

UNDERSTANDING THE HAZARD

Wind From Tropical Storms

NATURAL HAZARDS

With proper knowledge and preparation, extensive wind damage can be avoided—even in the most severe storms. This document identifies areas in a building that are most vulnerable to damage, and how to substantially reduce the risk.

UTH TOPIC CATEGORIES:

CONSTRUCTION

EQUIPMENT

FIRE PROTECTION

HUMAN ELEMENT

NATURAL HAZARDS

PROCESS HAZARDS

This series of publications is designed to help you understand the everyday hazards present at your company's facilities. For more information on how you can better understand the risks your business and operations face every day, contact FM Global.



The Hazard

No peril can match the wind of a severe tropical storm (hurricanes, typhoons and cyclones) in its ability to cause widespread devastation. So it comes as no surprise that wind has been one of the most significant contributors to FM Global client losses. During a recent 10-year period, 9% of all the damage sustained by FM Global clients was related to wind. Approximately 70% of all wind losses are attributed to damage during severe tropical storms.

The costliest impact of these storms is the damage that results when the building's envelope is torn open and lets wind and rain into the facility. Below are the most frequent and damaging ways that the building envelope can be opened:

- Roofing covering and insulation tear up and off from the deck.
- Roof-mounted equipment becomes dislodged, opening the roof deck and tearing the roof covering.
- Inadequately secured metal panels or exterior insulation finish systems (EIFS) tear away from the structure.
- Windows are broken by windblown debris, such as surrounding trees or gravel from nearby roofs.
- Windows are blown in or out by the pressure exerted on the building.
- Wind-driven rain penetrates walls at window and door openings.

During a windstorm, damage to the building's structural frame seldom occurs. Yet, a very small breach in the building envelope can destroy a large area of the interior. For this reason, keeping the building envelope sealed is one of the most effective ways of preventing windstorm damage at your facility.

Science of the Hazard

Tropical cyclones are known by many names. In the South Pacific and Indian Oceans they are cyclones, in the Western Pacific they are typhoons and in the Eastern Pacific and Atlantic Oceans, they are hurricanes.

Tropical cyclones spin around a central low-pressure core. The direction of circulation is governed by the rotation of the earth. Storms in the Northern Hemisphere spin counterclockwise, while storms in the Southern Hemisphere spin clockwise.

In the Northern Hemisphere the winds on the eastern side of the storm are typically strongest. In the Southern Hemisphere, the western side of the storm offers the strongest winds.

Keeping the building envelope in one piece through a storm is a simple matter of wind resistance. If the roof, walls and windows can withstand forces exerted by wind and windborne debris, your facility will survive.

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What You Can Do at Your Facility

NOW:

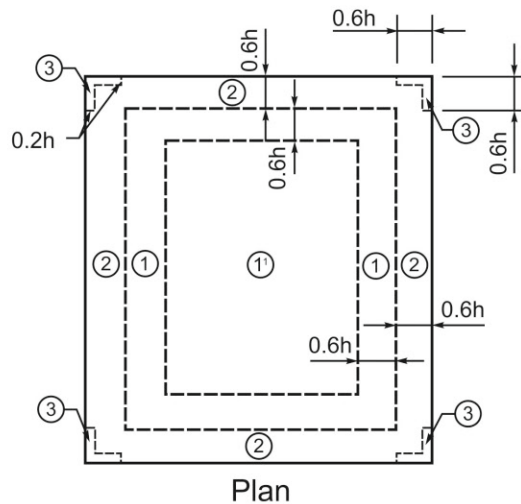
- Screw down the perimeter roof flashing. This part of the building is subject to the strongest forces and is critical to keeping the covering in place.
- Secure roof-mounted equipment. Unsecured equipment can be dislodged, causing damage to the roof and allowing water to enter the building.
- Know your weaknesses. If a roof is suspect, create a contingency plan to ready yourself for a storm. The corners of the roof will likely fail first, so plan to move or cover the stock under these areas.
- Ask your FM Global engineer whether the roof will withstand likely wind forces.

SOON:

- Provide additional fastening and weatherproofing in the corners and perimeter of the roof to meet FM Global recommendations.

How does wind act on the building?

Wind forces on a building create an action similar to that of wind passing over an aircraft wing. Changes in the wind's direction as it passes over and around the building result in uplift or suction forces. These forces vary dramatically in magnitude on different parts of the building. For example, for low-slope roofs (7° or less) at the **perimeter edge** of the roof the uplift force can be over 30% higher than on the main (**field**) part of the roof. In the **corners**, the wind forces can be approximately 80% higher. In the case where a single window or door fails, positive pressure can be created within the building envelope to further increase total wind load to the roof. Clearly, this means that if the corners of the roof experience the strongest force, these are the areas that will probably fail first. FM Global's loss experience bears this out. It also tells us that if these small corner areas are reinforced with increased fastening, they are less likely to fail.



h = the roof eave height.

Zone 3: The roof corners, with L-shaped dimension = $0.6h$ by $0.6h$ by $0.2h$.

Zone 2: The roof perimeter, between the corners, with rectangular dimension and width = $0.6h$ from roof edges.

Zone 1: The field-of-roof (are inside corners and perimeter corners) up to a distance of $1.2h$ from the edge of the roof.

Zone 1': Applies to relatively wide buildings ($>2.4h$) and covers the remaining roof area inward from Zone 1.

Engineers have understood this issue for some time and have developed design standards that take into account these different forces. However, as with most engineering standards, the choices made in the design process will have a dramatic impact on the resulting strength. Many are surprised that, while the building might be "designed to code," the wrong choices can mean that it will still suffer damage in a windstorm.

Codes deal more with design loads than with ways to resist those loads and are more focused on life safety than property protection. FM Approved roofs use tested systems that were designed by their manufacturers to meet FM Approval. This goes well beyond the theoretical design approach. FM Approved roof systems are actually load-tested and verified to meet specific wind pressure parameters and then listed accordingly.

What windspeed should I design for at my facility?

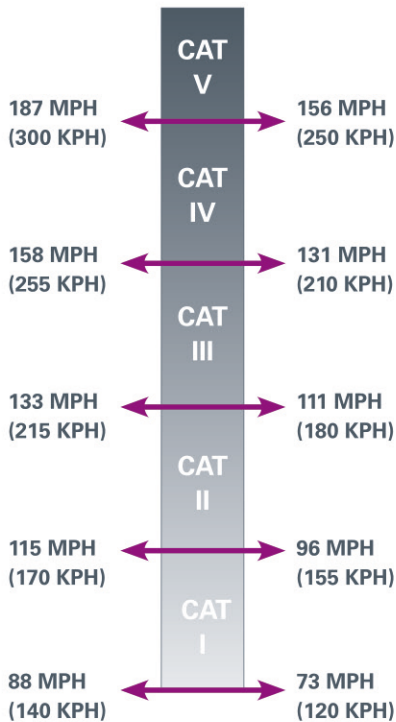
Windspeed selection is the most fundamental choice that designers make in calculating wind forces. However, selecting a speed off a map needs to be done with an understanding of the event being described by that windspeed.

Wind maps are developed through a statistical analysis of windspeed measurements. The maps most often represent the annual probability or likelihood of the windspeed being equaled or exceeded. For example, a 50-year wind map might show a 2% probability that a given windspeed will be exceeded. This level of

What You Can Do at Your Facility

3-SECOND
GUST
WINDSPEED*

60-SECOND
MEAN
WINDSPEED



It is important to know which basis is being applied when discussing the intensity of a windstorm. Windspeed can be measured by various averaging times, such as the 3-second gust and 60-second mean. The comparison above shows the relationship between these two measurements. For example, a windspeed at the threshold of a Category 3 hurricane is 133 mph by the 3-second gust windspeed, which compares to 111 mph by the 60-second mean windspeed.

**These windspeeds are over water and are effective at a height of 33 ft. (10 m) in open terrain.*

probability sounds remote at first, but don't be misled into thinking this is a storm that will occur only once every 50 years. Remember that it is a 2% probability of exceedence per year. Statistically, this means that if your facility life is 30 years, you have a 46% overall probability that the windspeed will be either equaled or exceeded.

Do you want to roll the dice?

Wind maps in building codes are good starting points for indicating the wind speeds your facility can expect, but history often tells us a good deal more. For example, if the code tells us to design for a windspeed of 90 mph (145 kph), and three storms with winds exceeding that speed have passed within 100 miles (62 km) in the past 20 years, your facility should probably be designed to withstand a higher windspeed. It may simply be a matter of luck that the storm took a turn or chose a path away from you.

So what does all this mean?

There are two important lessons to take from this:

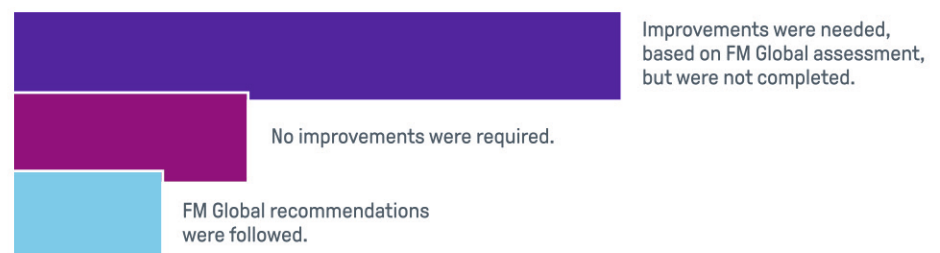
1. Wind acts on different parts of the building in different ways. The corner and edge areas of the roof experience significantly more pressure and are often the first to fail. These areas need to be well secured. Since they are smaller areas, enhancement is well justified by the reduction of damage to buildings and their contents.
2. The wind pressures your facility is designed to withstand should be realistic for its entire lifetime. Life safety-based design codes most often design for a windspeed that is likely to be exceeded while your facility is still standing. Use code wind maps as a starting point and then apply common sense based on history.

Loss Experience

Windstorms contribute significantly to the overall losses of FM Global clients — an average of US\$380 million per year, and over 9% of total losses during a recent 10-year period. Nearly all of these losses could have been prevented.

A review of losses following the 2017 Atlantic hurricane season showed FM Global engineering to be very effective at identifying where roofing losses will occur, and how to build new construction or retrofit existing construction economically, to avoid wind losses. More important, FM Global engineering guidelines were very effective at reducing damage. As seen in the chart below, facilities that did not follow FM Global recommendations for roofing enhancements suffered over 4 times as much damage as those who acted on our advice.

RELATIVE LOSS DAMAGE DURING 2017 ATLANTIC HURRICANE SEASON



Source: FM Global clients

Need more information?

Ask your FM Global engineer or client service team about the following:

- FM Global data sheets related to wind design.

Ordering Information

For additional copies of *Understanding the Hazard* publications, contact your FM Global engineer or client service team.

Additional FM Global brochures and educational material can be found in the FM Global Resource Catalog and ordered or downloaded online at fmglobalcatalog.com. Or, for personal assistance worldwide, contact our U.S.-based customer services team, Monday – Friday, 8 a.m. – 5 p.m. ET :
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But what about...

...THE COST OF IMPROVING MY ROOF?

The focus of FM Global's wind engineering efforts is on the building envelope, not the main frame structure. Our experience has shown that the structural frame, when designed to code, will likely be adequate. A focus on the envelope (typically the roof) normally involves the addition of fasteners and weatherproofing, usually at the corners and edges. The cost of improvement is well justified.

...THE FACT THAT MY BUILDING MEETS THE CODE?

Codes are established with the primary goal of life safety in mind. Buildings with high occupancy levels, such as schools, typically require a design that withstands higher windspeeds. In this context, the fact that your facility meets the code does not necessarily mean it is designed to protect your business from the elements during its lifetime.

...THE FACT MY BUILDING HAS BEEN HERE 20 YEARS AND I'VE NEVER HAD A PROBLEM. IT HAS EVEN SURVIVED A HURRICANE!

The diameter of the damaging winds of a hurricane, typhoon or cyclone is typically 50 to 100 miles (100 to 200 km), while the storm area can be 100 to 300 miles wide (200 to 500 km). Within these areas the windspeeds vary significantly. Your building likely experienced wind pressures well below the design pressure. Given this range of windspeed and area, it is impossible to predict from past storms how well your facility may survive the storms of the future.



Don't Let This Happen to You...

Inadequate securement of the roof deck and above-deck components allowed extensive damage at this facility.