Frequently Asked Questions

Design and Construction Guidance for Community Shelters

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FEMA

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CLEMSON UNIVERSITY

WIND ENGINEERING RESEARCH CENTER
TEXAS TECH UNIVERSITY

FEMA 361 Chapter 1 – Introduction

1.1 What shelter costs are considered for FEMA funds?

A. FEMA's Hazard Mitigation Grant Program (HMGP) provides grants to states for their use in conducting mitigation activities following a Presidential declaration of a major disaster. HMGP grants are awarded through a cost-sharing arrangement in which the Federal government provides a grant of up to 75 percent of eligible project costs. Therefore, a non-Federal contribution of at least 25 percent is required. What is actually funded by the grant in a project depends on the policy of the State Hazard Mitigation Officers (SHMOs) and should be discussed when the application is prepared.

B. Eligible costs could include the additional cost of shelter design and inspections required under the guidance provided in FEMA 361. The additional costs of shelter construction would also be eligible; these would be the costs of elements such as hardened walls and roofs; stronger door assemblies; protected mechanical, electrical and plumbing components; and basic interior finishes.

C. Ineligible costs would include those related to non-shelter portions of the building; kitchen and restroom fixtures not related to the shelter function; unprotected mechanical, electrical and plumbing components; and upgrade finishes.

1.2 It there a list of materials and equipment that is acceptable for consideration in the grants offered by FEMA to compensate for construction?

A. Before starting design or construction of a shelter, sub-grant recipients should contact the SHMO to determine the items eligible for reimbursement. If necessary, the SHMO can contact the FEMA Regional Office to discuss specific items. In general, only the additional costs of strengthening the structural system and protecting the mechanical systems will be eligible. The intent of the HMGP is to prevent the future loss of life and property, not to provide new or refurbished facilities.

1.3 Based on current information, it appears that some information in FEMA 361 is out of date. Does FEMA have plans to update the document and, if so, how often?

A. There is no definite plan to update FEMA 361 at this time. An International Code Council Consensus Committee on Storm Shelters has been formed to develop a Storm Shelter Standard that, when completed, may replace the FEMA guidance. The standard will address both residential and non-residential shelters. For more information concerning the standard, see www.iccsafe.org/standards/isstm.html.

1.4 Is FEMA considered setting up a certification program under which the structure design is reviewed by FEMA and a formal design certificate is granted to the building owner? (This could be an owner volunteer program with a FEMA fee associated with it.)

A. FEMA has no plans to start a certification program. The best way to correct this problem is through education. Owners need to be educated so that they can clearly communicate their expectations to the design professional. At the same time, the design community needs to be educated so that, when a client asks for a tornado shelter, designers know that they should be using FEMA 361 guidance.

1.5 If a community is building an existing multi-use room, what items need to be changed to make it a community shelter? What costs are associated with these changes?

A. Increasing footing size, hardening walls, and replacing a typical bar joist metal deck roof with a precast concrete roof are some of the main modifications necessary for strengthening the structure. Replacing doors, door hardware, and windows; protecting mechanical openings; and installing redundant emergency lighting are some of the other necessary changes. This additional work typically results in additional A/E fees. Refer to question 1.6 on additional cost information.

1.6 What does it cost to build a community shelter?

A. Cost information on community shelters in the Midwest region of the United States is as follows:

Description	Cost Range (per square foot of floor area)
Total cost to build a community shelter	$60 - $180
Extra cost to harden a conventional reinforced concrete structure to meet FEMA 361 guidance	$40 - $60
Extra cost to harden a conventional precast concrete structure to meet FEMA 361 guidance	$40
Extra cost to harden a reinforced masonry structure to meet FEMA 361 guidance	$125

- This cost information is based on 20 community shelters in the Midwest region.
- Total cost is the cost to design and build the building, including the cost to harden the structure.
- The floor area of the shelters varies from 600 square feet to 9,700 square feet.
- The numbers are based primarily on estimated costs, not actual costs.
- The majority of the shelters considered for this estimate are part of a larger project (e.g., a school).
- The cost for hardening a reinforced masonry structure is based on very limited number of data (i.e., only two projects).

FEMA 361 Chapter 4 – Shelter Types, Location, and Siting Concepts

4.1 Can the community shelter be built with an outside wall or as a free-standing structure?

A. Yes. The shelter design assumes that the surrounding structure and/or adjacent buildings are removed by the effects of the storm. Therefore, the adjacent or surrounding structure cannot be depended on to protect the shelter. The shelter is therefore designed to resist all debris impacts and wind pressures.

4.2 Can my community shelter be located in the basement of a building?

A. Yes, it can. However, the shelter must meet the requirements of the Americans with Disabilities Act (ADA). This means wheelchair access must be provided, by either a ramp or an elevator with the required backup power and hydraulic services.

B. Debris may also hinder egress from and ventilation of a basement location following a storm. This potential problem should be addressed in the shelter operations plan.

FEMA 361 Chapter 6 – Performance Criteria for Debris Impact

6.1 Where can I find information on door hardware?

A. Information is available on the Texas Tech University (TTU) web site at www.wind.ttu.edu/inshelter/tested_doorCompo.asp. The Securitech Company in New York City (www.securitech.com) has the only set of panic hardware that has been successfully tested to meet FEMA 361 requirements. Positive Lock (www.positivelock.com) has emergency exit door hardware that has also passed the test.

B. Product representatives should be contacted about specific hardware. Be sure to state that the product must meet FEMA 361 criteria for your wind zone (see Figure 2-2 in FEMA 361).

6.2 Does each manufacturer's piece of door hardware, e.g., hinges, dead bolts, panic devices, have to be tested with a particular manufacturer's door/frame to determine whether the entire "system" meets the FEMA 361 testing criteria?

A. Yes. In FEMA 361, the test is performed on the door assembly (i.e., door, hardware, and frame).

6.3 If the local code official allows, can the community shelter door be locked with three deadbolts?

A. Yes. Three deadbolts may be used for shelter doors that are not needed for egress, if acceptable to local code officials.

6.4 How many doors should a shelter have?

A. Building codes dictate the number and location of doors required for spaces of multi-occupancy.

B. A number of doors sufficient to allow all shelter occupants to enter the shelter within 5 minutes of warning should be available. Typically the number of doors required to meet building code requirements will be sufficient for shelter use.

6.5 What door types are acceptable for community shelters? Will a heavy solid-core wood door work?

A. Actual tests of all types of wooden doors have been unsuccessful. In FEMA 361, doors are rated as a complete assembly – door, 2-point or 3-point locking hardware (single-action activation), and steel frame. These tested assemblies include both single and double doors. Door assemblies (door, frame, and hardware) that have successfully passed the pressure test

(1.75 psi) and three impact tests (15-pound 2x4 traveling at 100mph) described in FEMA 361 are summarized in the following table*.

Name of Manufacturer	Web Site	Type of Door / Hardware Tested
Ceco Doors	www.cecodoor.com	Single- and double-door assembly with removable mullions
Curries Doors	www.curries.com	Single- and double-door assembly with removable mullions
SteelCraft Door Assemblies	www.steelcraft.com	Single and double doors with mullion Single and double doors without mullion Single and double doors with emergency exit hardware Single and double doors with classroom function hardware
Mesker	http://www.meskerdoor.com/	Single door
Ambico	http://www.doors-ambico.com/hub.html	Single or double doors with removal mullions, up to 4'0" x 8'0" each
Securitech	www.securitech.com	Classroom function Hardware, panic bar operator
PositiveLock		Emergency exit hardware

*Additional door assemblies that meet the criteria may be available as a result of additional testing performed since this list was compiled.

This information can also be found at the TTU Wind Science and Engineering Research Center web site:

www.wind.ttu.edu/inshelter/tested_doorCompo.asp

When reviewing the data at the TTU web site, look only for door assemblies that have passed the FEMA 361 test. The test requirements (pressure criteria and test setup) in FEMA 320 (*Taking Shelter From the Storm: Building a Safe Room Inside Your House*) are not the same as those in FEMA 361.

6.6 Can wood doors be used in a shelter and comply with FEMA 361?

A. Tests on all type of wood doors have **not** been successful. See the answer to question 6.5.

6.7 The most common size of door that has been tested and passed the FEMA 361 test criteria is 3 feet 0 inches by 7 feet 0 inches (for any single leaf). Is one to assume that a smaller door will meet the testing criteria?

A. Yes, doors smaller than 3 feet 0 inches by 7 feet 0 inches are approved provided they are of the same model of construction and are equipped with the same hardware and frame as those that have been successfully tested.

6.8 Can double doors be used in the shelters?

A. Yes, double-door assemblies using fixed mullions, removable mullions, and no mullions have been successfully tested. See the answer to question 6.5.

6.9 In which direction must community shelter doors swing?

A. Community shelters normally house large numbers of people. According to most model building codes, the shelter would be rated as an assembly occupancy, which would require the door to swing in the direction of egress and be locked/latched with panic hardware.

B. Doors not needed for egress can swing in either direction subject to building code requirements.

6.10 Assuming the shelter is a school classroom, can the door swing into the room?

A. With the approval of local code officials, the door can swing into the classroom/shelter and be locked with a 2-point or 3-point single-action latch that is lever operated with classroom function hardware. The classroom function allows the door to be locked on the outside, but operates freely from the inside.

6.11 What wall systems are recommended for community shelters?

A. Any of the wall systems shown in the construction drawings in FEMA 320 are suitable. However, because a community shelter will be larger and taller than a residential shelter, the reinforced concrete masonry unit (CMU), reinforced concrete, or insulating concrete form (ICF) shelter systems are likely to better satisfy the design criteria.

B. Appendix E of FEMA 361 documents the performance of wall sections that passed the missile impact tests.

6.12 Are special wall and roof materials required for a community shelter?

A. Regarding missile impacts, the same wall and roof designs in the FEMA 320 construction drawings are applicable for community shelters. However, because community shelters are large spaces with tall walls and long roof spans, wind pressures on these surfaces become a major concern. The architect/engineer should adhere to the guidelines for wind pressure calculations prescribed by ASCE 7, *Minimum Design Loads for Buildings and Other Structures*.

6.13 What are acceptable assemblies for roof structure?

A. Flat-slab reinforced concrete roofs and ICF roof slabs are two types of roof structures that are capable of resisting missile impacts. Refer to Section 6.2.7 of FEMA 361.

6.14 Are steel roof designs suitable for community shelters?

A. Steel joist roof systems with steel/concrete composite decks can be used. The weight of the concrete deck is designed to overcome the uplift forces, and the joists are designed to handle the static dead loads and normal loads.

6.15 Can windows be located in the shelter?

A. Yes, if they are protected from the design wind pressure and missile impacts. Impact tests on various types of glazing materials have been unsuccessful. Tests have been conducted on tempered, laminated, and bullet-resistant glass with unsatisfactory results. Where the shelter has to have windows (e.g., a school classroom), designers have chosen to use tested door assemblies with three locks as interior shutters over the windows. Windows can be protected from debris impacts by alcoves; however, the window assembly must be rated for the design storm pressures. To see an example of wind protection shutters installed in a classroom, see the FEMA case study on Kansas school shelters, *Protecting School Children from Tornadoes: State of Kansas School Shelter Initiative*, which is available on the FEMA website.

6.16 What is the biggest concern in the design of community shelters, wind pressure or debris impacts?

A. Wall and roof systems developed and tested for resistance to debris impacts can be the same for both residential or community shelters. Community shelters normally are large spaces with long, tall walls and long roof spans, which are more susceptible to wind pressure than the smaller walls and roof spans in residential shelters. Wind pressure, therefore, becomes the major factor in the design of community shelters.

6.17 Does glass block or laminated glass meet the FEMA 361 test criteria?

A. No

6.18 The vertical missile speed criterion is 67 mph; however, all the test results are for a missile traveling at 100 mph. Can the roof design take into account the reduced impact load?

A. All of the testing on roof assemblies has been conducted with missiles traveling at 100 mph. Therefore, there is no test result to verify roof design for a missile traveling at 67 mph. However, it is possible for engineers to design the roof for a 67 mph missile using analytical or numerical procedures like a finite element method. This will be a difficult and time-consuming task.

6.19 How can the designer determine what door components are part of a tested assembly? Does FEMA approve door assemblies?

A. FEMA does not approve or disapprove door assemblies. TTU testing states that the assemblies "are in accordance to the guidelines of FEMA 361." The TTU website (www.wind.ttu.edu) lists all successfully tested door assemblies for FEMA 361. The door assembly consists of the door, frame, and all hardware.

B. The designer should contact the door mfg. to determine the hardware components that are part of the tested assembly.

6.20 For concrete wall sections thicker than 6 inches, can the amount of reinforcing steel be reduced without compromising resistance to impact loads?

A. It is very likely that the amount of reinforcing steel can be reduced. However, there are no test results to support this. Design wind pressure will probably dictate the amount of reinforcing steel needed for the wall. Steel reinforcement may be reduced if the reduction is supported by analysis/calculation. For a typical reinforced concrete wall, the concrete provides the primary resistance to missile impacts, not the reinforcing. This can be seen from results of concrete wall tests conducted at the Wind Engineering Research Center TTU. Two 6-inch-thick concrete walls were subjected to the impact of a 2 x 4 stud traveling at up to 100 mph. In one of the walls, there were #4 vertical reinforcing bars at 12 inches on center. In the other wall, there were #4 vertical reinforcing bars at 24 inches on center. Both walls stopped the 2 x 4 stud from penetrating. On both walls, no cracking, front face scabbing, or back face spalling of concrete was observed. Because one wall has half the reinforcing of the other and both walls are of the same thickness, it can be concluded that the primary resistance to missile impact comes from the concrete, not from the reinforcing.

6.21 Does the door assembly have to be tested by TTU, or is other testing acceptable?

A. FEMA does not require that the door assembly be tested by TTU. However, at this time, TTU has the only facility with the capability to test door assemblies. The International Hurricane Research Center at Florida International University (www.ihc.fiu.edu) will have the capability to conduct the tests on door assemblies within the next few months. Ultimately, it is the responsibility of the engineer-of-record to ensure that the door assemblies selected for the shelter are adequate for the design loads.

FEMA 361 Chapter 8 – Human Factor Criteria

8.1 Are restrooms necessary in a community shelter?

A. Yes, the recommendation is to provide at least two toilets for both tornado and hurricane shelters. In addition to this minimum, hurricane shelters should have at least one toilet for every 75 shelter occupants. In hurricane shelters, which will be occupied for a longer time, the toilets must be able to function without power, water supply, and possibly waste disposal. Chemical toilets are a practical alternative to standard toilets. Shelter operators should ensure that the toilets are installed in a separate room or screened for privacy**.**

8.2 Large community shelters often have restrooms and heating-ventilating-air conditioning systems. Do plumbing stacks through roofs and fresh air intakes pose a risk to the safety of the shelter occupants?

A. Plumbing vents through roofs are small enough that they pose little, if any, risk to the shelter occupants. Fresh air vents in roofs and walls should be protected. Methods of protection include installing heavy-gauge metal plate shrouds around such openings and installing steel grillage in the openings to prevent the passage of large pieces of debris. The plate shroud is merely a saddle that is welded or bolted in place over the opening. Grillage can be 10-gauge expanded metal or 1/2-inch rebar criss-crossed at 3 inches on center maximum.

8.3 Do the roof deck penetrations of roof drains require protection?

A. See the answer to question 8.2. Roof drains, like plumbing vents, are small enough that they pose little, if any, risk to the occupants.

8.4 What type of protection is required for mechanical openings into the shelter envelope? Does each opening need some sort of protection?

A. Yes. Mechanical openings are large enough that debris entering the shelter through these openings could pose risk to the shelter occupants; therefore, all mechanical openings should be protected. See the answer to question 8.2.

8.5 With all the plumbing vents and ventilation openings, how is the shelter protected from pressurization by the storm?

A. These openings will result in an increase in the shelter internal pressure. However, use of the internal pressure coefficient (GC_{pi} = +/- 0.55) in the load calculations, as indicated in FEMA 361, accounts for this increased pressure.

8.6 Does the square footage recommendations person listed in sections 8.2.1 and 8.2.2 take into account space that is occupied by walls, millwork, furniture, etc. or is there a factor that should be utilized to determine the area required by a shelter?

A. No. In the FEMA 361 Appendix B Site Assessment Checklists, the Available Square Footage (ASF) is all the areas (open, bathroom, kitchen, storage room, etc.) in the building that provide space for the entire population during a high-wind event. The Usable Square Footage (USF) is equal to ASF x Usability Factor. The Usability Factor is an estimate of how much of the Available Square Footage area is usable by occupants and may range from 0.85 for open areas to 0.5 for bathrooms, kitchens, storage rooms, etc. The Required Square Footage (RSF) is equal to the Maximum Expected Population x 5 square feet (Tornado shelter—all adults standing) or x 10 square feet (Hurricane shelter). Other usability factors may be used to account for greater or lesser amounts of fixtures or equipment, storage, or furniture. The requirement is that Usable Square Footage of the shelter must be greater than the Required Square Footage.

8.7 If an generator is present and powers the emergency lighting or mechanical ventilation system for the shelter, does the generator have to be protected?

A. Yes. The generator must be protected to the same level as the shelter occupants. It is important that the generator be functional in a high wind event.

8.8 In Appendix B, in the Wind Hazard check-list, under non-structural issues, if a back-up power source/generator is present but unprotected, is the answer to that question Yes or No?

A. No, because there is a good possibility that the backup power source/generator may be damaged at the time of need. Answering No will also trigger a warning concerning the need to add protection for the backup source.

FEMA 361 Chapter 9 – Emergency Management Considerations

9.1 What should be included in the emergency equipment and supplies for a tornado shelter? For a hurricane shelter?

A. For tornado shelters, the following should be included:

- NOAA Weather Radio
- School radio system
- Cellular phone/communications
- Phone numbers for emergency personnel
- At least two copies of the Shelter Operations Plan
- Flashlights and batteries
- Fire extinguishers
- Blankets
- Trash receptacles
- First-aid kit
- Toilet paper
- Paper towels
- Portable chemical toilets (when regular toilets are not contained in the shelter)
- Water (if a drinking fountain is unavailable in the shelter or if the fountain relies on electrical power)
- Infant and children supplies (if applicable, for any after-school activities)

For hurricane shelters, see Table 9.1 of FEMA 361.