Mitigation Case Studies

Clara Barton Hospital Shelter

Hoisington, Kansas

May 2004

FEMA

“Each time there’s a disaster, we sit down and look for ways to save lives and reduce future damage with mitigation measures. We decided our best course of action was to construct a shelter at the hospital.”

— **Lloyd Arnold,**
Kansas Division of Emergency Management

KDEM

Severe damage to the hospital’s clinic building.

Case Studies

HOISINGTON, KANSAS

Hospital Critical Facility Shelter

On April 21, 2001, an F4 tornado struck Hoisington, Kansas (population 2,975), severely damaging 230 homes and businesses and leaving one person dead. The Clara Barton Hospital sustained extensive damage, estimated at nearly 1.5 million dollars. The destruction and potential loss of life from that event was an alarming wake-up call for the region.

Following the tornado, Lloyd Arnold, of the Kansas Division of Emergency Management (KDEM), and Hospital Administrator Jim Turnbull discussed ways to ensure the safety of the patients and staff in the event of another tornado. They decided to build a shelter at the hospital — the first hospital shelter in the state to meet the design, performance, and construction criteria presented in *Design and Construction Guidance for Community Shelters*, FEMA publication 361.


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RED CROSS

Severe damage to metal stud walls of the hospital's clinic building.

Rear view of damaged clinic building (left) and main hospital building (right).

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Between 1950 and 2003, the National Climatic Data Center reported 51 tornadoes for Barton County resulting in 2 deaths and 39 injuries.

At 7:49 p.m. on April 21st, ham radio operator Carl Andersen, the Barton County Emergency Coordinator for emergency radio communication at the Emergency Operations Center (EOC) in Great Bend, Kansas, sent out a warning that storms were reported in the neighboring counties to the west. At that point, the warning was only for hail. However by 9:15 p.m., it had changed to a tornado warning because of funnel cloud sightings in the Hoisington area. At 9:30 p.m., another radio operator, Larry Bruce, reported back to the EOC that a storm had just passed through Hoisington, approximately 10 miles north of Great Bend. Little did anyone suspect at the time that the reported storm had produced an F4 tornado. These amateur radio exchanges are described by Robert Haneke, Kansas District 5 Emergency coordinator, WGOQ, in Anatomy of a Tornado Response: Hoisington, Kansas (http://www.arrl.org/news/stories/2001/04/26/3/).

With severe weather approaching, Clara Barton's Administrator Jim Turnbull gave the staff instructions to move the patients to safer areas within the hospital. No sooner had the patients been relocated to a central hallway with no windows and the visitors moved into the basement, than the tornado hit the hospital, ripping the roof off its clinic and smashing nearly every window in the main building. Approximately 30 people were in the hospital at the time of the tornado, including 3 patients, a newborn baby, staff, and visitors. The sirens in town did not sound that night because the poles they were mounted on snapped during the first few moments of the storm.

After the danger from severe weather had passed, the patients were moved from the hallway to a triage area set up at the back of the hospital where four windows remained intact. The hospital had reserve power from an emergency generator, which kept lights and electricity on within some areas of the main hospital building. Because of the damaged condition of the hospital, the local Disaster Field Office and the Red Cross worked together to set up an emergency field hospital at the Municipal Building in Hoisington. After the tornado had passed, patients were moved to the field hospital.

What to do in the event of a tornado when a shelter is not available:

If you are in a building without a shelter or designated shelter area:

- Go at once to the basement or the lowest level of the building. Go to an inner hallway or a smaller inner room, without windows, such as a hallway, bathroom, or closet.
- Avoid places with long-span roofs such as auditoriums and cafeterias.

Visit FEMA's website for more information – www.fema.gov/mit/saferoom

Clara Barton Administrators Take Action

This tornado incident provided the hospital staff with enough reason to act, and act quickly. A decision was made to reconstruct the clinic, not merely the way it was constructed previously, but in a way that would enable the hospital and community to provide an improved shelter in terms of both design and construction.

Funding the Shelter

Funds for the shelter were obtained through the FEMA Public Assistance Program. Following a Federally Declared Disaster, this program provides supplemental Federal disaster grant assistance for the repair, replacement, or restoration of disaster-damaged, publicly owned facilities and the facilities of certain Private Non-Profit (PNP) organizations. Eligible PNP facilities must be open to the public and perform essential services of a governmental nature. Public assistance funds will cover at least 75 percent of the cost of the project.

FEMA modified the Public Assistance Program in August 1998 to provide more flexibility in funding mitigation measures under Section 406 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act.

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Front view of damaged hospital building.

Critical Facilities Must Operate During and Following a Disaster

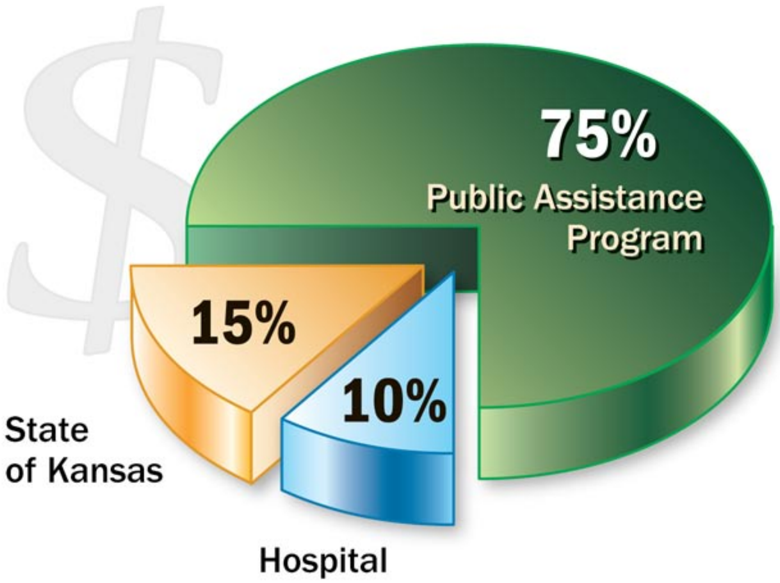
It is necessary for hospitals and other critical facilities, such as fire stations, police stations, and EOCs, to remain operational during an event and maintain service afterwards. The local hospital is typically the first place to which the injured are taken after a disaster occurs. If the hospital cannot function because of damage to the building, then those seeking immediate medical attention must be rerouted to a functioning hospital. In rural areas such as Barton County, towns are spread out and the next hospital could be many miles away.

Construction Techniques Can Help Minimize Damage to a Building

While it is not always economically feasible for entire buildings to be constructed as shelters that meet FEMA 361 criteria, certain construction techniques such as strengthening connections between structural elements and systems and specifying the use of stronger and more wind- and impact-resistant materials on the building envelope will increase buildings' resistance to wind and debris impact damage. When the Clara Barton Hospital's clinic building was reconstructed, the connections between the roof and walls were strengthened and a brick veneer was added to increase the exterior wall's resistance to the impact of windborne debris.

The main hospital building survived the F4 tornado with broken windows and power loss. A new emergency generator, large enough to provide power for the entire building, was installed after the event because the existing generator served only some areas of the hospital. The protection and maintenance of these emergency generators is a critical issue. Emergency generators must be protected to the same level as the shelter occupants. The new generator for the hospital is located outside the building, mounted on a concrete slab that is adjacent to an exterior wall and provided with a lockable steel shell. To ensure its reliability during an emergency, the generator is tested every Monday by the hospital's maintenance staff.

Hospital Critical Facility Shelter



The new initiative allows Federal contributions for the restoration, repair, and replacement of damaged infrastructure, PNP facilities, and other public facilities that provide critical services. Critical services include power, water (including water provided by irrigation), sewer, wastewater treatment, communications, and emergency medical care. Architectural projects that fall under this category include roofs, shutters, anchoring, and bracing for damaged critical facilities. Section 406 also provides funding for associated expenses. Examples of associated expenses are costs of mobilizing the National Guard, costs of using prison labor, and base and overtime wages for employees and extra hires for the state.

Clara Barton Hospital qualified for Public Assistance funds because it is a PNP organization and provides a critical service to the community. The Public Assistance Program funded 75 percent of the shelter cost, the State of Kansas provided 15 percent, and the hospital covered the remaining 10 percent.

Hoisington High School Gets New Shelter After Tornado Damage

Hoisington High School was another victim of the F4 tornado in April 2001. The building envelope was severely compromised in several places, rendering the building unfit for occupation for several weeks. The roof of the auditorium was torn away, the exterior wall of the art room was blown in, the technology building was damaged, and windows were smashed. Outside the school, parked buses were destroyed and the light poles for the football field were bent in half by the high winds. School had to be canceled until alternative arrangements for the students could be made.

Adding to the drama of that fearful night was the threat to students at the high school prom, which was underway at the local Knights of Columbus hall in Hoisington. The students were rushed to the basement of the building before the tornado struck and no one was hurt. As part of the mitigation strategy in Hoisington, Public Assistance funds were obtained for the construction of a shelter at the high school, the same type of funding used for the hospital shelter.

The tornado caused serious damage to Hoisington High School. Part of the roof structure was removed by the high winds.

Hospital Critical Facility Shelter

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This photograph, taken before construction of the shelter, shows the area between the hospital building (left) and clinic building (right) where the shelter is now located

Shelter Layout

The new shelter is located between the main hospital building and the clinic building to facilitate easy access from both areas. The shelter is connected to the two buildings with interior doors that meet the criteria presented in FEMA 361, *Design and Construction Guidance for Community Shelters*. The shelter has one exterior door (meets the FEMA 361 criteria) and no windows. The shelter has 1,026 square feet of finished area and is designed to accommodate 14 patients – assuming 6 are seated, 6 are in wheelchairs, and 2 are bedridden – and 30 standing staff members, with space for an additional 67 evacuees. The maximum number of occupants the shelter is designed to hold is 111. The shelter layout includes one large open area, two restrooms, a mechanical room, and a storage room. Typically, the open area is used for meetings and training classes.

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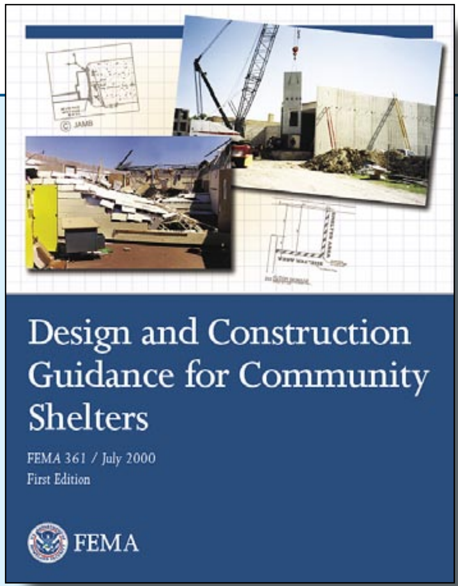
Shelter, as seen from the front, between hospital building (left) and clinic building (right).

To design a successful shelter, the architect or engineer should be familiar with the high loads caused by extreme wind, the guidance provided by FEMA 361, *Design and Construction Guidance for Community Shelters*, and the special inspections and quality control required.

FEMA 361, contains tornado and hurricane statistics, wind speed and wind hazard data, a shelter benefit-cost model on CD-ROM, evaluation checklists for potential shelter areas in existing buildings, and other information that will help the reader assess risks in a specific area, determine the need for a shelter, and decide where and how a shelter should be built. FEMA 361 also contains information about meeting the requirements of the Americans with Disabilities Act in shelter design.



Shelter Construction

The extreme forces of a tornado require that a shelter envelope be designed to resist high wind pressures and the impact of windborne debris. To calculate the wind and debris loads for the new shelter, architect Linnea Winter and structural engineer Jim Jantz, of MKEC Engineering Consultants, Inc., Wichita, Kansas, consulted FEMA 361.

The walls, roof, and doors to the shelter were designed, at a minimum, to resist 250 mph (3-second gust) wind speeds and the impact of windborne debris (15-pound wood 2 x 4) traveling at 100 mph.

Although the shelter adjoins the hospital and clinic (see plan view on next page), it is designed as a stand-alone structure; therefore, it does not rely on the walls of the hospital building or clinic building to resist the extreme wind loads. This design helps ensure the safety of the occupants in case the hospital or clinic buildings are damaged extensively or destroyed.

The wall system is Insulating Concrete Form (ICF) construction. This type of construction comprises 12-inch poured-in-place concrete, with polystyrene forms left in place, reinforced with #5 bars spaced at 8 inches on center (see cross-section of wall and roof on next page).

Shelter Capacity and Size

FEMA 361 includes requirements for shelter size based on the number and type of expected shelter occupants. For the Clara Barton Hospital shelter, the required size would be as follows:

Total of 14 patients (average)

6 seated patients at 6 square feet each =	36 square feet
6 patients in wheelchairs at 10 square feet each =	60 square feet
2 bedridden patients at 30 square feet each =	60 square feet

Total of 30 staff (average)

30 standing adults at 5 square feet each =	150 square feet

Total of 70 additional evacuees (average)

70 standing adults at 5 square feet each =	350 square feet
Total area required to meet FEMA 361 criteria =	656 square feet

The shelter also includes restroom space for two toilets.*

Restrooms =	128 square feet

* FEMA 361 recommends that a minimum of two toilets be provided in the shelter but does not require or recommend a minimum area for the toilets.

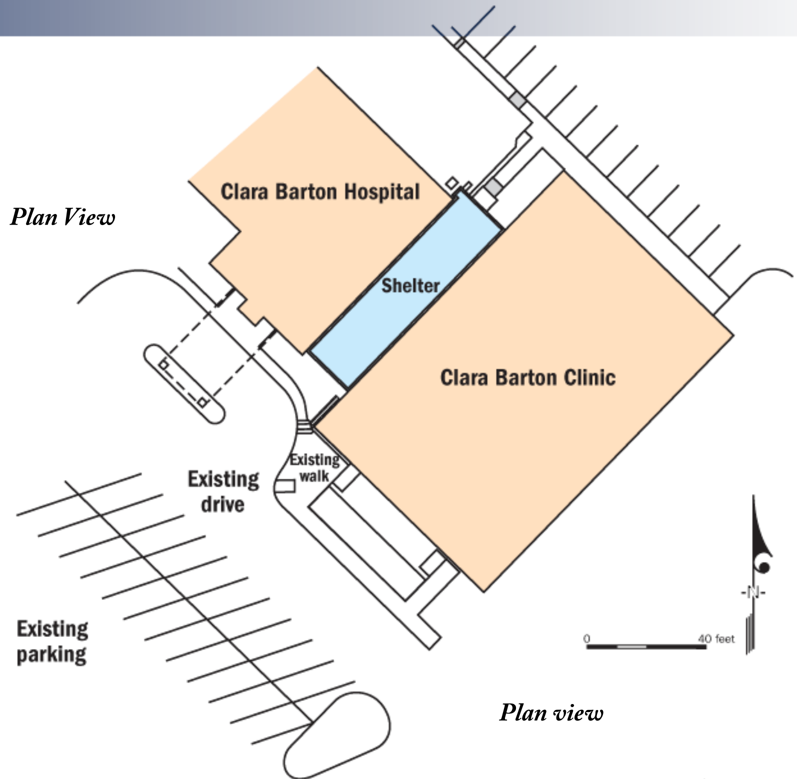
The shelter also includes the following:

One storage room =	64 square feet
One mechanical room =	64 square feet
Circulation area as required by design =	80 square feet
Total area required by design of hospital shelter =	992 square feet

Actual finished shelter area is 14 feet x 73.3 feet = 1,026.2 square feet

As these figures indicate, the Clara Barton Hospital shelter meets the size requirements of FEMA 361 while including space for additional functions.

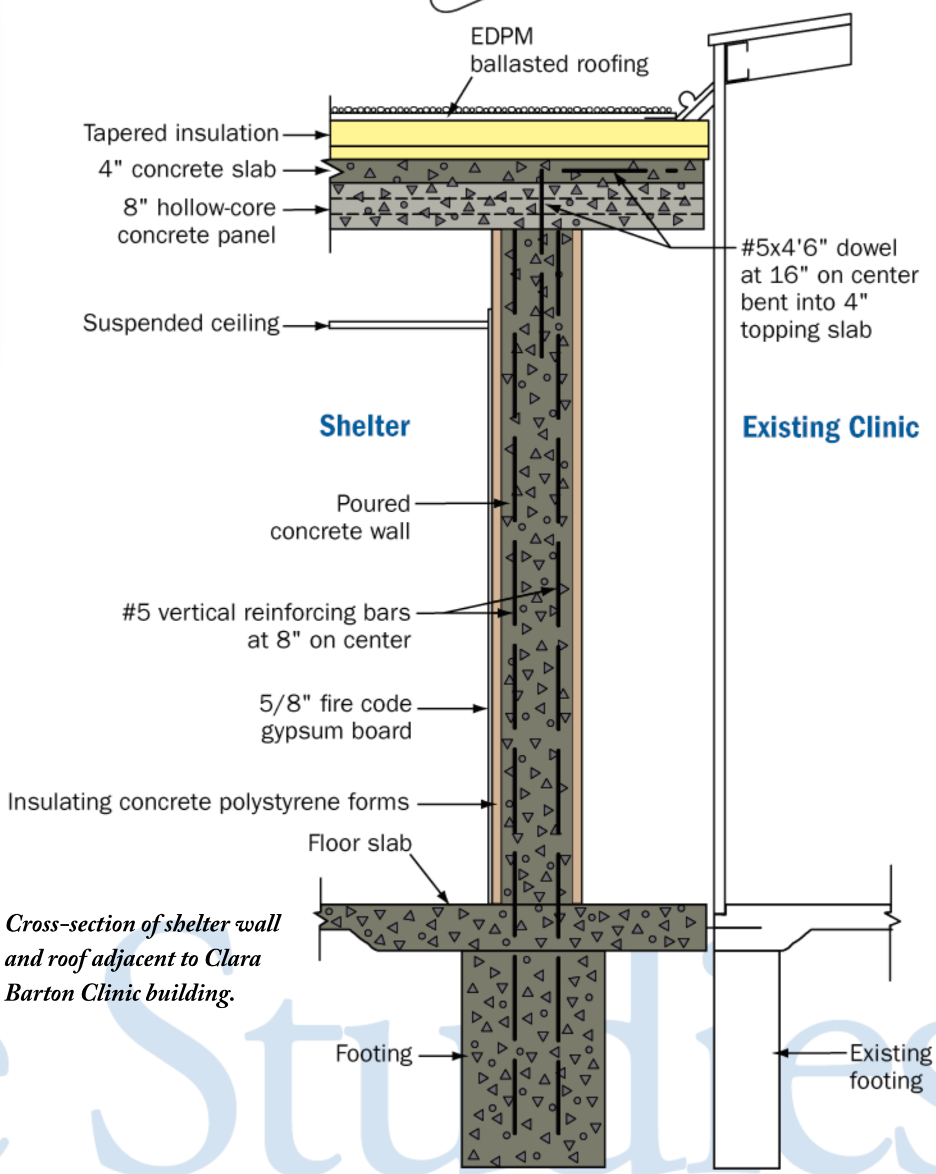
All perimeter walls were constructed with insulating concrete forms and reinforced with #5 bars spaced 8 inches on center to resist 250 mph wind speeds.



Plan view

Interior of shelter, showing insulating concrete form perimeter walls.

The roof structural system consists of pre-cast, pre-stressed, 8-inch-deep hollow-core concrete panels covered by a 4-inch reinforced concrete slab (#4 bars spaced at 12 inches on center in both directions, longitudinally and laterally). The concrete panels are designed for a gross wind uplift pressure of 206 pounds per square foot.



Cross-section of shelter wall and roof adjacent to Clara Barton Clinic building.

Hospital Critical Facility Shelter

The architect and the structural engineer ensured that the connections between the shelter foundation and walls and between the walls and roof were adequate to resist the design loads specified by FEMA 361.

The Clara Barton Hospital shelter uses a gravity or passive air ventilation system with ducts that open to an outside air supply. A benefit to a passive air system is that no electricity is required to operate the system. The hospital shelter has both vertical (roof fresh air intakes – see cross-section on next page) and horizontal (wall fresh air intakes) ventilation openings. Although horizontal ventilation openings may be easier to design and construct, vertical ventilation openings have a smaller probability of being penetrated by a missile. All ventilation openings must be protected and must meet the missile impact requirement presented in FEMA 361. The air intakes of the Clara Barton shelter are protected by a grid of #3 reinforcing bars spaced at no more that 3.5 inches on center. This steel grid should prevent windborne missiles from damaging the ventilation system.

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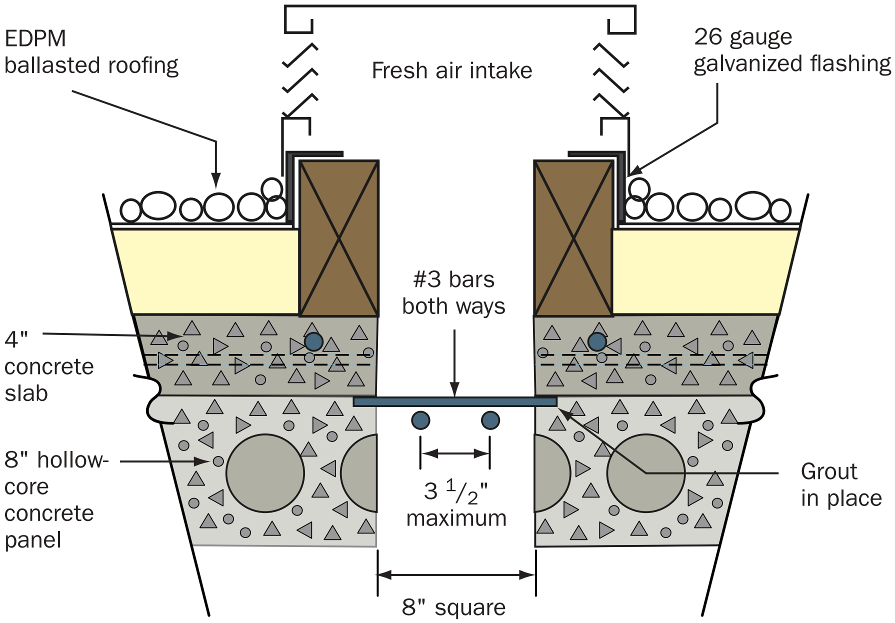
Construction of the reinforced ICF exterior wall at the rear of the shelter (top). Interior walls of shelter with gypsum board finish (bottom).

Ventilation

Fresh air venting is required in the construction of all shelters. The shelter ventilation system must be capable of providing the minimum number of air changes required by the governing building or mechanical code for the shelter's occupancy classification under normal use. For example, if the shelter will typically be used as a meeting room, the ventilation would be designed for the occupancy classification of the meeting room, not the shelter capacity. 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. However, the designer should 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 from the most recent edition of the International Building Code (IBC) are recommended. The IBC is published by the International Code Council (www.iccsafe.org).



Cross-section of roof fresh air intake.

CAUTION

If a powered ventilation system is used, it should be connected to a backup generator to ensure that ventilation will occur during a power outage. The generator and its related components (e.g., fuel supply, transfer switch) must be protected to the same degree as the occupants of the shelter. Therefore, sources of backup power located outside the shelter must be housed within an enclosure that meets FEMA 361 criteria.

A Design Challenge: Doors

Doors posed a particular problem in the design of this shelter. The architect needed to find double doors that met the criteria specified by FEMA 361. In addition, the hospital had a special need for double doors without a center mullion (center vertical support) that would allow rolling beds and medical equipment to be moved into the shelter area.

After checking with area suppliers to determine the storm protection door system most often used in the region, the architect selected doors manufactured by Steelcraft. At the time, Texas Tech University was testing Steelcraft's Paladin™ double-door model for compliance with FEMA 361. After Texas Tech completed the testing and verified that the Paladin™ double doors did meet FEMA 361 criteria, the doors were shipped to the hospital and installed.

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The double door without mullion allows hospital staff to move patients in rolling beds into the shelter.

FEMA 361 requires that all doors and windows be able to resist the impact of a 15-pound wood 2 x 4 (referred to as a "missile") traveling horizontally at 100 mph.

Doors and windows should be tested with the exact installation methods to be used on the actual site. Some doors that can resist missile impacts on their own have failed as a system when the framing attachment to the walls has come loose under missile impact and the entire door and frame have been pushed out of the wall. Therefore, the door frames have to be attached properly to the building for the entire system to work. The same concept applies to door hardware. Often the door may resist debris impacts, but the hardware snaps or bends, leaving the door free to swing open.

CLARA BARTON HOSPITAL

View of the FEMA 361-compliant double door with 3-point latching hardware from inside shelter.

Testing of Door Assemblies

Texas Tech University rates complete door assemblies – door, 6-point locking hardware (single-action activation), and steel frame – based on FEMA 361 criteria. These tested assemblies include both single and double doors. Door assemblies (door, frame, and hardware) that have successfully passed the pressure test (1.75 pounds per square inch) and three impact tests (15-pound wood 2x4 traveling at 100 mph) are summarized in the following table.

List of Commercially Available Doors/Hardware Tested at Texas Tech University (TTU)* and Found To Comply With FEMA 361 Requirements

Name of Manufacturer	Type of Door/Hardware Tested	Websites
Ceco Door Products	Double-door assembly with removable mullion	www.cecodoor.com
Curries	Single- and double-door assemblies with removable mullion	www.curries.com
Steelcraft	Door pairs with mullion Door pairs without mullion Door pairs with emergency exit hardware Door pairs with classroom function hardware	www.steelcraft.com
Securitech	Classroom function hardware, panic bar operator	www.securitech.com
PositiveLock, Inc.	Emergency exit hardware	www.positivelock.com

*Wind Science and Engineering Research Center

More door assemblies that meet the FEMA 361 criteria may now be available as a result of testing performed since the above list was compiled. When reviewing the information on the TTU website, look only for door assemblies that have passed the FEMA 361 test. Note that the door requirements discussed in FEMA publication 320, *Taking Shelter From the Storm: Building a Safe Room Inside Your House*, are not the same as those presented in FEMA 361.

CLARA BARTON HOSPITAL

Multiple Uses Make Shelter Popular With Community

"The shelter has been very well received by the town. It is used for city meetings, Lion's Club meetings, and other town gatherings. It has also been used by the townspeople during tornado warnings." Lloyd Arnold

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Signs identifying the room as a shelter are posted inside the hospital (top).

Minimal furniture in the room is light and mobile for easy removal in order to clear the space for patients in an emergency (bottom).

According to Jim Blackwell, the hospital financial administrator, the shelter is open to the general public. There are signs in both the hospital and the clinic buildings that direct visitors and staff to the shelter in the case of a tornado warning. A number of community residents have retreated to the shelter for protection during tornado watches and warnings.

Hospital Administrator Chris Stipe has spread the word to the community that the shelter is available for use for meetings by the town government, schools, clubs, and other non-profit groups. The hospital uses the shelter for educational seminars, displays, and staff meetings. Because the shelter space is used by a number of groups, it is an ideal location for providing information, educating the public on safety issues related to tornadoes, and promoting shelter and safe room construction throughout the community.

Hospital Critical Facility Shelter

Summary

The Town of Hoisington has shown remarkable recovery since the violent F4 tornado in 2001. Photos of the town in the aftermath show incredible devastation, while now, a few years later, a visitor might notice only that the trees along the streets are relatively young. The famous Kansas "Can Do" attitude is well represented by the recovery of this little town. This attitude has resulted in securing a safe place for the patients and staff of Clara Barton Hospital and additional peace of mind for the community.


KDEM

A view of the completed hospital complex.

Useful Resources for Designing Shelters

Department of Homeland Security/FEMA

Section 406 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act
http://www.fema.gov/about/stafact.shtm

FEMA 361, *Design and Construction Guidance for Community Shelters,* Washington, DC
http://www.fema.gov/libraryviewRecord.do?id=1657

FEMA 320, *Taking Shelter From the Storm: Building a Safe Rome Inside Your House*, Washington, DC
http://www.fema.gov/library/viewRecord.do?id=1536

American Society of Civil Engineers

Minimum Design Loads for Buildings and Other Structures, ASCE 7-02, 2002, American Society of Civil Engineers, ISBN: 0-7844-0624-3
http://www.pubs.asce.org/ASCE7.html?99913

Related Websites

FEMA Safe Rooms – http://www.fema.gov/plan/prevent/saferoom/index.shtm

Texas Tech University Wind Science and Engineering Research Center – http://www.wind.ttu.edu/

National Storm Shelter Association – http://www.nssa.cc/