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This digital document created and presented by Richard Fleetwood. He is the founder, author, producer, and webmaster of the **SurvivalRing** *(http://www.survivalring.org)* and **Civil Defense Now!** *(http://www.survivalring.org/cd-main.htm)* websites.

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There are too many situations and incidents that can come to pass in everyday life, that when time is taken to learn and skills obtained, can mean the difference between life and death. Sept. 11, 2001 proved to the world that no matter how safe a person thinks they may be, death and injury can come from the most UN-LIKELY place, at any time. The documents presented in this series of digitized works, can help the average person with the knowledge within, to know how to save those persons closest to them in REAL disaster. Help spread this idea of sharing SURVIVAL INFORMATION.

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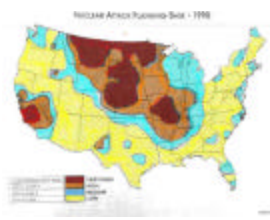

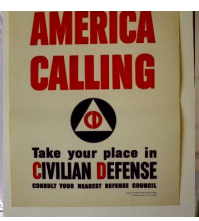

8 Human Factors Criteria

Human factors criteria for the community shelters build on existing guidance provided in Chapters 5 and 6. Although existing documents do not address all the human factors involved in the design of high-wind shelters, they provide the basis for the criteria summarized in this chapter. If shelters are located in areas at risk for both tornadoes and hurricanes, the design should incorporate the human factor criteria for hurricanes. These criteria are detailed in the following sections.

8.1 Ventilation

Ventilation for a shelter should comply with the building codes or ordinances adopted by the local jurisdiction. Ventilation should be provided to the shelter area through either the floor or the ceiling. Although horizontal ventilation openings may be easier to design and construct, vertical ventilation openings have a smaller probability of being penetrated by a missile. Nevertheless, a protective shroud or cowling that meets the missile impact requirements of Chapters 5 and 6 should be provided to protect any ventilation openings in the shelter that are exposed to possible missile impacts, such as the point where ductwork for a normal-use ventilation system penetrates the wall or roof of the shelter.

The ventilation system for both single- and multi-use shelters must be capable of providing the minimum number of air changes required by the building code for the shelter's occupancy classification. For single-use shelters, 15 ft^3 per person per minute is the minimum air exchange recommended—this recommendation is based on guidance outlined in the International Mechanical Code (IMC). For multi-use shelters, the design of mechanical ventilation systems is recommended to accommodate the air exchange requirements for the occupancy classification of the normal use of the shelter area. Although the ventilation system may be overwhelmed in a rare event when the area is used as a shelter, air exchange will still take place. The designer should still confirm with the local building official that the ventilation system may be designed for the normal-use occupancy. In the event the community where the shelter is to be located has not adopted a model building and/or mechanical code, the requirements of the most recent edition of the IBC are recommended.

Passive means of ventilation may be used as long as the building code requirements for normal use are met. Ventilation may be accomplished with passive air systems using ducts that open to an outside air supply. For

example, the 1997 Uniform Building Code (UBC) provisions for natural ventilation requires exterior openings with a minimum area of 1/20 of the total floor area. When complying with code requirements for openings, the designer needs to protect the openings to prevent windborne debris from entering the shelter.

However, any buildings that support hospitals or other life-critical operations should consider appropriate design, maintenance, and operational plans that ensure continuous operation of all mechanical equipment during and after a tornado or hurricane. In these instances, a failure of the air-handling system may have a severe effect on life safety. For these types of facilities, protecting the backup power supply that provides power to the ventilation system of the shelter is recommended.

8.2 Square Footage/Occupancy Requirements

Occupancy recommendations for tornado and hurricane shelter design are provided in this section. The recommended minimums are 5 ft^2 per person for tornado shelters and 10 ft^2 per person for hurricane shelters. Additional guidance is provided in Sections 8.2.1 and 8.2.2 for square footage requirements other than the minimum requirements.

The shelter designer should be aware of the occupancy requirements of the building code governing the construction of the shelter. The occupancy loads in the building codes have historically been developed for life safety considerations. Most building codes will require the maximum occupancy of the shelter area to be clearly posted. Multi-use occupancy classifications are provided in the IBC and state and local building codes. Conflicts may arise between the code-specified occupancy classifications for normal use and the occupancy needed for sheltering. For example, according to the IBC, the occupancy classification for educational use is 20 ft^2 per person; however, the recommendation for a tornado shelter is 5 ft^2 per person. Without proper signage and posted occupancy requirements, using an area in a school as a shelter can create a potential conflict regarding the allowed numbers of persons in the shelter. If both the normal maximum occupancy and the shelter maximum occupancy are posted, and the shelter occupancy is not based on a minimum less than the recommended 5 ft^2 per person, the shelter design should be acceptable to the building official. The IBC and the model building codes all have provisions that allow occupancies as concentrated as 5 ft^2 per person.

8.2.1 Tornado Shelter Square Footage Recommendations

Section 8.2 recommends a minimum of 5 ft^2 per person for tornado shelters. However, other circumstances and human factors may require the shelter to accommodate persons who require more than 5 ft^2. Square footage

recommendations for persons with special needs are presented below; these recommendations are the same as those provided in the FEMA 1999 *National Performance Criteria for Tornado Shelters*:

- 5 ft^2 per person adults standing
- 6 ft^2 per person adults seated
- 5 ft^2 per person children (under the age of 10)
- 10 ft^2 per person wheelchair users
- 30 ft^2 per person bedridden persons

8.2.2 Hurricane Shelter Square Footage Recommendations

Section 8.2 recommends a minimum of 10 ft^2 per person for hurricane shelters (for a hurricane event only—an event expected to last less than 36 hours). This square footage requirement is a result of discussions among the Project Team and the Review Committee, who considered many issues regarding sheltering, including the recommendations of American Red Cross (ARC) Publication No. 4496. The ARC publication recommends the following minimum floor areas (Note: the ARC square footage criteria are based on long-term use of the shelter, i.e., use of the shelter both as a refuge area during the event and as a recovery center after the event):

- 20 ft^2 per person for a short-term stay (i.e., a few days)
- 40 ft^2 per person for a long-term stay (i.e., days to weeks)

Again, the designer should be aware that there can be conflicts between the occupancy rating for the intended normal use of the shelter and the occupancy required for sheltering. This occupancy conflict can directly affect egress requirements for the shelter. For example, for a 5,000-ft^2 proposed shelter area, the normal occupancy load is 5,100/20 = 255 people, while the shelter occupancy load is 5,100/10 = 510 people. For both educational and shelter uses, the IBC requires 0.20 inch of egress per person for buildings not equipped with a sprinkler system. For normal (educational) use, this calculates to 51 inches of required egress and, because of code, a minimum of two doors. Therefore, two 32-inch doors (64-inch total net egress) should be provided. For shelter use, the requirement is for 102 inches and a minimum of three doors. Therefore, three 36-inch doors (108-inch total net egress) should be provided. Although guidance concerning code compliance is provided in Chapter 6 of this manual, the conflicts between these two occupancy requirements for egress must be resolved with state and/or local officials. Future code requirements concerning occupancies and egress may address extreme events and temporary circumstances.

8.3 Distance/Travel Time and Accessibility

The shelter designer should consider the time required for all occupants of a building or facility to reach the shelter. The National Weather Service (NWS) has made great strides in predicting tornadoes and hurricanes and providing warnings that allow time to seek shelter. For tornadoes, the time span is often short between the NWS warning and the onset of the tornado. This manual recommends that a tornado shelter be designed and located in such a way that the following access criteria are met: all potential users of the shelter should be able to reach it within 5 minutes, and the shelter doors should be secured within 10 minutes. For hurricane shelters, these restrictions do not apply, because warnings are issued much earlier, allowing more time for preparation.

Travel time may be especially important when shelter users have disabilities that impair their mobility. Those with special needs may require assistance from others to reach the shelter; wheelchair users may require a particular route that accommodates the wheelchair. The designer must consider these factors in order to provide the shortest possible access time and most accessible route for all potential shelter occupants.

Access is an important element of shelter design. If obstructions exist along the travel route, or if the shelter is cluttered with non-essential equipment and storage items, access to the shelter will be impeded. It is essential that the path remain unencumbered to allow orderly access to the shelter. Hindering access in any way can lead to chaos and panic. In addition, siting factors that affect access should be considered (see Chapter 4). For example, at a community shelter built to serve a residential neighborhood, parking at the shelter site may complicate access to the shelter; at a non-residential shelter, such as at a manufacturing plant, mechanical equipment can impede access.

CROSS-REFERENCE

Chapter 4 discusses how the siting of shelters can affect access routes and travel time.

Unstable or poorly secured structural or C&C elements could potentially block access if a collapse occurs that creates debris piles along the access route or at entrances. A likely scenario is an overhead canopy or large overhang that lacks the capacity to withstand high wind forces and collapses over the entranceway. Prior to collapse, these entranceways and canopies may reduce wind pressures and protect any openings from windborne debris impacts. However, if they are not designed to withstand the design wind forces acting on the building, they may be damaged during a wind event and may prevent access to and egress from the shelter area. If canopies and overhangs are not designed for the design wind speed, they should either be retrofitted and reinforced or be removed.

8.3.1 Americans with Disabilities Act (ADA)

The needs of persons with disabilities requiring shelter space should be considered. The appropriate access for persons with disabilities must be provided in accordance with all Federal, state, and local ADA requirements and ordinances. If the minimum requirements dictate only one ADA-compliant access point for the shelter, the design professional should consider providing a second ADA-compliant access point for use in the event that the primary access point is blocked or inoperable. Additional guidance for compliance with the ADA can be found in many privately produced publications.

The design professional can ensure that the operations plan developed for the shelter adheres to requirements of the ADA by assisting the owner/operator of the shelter in the development of the plan. All shelters should be managed with an operations and maintenance plan. Examples of Shelter Operations Plans are provided in Chapter 9 for community shelters intended to serve residential areas and for non-residential community shelters. Developing a sound operations plan is extremely important if compliance with ADA at the shelter site requires the use of lifts, elevators, ramps, or other considerations for shelters that are not directly accessible to non-ambulatory persons.

NOTE

For more information about providing for the needs of disabled persons during emergencies, refer to FEMA's United States Fire Administration publication *Emergency Procedures for Employees with Disabilities in Office Occupancies*.

8.3.2 Special Needs

The use of the shelter also needs to be considered in the design. The design professional should be aware of the need of specific users for whom a shelter is being constructed. Occupancy classifications, life safety code, and ADA requirements may dictate the design of such elements as door opening sizes and number of doors, but use of the shelter by hospitals, nursing homes, assisted living facilities, and other special needs groups may affect access requirements to the shelter. For example, strict requirements are outlined in the IBC and the model codes regarding the provision of uninterruptable power supplies for life support equipment (e.g., oxygen) for patients in hospitals and other healthcare facilities.

In addition, strict requirements concerning issues such as egress, emergency lighting, and detection-alarm-communication systems are presented in Chapter 10 of the IBC and in the NFPA Life Safety Code (NFPA 101, 1997 Edition, Chapter 12) for health care occupancies. The egress requirements for egress distances, door widths, and locking devices on doors for health care occupancies are more restrictive than those for an assembly occupancy classification in non-health care facilities based on one of the model building codes for non-health care facilities. Additional requirements also exist for health care facilities that address automatic fire doors, maximum allowable room sizes, and maximum allowable distances to egress points. The combination of all these requirements could lead to the construction of multiple small shelters in a health care facility rather than one large shelter.

8.4 Lighting

For the regular (i.e., non-shelter) use of multi-use shelters, lighting, including emergency lighting for assembly occupancies, is required by all model building codes. Emergency lighting is recommended for community shelters. A backup power source for lighting is essential during a disaster because the main power source is often disrupted. A battery-powered system is recommended as the backup source because it can be located, and fully protected, within the shelter. Flashlights stored in cabinets are useful as secondary lighting provisions but should not be used as the primary backup lighting system. A reliable lighting system will help calm shelter occupants during a disaster. Failing to provide proper illumination in a shelter may make it difficult for shelter owners/operators to minimize the agitation and stress of the shelter occupants during the event. If the backup power supply for the lighting system is not contained within the shelter, it should be protected with a structure designed to the same criteria as the shelter itself.

Natural lighting provided by windows and doors is often a local design requirement but is not required by the IBC for assembly occupancies. At this time, no glazing system proposed to provide natural lighting for shelters meets the missile impact requirements presented in Chapter 6.

8.5 Occupancy Duration

The duration of occupancy of a shelter will vary depending on the intended event for which the shelter has been designed. Occupancy duration is an important factor that influences many aspects of the design process. Shelters designed to the criteria in this manual are designed to provide protection from a wind event only. The intent is to save lives during an actual tornado or hurricane. In the interest of developing cost-effective designs, some items that would have increased occupant comfort were not included in the recommended design criteria. However, examples of items that might help to make shelters more comfortable and functional during an event, and during post disaster recovery efforts, are discussed in Section 8.6 and are listed in the two sample operations plans in Chapter 9.

8.5.1 Tornadoes

Historical data indicate that tornado shelters will typically have a maximum occupancy time of 2 hours. Because the occupancy time is so short, many items that are needed for the comfort of occupants for longer durations (in hurricane shelters) are not recommended for a tornado shelter.

8.5.2 Hurricanes

Historical data indicate that hurricane shelters will typically have a maximum occupancy time of 36 hours. For this reason, the occupants of a hurricane shelter need more space and comforts than the occupants of a tornado shelter.

8.6 Emergency Provisions

Emergency provisions will also vary for different wind events. In general, emergency provisions will include food and water, sanitation management, emergency supplies, and communication equipment. A summary of these issues is presented in the following sections.

8.6.1 Food and Water

For tornado shelters, because of the short duration of occupancy, stored food is not a primary concern; however, water should be provided. For hurricane shelters, providing and storing food and water are of primary concern. As noted previously, the duration of occupancy in a hurricane shelter could be as long as 36 hours. Food and water will be required, and storage areas for them will need to be included in the design of the shelter. FEMA and ARC publications concerning food and water storage in shelters may be found on the World Wide Web at www.fema.gov and at www.redcross.org.

8.6.2 Sanitation Management

A minimum of two toilets are recommended for both tornado and hurricane shelters. Although the short duration of a tornado might suggest that toilets are not an essential requirement for a tornado shelter, the shelter owner/operator is advised to provide two toilets or at least two self-contained, chemical-type receptacles/toilets (and a room or private area where they may be used) for shelter occupants. Meeting this criterion will provide separate facilities for men and women.

Toilets will be needed by the occupants of hurricane shelters because of the long duration of hurricanes. The toilets will need to function without power, water supply, and possibly waste disposal. Although sanitation facilities may be damaged during a hurricane, siting of a shelter above a pump station (if required at a shelter site) would allow the system to have some capacity during the event. Whether equipped with standard or chemical toilets, the shelter should have at least one toilet for every 75 occupants, in addition to the two minimum recommended toilets.

8.6.3 Emergency Supplies

Shelter space should contain, at a minimum, the following safety equipment:

- flashlights with continuously charging batteries (one flashlight per 10 shelter occupants)
- fire extinguishers (number required based on occupancy type) appropriate for use in a closed environment with human occupancy, surface mounted on the shelter wall
- first-aid kits rated for the shelter occupancy
- NOAA weather radio with continuously charging batteries
- radio with continuously charging batteries for receiving commercial radio broadcasts
- supply of extra batteries to operate radios and flashlights
- audible sounding device that continuously charges or operates without a power source (e.g., canned air horn) to signal rescue workers if shelter egress is blocked

8.6.4 Communications

A means of communication other than landline telephone is recommended for all shelters. Both tornadoes and hurricanes are likely to cause a disruption in telephone service. At least one means of backup communication should be stored in or brought to the shelter. This could be a ham radio, cellular telephone, citizen band radio, or emergency radios capable of reaching police, fire, or other emergency service. If cellular telephones are relied upon for communications, the owners/operators of the shelter should install a signal amplifier to send/receive cellular signals from within the shelter. It should be noted that cellular systems may be completely saturated in the hours immediately after an event if regular telephone service has been interrupted.

Finally, the shelter should contain either a battery-powered radio transmitter or a signal-emitting device that can be used to signal the location of the shelter to local emergency personnel should occupants in the shelter become trapped by debris blocking the shelter access door. The shelter owner/operator is also encouraged to inform police, fire, and rescue organizations of the shelter location before an event occurs. These recommendations apply to both aboveground and belowground shelters.

8.7 Emergency Power

Shelters designed for both tornadoes and hurricanes will have different emergency (backup) power needs. These needs are based upon the length of time that people will stay in the shelters (i.e., shorter duration for tornadoes and longer duration for hurricanes). In addition to the essential requirements that must be provided in the design of the shelter, comfort and convenience should be addressed.

For tornado shelters, the most critical use of emergency power is for lighting. Emergency power may also be required in order to meet the ventilation requirements described in Section 8.1. The user of the shelter should set this requirement for special needs facilities, but most tornado shelters would not require additional emergency power.

For hurricane shelters, emergency power may be required for both lighting and ventilation. This is particularly important for shelters in hospitals and other special needs facilities. Therefore, a backup generator is recommended. Any generator relied on for emergency power should be protected with an enclosure designed to the same criteria as the shelter.