Safe Rooms: Selecting Design Criteria

TORNADO RECOVERY ADVISORY *RA2, June 2011*

Purpose and Intended Audience

The intended audience for this Tornado Recovery Advisory is anyone involved in the planning, policy-making, design, construction, or approval of safe rooms, including designers, emergency managers, public officials, policy or decision-makers, building code officials, and home or building owners. Homeowners and renters should also refer to the Tornado Recovery Advisory No. 3 titled "Residential Sheltering: In-Residence and Stand-Alone Safe Rooms" (updated in 2011). The purpose of this advisory is to identify the design guidance, code requirements, and other criteria that pertain to the design and construction of safe rooms for tornadoes and hurricanes. Different safe room and storm shelter criteria offer different levels of protection to safe room occupants.

Community safe room being constructed to FEMA 361 criteria in Wichita, KS.

This Recovery Advisory Addresses:

- How safe room construction is different from typical building construction
  - Structural systems
  - Wind-borne debris resistance
- Safe rooms vs. storm shelters
- Selecting refuge areas in buildings

How Safe Room Construction is Different from Typical Building Construction

A safe room is typically an interior room, space within a building, or an entirely separate building, designed and constructed to protect its occupants from tornadoes or hurricanes. Safe rooms are intended to provide near-absolute protection against both wind forces and the impact of wind-borne debris. The level of occupant protection provided by a space specifically designed as a safe room is intended to be much greater than the protection provided by buildings that comply with the minimum requirements of building codes. Until the 2009 International Codes adopted the International Construction Code/National Storm Shelter Association (ICC/NSSA) *Standard for the Design and Construction of Storm Shelters* (ICC-500), the model building codes did not cite design and construction criteria for life safety for sheltering, nor do they provide design criteria for tornado-resistant construction. Information about the ICC shelter criteria and FEMA safe room criteria that provide life-safety protection can be found in other guidance documents referenced in this recovery advisory.

> The term "hardened" refers to specialized design and construction applied to a room or building to allow it to resist wind pressures and wind-borne debris impacts during a high-wind event and serve as a shelter.

Safe rooms typically fall into two categories: residential safe rooms and community (non-residential) safe rooms.

- There are two general types of residential safe rooms: in-residence safe rooms and stand-alone safe rooms, located adjacent to or near a residence. An ***in-residence safe room*** is a small, specially designed ("hardened") room, such as a bathroom or closet, designed as a place of refuge for the people who live in the house. A ***stand-alone residential safe room*** is similar in function and design, but it is a separate structure installed outside the house, either above or below the ground surface. Refer also to Tornado Recovery Advisory No. 3 titled *"Residential Sheltering: In-Residence and Stand-Alone Safe Rooms" (updated in 2011).*
- A ***community safe room*** is intended to protect a larger number of people: anywhere from approximately 16 to several hundred individuals. Community safe rooms include not only public safe rooms but also private safe rooms for businesses and other organizations.
- Guidance on designing and constructing safe rooms can be found in FEMA 320, *Taking Shelter from the Storm: Building a Safe Room For Your Home or Small Business* (2008) and FEMA 361, *Design and Construction Guidance for Community Safe Rooms* (2008).

Structural Systems

The primary difference in a building's structural system when designed for use as a safe room, rather than for conventional use, is the magnitude of the wind forces that it is designed to withstand.

Buildings are designed to withstand a certain wind speed (termed "basic [or design] wind speed") based on historic wind speeds documented for different areas of the country. The highest design wind speed used in conventional construction is near the coastal areas of the Atlantic and Gulf Coasts and is in the range of 140–150 mph, 3-second gust in most locations. By contrast, the design wind speed recommended by FEMA[1] for safe rooms in these same areas is in the range of 200–250 mph, 3-second gust; this design wind speed is intended to provide "near-absolute protection."

Wind pressures are generally calculated as a function of the square of the design wind speed. As a result, the structural systems of a safe room are designed for forces up to almost eight times higher than those used for typical building construction. Consequently, the structural systems of a safe room (and the connections between them) are very robust.

Wind-Borne Debris Resistance

Wind-borne debris, commonly referred to as missiles, causes many of the injuries and much of the damage from tornadoes and hurricanes. Windows and the glazing in exterior doors of conventional buildings are not required to resist wind-borne debris, except for buildings in wind-borne debris regions.[2] Impact-resistant glazing can either be laminated glass, polycarbonate, or shutters. The American Society of Civil Engineers (ASCE) Standard 7 missile criteria were developed to minimize property damage and improve building performance; they were not developed to protect occupants. To provide occupant protection, the criteria used in designing safe rooms include substantially greater wind-borne debris loads and will be detailed later in this recovery advisory.

> If glazing is present in a tornado safe room, it should be protected by an interior-mounted shutter that can be quickly and easily deployed by the safe room occupants, or be designed to resist the wind-borne debris impact and wind pressure tests cited in FEMA 361 and prescribed in ICC-500, Chapter 8.

The roof deck, walls, and doors of conventional construction are also not required by the building code to resist wind-borne debris. However, the roof deck and walls around a safe room space, and the doors leading into it, must resist wind-borne debris if the space inside is to provide occupant protection. Additional information regarding the different levels of wind-borne debris loads is provided below.

1 FEMA 361, *Design and Construction Guidance for Community Safe Rooms,* Second Edition (August 2008)
2 ASCE 7, American Society of Civil Engineers Standard 7, *Minimum Design Loads for Buildings and Other Structures* (2010)

Safe Rooms vs. Storm Shelters

Safe rooms and storm shelters provide different levels of protection depending on the design criteria used. The level of protection provided by a safe room is a function of the design wind speed (and resulting wind pressure) used in designing it, and of the wind-borne debris load criteria. In addition to FEMA 320 and FEMA 361, the International Construction Code/ National Storm Shelter Association (ICC/NSSA) *Standard for the Design and Construction of Storm Shelters* (ICC-500) provides design and construction criteria for storm shelters. FEMA's safe room criteria and ICC-500's storm shelter criteria are similar, with a few differences such as citing with respect to flood hazards and the horizontal missile impact test speed for the hurricane hazard. While the two criteria are similar, FEMA changed the name of its guidance from "shelters" to "safe rooms" when ICC-500 was released to avoid confusion. In addition, FEMA 361, which was updated at the same time ICC-500 was released, references ICC-500 for certain criteria in the design and construction of a safe room, such as testing standards for missile impact and wind pressure resistance.

Design wind speed and wind pressure criteria: Wind pressure criteria are given by different guides, codes, and standards. The wind pressure criteria specify how strong the safe room must be. The design wind speed is the major factor in determining the magnitude of the wind pressure that the building is designed to withstand. In FEMA's safe room publications and ICC-500, the same wind speed hazard maps are used to recommend design wind speeds ranging from 130 to 255 mph. The 2009 *International Residential Code* and the 2009 *International Building Code,* which establish the minimum requirements for residential and other building construction, include design wind speeds ranging from 90 to 150 mph throughout most of the country. Table 1 provides a comparison of safe room/shelter design criteria options.

Wind-borne debris load criteria: Table 2 presents wind-borne debris criteria given in various guides, codes, and standards. Table 2 shows the different test missiles and the corresponding momentum they carry with them as they strike a safe room. The first entries on the table (Tornado Missile Testing Requirements) are the FEMA missile guidance for residential and community safe rooms that provide near-absolute protection.

HMGP funds were used for this Public Safety Complex constructed so that the entire facility is compliant with FEMA 361 criteria. Robert J. Curry Public Safety Complex, Gulfport, MS.

HMGP-funded community safe room constructed in the basement of a new fire station in Brookside, AL.

Table 1. Wind Safe Room/Shelter Design and Construction Codes, Standards, Guidance Comparison[1] *(page 1 of 2)*

Title or Name of Document	Code, Regulation, Standard, or Statute?	Wind Hazard	Wind Map
FEMA Safe Room Publications: **FEMA 320** Taking Shelter from the Storm: Building a Safe Room For Your Home or Small Business (2008) **FEMA 361** Design and Construction Guidance for Community Safe Rooms (2008)	FEMA guidance document, not a code or standard. "Best Practice" for high-wind safe rooms	Tornado and Hurricane	**FEMA 320:** Hazard map, maximum wind hazard speed of 250 mph used for design **FEMA 361:** Map with four wind speed zones for design (wind mri[2] is 10,000–100,000 years). This map is often referred to as the "FEMA 361 map"
International Code Council/National Storm Shelter Association (ICC/NSSA) High Wind Shelter Standard (ICC-500)	Consensus standard for shelter design and construction. Incorporated by reference into the 2009 IBC and IRC.	Tornado and Hurricane	**Tornado:** Uses FEMA 361 map **Hurricane:** Uses revised ASCE 7 map with contours at 10,000 year mri with minimum shelter design wind speed of 160 mph, maximum approximately 255 mph
Florida State Emergency Shelter Program (SESP) – Florida's interpretation of the American Red Cross (ARC) 4496 Guidance. Note: shelters in this category range from EHPA-recommended design levels, shown in this row, to the code requirement levels (next row), to the ARC 4496 requirements (see below).	Guidance in the Florida Building Code (FBC) "recommending" above-code requirements for EHPAs. See also Appendix G of the Florida SESP report for detailed design guidance.	Hurricane	FBC map, based on ASCE 7-05 (maps basically equivalent); mri is 50–100 years in coastal areas and adjusted with importance factor
ASCE 7-10	2010 edition of ASCE standard on minimum design loads for buildings and other structures.	Hurricane	ASCE 7-10 departs from previous editions and provides multiple wind maps for various "building risk categories" (which are based on occupancy type). The maps have wind speeds based on different mri.
FBC 2000, IBC/IRC 2000 through 2009, ASCE 7-98 through 2005	Building code and design standards for regular (non-shelter) buildings. Some additional guidance is provided in commentary.	Hurricane	ASCE 7 has its own wind speed map based on historical and probabilistic data; mri is 50–100 years in coastal areas and adjusted with importance factor
Institute for Business and Home Safety (IBHS) Fortified Home Program – intended as guidance to improve the performance of residential buildings during natural hazard events, including high-wind events. Not considered adequate for sheltering.	Guidance provided to improve performance of regular (non-shelter) buildings in high winds	Tornado and Hurricane	ASCE 7 or modern State building code map
FBC EHPAs – code requirements for public "shelters" (FBC Section 423.25)	Statewide code requirements for EHPAs	Hurricane	The minimum requirement is based on ASCE 7 (maps basically equivalent); mri is 50–100 years in coastal areas and adjusted with importance factor; the missile impact criteria for openings, walls, and roof as provided in SSTD 12,[3] must also be met
Building Codes: Pre-2000	Building code and design standards for regular (non-shelter) buildings	Hurricane	Each of the older codes used their own published wind contour maps
ARC 4496 Standards for Hurricane Evacuation Shelter Selection	Guidance for identifying buildings to use as hurricane evacuation shelters	Hurricane	ASCE 7-98 or ANSI A58 structural design criteria
Other: Information for selecting areas of refuge/last resort	Guidance from FEMA and others for selecting best-available refuge areas	Tornado and Hurricane	None

NOTES:
1. The wind shelter guidance and requirements shown here are presented from highest to least amount of protection provided
2. Mean recurrence intervals (mri) for wind speeds maps are identified by the code or standard that developed the map. Typically, the mri for non-shelter construction in non-hurricane-prone areas is 50 years and in hurricane-prone regions, approximately 100 years.
3. Standard Building Code/Standard 12 – Test Standards for Determining Resistance from Windborne Debris

Table 1. Wind Safe Room/Shelter Design and Construction Codes, Standards, Guidance Comparison[1] (page 2 of 2)

Wind Design Coefficient Considerations[4,5]	Debris Impact Criteria[6]	Remarks
FEMA 320: N/A – prescriptive design guidance for maximum hazard **FEMA 361:** Use FEMA 361 wind speed map with four zones. Calculate pressures using ASCE 7 methods and use I=1.0, Kd=1.0, Exposure C, no topographic effects, GCpi=+/-0.55 (this will account for atmospheric pressure change [APC])	Test all safe rooms with the representative missile (missile speed dependent on site design wind speed): **FEMA 320:** 15 lb 2x4 at 100 mph (horizontal) and 67 mph (vertical) **FEMA 361 Tornado:** 15 lb 2x4 at 80-100 mph (vertical) and 2/3 of this speed (horizontal) **FEMA 361 Hurricane:** 9 lb 2x4 at 0.1 times the wind speed (horizontal) and 0.5 times the wind speed (vertical)	**FEMA 320:** Intent is to provide "near-absolute protection." No certification is provided. **FEMA 361:** Intent is to provide "near-absolute protection." Safe room operations guidance is provided. Occupancy issues are addressed. Wall section details provided. No certification is provided.
Tornado: Use FEMA 361 wind speed map. Calculate pressures using ASCE 7 methods and use I=1.0, Kd=1.0, Exposure C with some exceptions, Kzt=need not exceed 1.0, GCpi=+/-0.55 or +/-0.18+APC **Hurricane:** Use revised ASCE 7 map and methods and use I=1.0, all other items as per ASCE 7, no APC consideration required.	Test shelters with representative missile (missile speed dependent on site design wind speed): **Tornado:** 15 lb 2x4 at 80–100 mph (vertical) and 2/3 of this speed (horizontal). **Hurricane:** 9 lb 2x4 at 0.1 times the wind speed (horizontal) and 0.4 times the wind speed (vertical)	Intent is to provide a standard for the design and construction of high-wind shelters. Will not use term "near-absolute protection." Occupancy, ventilation, and use issues are also addressed. Shelter operations guidance is provided in the commentary only (commentary is a separate document—not a consensus document).
Recommends that designer add 40 mph to basic wind speed identified on map, Exposure C, I=1.15, Kd=1.00, GCpi as required by design (typically +/-0.18), but recommends +/-0.55 for tornado shelter uses.	In wind-borne debris region (120 mph+): Small – pea gravel; Large – 9 lb 2x4 at 75 mph (horizontal), up to 60 feet above grade, but recommends 15 lb 2x4 at 50 mph (horizontal)	The building, or a portion of a building, is defined as an essential facility and as a shelter. Designer is required to submit signed/sealed statement to building department and State offices stating the structure has been designed as a shelter (EHPA plus added recommended criteria).
Method is basis of most wind pressure calculation methods. All items in design process are site-specific. Unlike ASCE 7-05, ASCE 7-10 does not use importance factor in wind calculation.	Uses the same reference as ASCE 7-05 for debris impact criteria (ASTM E 1996), with wind zones modified to account for higher basic wind speeds (see C26.10 of ASCE 7-10 for more information).	The 2009 model I-codes reference ASCE 7-05. However, ASCE 7-10 will be referenced in the 2012 IBC. The 2010 Florida Building Code references ASCE 7-10.
Method is basis of most wind pressure calculation methods. All items in design process are site-specific. Use I=1.15 for critical and essential facilities.	In wind-borne debris region (120 mph+): Small – pea gravel; Large – 9 lb 2x4 at 34 mph (horizontal) and areas > 130 mph: 9 lb 2x4 at 55 mph (horizontal), up to 60 feet above grade. Note: 2006 IBC requires the 9-lb 2x4 (large) missile to be tested at 55 mph for critical and essential facilities	Code requires increased design parameters only for buildings designated as critical or essential facilities.
Based on regional hazards, recommendations are provided to improve and strengthen the load path and the performance of the building exterior.	Window and glazing protection is recommended for most hurricane-prone areas, not just areas with a basic wind speed of 120 mph and greater.	This program provides design and construction guidance to improve building performance for high-wind events. Compliance will likely improve building performance but does not imply that the building is safe or that it is appropriate to use as a shelter.
Use basic wind speed at site as identified on FBC wind speed map, use exposure at site, use Category III (Essential Buildings), use wind loads in accordance with ASCE 7.	Use the missile impact criteria for the building enclosure, including walls, roofs, glazed openings, louvers, and doors, per SBC/SSTD 12.	The building or a portion of a building is defined as an essential facility and as an EHPA. Designer is required to submit signed/sealed statement to building department and State offices stating the structure has been designed as an EHPA.
Typically these older codes provided a hurricane regional factor for design wind speeds, but little attention was paid to components and cladding	Not required for all buildings. Where required, the Standard Building Code[7] developed and recommended debris impact standards for use in hurricane-prone regions.	These codes specified limited hazard-resistant requirements. Some guidance was provided with SSTD 10 from SBCCI for the design and construction of buildings in high-wind and hurricane-prone regions. Buildings constructed to these early codes were not required to have structural systems capable of resisting wind loads.
None	None	Provides guidance on how to select buildings and areas of a building for use as a high-wind shelter or refuge area. Does not provide or require a technical assessment of the proposed shelter facility.
None	None	Best available refuge areas should be identified in all buildings without shelters. FEMA 431, *Tornado Protection: Selecting Refuge Areas in Buildings,* provides guidance to help identify the best available refuge areas in existing buildings. Because best available refuge areas are not specifically designed as shelters, their occupants may be injured or killed during a tornado or hurricane.

NOTES (continued):

4. ASCE 7-05 Building Design Loads for Buildings and Other Structures (2005) is the load determination standard referenced by the model building codes. The wind design procedures used for any shelter type in this table use one of the wind design methods as specified in ASCE 7-05, but with changes to certain design coefficients that are identified by the different codes, standards, or guidance summarized in this table.
5. From ASCE 7 method: I = importance factor; Kd = wind directionality factor; GCpi = internal pressure coefficient
6. Roof deck, walls, doors, openings, and opening protection systems must all be tested to show resistance to the design missile for the FEMA, ICC, and FL EHPA criteria
7. From the Southern Building Code Congress International, Inc. (SBCCI)

Table 2. Wind-Borne Debris Criteria

Guidance, Code, or Standard Criteria for the Design Missile	Debris Test Speed (mph)	Large Missile Specimen	Momentum at Impact (lbf s)
Tornado Missile Testing Requirements			
FEMA 320/FEMA 361	100 (maximum) 80 (minimum)	15# 2x4 15# 2x4	68 55
International Code Council (ICC) ICC-500 Storm Shelter Standard	100 (maximum) 80 (minimum)	15# 2x4 15# 2x4	68 55
Hurricane Missile Testing Requirements			
FEMA 320/FEMA 361	128 (maximum) 80 (minimum)	9# 2x4 9# 2x4	53 33
ICC 500 Storm Shelter Standard	102 (maximum) 64 (minimum)	9# 2x4 9# 2x4	42 26
Florida State Emergency Shelter Program (SESP) Criteria and Emergency Operations Center (EOC) Design Criteria	50 (EOC recommended) 55 (EHPA recommended) 34 (EHPA minimum)	15# 2x4 9# 2x4 9# 2x4	34 23 14
IBC/IRC 2009, ASCE 7-10, Florida Building Code, ASTM E 1886/E 1996	55 34	9# 2x4 9# 2x4	23 14

NOTES:
IBC/IRC – International Building Code/International Residential Code
lbf-s – Pounds (force) seconds
EHPA – Enhanced Hurricane Protection Area

Using Wind Shelter Design and Construction Codes: An Example

Table 3 shows comparative data for two locations using the design criteria presented in Table 1. Where no guidance is provided for sheltering or basic construction, “N/A” (not applicable) is stated. Where the requirement is not required, “Not required” is stated.

Selecting Refuge Areas in Buildings

Building owners should be aware of any existing public shelters near their building. For instance, new schools in many States are required to include an ICC-500-compliant storm shelter. If no sheltering options are located nearby, building owners should consider whether their building can be retrofitted for a shelter or safe room. While it is recommended that a safe room be installed, this may not solve the immediate problem of needing to identify the best available refuge areas in a building.

During severe weather, building occupants should be moved to a location in the building that is protected from potential wind-borne debris and the least susceptible to collapse. While these areas do not provide near-absolute protection (unless designed as safe rooms), they may limit the number of occupants injured or killed. Appropriate refuge areas should be identified by architects, engineers, or design professionals familiar with FEMA 361 (2008) and FEMA P-431, *Tornado Protection: Selecting Refuge Areas in Buildings* (2009). These refuge areas are usually interior locations with short-span roof systems, reinforced masonry walls, and no glass openings.

Post-disaster assessments following April 2011 Tornado Outbreak demonstrated that administrative officials or others involved in local planning efforts often identified refuge areas without the guidance of an experienced design professional. While it was clear that an effort was made to protect the occupants, many of these refuge areas were located in large spaces—such as gymnasiums or auditoriums—or in areas near exterior windows and doors. Additionally, many of the selected refuge areas were observed to be surrounded by wall systems subject to collapse in high-wind events. In some cases, the refuge areas had insufficient space for all of the building occupants, or were in locations which would be difficult to move the occupants to in a reasonable period of time. While there were no reports of fatalities in the refuge areas studied, it was likely because the areas were not occupied when the storms struck because many of refuge areas had collapsed or filled with broken glass from windows shattered by wind-borne debris.

Administrative officials interviewed in several communities after the April 2011 Tornado Outbreak indicated that they had been unable to obtain the expertise of a design professional in selecting the appropriate refuge area. The reason cited was liability concerns on the part of the design professional. To ease this concern,

Table 3. Design Criteria Comparison

Shelter Design Standard, Code, or Document	Data[1]	Example Location # 1: Miami, FL	Example Location #2: Joplin, MO
FEMA 361 [2]	Design wind speed	200 mph (tornado) 225 mph (hurricane)	250 mph
	Pressure on windward wall	107 psf[3] (tornado) 135 psf (hurricane)	167 psf
	Pressure on roof section	239 psf (tornado, suction) 303 psf (hurricane, suction)	374 psf (suction)
	Test missile momentum at impact	61 lb_f-s (tornado) 46 lb_f-s (hurricane)	68 lb_f-s
ICC-500	Design wind speed	200 mph (tornado) 225 mph (hurricane)	250 mph
	Pressure on windward wall	107 psf (tornado) 135 psf (hurricane)	167 psf
	Pressure on roof section	239 psf (tornado, suction) 303 psf (hurricane, suction)	374 psf (suction)
	Test missile momentum at impact	61 lb_f-s (tornado) 37 lb_f-s (hurricane)	68 lb_f-s
FBC EHPA/SESP (using + 40 mph recommendation)	Design wind speed	186 mph	N/A
	Pressure on windward wall	106 psf	N/A
	Pressure on roof section	238 psf (suction)	N/A
	Test missile momentum at impact	34 lb_f-s	N/A
ASCE 7-10 (ASTM E 1996)	Design wind speed	170 mph	115 mph
	Pressure on windward wall	77 psf	35 psf
	Pressure on roof section	173 psf (suction)	79 psf (suction)
	Test missile momentum at impact	14 lb_f-s	Not required
ASCE 7-05/IBC 2009 (ASTM E 1996) [4,5]	Design wind speed	150 mph	90 mph
	Pressure on windward wall	69 psf	25 psf
	Pressure on roof section	155 psf (suction)	56 psf (suction)
	Test missile momentum at impact	14 lb_f-s	Not required
IBHS	Design wind speed	150 mph	90 mph
	Pressure on windward wall	69 psf	25 psf
	Pressure on roof section	155 psf (suction)	56 psf (suction)
	Test missile momentum at impact	14 lb_f-s	Not required
FBC EHPA	Design wind speed	146 mph	N/A
	Pressure on windward wall	66 psf	N/A
	Pressure on roof section	147 psf (suction)	N/A
	Test missile momentum at impact	23 lb_f-s	N/A
Pre-2000 Building Codes	Design wind speed	140 mph and less	90 mph and less
	Pressure on windward wall	< 40 psf (varies)	< 15 psf (varies)
	Pressure on roof section	< 120 psf (varies)	< 45 psf (varies)
	Test missile momentum at impact	Not required by all codes	Not required
ARC 4496	Design wind speed	N/A	N/A
	Pressure on windward wall	N/A	N/A
	Pressure on roof section	N/A	N/A
	Test missile momentum at impact	N/A	N/A
Areas of Last Resort	Design wind speed	Unknown	Unknown
	Pressure on windward wall	Unknown	Unknown
	Pressure on roof section	Unknown	Unknown
	Test missile momentum at impact	Not required	Not required

NOTES:
1. Wind pressures were calculated based on a 40-foot x 40-foot square building, with a 10-foot eave height and a 10-degree roof pitch, partially enclosed
2. For a combined tornado/hurricane safe room, the more restrictive criteria apply. FEMA 320 criteria are based on a 250-mph wind speed regardless of location
3. psf – Pounds per square foot; lb_f-s – Pounds (force) seconds
4. Non-storm shelter wind design criteria
5. IBC/IRC 2000, 2003, and 2006 editions and ASCE 7-98 have similar wind design criteria

engineers are encouraged to add the following information and qualifiers to their contract and their findings report:

- The identified area should be considered by building owners as only a "best available area of refuge" and occupants could still be injured or killed
- The findings should include:
  - The level of testing completed during the identification of the area
  - The total number of occupants the area can hold
  - The approximate maximum safe wind speed for the best available refuge area
  - The timeframe before which the area should be re-evaluated
  - An outline of potential modifications that could be made to the structure to improve its performance in high-wind events
- State that changes to the building may make the refuge area no longer the best available refuge area

Agreement between the client and the design professional on these points may ease some of the liability concerns. Administrators and facilities managers for buildings with large occupancies should also review FEMA P-431 (2009) and the refuge area evaluation checklists presented in Appendix B of FEMA 361.

Operating a Safe Room

In addition to the safe room's structural performance requirements, the following operational, maintenance, and human factors criteria must be considered for a successful safe room:

- Standby power (e.g., generator)
- Protection of critical support systems such as a generator
- Occupancy duration
- Ventilation
- Minimum square footage per occupant
- Egress
- Distance and travel time for occupants traveling to the safe room
- Access for disabled occupants
- Special needs requirements
- Lighting
- Emergency provisions (food, water, sanitation management, emergency supplies, communication equipment)
- Operations and maintenance plans for the safe room

Each of these items is further elaborated in FEMA 361 and ICC-500. Not all items must be considered for a residential safe room, but they are especially important when designing a community safe room.

Useful Links and Shelter Resources

Taking Shelter from the Storm: Building a Safe Room For Your Home or Small Business (FEMA 320), August 2008, 3rd Edition http://www.fema.gov/library/viewRecord.do?id=1536

Design and Construction Guidance for Community Safe Rooms (FEMA 361), August 2008 2nd Edition http://www.fema.gov/library/viewRecord.do?id=1657

Tornado Protection: Selecting Refuge Areas in Buildings (FEMA P-431), October 2009 2nd Edition http://www.fema.gov/library/viewRecord.do?id=1563

ICC/NSSA Standard for the Design and Construction of Storm Shelters, International Code Council and the National Storm Shelter Association (ICC-500), June 2008 http://www.iccsafe.org/Store/Pages/Product.aspx?id=8850P08_PD-X-SS-P-2008-000001#longdesc

National Storm Shelter Association (NSSA); http://www.NSSA.cc