1 Introduction

This publication provides guidance for architects, engineers, building officials, local officials and emergency managers, and prospective safe room owners and operators about the design, construction, and operation of safe rooms and storm shelters, and for extreme-wind events. It presents important information about the design and construction of community safe rooms that will provide protection during tornado and hurricane events.

1.1 Purpose

This publication presents the design and construction guidance that the Federal Emergency Management Agency (FEMA) believes is necessary to provide life-safety protection during extreme-wind events. This guidance interprets the new International Code Council® (ICC®) *ICC/NSSA Standard for the Design and Construction of Storm Shelters* [(ICC-500, produced in consensus with the National Storm Shelter Association (NSSA)] design criteria and provides technical design guidance and emergency management considerations to individuals who are looking for "best-practices" that are above minimums in the codes and standards. FEMA continues to advocate the design and construction of safe rooms as evident by its continuing support of safe room initiatives through several grant programs. Since the initiation of its safe room program, FEMA has provided federal funds totaling over $200,000,000 for the design and construction of more than 500 community safe rooms. Through residential safe room initiatives over the same time, FEMA has provided support for the design and construction of nearly 20,000 residential safe rooms with federal funds totaling more than $50,000,000. These projects were completed in both tornado-prone and hurricane-prone regions of the country.[1] Although this publication provides technical information that must be adhered to as part of the funding requirements of the FEMA safe room policy,[2] this is not its primary purpose. Rather, the most important aspect of this publication is that it provides the criteria necessary for any safe room, private or public, to be constructed so that it is capable of providing "near-absolute protection" for its occupants during extreme-wind events.

The first edition of FEMA 361, released in July 2000, set forth design and construction criteria for tornado and hurricane shelters where none had been provided. These criteria were the basis of many community safe rooms that have been designed, constructed, and funded by FEMA since 2000. This second edition of FEMA 361 continues to provide guidance in the design and construction of tornado and hurricane safe rooms, but now references much of the ICC-500

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[1] FEMA safe room program statistics are current through March 2008. The dollar figures provided are the estimated federal share obligated towards the design and construction of the safe rooms.

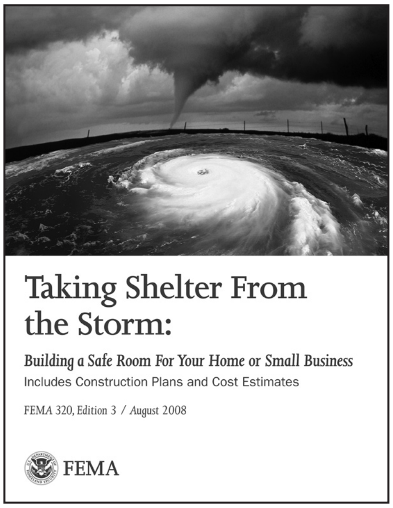
[2] FEMA's policy on the eligibility of the design and construction of safe rooms for federal funding is provided in FEMA Mitigation Interim Policy MRR-2-07-1, *Hazard Mitigation Assistance for Safe Rooms*, dated March 7, 2008.

Storm Shelter Standard. FEMA supports the development of hazard-resistant codes and standards through the monitoring of, and participation in the process of creating these documents, including the ICC-500.

Codes and standards are typically produced by consensus committees through open, public forums and there are always topics and subject areas where compromises are made in the preparation of the design criteria. As such, FEMA has identified specific design criteria in this publication to be more conservative than what is presented in the ICC-500 in large part due to emergency management considerations and maintaining near-absolute protection. FEMA believes the criteria in this updated publication should be incorporated into safe room design and construction projects to best protect individuals from wind and debris during wind storms. This second edition of FEMA 361 relies upon much of the ICC-500, but also identifies the specific technical criteria where the FEMA guidance meets or exceeds the minimum requirements of the ICC-500. This approach is consistent with past publications produced by FEMA. FEMA guidance publications have provided, and will continue to provide, “best-practices” guidance above and beyond the minimum criteria and scope of the consensus codes and standards for design and construction of buildings and structures to resist natural and manmade hazards.

1.2 Safe Rooms vs. Shelters

“Safe room” and “shelter” are two terms that have been used interchangeably in past publications, guidance documents, and other shelter-related materials. However, with the release of the ICC-500 standard, there is a need to identify or describe shelters that meet the FEMA criteria for life-safety protection and those that meet the ICC-500 standard. To help clarify the difference between shelters designed to the ICC-500 standard and the FEMA 320 and 361 guidance, this publication will refer to all shelters constructed to meet the FEMA criteria (whether for individuals, residences, small businesses, schools, or communities) as safe rooms. All safe room criteria in this publication meet or exceed the shelter requirements of the ICC-500.



Taking Shelter From the Storm:

Building a Safe Room For Your Home or Small Business

Includes Construction Plans and Cost Estimates

FEMA 320, Edition 3 / August 2008

FEMA

Safe rooms designed and constructed in accordance with the guidance presented in this publication provide “near-absolute protection” from extreme-wind events. Near-absolute protection means that, based on our current knowledge of tornadoes and hurricanes, the occupants of a safe room built according to this guidance will have a very high probability of being protected from injury or death. Our knowledge of tornadoes and hurricanes is based on substantial meteorological records as well as extensive investigations of damage from extreme winds. However, since extreme-wind events may occur or have hypothetically occurred in the past, to date a wind event exceeding the maximum design criteria in this publication has not been observed. For this reason, the protection provided by these safe rooms is called near-absolute rather than absolute.

TORNADO OCCURRENCE AND RESULTANT LOSSES ARE INCREASING

In 1950, the National Weather Service (NWS) started keeping organized records of tornadoes occurring in the United States (U.S.). Since that time, 1953 was the deadliest year (519 deaths). The average in recent years has been 62 deaths per year. Deaths caused by tornadoes were 38, 67, and 81 for 2005, 2006, and 2007, respectively. As of May of this year, 110 deaths have been caused by tornadoes.

In addition to deaths, tornadoes cause injuries and devastating losses of personal property. Insurance claim losses from a single tornadic event of $1 billion and higher are becoming more frequent. So far in 2008, tornadoes have resulted in insured losses of more than $1 billion (almost $850 million from the mid-South outbreaks on February 5 and 6; in March, Atlanta and its surrounding counties were struck by a tornado that caused $349 million in losses).

Although hurricanes and earthquakes generally 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.

This photograph from FEMA's photo library shows the vivid reality of how lives are impacted by tornadoes. (Lafayette, TN – February 5, 2008)

SOURCE: JOCELYN AUGUSTINO/FEMA

SOURCE: A.M. BEST, CNN

For the purpose of this publication, a community safe room is defined 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 up to several hundred or more. These numbers exceed the maximum occupancy of small, in-residence safe rooms recommended in the second edition of FEMA 320, *Taking Shelter From the Storm: Building a Safe Room Inside Your House*. It should be noted that a third edition of FEMA 320 is being prepared and will be released in conjunction with this update of FEMA 361.

The two types of community safe rooms covered by the guidance in this publication include:

- Stand-alone safe room – a separate building (i.e., not within or attached to any other building) that is designed and constructed or retrofitted to withstand extreme winds and the impact of windborne debris (missiles) during tornadoes, hurricanes, or other extreme-wind events.
- Internal safe room – a specially designed and constructed room or area within or attached to a larger building; the safe room (room or area) that may be designed and constructed or retrofitted to be structurally independent of the larger building, but provides the same wind and missile protection as a stand-alone safe room.

These safe rooms are intended to provide protection during a short-term extreme-wind event (i.e., an event that normally lasts no more than 24 hours) such as a tornado or hurricane. (Minimum safe room occupancy times are 2 and 24 hours for tornadoes and hurricanes, respectively.) They are **not** recovery shelters intended to provide services and housing for people whose homes have been damaged or destroyed by fires, disasters, or catastrophes.

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. Stand-alone community safe rooms may be constructed in neighborhoods where existing homes lack shelters or where the homes are subject to damage from extreme-wind events. Community safe rooms may be intended for use by the occupants of buildings they are constructed within or near, or they may be intended for use by the residents of surrounding or nearby neighborhoods or designated areas.

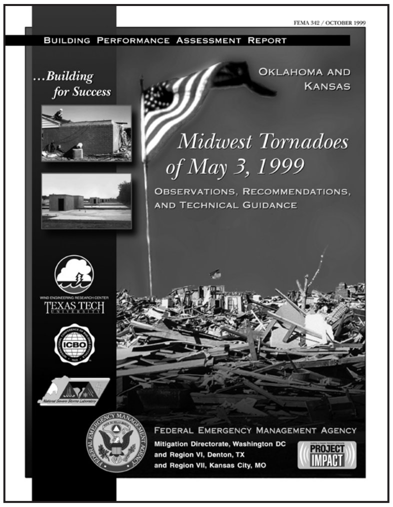
This publication provides detailed guidance concerning the design and construction of both stand-alone and internal community safe rooms for extreme-wind events – guidance that is currently not available in other design guides or in building codes or standards. It is a compilation of the best information available at the time of publication. Safe room location, design loads, performance criteria, and human factor criteria that should be considered for the design and construction of such safe rooms are discussed herein. Case studies (one for a stand-alone safe room and one for an internal safe room) are presented in Appendices C and D, respectively, and illustrate how to evaluate existing shelter areas and make safe room selections, and provide construction drawings, emergency operations plans, and cost estimates. Many factors may influence the decision to construct a community safe room. They include the following:

- The likelihood of an area being threatened by an extreme-wind event
- The consequences (deaths and injuries) of an extreme-wind event
- The cost of constructing a safe room

Therefore, this publication also provides decision-making tools that include safe room hazard evaluation checklists and information about economic analysis software. These tools provide an effective means of addressing all or many of the considerations that can affect the decision either to build or to not build a community safe room.

1.3 Background

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. This section provides background information about recent tornadoes and hurricanes, post-disaster assessments, research activities, and design criteria development carried out by FEMA and other organizations in an attempt to improve the guidance for safe room design and construction.


FEMA 342 / OCTOBER 1999

BUILDING PERFORMANCE ASSESSMENT REPORT

…Building for Success

OKLAHOMA AND KANSAS

Midwest Tornadoes of May 3, 1999

OBSERVATIONS, RECOMMENDATIONS, AND TECHNICAL GUIDANCE

FEDERAL EMERGENCY MANAGEMENT AGENCY
Mitigation Directorate, Washington DC
and Region VI, Denton, TX
and Region VII, Kansas City, MO

1.3.1 Tornado Events

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,[3] as well as devastating personal and property losses. According to the *Glossary of Meteorology* (AMS 2000), a tornado is “a violently rotating column of air, pendant from a cumuliform cloud or underneath a cumuliform cloud, and often (but not always) visible as a funnel cloud.” The most violent tornadoes are capable of tremendous destruction with wind speeds of up to 250 miles per hour (mph) near ground level. Damage paths over 50 miles long and over 1 mile wide have been reported. During the Great Plains Tornado Outbreak of May 3, 1999, 67 tornadoes struck Oklahoma and Kansas, including numerous EF4 and EF5 tornadoes (EF4 and EF5 are classifications based on the Enhanced Fujita (EF) Tornado Scale – see Table 4-1 in Chapter 4). This tornado outbreak resulted in 49 deaths and leveled neighborhoods. Additional information about the Oklahoma and Kansas tornadoes is available in the FEMA Mitigation Assessment Team (MAT) report *Midwest Tornadoes of May 3, 1999*, FEMA 342. These events had a great influence on FEMA and the decision to develop the first edition of FEMA 361 in June 2000. Figure 1-1 shows Kelley Elementary School in Moore, Oklahoma, and the central corridor of the school, which was the designated tornado refuge area. When the tornado hit, classes were over for the day. However, had this tornado occurred earlier in the day, the effect on individuals taking shelter would have been disastrous.

Similar deadly storm outbreaks have occurred since that time. Almost 4 years to the day after the May 3, 1999, tornadoes, 80 tornadoes were reported across eight states, including Kansas, Oklahoma, and Missouri. The tornadoes struck on May 8, 2003, causing 37 deaths and destroying hundreds of homes and businesses. Again in May, but in 2007, a smaller tornado outbreak occurred. On May 4th, 12 tornadoes were spawned by an intense supercell.

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[3] Tornado occurrence data obtained from the NOAA Storm Prediction Center records at http://www.spc.noaa.gov/climo/historical.html.

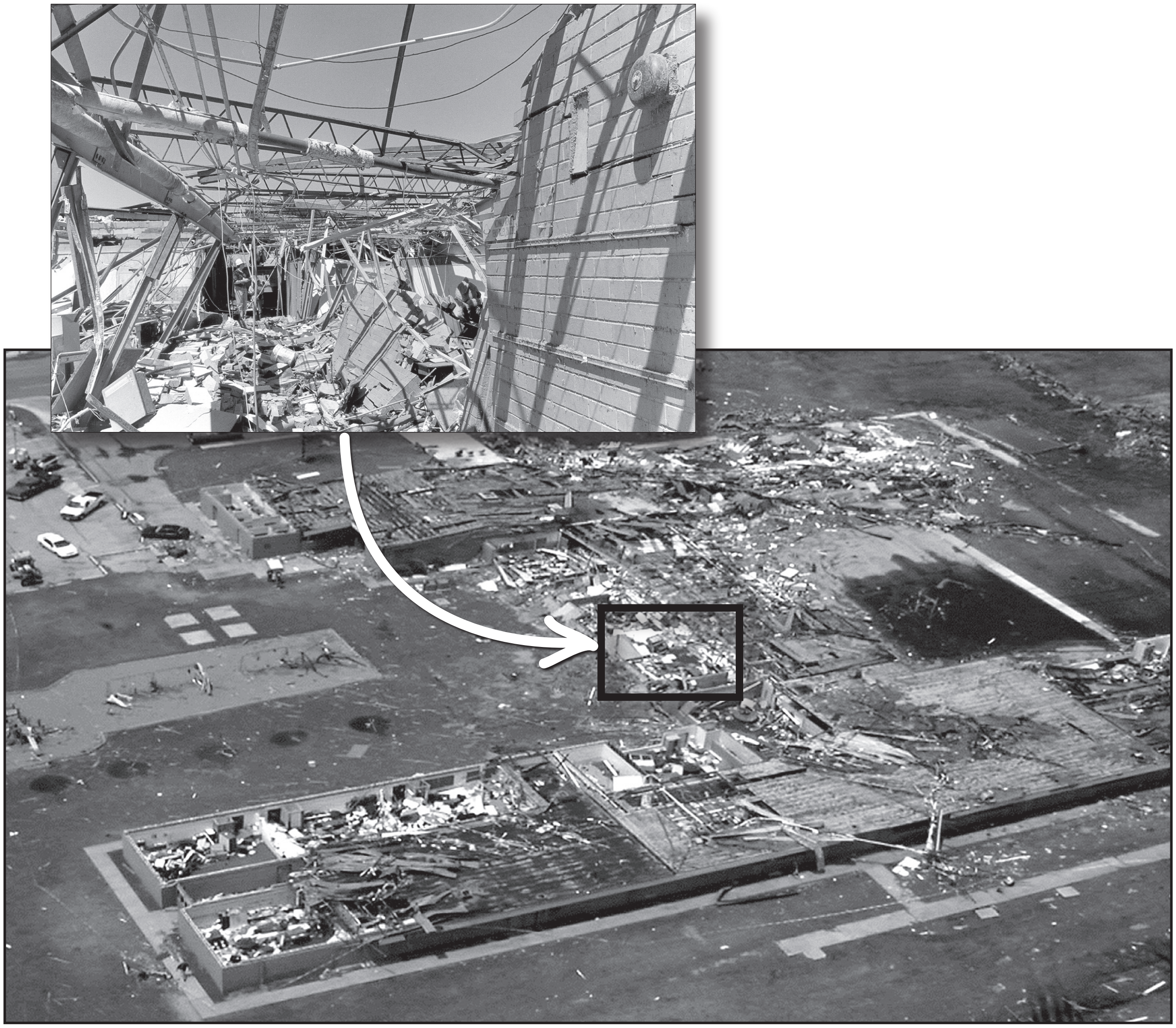

Figure 1-1. Destroyed tornado refuge area at Kelley Elementary School, Moore, Oklahoma (1999)

One of these tornadoes was rated an EF5. Wind speeds from this tornado were estimated to be greater than 205 mph (3-second gust). The tornado had a reported swath of 1.7 miles, and destroyed approximately 95 percent of Greensburg, Kansas, causing 11 deaths in the town.

Prior to the Greensburg tornado, Florida was impacted by a tornado outbreak in February 2007. A small, but deadly outbreak of three tornadoes struck northeast Florida from the Lady Lake area to New Smyrna Beach on the coast. These three tornadoes killed 21 people and injured dozens of others. Of the three tornadoes, two were rated EF3 and one was rated EF1. Because these tornadoes struck in the middle of the night, almost all of the fatalities were to individuals who were in their homes. The unfortunate events of February 2007 remind us that, even in hurricane-prone areas where many homes are considered to be more “hazard-resistant,” they are not designed to provide life-safety protection. The two EF3 tornadoes, in the middle of the EF Scale, were not the large EF4 and EF5 tornadoes typically associated with major storm fatalities. These lower intensity, and more common tornadoes, highlight the tornado hazard that exists in hurricane-prone regions and calls attention to the threat posed to homeowners by smaller tornadoes because residential construction is typically not designed to provide near-absolute protection for their occupants.

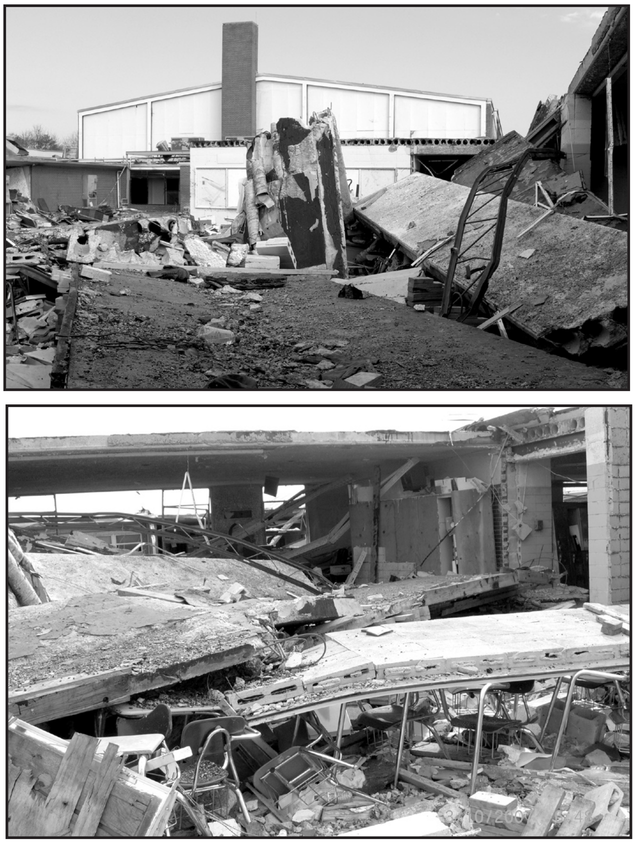
Figure 1-2. Destroyed tornado refuge area at Enterprise High School, Enterprise, Alabama (2007)

Also in 2007, a significant tornado developed near Enterprise, Alabama on March 1st, again 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 directly impacting Enterprise High School (see Figure 1-2). 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 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.)."*

The events in Moore, Oklahoma, Greensburg, Kansas, and Enterprise, Alabama, as well as other events not detailed here, show the deadly and destructive potential of tornadoes. Such events continue to illustrate the compelling need for shelters and safe rooms capable of protecting human lives against the risk of tornadoes. This publication provides design criteria for the design and construction of community safe rooms that should provide the level of protection needed to protect lives from tornadic events.

NOTE

FEMA 320, *Taking Shelter From the Storm: Building a Safe Room For Your Home or Small Business*, is another FEMA publication that provides guidance on safe rooms for tornado and hurricane protection. FEMA 320 presents a summary of storm hazards and prescriptive designs of both above- and in-ground safe rooms that meet the design criteria of FEMA 361 and the ICC-500 for residential and small community shelters.

1.3.2 Hurricane Events

A hurricane, as defined by NOAA, is a tropical cyclone in which the maximum sustained surface wind (using the U.S. 1-minute average) is 74 mph. The term hurricane is used for Northern Hemisphere tropical cyclones east of the International Dateline to the Greenwich Meridian. Around its core, winds can grow with great velocity, generating violent seas. As the storm moves ashore, it can push ocean waters inland (this effect is known as storm surge) while spawning tornadoes and producing torrential rains and floods. In this publication, the term storm surge means an abnormal rise in sea level accompanying a hurricane or other intense storm, whose height is the difference between the observed level of the sea surface and the level that would have occurred in the absence of the cyclone. Storm surge is usually estimated by subtracting the normal or astronomic high tide from the observed storm tide (see Figure 3-3 of Chapter 3).

On average, 10 tropical storms (6 of which become hurricanes) develop each year in the Atlantic Ocean.[4] Approximately five hurricanes strike the United States mainland every 3 years; two of those storms will be major hurricanes (Category 3 or greater on the Saffir-Simpson Hurricane Scale – see Table 4-2 in Chapter 4). The loss of life and property from hurricane-generated winds and floodwaters can be staggering. Although these storms do not make landfall in the U.S. every year, from 1900 through 2006, hurricanes caused 17,832 deaths and substantial numbers of injuries, as well as extensive personal and property losses. Tornadoes of weak to moderate intensity (typically EF0 to EF2) occasionally accompany tropical storms and hurricanes that move over land. These tornadoes are usually to the right and ahead of the path of the storm center as it comes onshore.

CROSS-REFERENCE

The Saffir-Simpson Hurricane Scale is discussed in Chapter 4.

In the western Pacific, hurricanes are called “typhoons.” The term typhoon is used for Pacific tropical cyclones north of the Equator and west of the International Dateline [(i.e., the Pacific Islands, including Guam and American Samoa)]. In the Indian Ocean, similar storms are called “cyclones.” Like hurricanes and tornadoes, typhoons and cyclones can generate extreme winds, flooding, high-velocity flows, damaging waves, significant erosion, and heavy rainfall. Historically,

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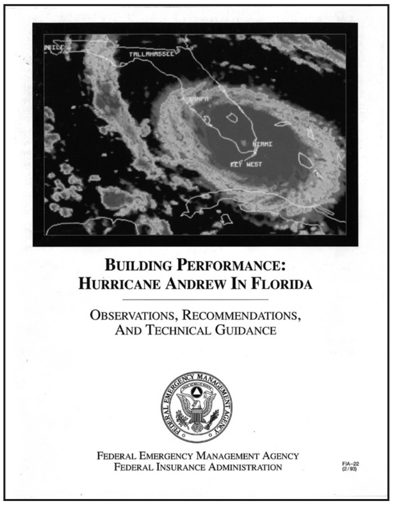
[4] Hurricane occurrence data obtained from NOAA historical records. Note: Although the statistical set goes back to 1851, data records older than 1900 may underreport occurrences since many coastal communities had not yet been established.

typhoons have been classified by strength as either typhoons (storms with less than 150 mph winds) or super typhoons (storms with wind speeds of 150 mph or greater), rather than by the Saffir-Simpson Hurricane Scale.

In recent years, multiple hurricanes have caused severe damage to coastal areas in the southern Atlantic and Gulf coast regions of the United States. One hurricane that had significant effects on not only the people and the community impacted, but also on design and construction requirements for all building types (residential, non-residential, and essential facilities) was Hurricane Andrew. The storm made landfall in southeastern Florida on August 24, 1992, generated strong winds and heavy rains over a vast portion of southern Dade County. This Category 4/5 hurricane (which is defined as having sustained wind speeds of approximately 155 mph) produced extreme winds and high storm surge, but the most extensive damage was caused by winds and not the storm surge. The storm caused unprecedented economic devastation; damage in the United States was estimated to be $21 billion dollars in insured losses (adjusted for inflation to 2006 dollars). In Dade County, the storm forces caused 15 deaths and left almost one-quarter million people temporarily homeless. Additional information about Hurricane Andrew was documented in the FEMA report *Building Performance: Hurricane Andrew in Florida*, FIA-22.



BUILDING PERFORMANCE:
HURRICANE ANDREW IN FLORIDA

OBSERVATIONS, RECOMMENDATIONS,
AND TECHNICAL GUIDANCE

FEDERAL EMERGENCY MANAGEMENT AGENCY
FEDERAL INSURANCE ADMINISTRATION

FIA–22
(2/93)

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. Often, there is a general lack of understanding of effects of exposing buildings not designed to provide life-safety protection from extreme-wind events. A variety of different types of "shelters" that are used before, during, and after storm events, provide different levels of protection. If the building or structure selected for use as a shelter cannot withstand the effects of hurricane winds, the results can be devastating. 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 above the 110 to 120 mph (3-second gust) wind speeds that were actually experienced. The building met minimum requirements established by the state for shelter facilities. The building was sheltering approximately 1,200 people when roof panels began lifting off and one end wall of the facility partially collapsed (see Figure 1-3). Shelter performance such as this prompts scrutiny of the different protection levels that have been developed over the years and again reinforces the need for better shelter design and construction guidance such as FEMA 361 and the ICC-500, which address the entire design and construction life-cycle from planning through design and construction of the facility, and provide a level of protection associated with life-safety of shelter occupants.

The most devastating hurricane in recent years, however, was Hurricane Katrina, the third strongest hurricane to make landfall in the history of the United States. Though crossing Florida as only a moderate Category 1 hurricane, it moved into the Gulf of Mexico where it rapidly increased to a Category 5 hurricane. After weakening just 24 hours prior to landfall, Katrina came ashore as a Category 3 storm in Louisiana and Mississippi. Hurricane Katrina went on to cause over 1,800 deaths and $81.2 billion in insured losses (making it the largest natural disaster in U.S. history). The storm caused the levees to break in New Orleans, pushing floodwaters throughout much of the city, and caused tremendous damage to many cities and towns all along the Mississippi coast. After the storm, FEMA dispatched a MAT to assess the performance of buildings impacted by the storm (see FEMA 549, *Hurricane Katrina in the Gulf Coast*). 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 very facilities that the public regularly assumes have to been hardened to resist hurricane winds and floodwaters.

Figure 1-3. Severely damaged hurricane shelter at Turner Agri-Civic Center, Arcadia, Florida (2004)

As with the tornado events discussed in the previous section, the events in Florida, Louisiana, and Mississippi represent just a small sampling of the deadly and destructive potential of hurricanes and continue to illustrate the compelling need for shelters and safe rooms capable of protecting human lives. FEMA 361 provides design criteria for the design and construction of community safe rooms for facilities that can resist such wind forces.

1.3.3 Post-Disaster Assessments, Research, and Design Development

When a hurricane, tornado, earthquake, or terrorist attack results in a catastrophic natural or manmade disaster in the United States or one of its territories, FEMA frequently deploys a technical building sciences team to document the performance of the built environment during the event. These teams are referred to as Mitigation Assessment Teams. The objectives of a MAT are to inspect damage to buildings, assess the performance of the buildings, evaluate design and construction practices, and evaluate building code requirements and enforcement. The MAT then makes recommendations for improving building performance in future storm events. The MAT consists of representatives from FEMA Headquarters, the FEMA Regional Offices, state and local governments, and public and private sector experts in design, construction, and building code development and enforcement.

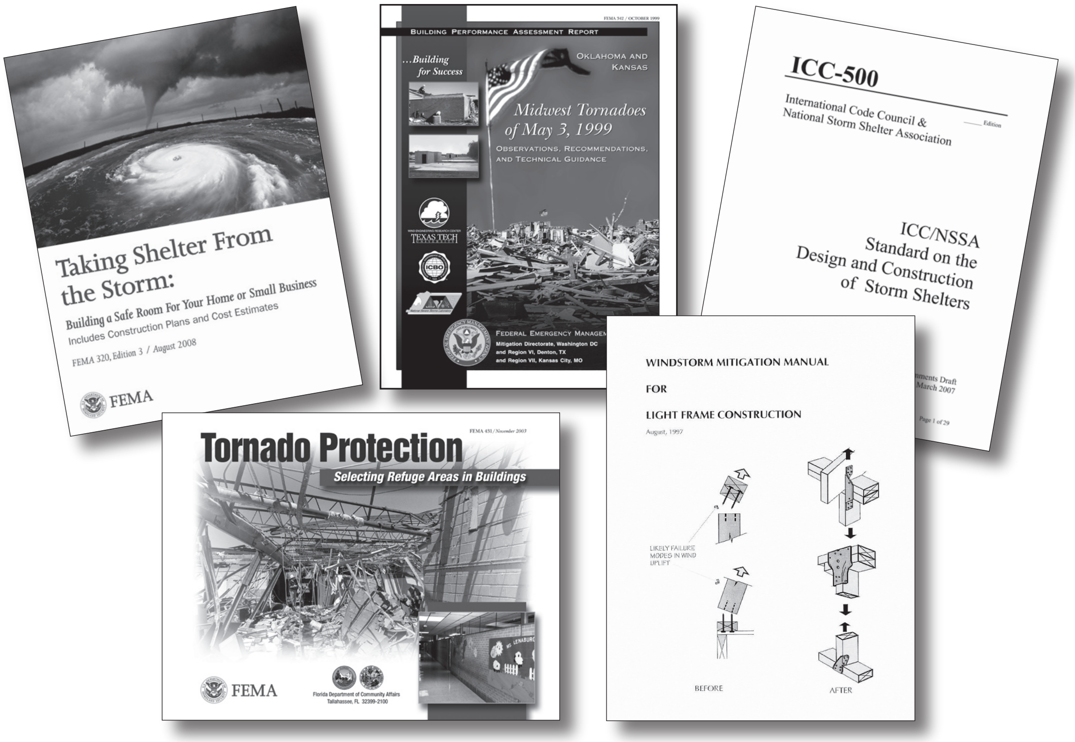
The findings from MATs outline building science issues of national significance that warrant further study. Since Hurricane Opal in 1989, MATs (and building science teams from preceding programs, such as the Building Performance Assessment Team [BPAT] program) have studied and reported on over 10 major hurricane or tornado events. In addition, FEMA uses smaller technical field assessment teams to support the MAT and other post-disaster activities to further document the performance of buildings and shelters during these events. For example, in 2007, in response to numerous outbreaks of tornadoes, FEMA ordered several teams into the field to assess building performance, damages, and associated issues. These teams produced a series of technical safe room and building improvement documents: the five February 2007 Tornado Recovery Advisories (RAs) (FEMA DR-1679, http://www.fema.gov/library/viewRecord.do?id=2631) and the three May 2007 Tornado RAs (FEMA DR-1699, http://www.fema.gov/library/viewRecord.do?id=2972, 2973, and 2974) prepared for public release to aid in post-disaster reconstruction. The RAs contain informative facts about tornadoes, their effects on various types of construction from manufactured housing to community safe rooms, the risk of tornado events associated with regions of the country, and potential mitigation actions that can be taken to reduce damages to older and new manufactured homes.

The MAT Process: In response to catastrophic hurricanes, floods, tornadoes, earthquakes, and other disasters, FEMA often deploys Mitigation Assessment Teams (MATs) to conduct field investigations at disaster sites. More information about the MAT program can be found at http://www.fema.gov/rebuild/mat/mat_faqs.shtm.

Additionally, studies have been conducted since the early 1970s to determine design parameters for safe rooms intended to provide protection from tornadoes, hurricanes, and other extreme-wind events. In 1998, using the results of research conducted by Texas Tech University's (TTU's) Wind Science and Engineering (WISE) Research Center, formerly the Wind Engineering Research Center (WERC), FEMA developed design guidance and construction plans for in-home safe rooms and prepared the booklet *Taking Shelter From the Storm: Building a Safe Room Inside Your House* (FEMA 320). As the title suggests, the guidance presented in FEMA 320 is specific to small safe rooms built inside individual houses.

Since the original guidance was published, several significant tornado and hurricane events have occurred. Considerable engineering and scientific research and investigations have been conducted that have resulted in various important findings. Also, using the original FEMA 361 publication as guidance, the International Code Council in partnership with FEMA and the National Storm Shelter Association (NSSA), formed a national committee that developed and 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®). This second edition of FEMA 361 updates the original guidance and takes into consideration the new ICC-500 standard, along with the additional research and studies that have been conducted since 2000.



Taking Shelter From the Storm:
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ICC-500
International Code Council &
National Storm Shelter Association
____ Edition
ICC/NSSA
Standard on the
Design and Construction
of Storm Shelters
nments Draft
March 2007
Page 1 of 29

FEMA 431 / November 2003
Tornado Protection
Selecting Refuge Areas in Buildings
FEMA
Florida Department of Community Affairs
Tallahassee, FL 32399-2100

WINDSTORM MITIGATION MANUAL
FOR
LIGHT FRAME CONSTRUCTION
August, 1997

This publication builds on the knowledge of field investigations, research, and technical reports and publications prepared by FEMA and other national and state agencies that have studied and researched the performance of the built environment during tornadoes and hurricanes. FEMA remains committed to the development of design and construction criteria and guidance for safe rooms capable of providing the highest quality of life-safety protection from extreme-wind events. Table 1-1 provides a listing of safe room and shelter publications and guidance documents that have been produced by FEMA over the past 32 years.

For questions related to safe room design criteria presented in FEMA 320 or FEMA 361, call the FEMA Building Science helpline at (866) 222-3580 or email saferoom@dhs.gov for technical assistance.

Table 1-1. Past FEMA Safe Room and Shelter Publications and Guidance

Date	Publication
April 1976	FEMA TR-83B, *Tornado Protection: Selecting and Designing Safe Areas in Buildings*
September 1980	FEMA TR-83A, *Interim Guidelines for Building Occupant Protection From Tornadoes and Extreme Winds*
September 1998	FEMA 320, *Taking Shelter From the Storm* (First Edition)
May 1999	FEMA *National Performance Criteria for Tornado Shelters*
August 1999	FEMA 320, *Taking Shelter From the Storm* (Second Edition)
July 2000	FEMA 361, *Design and Construction Guidance for Community Shelters*
October 2001	FEMA 388, *Safe Room and Shelter Resource* – CD
November 2003	FEMA 431, *Tornado Protection – Selecting Refuge Areas in Buildings* (in cooperation with the Florida Department of Community Affairs)
March 2007	2007 *Florida Tornado Outbreak – Tornado Recovery Advisories*
September 2007	*Greensburg, KS Tornado – Tornado Recovery Advisories*

1.4 Organization of the Publication

This publication consists of 10 chapters and 8 appendices. This first chapter is the introduction and provides the purpose and background for the publication. The following is a list of the other chapters herein:

Chapter 2 describes the objectives of designing community safe rooms (the primary objective is the safety of the occupants within the safe rooms), and discusses risk assessment tools and compares FEMA safe room criteria with other shelter criteria.

Chapter 3 presents the FEMA design criteria for both tornado and hurricane safe rooms. Details include applicable ICC-500 design requirements, code compliance, peer review, and design documentation.

Chapter 4 discusses the characteristics of tornadoes and hurricanes, and their effects on structures.

Chapter 5 provides commentary on some of the design criteria given in Chapter 3, safe room location concepts (including safe rooms accessed from the interior or exterior of a building), modifying and upgrading existing interior space, safe room location and accessibility, and types of safe rooms.

Chapter 6 presents commentary on the wind and flood load design criteria for safe room structures (e.g., determination of wind loads, protection against penetration by windborne missiles, and proper anchorage and connection).

Chapter 7 provides commentary on the performance criteria for windborne missile impacts, doors and door frames, windows, and roofs.

Chapter 8 presents the human factors criteria for safe rooms (e.g., proper ventilation, square footage per safe room occupant, accessibility, lighting, occupancy durations, emergency food and water, sanitary management, emergency supplies, and emergency power).

Chapter 9 discusses emergency management considerations, including parameters for developing a plan of action to respond to an extreme-wind event for both community safe rooms and safe rooms in commercial buildings, and preparation of a safe room maintenance plan.

Chapter 10 provides a list of references used in the preparation of this publication.

Appendix A presents a list of the key people involved in preparation of both the first and second editions of the publication. This includes the Project Team, the Review Committee, and a list of individuals and agencies that FEMA would like to acknowledge.

Appendix B contains checklists for use in assessing wind, flood, and seismic hazards at a potential safe room site and for refuge areas. It also contains checklists for designers and planners to use when planning and establishing the design criteria for a new tornado or hurricane community safe room.

Appendices C and D each present a case study in which a community safe room was designed. The case studies include wind load analyses, conceptual safe room design plans, and cost estimates. Appendix C contains conceptual design plans for a community safe room for a community in North Carolina. Appendix D contains conceptual design plans for a safe room for a school building in Wichita, Kansas.

Appendices E and F provide the results of missile impact tests on a variety of different safe room wall sections, and safe room doors and door hardware, respectively.

Appendix G presents design guidance regarding impact protection for wood sheathing.

Appendix H contains the list of acronyms and abbreviations used in this publication.