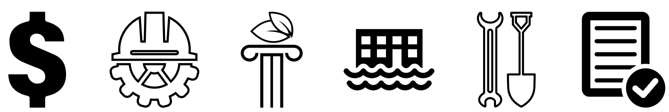
Mitigation Solution: Elevate or Relocate

Option 1: Increase the Equipment Elevation

While many towers and masts themselves cannot be elevated, they support and are supported by equipment that is located on or near the tower or mast. This support equipment should be elevated above the design flood elevation to help protect it against flood damage. When evaluating this option, consider the following:

- Design the first-floor elevation of equipment shelters to be above the design flood elevation.
- Mount floor-supported equipment on the walls or ceiling to raise the elevation of the equipment.
- Elevate the equipment shelter itself above the flood protection level (e.g., design flood elevation) to protect it from flooding. Building elevation is discussed in Fact Sheet 3.1, *Foundations.*
- If an equipment shelter is not available, mount equipment on the tower above the design flood elevation.

CONSIDERATIONS:

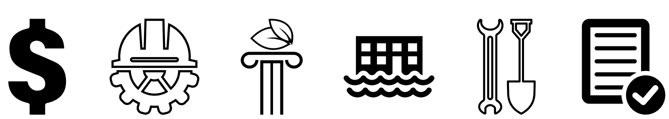


Option 2: Elevate or Change the Site Grading

Flooding at a tower site can block or close the access road. It also can erode and undermine the foundation, leading to uneven foundation settlement, causing further damages. Some measures that can be implemented to help prevent access road and foundation damage include:

- If a tower or mast is in a floodplain, evaluate options to relocate it outside the floodplain. If relocation is not possible, ensure roads used to access the facility will not be made impassable by floodwaters. This could involve raising the road grade, improving roadside drainage, or a combination of these measures. See Fact Sheet 1.3, *Drainage and Culverts*, for additional information about improving road drainage.
- Site location, grading and access should consider increased quantities of stormwater runoff. Site grading designs should consider how to direct large volumes of stormwater runoff away from towers or masts and access roads.
- Designs should include best practices and align with state and local requirements.

CONSIDERATIONS:



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