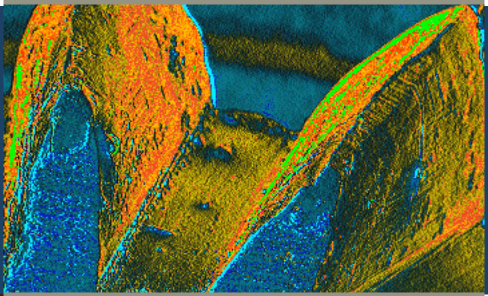
Structural Damage:
The Tornado Effect



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Stormy Beginning

Tornado season usually begins in March, and forecaster Accu-Weather predicts above-normal tornado numbers for 2012. The warmer-than-normal water in the Gulf of Mexico will provide the moist, unstable air to produce thunderstorms that spawn tornadoes.

Credit: National Oceanic and Atmospheric Administration

1,894
total number of tornadoes in the U.S. (2011)

Source: Storm Prediction Center

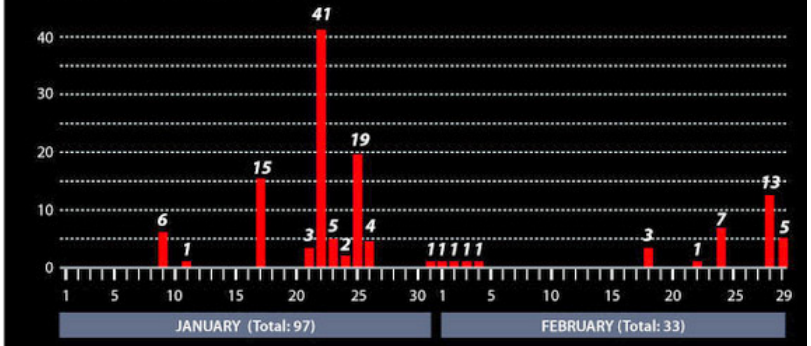
550
Americans killed in tornadoes (2011)

Source: Weather Service

$28.7 billion
of damage caused by tornadoes (2011)

Source: U.S. National Climatic Data Center

Tornadoes in 2012, by date*



*Tornado numbers are preliminary

La Niña events

La Niña is associated with cooler-than-normal water temperatures in the Equatorial Pacific Ocean, unlike El Niño, which is associated with warmer-than-normal water. On average, La Niña winters are warmer than normal in the Southeast U.S. and colder than normal in the Northwest.

Note: Width of bar denotes length of La Niña event

SOURCES: WASHINGTON POST, STORM PREDICTION CENTER, U.S. NATIONAL CLIMATIC DATA CENTER, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, WEATHER SERVICE, ACCUWEATHER

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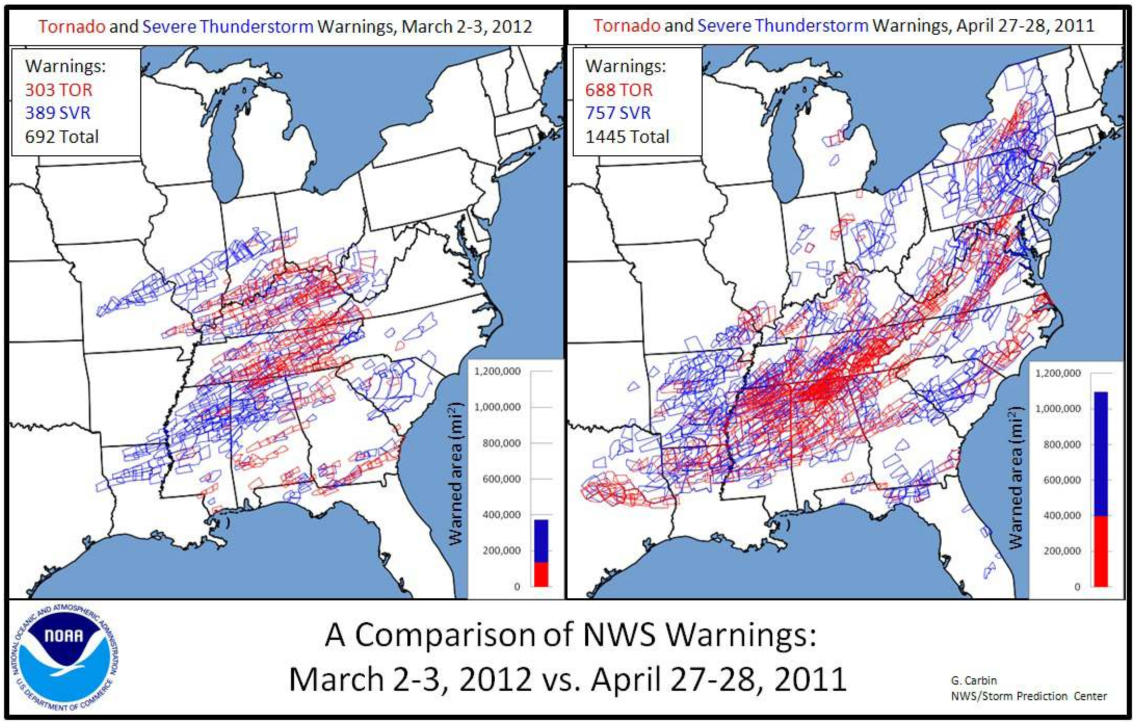
2012: Tornado Season…



Tornadoes - By Definition

A tornado is "a violently rotating column of air, in contact with the ground, either pendant from a cumuliform cloud or underneath a cumuliform cloud, and often (but not always) visible as a funnel cloud".[1]

For a vortex to be classified as a tornado, it must be in contact with both the ground and the cloud base. Scientists have not yet created a complete definition of the word; for example, there is disagreement as to whether separate touchdowns of the same funnel constitute separate tornadoes.[2]

Size and Shape

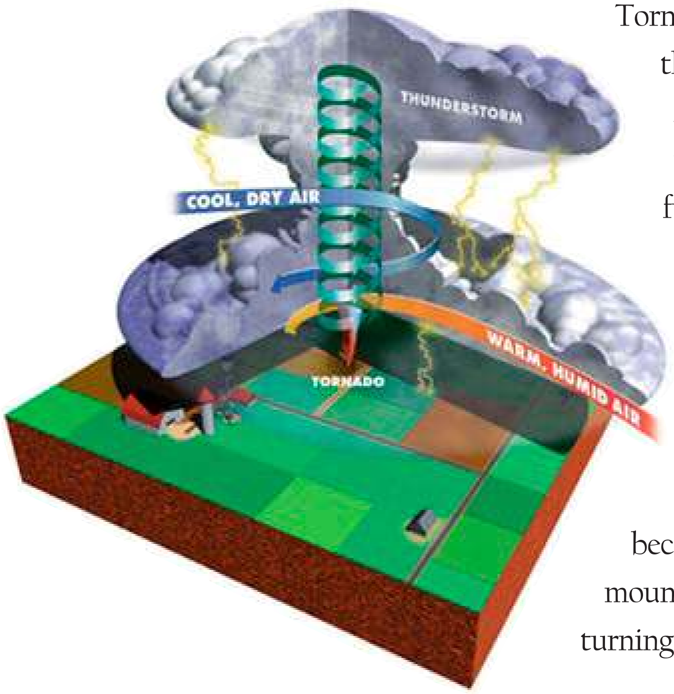
Most tornadoes take on the appearance of a narrow funnel, a few hundred yards (meters) across, with a small cloud of debris near the ground. Tornadoes may be obscured completely by rain or dust. These tornadoes are especially dangerous, as even experienced meteorologists might not see them.[3] Tornadoes can appear in many shapes and sizes.

Small, relatively weak landspouts may be visible only as a small swirl of dust on the ground. Although the condensation funnel may not extend all the way to the ground, if associated surface winds are greater than 40 mph (64 km/h), the circulation is considered a tornado.[4] A tornado with a nearly cylindrical profile and relative low height is sometimes referred to as a "stovepipe" tornado. Large single-vortex tornadoes can look like large wedges stuck into the ground, and so are known as "wedge tornadoes" or "wedges". The "stovepipe" classification is also used for this type of tornado, if it otherwise fits that profile. A wedge can

be so wide that it appears to be a block of dark clouds, wider than the distance from the cloud base to the ground. Many, but not all major tornadoes are wedges.[5]

Tornadoes in the dissipating stage can resemble narrow tubes or ropes, and often curl or twist into complex shapes. These tornadoes are said to be "roping out", or becoming a "rope tornado". When they rope out, the length of their funnel increases, which forces the winds within the funnel to weaken due to conservation of angular momentum.[6] Multiple-vortex tornadoes can appear as a family of swirls circling a common center, or may be completely obscured by condensation, dust, and debris, appearing to be a single funnel.[7] In the United States, tornadoes are around 500 feet (150 m) across on average and stay on the ground for 5 miles (8.0 km).[8] Yet, there is a wide range of tornado sizes. Weak tornadoes, or strong yet dissipating tornadoes, can be exceedingly narrow, sometimes only a few feet or couple meters across.

Appearance



Tornadoes can have a wide range of colors, depending on the environment in which they form. Those which form in a dry environment can be nearly invisible, marked only by swirling debris at the base of the funnel. Condensation funnels which pick up little or no debris can be gray to white. While traveling over a body of water as a waterspout, they can turn very white or even blue. Funnels which move slowly, ingesting a lot of debris and dirt, are usually darker, taking on the color of debris. Tornadoes in the Great Plains can turn red because of the reddish tint of the soil, and tornadoes in mountainous areas can travel over snow-covered ground, turning white.[9]

Lighting conditions are a major factor in the appearance of a tornado. A tornado which is "back-lit" (viewed with the sun behind it) appears very dark. The same tornado, viewed with the sun at the observer's back, may appear gray or brilliant white. Tornadoes which occur near the time of sunset can be many different colors, appearing in hues of yellow, orange, and pink.[10][11]

Dust kicked up by the winds of the parent thunderstorm, heavy rain and hail, and the darkness of night are all factors which can reduce the visibility of tornadoes. Tornadoes occurring in these conditions are especially dangerous, since only weather radar observations, or possibly the sound of an approaching tornado, serve as any warning to those in the storm's path. Most significant tornadoes form under the

storm's updraft base, which is rain-free,[12] making them visible.[13] Also, most tornadoes occur in the late afternoon, when the bright sun can penetrate even the thickest clouds.[14] Night-time tornadoes are often illuminated by frequent lightning.

There is mounting evidence, including Doppler On Wheels mobile radar images and eyewitness accounts, that most tornadoes have a clear, calm center with extremely low pressure, akin to the eye of tropical cyclones. This area would be clear (possibly full of dust), have relatively light winds, and be very dark, since the light would be blocked by swirling debris on the outside of the tornado. [15][16][17]

Rotation

Tornadoes normally rotate cyclonically in direction (counterclockwise in the northern hemisphere, clockwise in the southern). While large-scale storms always rotate cyclonically due to the Coriolis effect, thunderstorms and tornadoes are so small that the direct influence of the Coriolis effect is unimportant, as indicated by their large Rossby numbers. Supercells and tornadoes rotate cyclonically in numerical simulations even when the Coriolis effect is neglected.[18][19] Low-level mesocyclones and tornadoes owe their rotation to complex processes within the supercell and ambient environment.[20]

Approximately 1 percent of tornadoes rotate in an anticyclonic direction in the northern hemisphere. Typically, systems as weak as landspouts and gustnadoes can rotate anticyclonically, and usually only those which form on the anticyclonic shear side of the descending rear flank downdraft in a cyclonic supercell.[21] On rare occasions, anticyclonic tornadoes form in association with the mesoanticyclone of an anticyclonic supercell, in the same manner as the typical cyclonic tornado, or as a companion tornado either as a satellite tornado or associated with anticyclonic eddies within a supercell.[22]

Tornadoes?

by Gary Jackson

It's not difficult to determine when a tornado passes through an area because extensive destruction is apparent along a narrow path. Generally the path travels from the southwest towards the northeast. This path of trouble is a consequence of the earth's shape, rotation, and the behavior of weather systems in the northern hemisphere. The type of structural devastation we typically see in residential construction is more severe due to the stronger winds associated with a tornado. We frequently are asked after tornado events to determine whether the structure is salvageable or be considered a total loss.

Technically, all structures can be repaired. The real task is to determine whether the cost and difficulties of repairs would exceed the practical value of the structure. In general, our primary focus is on the structural members; however, other features that impact the cost and difficulties of repairs are assessed, including insulation, electrical wiring, and the type of construction. Included in the scope of our structural evaluation is determining whether a structure provides a safety hazard to the public. If a house is in an eminent danger of collapse, torn from its foundation, or the total structure is racked it is usually considered a total loss.

When an area is damaged by straight line winds; in general, the trees and branches are all blown in the same direction. Typical straight line wind damage includes: lifted and torn shingles, missing trim, rain gutters, and downspouts.

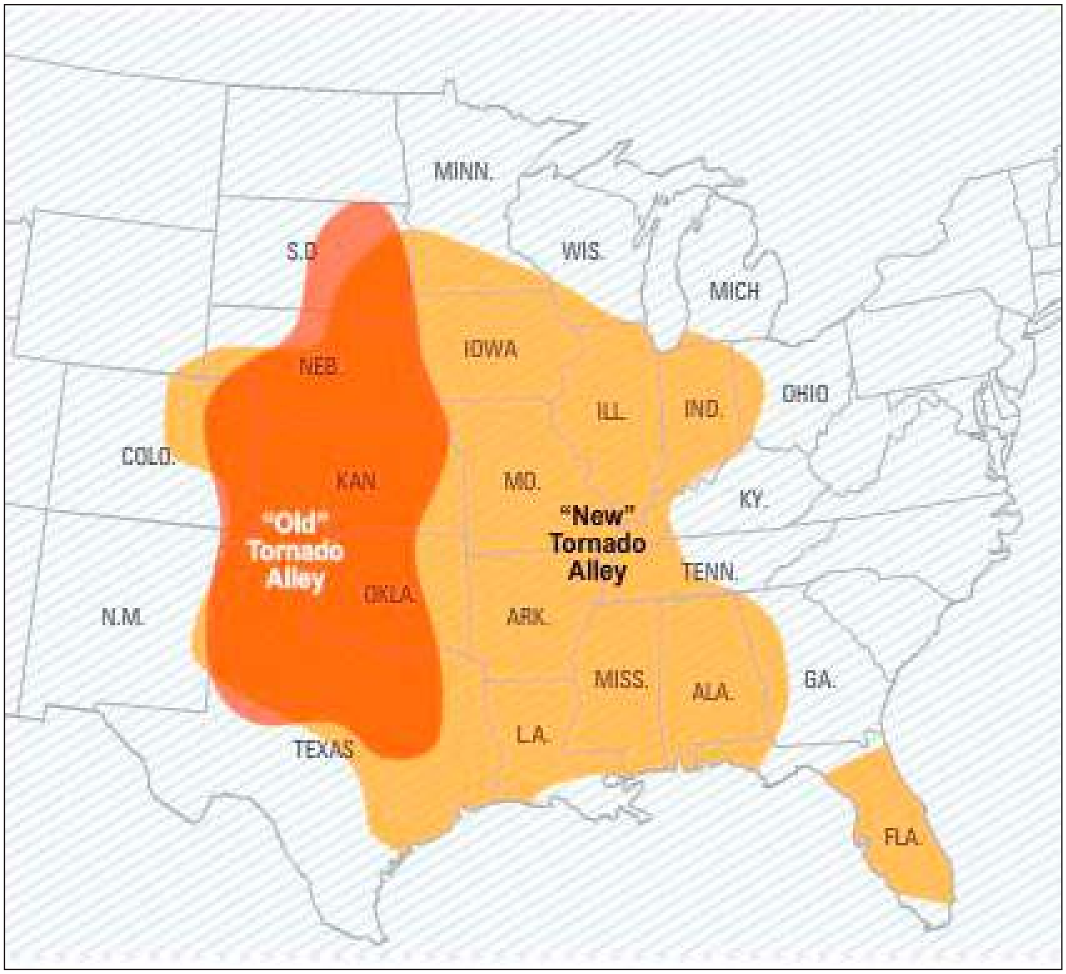
When a tornado passes through an area there will be trees uprooted, branches broken, and debris scattered all directions due to the varies wind directions inside a tornado.

Differentiating new storm related damage from old or pre-existing damage can accomplished be done visually. A new crack in concrete, brick, mortar, etc. will have sharp clean fracture surfaces while old cracks will be dirty, with the edges worn and may reveal insect nesting activity or paint inside the crack.

When we are sent on tornado damage assignments we will frequently do multiple inspections in the same day, sometimes looking at 3 or 4 homes in the same area. This reduces the cost by combining travel expenses and collects the information in a timely manner so the insured can be accommodated with temporary housing if necessary. In general, the cause of the damage is not in dispute, and the scope of the project is determining practicality of home repair.

Where is Tornado Alley?

“Tornado Alley” typically includes the Plains states from the Dakotas to Texas. However, a new study shows that the frequency and severity of tornadoes are actually much more widespread, so Tornado Alley should also include several states in the upper Midwest and Deep South, along with Florida. [23]



Where to get Your Information by Brian Haygood

With the advent of the internet, finding information on a subject is a “click” away. Tornado information is readily available and two sites provide tremendous information on the history and minute by minute of tornado activity.

The first website discussed is www.wunderground.com/tornado/, this site provides a historical and current map of tornado activity with interactive maps, videos and photos that cover aspect of tornado activity. The main interactive map shows mapped ground tracking, width, length and path, along with enhanced Fujita ratings of current and historical tornado activity. Another website that provides historical tornado activity up to the year 2010, is www.tornadohistoryproject.com, a interactive map gives you the opportunity to choose a tornado location by Year, Month, Day, State, Fujita, and County.

Fujita Ratings Explained

Dr. Ted Fujita (1971) developed the Fujita Scale to provide a method to rate the intensity of tornadoes. The intent of the scale was to distinguish between weak tornadoes and strong tornadoes. There was a need to be able to rate tornadoes in the historical database as well as future tornadoes as they occur. The meteorological and engineering communities almost immediately accepted the Fujita Scale.

Although the Fujita Scale has been in use for 33 years, the limitations of the scale are well known to the users. The primary limitations are a lack of damage indicators, no account of construction quality and variability and no definitive correlation between damage and wind speed. These limitations have led to inconsistent rating of tornadoes and in some cases an overestimate of tornado wind speeds. A enhanced Fujita Scale was created in 2004, to more accurately categorize tornado activity. The complete report can be downloaded at **http://www.depts.ttu.edu/weweb/pubs/fscale/efscale.pdf**.

Rating a Tornado Event

The rating of a tornado event should represent an estimate of the highest wind speed that occurred during the life cycle of the tornado. It is well known that wind speed intensity varies both along the length and across the width of a tornado damage path. It may not be possible to estimate the true tornado wind speed, if the actual wind speed is greater than the upper bound wind speed of the damage indicators (DI) being considered. For example, the upper bound wind speed for total destruction of a one and two-family residence home is 220 mph. The actual wind speed in the tornado could have been higher since there is not another Degrees of Damage (DOD) to indicate a higher wind speed. Ideally the recommended approach for assigning an EF-Scale rating to a tornado event involves the following steps:

- Conduct an aerial survey of damage path to identify possible damage indicators and define the extent of the damage path
- Select several DIs that tend to indicate the highest wind speed within the damage path
- Locate those DIs within the damage path
- Conduct a ground survey and carefully examine the DIs of interest

- Follow the steps outlined for assigning EF-Scale rating to individual DIs and document the results
- Consider the estimated wind speeds of several DIs, if available, and arrive at an EF-Scale rating for the tornado event
- Rate the tornado intensity by applying the highest rated DI, provided there is supporting evidence of similar damage intensity immediately surrounding the DI.
- Record the basis for assigning an EF-Scale rating to the tornado event
- Record other pertinent data relating to the tornado event.

Straight Line Winds?

by Brian Haygood

Straight line winds are produced by the downward momentum in the downdraft region of a thunderstorm. An environment conducive to strong straight-line wind is one in which the updrafts and thus downdrafts are strong, the air is dry in the middle troposphere and the storm has a fast forward motion. Straight-line wind damage will push debris in the same direction the wind is blowing (hence the creation of the term straight-line). Tornado damage will scatter the debris in a variety of different directions since the winds of a tornado are rotating violently.

Wind Behavior

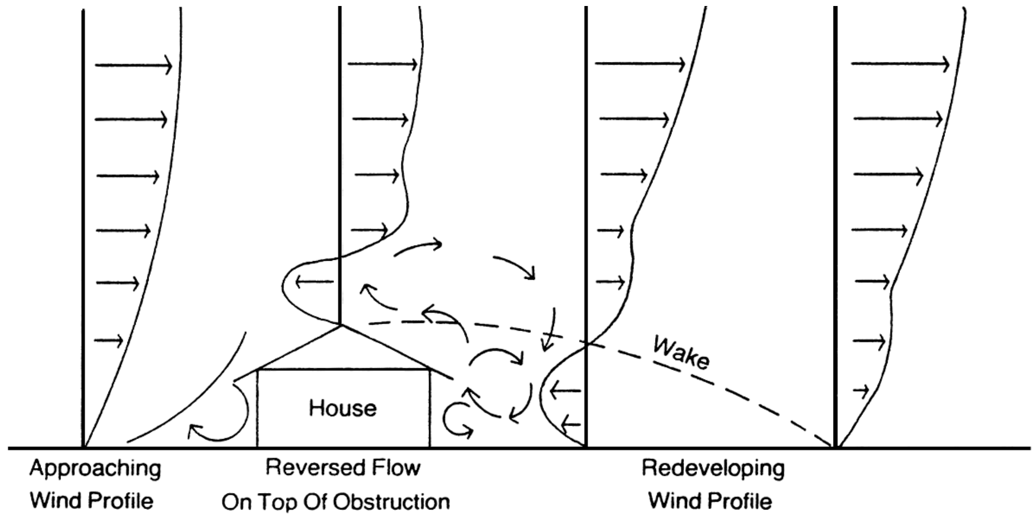


Fig. 2–22: Wind turbulence caused by ground-level obstruction.

The wind speed is always fluctuating and thus the energy content of the wind is always changing.
Exactly how large the variation is depends both on the weather and on local surface conditions and obstacles.
The mathematics of wind behavior: Speed, energy, and power -

Wind energy is proportional to wind speed squared

Kinetic energy of a moving object is $KE = 1/2\ mV^2$ where KE= Kinetic Energy, m= mass of the moving object, v= velocity

Wind power is proportional to wind speed cubed, Power is Kinetic Energy times velocity

$P = (KE)\ V = 1/2\ mV^3$

Energy is the ability to do work. Power is the rate at which work can be done.

A Simplified Wind Load Method

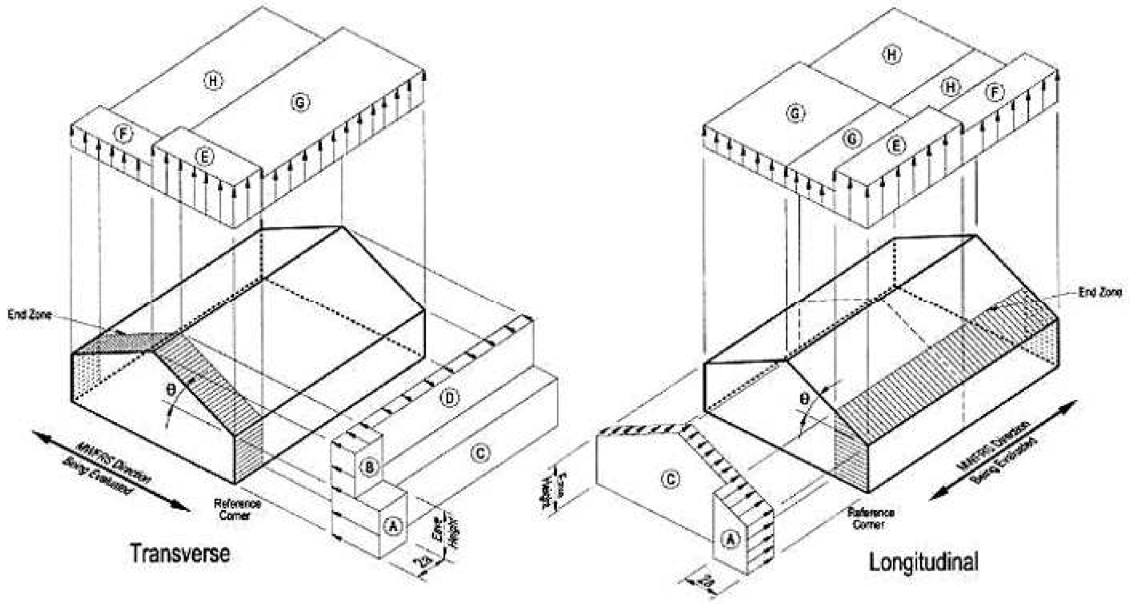
The idea is to determine the wind pressure on a given surface of the structure, allowing one to predict wind loads a structure will face. Following the method should result in a structure that is 25% overbuilt. This means an actual structure built to code should not fail until it faces wind pressures 25% stronger than the highest expected gusts impart. Pressure (simplified) on a portion, or "zone" of a building's surface is determined by the following equation:

$$p_s = \lambda I_W P_{s30} \quad \text{(Equation 16-34)}$$

Where,

λ adds more wind pressure for tall or exposed buildings I_W adds more safety for important buildings, and P_{s30} is the basic pressure for a building under thirty (30) feet tall.

In The Zones



Zones, or portions of a structure, give an idea of where damage is more or less likely to occur.
Establish the Basic Wind Speed, V is read from maps like that on a slide of ten (10), or may be increased for a given municipality. Most buildings have a importance factor of "1", hospitals and storm shelters use "1.15" (built to withstand 15% higher loads).

Wind Exposure - B, C, or D

Exposure B, urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions. Exposure C, open terrain with obstructions under thirty (30) feet tall, including flat open country, grasslands, and shorelines in hurricane-prone regions. Exposure D, flat, unobstructed areas exposed to wind flowing over open water for a distance of over one mile (excluding shorelines noted above), extending fifteen hundred (1500) feet from the shoreline.

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