

# STANDING SEAM SPOTLIGHT

## An Educational Bulletin for Metal Roofing Professionals

### Designing Safe Houses to Withstand Nature's Fury

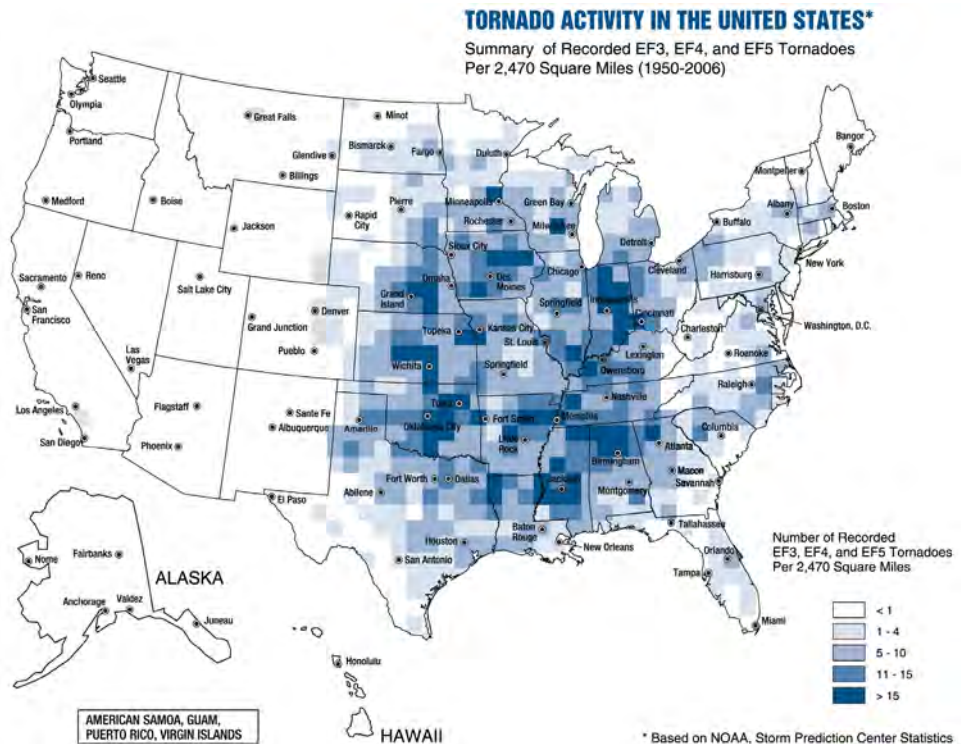
by Amy Stokes

*Tornadoes and hurricanes are among the most destructive forces of nature. Unfortunately, these types of wind storms continue to cause injury and death to people who are unable to safely evacuate or find shelter from these events. In some cases, even designated shelters failed to protect those within. Buildings that will be used either entirely or partially as a storm shelter must be able to provide the needed refuge when called upon. That is why the FEMA 361 standard provides guidance on the design of community shelters and safe rooms.*

Community shelters are intended to provide a much greater level of protection against wind and the impact of windborne debris to its occupants than the protection provided by conventional buildings that merely comply with the minimum requirements of building codes. According to FEMA, building codes have not adequately addressed the design and construction criteria required to provide life safety during sheltering, nor have they provided design criteria for tornadoes.

Since the early 1970s, studies have been conducted to evaluate and establish appropriate design parameters for community shelters from tornadoes, hurricanes, and other extreme wind events. The International Code Council in partnership with FEMA and the National Storm Shelter Association (NSSA), formed a national committee that released a new consensus standard to codify the design and construction requirements of extreme-wind storm shelters. This new standard, the ICC/NSSA Standard for the Design and Construction of Storm Shelters (ICC-500), was completed in the summer of 2008 and will be incorporated by reference into the 2009 International Building Code® (IBC®) and the International Residential Code® (IRC®).

## SHELTER FROM THE STORM



FEMA 361, Design and Construction Guidance for Community Safe Rooms was developed to provide design professionals with guidance on the design of community "safe rooms" that can accommodate large groups of people for protection from extreme-wind events for larger, at-risk populations. FEMA uses the term "safe room" to describe a shelter that is constructed to meet the FEMA criteria, which meets or exceed the shelter requirements of the ICC-500.

A safe room can be either a stand alone building, or it can be a room or an area within or attached to a larger building, that is constructed in accordance with the FEMA 361 guidelines to provide "near-absolute protection" from extreme-wind events.

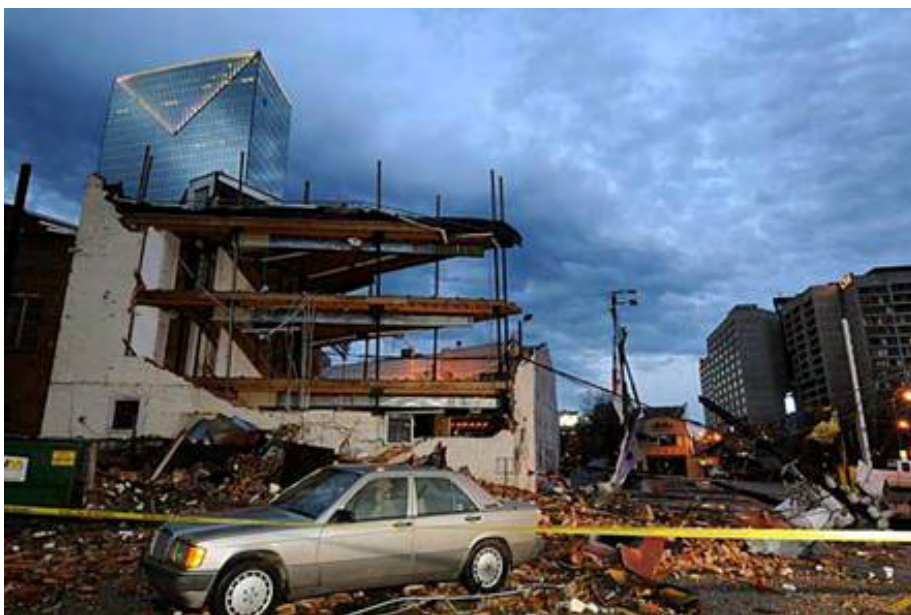
## Frequency and Cost of Tornadoes on the Rise

On average, more than 1,275 tornadoes have been reported nationwide each year since 1997. From 1950 through 2006, tornadoes have caused 5,506 deaths and 93,287 injuries, as well as devastating personal and property losses.

According to the National Weather Service, 1953 was the deadliest year with 519 tornado-related deaths. The average in recent years has been 62 deaths per year, with 38 occurring in 2005, 67 in 2006 and 81 in 2007. As of May 2008, tornadoes were responsible for 110 deaths.

Insurance claim losses from a single tornadic event of \$1 billion and higher are becoming more frequent. Even though hurricanes and earthquakes typically generate higher losses per event, since 1953 tornadoes (and related weather events) have caused an average of 57 percent of all U.S. insured catastrophic losses. In 2007, that number increased to 69 percent.

In March of last year, we at IMETCO witnessed first hand (and live on T.V.), even how devastating a tornado on the low end of the Enhanced Fujita Scale can be, when downtown Atlanta was hit by an EF1 tornado that strengthened to an EF2 as it moved across the heart of the city causing \$349 million in losses. The iconic Peachtree Plaza hotel that defines the Atlanta skyline still has openings where windows used to be. Spectators of the SEC Tournament, which was in progress at the Georgia Dome when the tornado hit, will never forget the moment when this storm ripped panels from the roof of the Dome as falling debris was captured live on ESPN.



On March 1, 2007, a significant tornado developed near Enterprise, Alabama; and with deadly results. The tornado was categorized as a lower-end EF4 and produced enough force to damage a significant portion of the town, including Enterprise High School. Eight students perished at the high school as they were sheltering-in-place. The school had identified a best-available area for refuge during a tornado, but no portion of the building had actually been hardened for tornado resistance to provide the level of protection consistent with a FEMA 361 safe room. After the event, the following statement was released by the investigators from the National Oceanic and Atmospheric Administration (NOAA – Tornadoes in Southern Alabama and Georgia, March 1, 2007; NOAA tornado assessment):

*“The high school in Enterprise followed proper protocol in terms of maximizing student safety. The eight fatalities at the high school appear to have been due to structural failure of the roof and walls, which collapsed on the students. Previous events have shown that hardened safe rooms provide better shelter from tornadoes than other permanent structures, especially during EF3 or greater tornadoes, and may be a critical component of adequate tornado safety plans, especially in mobile home parks, homes with standard grade construction, and non-residential buildings in which many people normally gather (schools, office buildings, etc.).”*

Events like these show the deadly and destructive potential of tornadoes, and continue to illustrate the compelling need for shelters and safe rooms capable of protecting human lives against the risk of tornadoes.

Tornado occurrence data obtained from NOAA Storm Prediction Center records at <http://www.spc.noaa.gov/climo/historical.html>.



Comparison Table for the Fujita and Enhanced Fujita Scales

Fujita Scale		EF Scale	
Fujita Scale	3-Second Gust Speed (mph)	EF Scale	3-Second Gust Speed (mph)
F0	45-78	EF0	65-85
F1	79-117	EF1	86-109
F2	118-161	EF2	110-137
F3	162-209	EF3	138-167
F4	210-261	EF4	168-199
F5	262-317	EF5	200-234

## Design Wind Speed and Windborne Debris Resistance

When a building is designed for use as a shelter, the primary difference in its structural system, versus that of a conventional use building, is the magnitude of the wind forces it is designed to withstand.

Conventional buildings are designed to withstand a certain wind speed based on historic documented wind speeds for different areas of the country. For example, the design wind speed used in conventional construction in the Midwest is a 90 mph, 3-second gust. By contrast, however, the design wind speed for a shelter in this same area recommended by FEMA is a 250 mph, 3-second gust to provide “near-absolute” protection.

Since wind pressures are calculated as a function of the square of the design wind speed, the structural systems of a shelter are designed for forces several times higher than those used for typical building construction. Consequently, the structural systems used in shelters, such as a structural metal roofing system, must be engineered and tested to provide extreme resistance to uplift.

Windborne debris causes much of the damage and injury, as the debris becomes high velocity missiles during tornadoes. Debris protection includes impact-resistant glazing and coverings such as shutters or metal roofing systems.

FEMA 361 explains that the ASCE 7 missile criteria were developed to minimize property damage and improve building performance; they were not developed to protect occupants. In a shelter, however, occupant protection is the primary design objective. A proper shelter design must withstand substantially greater windborne debris loads, with the roof deck and walls around a shelter space (and the doors leading into it) also be engineered and tested to resist windborne debris.

## Gimme Shelter

Facilities designated as shelters are given the responsibility of protecting the lives of those taking refuge within them. Yet damage to these “shelters” or “hardened areas” continues to be observed, which undermines public confidence. If the building or structure selected for use as a shelter cannot withstand the effects of extreme winds, the results can be deadly.

Hurricane Katrina caused more than 1,800 deaths and \$81.2 billion in insured losses (making it the largest natural disaster in U.S. history). After the storm, FEMA dispatched a Mitigation Assessment Team (MAT) to assess the performance of buildings impacted by the storm. Among the many findings and conclusions made by the MAT, it was determined that buildings functioning as critical and essential facilities (which were often used as shelters during the storm) did not perform better than their commercial counterparts. The same construction issues that affected residential and commercial buildings were observed in critical and essential facilities -- the same facilities that the public regularly assumes will protect them from winds and floodwaters!

In 2004, Hurricane Charley moved over Florida as a Category 4 hurricane. In an inland county, a facility had recently been constructed to design wind speeds, which exceeded the 110 to 120 mph (3-second gust) wind speeds that were actually experienced.

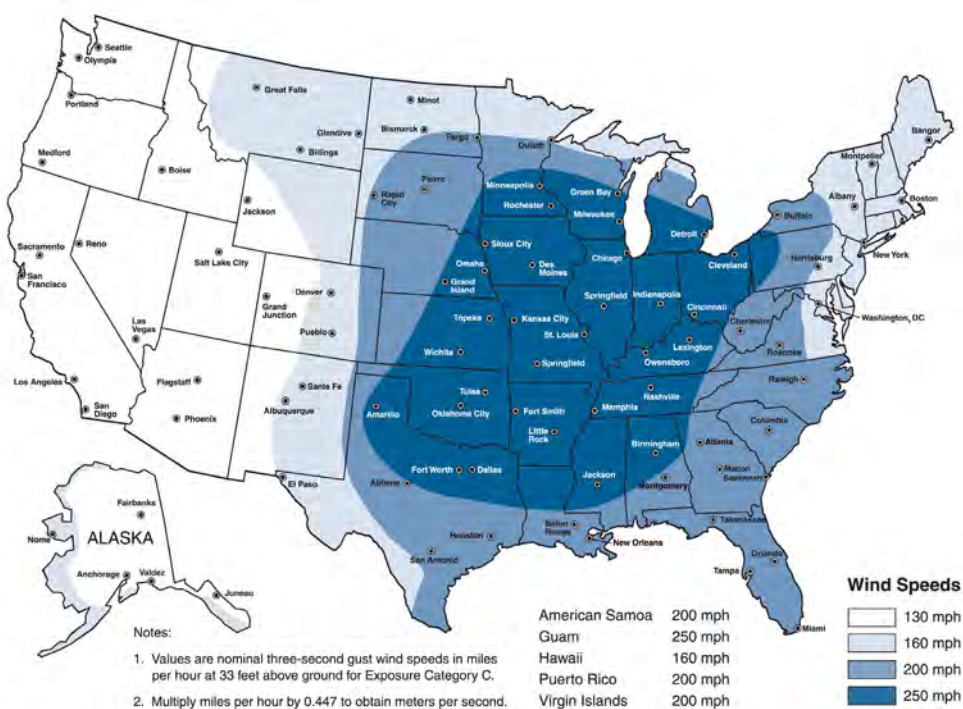
The building actually met minimum requirements established by the state for shelter facilities. It was sheltering approximately 1,200 people when roof panels began lifting off and an end-wall partially collapsed.

Shelter performance such as this prompts scrutiny of the different protection levels, which have been developed over the years and again reinforces the need for better shelter design and construction guidance. FEMA 361 and the ICC-500 address the entire design and construction life-cycle, from planning through design and construction of the facility, to provide a life-safety level of protection to shelter occupants

FEMA 361 defines a community safe room as “a shelter that is designed and constructed to protect a large number of people from a natural hazard event. The number of persons taking refuge in the safe room will typically be more than 16, and could be as many as several hundred -- or more.”

Safe rooms are intended to provide protection during a short-term extreme-wind event, such as a tornado or hurricane. Both stand-alone and internal community safe rooms may be constructed near or within school buildings, hospitals and other critical facilities, nursing homes, commercial buildings, disaster recovery shelters, and other buildings or facilities occupied by large numbers of people. Community safe rooms may be intended for use either by the occupants of buildings they are constructed within, or by the residents of surrounding areas.

The FEMA 361 publication provides detailed guidance concerning the design and construction of both stand-alone and internal community safe rooms for extreme-wind events - guidance that, until now, has not been available in other design guides or in building codes or standards.



Wind Zones in the United States (Federal Emergency Management Agency)

- Notes:
1. Values are nominal three-second gust wind speeds in miles per hour at 33 feet above ground for Exposure Category C.
  2. Multiply miles per hour by 0.447 to obtain meters per second.