SAFE ROOMS SAVE LIVES

THE 1999 ATLANTIC hurricane season broke records with 17 major disasters declared in 14 states. Last year over 1,000 tornadoes swooped across the nation. This is a typical annual number. Tornadoes claimed 226 lives in the United States in1998 and 1999. Treacherous high winds endanger lives every day. Virtually every state in the union has been affected by a "considerable" tornado (see "Fujita Categories" on page 20 and the "Saffir-Simpson Scale" on page 22). Perhaps it is time to ask: what more can be done to further protect lives and reduce injuries in my jurisdiction or how can the buildings I build or design be constructed to save more lives during extreme weather?

As you know, mitigation and early warning are the major components in the goals of saving lives and keeping property damage to a minimum. (For early warning information, see "Providing Early Warnings" on page 23.)

A housing stock governed by good building codes is a tried and true method to attain these goals. The Federal Emergency Management Agency (FEMA) Director James L. Witt said at the 1999 ICC Codes Forum, "When disaster strikes, no matter where or how, building codes — and local code officials — are America's first line of defense against tragedy. I know. In six years as head of FEMA, I've seen the life-or-death consequences of codes in action in every type of disaster."

TECHNOLOGY AND RESEARCH MEET THE NEED

Yet, there is more that could be done. According to FEMA, a concrete and steel reinforced safe room or an underground shelter built into or retrofitted into a house further protects its occupants from the dangerous forces of nature. When these structures meet the specifications published in FEMA 320, *Taking Shelter From the Storm: Building a Safe Room Inside Your House*, they provide a place to seek safe shelter during extreme wind events and they can also relieve some of the anxiety created by the threat of an oncoming storm. FEMA 320, which has recently been released in an expanded second edition, also includes construction plans, cost estimates and additional important information for homeowners.

A brochure published by FEMA's research partner, the Wind Engineering Research Center, Texas Tech University, explains, "Post-storm inspections of hundreds of homes in more than 90 towns and cities struck by tornadoes revealed that in many instances a small room in the central portion of the house remained standing even when the house was severely damaged or completely destroyed (see picture on page 19). The idea was then conceived that these interior rooms could economically be strengthened to provide a high degree of occupant protection."

The brochure continues, "The accessibility of a shelter within the house makes the inresidence shelter (safe room) highly advantageous over an outdoor cellar or community shelter because it eliminates the extreme danger of being struck by flying debris while attempting to reach a cellar or community shelter. Unlike the cellar, the inresidence shelter has

A small room left standing in the center of a destroyed house.
Photo courtesy of Wind Engineering Research Center, Texas Tech University.

a daily functional use — bathroom, closet, utility room, etc. It permits a family to continue regular living patterns during a weather watch with the peace of mind of knowing that a place of safety from extreme winds is only a few seconds away."

Shelters with the same level of protection can be provided by other residential shelter designs that are not included in FEMA 320 and for larger shelter designs by using the National Performance Criteria developed by FEMA in cooperation with the Wind Engineering Research Center. These performance criteria are to be used by design professionals, building officials and emergency management officials to ensure that the shelters provide a consistently high level of protection. The criteria document can be downloaded from FEMA's web site.

DETERMINING THE RISK

To determine the risk in the area you serve, refer to the United States tornado and wind zone maps located on page 21. The information on these maps is based on 40 years of tornado history and 100 years of hurricane history. The United States has been divided into four zones that geographically reflect the number and strength of extreme windstorms. First, note how many tornadoes were recorded per 1,000 square miles by checking the color code for that area on the Tornado Activity Map. Next, locate the wind zone in an area by checking color code for your area on the Wind Zone Map. Then, determine if the risk for your area is low, moderate or high by checking the Assessing Your Risk Chart on page 21. Note that some areas of low or moderate risk, shown as pale blue or medium blue in the worksheet, are within the region of the United States that is subject to hurricanes (see Wind Zone Map). In this hurricane-susceptible region, your risk is considered high, even if the chart indicates only a moderate or low risk. Residents should also be aware that hurricanes frequently spawn tornadoes.

However, the old adage, "Hide from wind and run from water" still applies. A safe room or shelter should not be built in any area expected to be flooded during a disaster. Residents of hazardous coastal areas with storm surges should be encouraged to abide by the warnings of their local emergency services and evacuate to safer ground when instructed to do so. According to FEMA, storm surges are the rise in the ocean level from the effects of the wind and the drop in atmospheric pressure associ-

(Continued on page 21)

Building Code Future Provisions for Tornado and Hurricane Community Shelters

FEMA is currently producing an updated document "Design and Construction Guidance for Tornado and Hurricane Community Shelters." The document will provide useful information for high-wind-resistant construction.

These shelters are essential in areas where hurricanes and tornadoes are common. It is not economically feasible for codes to require that homes be built to withstand these storms.

As the criteria for shelters is agreed upon and documents on the design and construction of community shelters becomes available, it is conceivable that there will be future provisions for them in building codes.

FUJITA CATEGORIES

According to the National Severe Storm Laboratory (NSSL), tornadoes can occur at any time of the year. In the southern states, peak tornado occurrence is March through May, while peak occurrence in the northern states is during the summer. In some states, a secondary tornado maximum occurs in the fall. Tornadoes are most likely to occur between 3 and 9 p.m., but have been known to occur at all hours of the day and night. The average tornado moves from southwest to northeast, but tornadoes have been known to move in any direction. The average forward speed is 30 miles per hour (mph), but may vary from nearly stationary to 70 mph. The total number of tornadoes is probably higher than indicated in the western states. Sparse population reduces the number of tornadoes reported.

FUJITA CATEGORIES AND TYPICAL DAMAGE

F-0: Light damage with winds 40-72 mph. Chimneys are damaged, tree branches are broken and shallow-rooted trees are tippled.

F-1: Moderate damage with winds 73-112 mph. Roof surfaces are peeled off, windows are broken, some tree trunks are snapped, unanchored mobile homes are overturned and attached garages may be destroyed.

F-2: Considerable damage with winds 113-157 mph. Roof structures are damaged, mobile homes are destroyed, debris becomes airborne (missiles are generated) and large trees are snapped or uprooted.

F-3: Severe damage with winds 158-206 mph. Roofs and walls are torn from structures, some small buildings are destroyed, nonreinforced masonry buildings are destroyed and most trees in the forest are uprooted.

F-4: Devastating damage with winds 207-260 mph. Well-constructed houses are destroyed, some structures are lifted from foundations and blown some distance, cars are blown some distance and large debris becomes airborne.

F-5: Incredible damage with winds 261-318 mph. Strong-frame houses are lifted from foundations, reinforced concrete structures are damaged, automobile-sized missiles become airborne and trees are completely debarked.

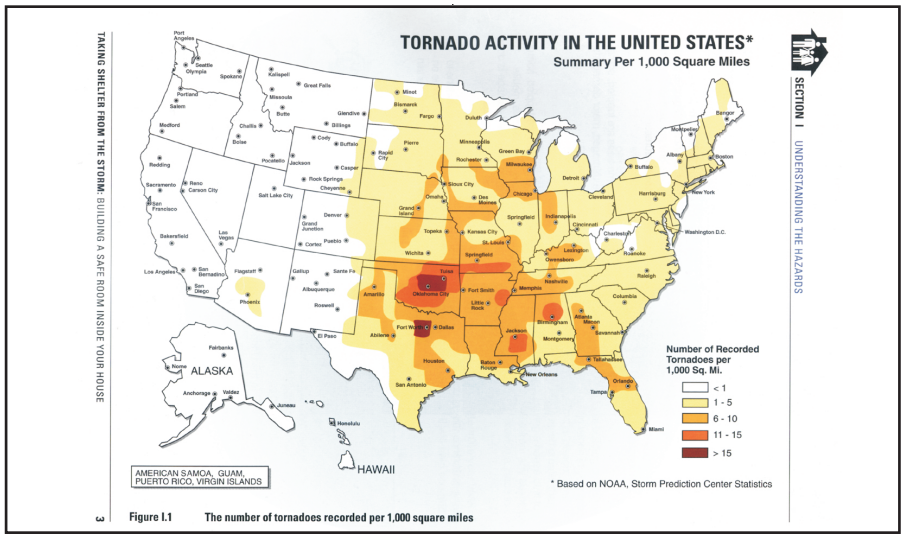

Figure I.1 The number of tornadoes recorded per 1,000 square miles

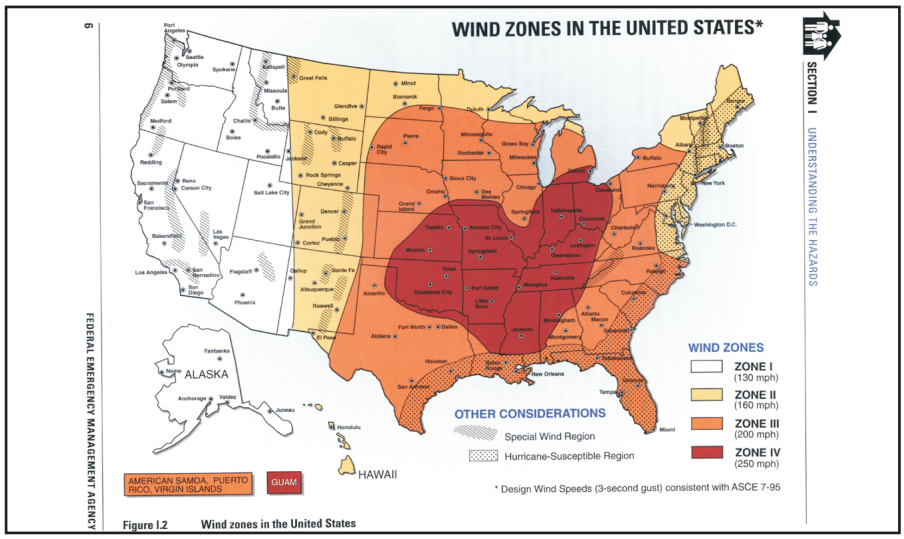

Figure I.2 Wind zones in the United States

ASSESSING YOUR RISK

NUMBER OF TORNADOES PER 1,000 SQUARE MILES (See Figure I.1)	WIND ZONE (See Figure I.2) I	II	III	IV
<1	LOW RISK	LOW RISK ★	LOW RISK ★	MODERATE RISK
1 - 5	LOW RISK	MODERATE RISK ★	HIGH RISK	HIGH RISK
6 - 10	LOW RISK	MODERATE RISK ★	HIGH RISK	HIGH RISK
11 - 15	HIGH RISK	HIGH RISK	HIGH RISK	HIGH RISK
>15	HIGH RISK	HIGH RISK	HIGH RISK	HIGH RISK

LOW RISK — Need for high-wind shelter is a matter of homeowner preference

MODERATE RISK — Shelter should be considered for protection from high winds

HIGH RISK — Shelter is preferred method of protection from high winds

★ Shelter is preferred method of protection from high winds if house is in hurricane-susceptible region

ated with hurricanes and other storms. Residents should also be aware of the dangers of flash floods that occur locally with great volumes of water. They are of short duration and generally result from heavy rainfall in the immediate vicinity. Flash floods cause 146 deaths annually. Specific information on flooding of an area can be obtained from FEMA's web site by clicking on Project Impact and Online Hazard Maps.

BUILDING FAILURE REVIEW

When assisting in the building, planning or inspection of houses with shelters, it is beneficial to review how extreme winds affect a building and why they cause buildings to fail. Tornado and hurricane winds are not constant. Wind speeds, even in extreme wind events, rapidly increase and decrease. An obstruction, such as a house, in the path of the wind causes the wind to change direction. This change in wind direction increases pressure on parts of the house. The combination of increased pressures and fluctuating wind speeds creates stress on the house that frequently causes connections between building components to fail. For example, the roof or siding can be pulled off or the windows can be pushed in.

Buildings that fail under the effects of extreme winds often appear to have exploded, giving rise to the misconception that the damage is caused by unequal

(Continued on next page)

SAFFIR-SIMPSON SCALE

According to the National Weather Service, the peak hurricane threat for the Gulf Coast and the Atlantic coast of the United States is mid-August to late October, although the official hurricane season extends through November. Hurricanes have made landfall in Florida more than in any other state. Texas is the second-most hurricane-affected state, but every state on the Gulf and bordering the Atlantic Ocean is susceptible to damage caused by hurricanes. In other parts of the world, such as the western Pacific, hurricanes can occur year-around.

SAFFIR-SIMPSON SCALE AND TYPICAL DAMAGE

C-1: Minimal damage primarily to shrubbery and trees, unanchored mobile homes and some signs. No real damage to structures.

C-2: Moderate damage occurs with some trees toppled and some roof coverings damaged. Major damage to mobile homes.

C-3: Extensive damage with large trees toppled and some structural damage done to roofs. Mobile homes are destroyed and damage is done to small homes and utility buildings.

C-4: Extreme and extensive damage is done to roofs, windows and doors. Roof systems on small buildings completely fail and some curtain walls fail.

C-5: Catastrophic damage occurs with considerable and widespread roof damage. Window and door damage is severe with extensive glass failures and some complete buildings fail.

wind pressures inside and outside the building. This misconception has led to the myth that during an extreme wind event, the windows and doors in a building should be opened to equalize the pressure. In fact, opening a window or door allows wind to enter a building and increases the risk of building failure.

Encourage the occupants to build their safe room or shelter so that it is readily accessible from all parts of the house and keep it free from clutter. The shelter must be adequately anchored to the house's foundation to resist overturning and uplifting. The connections between all parts of the shelter must be strong enough to resist failure, and the walls, roof and door must resist penetration by wind-borne missiles or flying debris.

DANGEROUS MISSILES

Damage by wind-borne missiles occurs when high wind speeds throw

objects at a building with enough force to penetrate windows, walls or the roof. In general, the stronger the wind, the larger and heavier the missiles it can carry and the greater the risk of severe damage. For example, an object such as a 2-inch by 4-inch wood stud weighing 15 pounds, when carried by a 250 miles-per-hour (mph) wind, can have a horizontal speed of 100 mph and enough force to penetrate most common building materials used in houses today. Even a reinforced masonry wall will be penetrated unless it has been designed and constructed to resist debris impact during extreme winds. Because missiles can severely damage and even penetrate walls and roofs, they threaten not only buildings but the occupants as well. Even small stones, branches, and other lighter missiles can easily break glass doors and windows causing damage and injuries.

GOOD NEWS TRAVELS FAST

To assist homeowners with financing a safe room, early this year, U.S. Department of Housing and Urban Development (HUD) Secretary Andrew Cuomo announced, "These storm shelters will save lives and prevent injuries when tornadoes and hurricanes strike. HUD is making it possible for more families to place these shelters in their homes." The announcement continued, "The mortgage insurance will be provided by the Federal Housing Administration (FHA), which is part of HUD.

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PROVIDING EARLY WARNINGS

As mentioned in "Safe Rooms Save Lives," early warning of impending extreme weather allows those in the path of danger to prepare and move to their safe room or shelter. Therefore, it may be advantageous for local officials to monitor the National Oceanic and Atmospheric Administration's (NOAA) Weather Radio in order to warn nearby residents of possible extreme situations. The recently modernized National Weather Service (NWS), which is a division of NOAA, now brings NOAA Weather Radio 2000 to every forecast office in the country for transmission of forecasts and warnings to local receivers.

NOAA Weather Radio is a nationwide, 24-hour-a-day network of radio stations broadcasting continuous weather information direct from a nearby National Weather Service Office. According to its web site, "NOAA Weather Radio is the single source for the most comprehensive weather and emergency information available to the public."

Working with the Federal Communications Commission's new Emergency Alert System, NOAA Weather Radio is also an "all hazards" radio network. It broadcasts warning and post-event information for all types of hazards, both natural and technological — such as chemical releases or oil spills.

A special radio receiver is required to receive NOAA Weather Radio. The NWS web site explains, "NOAA Weather Radio receivers can be purchased at many retail stores that sell electronic merchandise, including stand-alone electric retail outlets, electronics departments within department stores, and some drug stores. NOAA Weather Radio receivers can also be purchased through some mail order catalogs."

There are two types of receivers. The residential grade is priced from $20 to $200 and some are equipped with an alarm feature. Industrial/commercial-grade equipment is designed for the reception of the Emergency Alert System broadcasts as well as NOAA Weather Radio broadcasts. Their prices may vary from hundreds to thousands of dollars.

For more information on the NOAA Weather Radio 2000, visit: www.nws.noaa.gov/nwr/

Rather than making mortgage loans directly, FHA insures loans made by private lenders to homeowners."

Project Impact is a program that makes funds available for the mitigation of natural hazards. Riley County, Kansas, the recipient of a FEMA Project Impact grant, is using a portion of the funds to increase the public's awareness of the benefits of safe rooms and FEMA 320. A student chapter of the Associated General Contractors (AGC) at Kansas State University, located in the town of Manhattan, in Riley County, is working with the county by building a scale model house containing a safe room as well as a static display of the floor plans and details referencing back to the scale model house. A standalone scale model of a concrete masonry safe room is also being constructed. The model will debut at the annual Kansas State University open house. It will then be displayed at various locations throughout the county for public access and viewing.

The recent tornado and severe storms in western Kentucky were motivating factors for the development of two workshops last February. The "Effect of Extreme Winds on Structures" was presented by Dr. Ernst Kiesling from the Wind Engineering Research Center. Dr. Kiesling discussed his research as a member of the design team that was instrumental in writing FEMA 320. "Constructing an Insulating Concrete Form Safe Room" was the second workshop. Representatives of Reward Wall Systems and a local contractor took participants step by step through the process of constructing a safe room utilizing hands-on demonstrations and actual materials that are commonly available in the area.

In Sioux City, Iowa, last summer, the construction of a tornado safe room highlighted Public Safety Awareness Day, at the Siouxland American Red Cross (see pictures on pages 25 and 26). At the event, FEMA Region VIII Director Rick Weiland said, "We have learned so much about disaster preparedness and tornado-safety over the years, and we have proven strategies to help people protect themselves. We know that tornado safe rooms work. There are people alive today in Oklahoma City because they had a safe shelter when the twister hit earlier this year. I applaud Sioux City metro officials and emergency managers for working so hard to get the word out that we are not helpless in the face of natural disasters; people can take actions to protect themselves and their families. Safe rooms are an excellent example of that." FEMA made approximately $50,000 available to Sioux City, Iowa, South Sioux City, Nebraska, and North Sioux City, South Dakota, an area considered high risk for extreme winds, to construct safe rooms and to develop a public information campaign to make residents aware of the warning and sheltering options available in the event of a tornado or other severe weather.

OKLAHOMANS CAN SURVIVE

Weiland, in Sioux City, was referring to the disastrous evening of May 3rd and the early morning of May 4, 1999 when severe storms and approximately 76 tornadoes ranging from F-1 to F-5 crossed the state of Oklahoma from southwest to northeast. (See "Chasing the Storm," *The Code Official*, July/August 1999 for the full tornado story.) There were 44 fatalities and approximately 4,000 primary residences were destroyed or received major damage.

Photo by Dave Gatley, Courtesy of FEMA. Workers are beginning to demonstrate the assembly of a safe room with light foam sections.

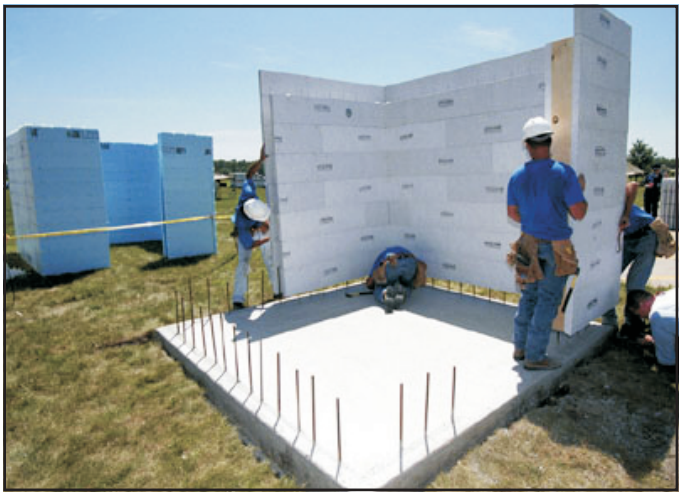

Photo by Dave Gatley, Courtesy of FEMA. Workers lift the preassembled wall section into place over the cement slab foundation. The concrete-filled, foam-formed walls will be reinforced with steel rebar. The safe room may be built into new housing or added inside or outside of existing structures at a relatively low cost.

Photo by Dave Gatley, Courtesy of FEMA. Workers assemble the roof panels, which will have a rebar and concrete covering.

Photo by Dave Gatley, Courtesy of FEMA. Workers pour concrete into the walls of the safe room.

Boyd West, Assistant Inspection Services Superintendent for Oklahoma City, Oklahoma, stated, "After seeing the devastation, I hope that all municipalities will now adopt and enforce stricter codes. However, some good may come out of this, since a number of families decided to include safe rooms in their rebuilding plans." In a recent telephone interview, Boyd added, "In the damaged areas, the majority of homes being built now include safe rooms or shelters. Many residents have taken advantage of FEMA's 'Oklahomans Can Survive' program."

"Oklahomans Can Survive," a rebate program, is a pilot initiative of FEMA, Oklahoma Department of Civil Emergency Management (ODCEM) and local communities to encourage the building of safe rooms. The first-ever rebate program grants $2,000 to eligible homeowners who had more than 50-percent damage to their primary resi-

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dence as a result of the May 3rd and 4th tornadoes and applied before November 30, 1999. If funding allows, the program will be expanded to homeowners who had any tornado damage on May 3rd and 4th and homeowners who wish to add a safe room to their primary residence. At the news conference on June 18, 1999 unveiling the Safe Room Rebate Program, FEMA Director James L. Witt explained, "The rebate may help Oklahomans focus on the benefits of safe rooms, instead of being concerned about the total cost of installing a safe room."

Oklahomans were asked to indicate whether they plan to include a safe room when rebuilding or repairing their storm-damaged homes. The state will provide rebates on a worst-first basis from $10 million in funds made available by FEMA for projects to reduce loss of lives and property from future severe storms. Priority has been given to the 16 counties and 14 communities included in President Clinton's disaster declaration for individual assistance.

Boyd explained, "FEMA approached us about the new rebate program and the City Council decided to go with it. FEMA publicized and promoted 'Oklahomans Can Survive' on local radio and television. Literature on the program was also distributed at meetings where there was a lot of damage. However, the funds are distributed locally." He continued, "Safe room construction must have a permit in order to be sure it meets the specifications of FEMA 320. The research for the permit also includes making sure the structure is not in a flood plain. Because of our soil properties, all underground structures must be engineered and have a state engineers seal. I really believe in safe rooms and, because of the F-5 tornadoes we experienced, I feel that we're extremely fortunate that we didn't have more deaths."

Additional information, publication FEMA 320 and the "National Performance Criteria for Tornado Shelters" can be ordered or downloaded from FEMA's web site at: www.fema.gov, or telephone: (888) 565-3896.

Photo by Dave Gatley, Courtesy of FEMA. Workers prepare the roofing with rebar prior to pouring concrete.