



Mitigation Case Studies

Protecting School Children from Tornadoes

State of Kansas School Shelter Initiative

August 2002



FEMA

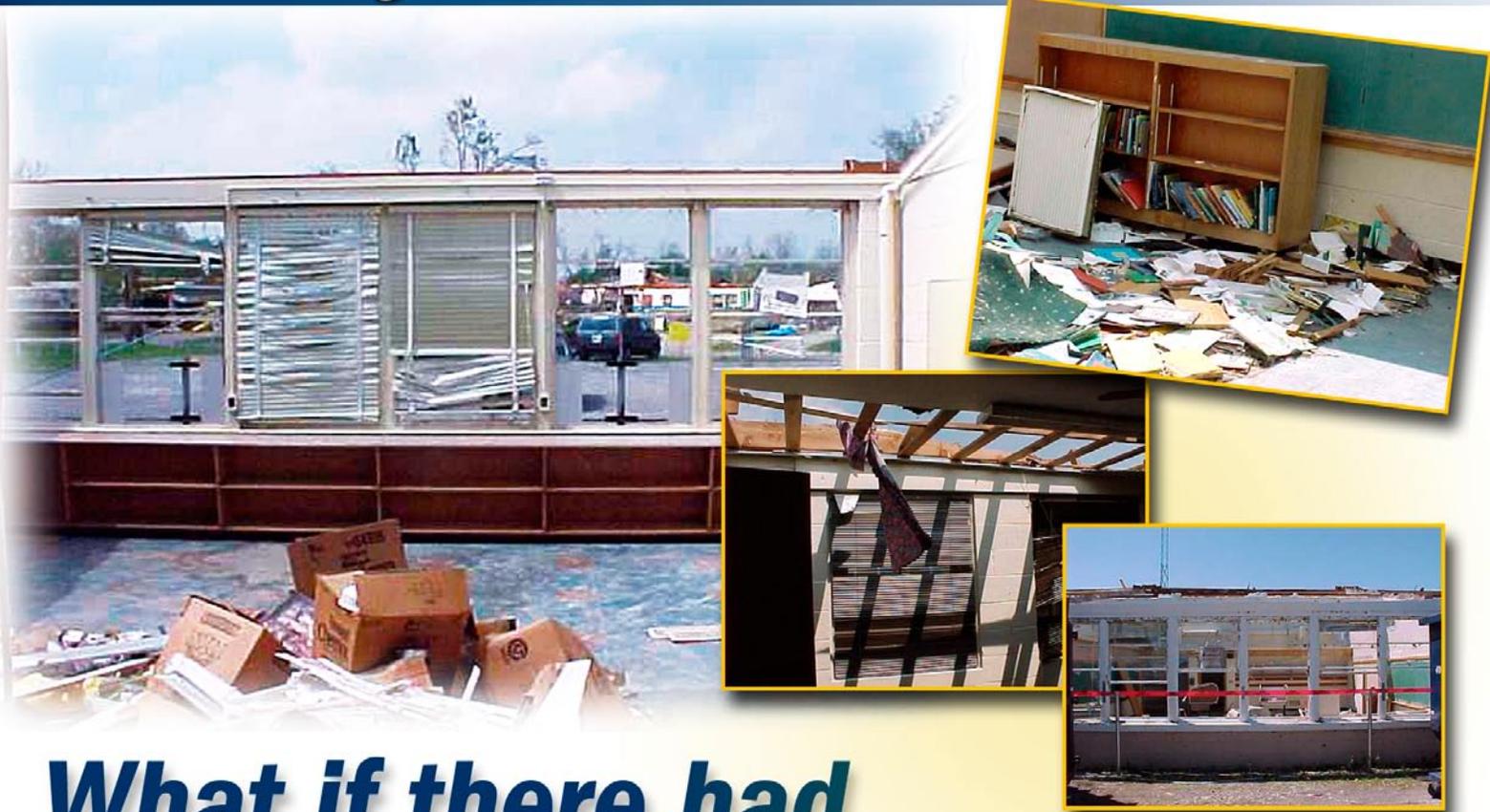


“How wonderful it is for students, staff, and parents to have a place for students to go while at school so that they will feel safe and secure during tornado activity.”

— Julie Hedrick, Supervisor of Architectural Services, Wichita Public School District

Case Studies

WICHITA, KANSAS



What if there had been children in the schools?

On May 3, 1999, a series of strong fronts moved through Oklahoma and Kansas, producing numerous tornadoes that tore through areas of both states considered to be parts of “Tornado Alley.” Two schools in Wichita, Kansas—Chisholm Life Special Education School for teenagers to young adults and Greiffenstein Special Education Center—were severely damaged. Luckily, the storms occurred after school hours and children were not present. **But what if there had been children in the schools?**

Before the May 3 tornado event, the Sedgwick County, Kansas, Emergency Management Office looked at schools in the Wichita Public School District and asked this exact question. Emergency Management Officials had conducted investigations and identified the safest places in the schools—areas of refuge where students and other school occupants could take shelter when threatened by a tornado.



Case Studies

PHOTOS COURTESY WICHITA PUBLIC SCHOOL DISTRICT

WICHITA, KANSAS

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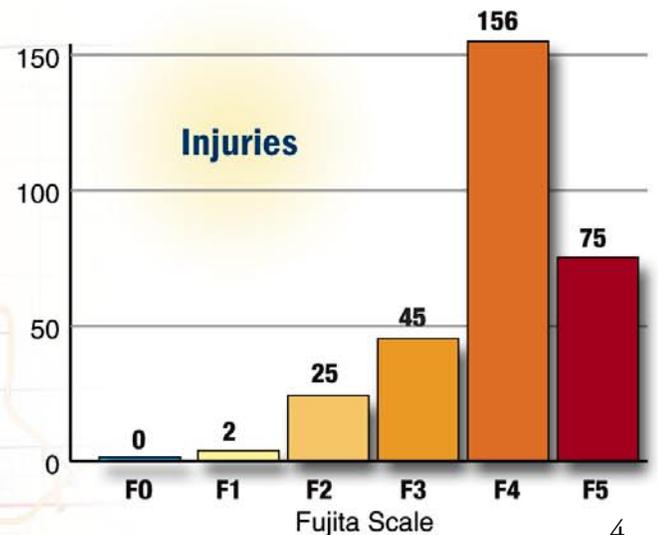
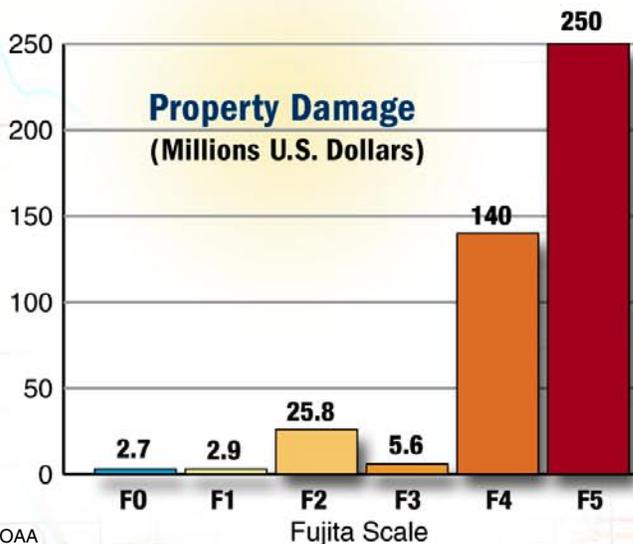
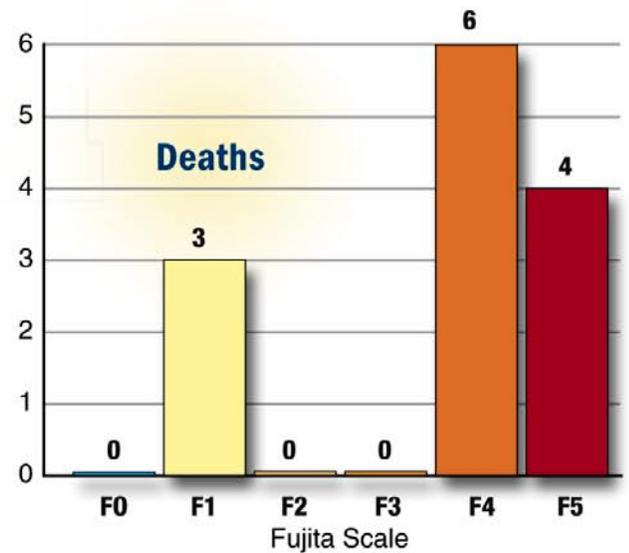
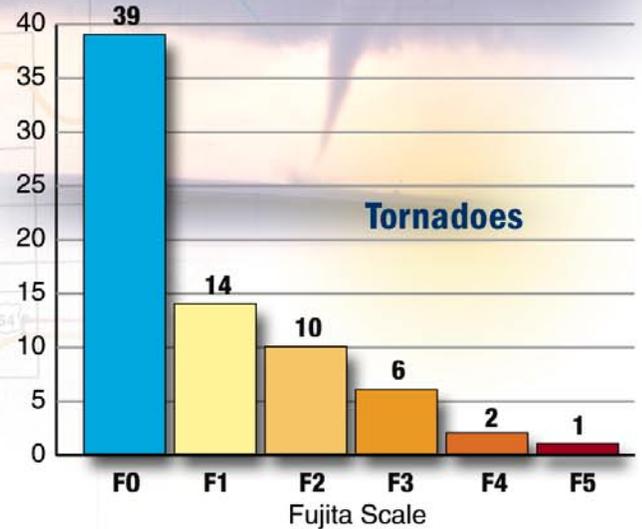
Damaged hallway at Greiffenstein Special Education Center.

Chisholm Life Special Education School and Greiffenstein Special Education Center had few interior areas for refuge; therefore, the hallways in these schools were designated as the best place to seek refuge. But in the May 3 event, the hallways

in both schools suffered extensive damage. At Greiffenstein, a tall boiler chimney collapsed into a hallway. If children had been present, injuries or deaths could have occurred. The information gathered by Federal, state, and local agencies from the damaged schools has led to a re-examination of the criteria used to determine places of safety.

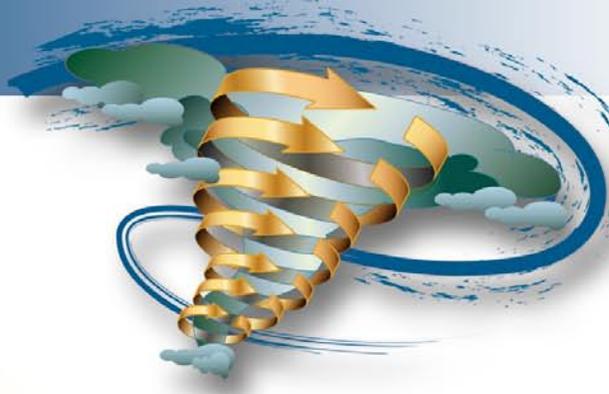
PHOTO COURTESY WICHITA PUBLIC SCHOOL DISTRICT

Sedgwick County Tornado Statistics (1/1/50 - 4/30/02)



SOURCE DATA: NOAA

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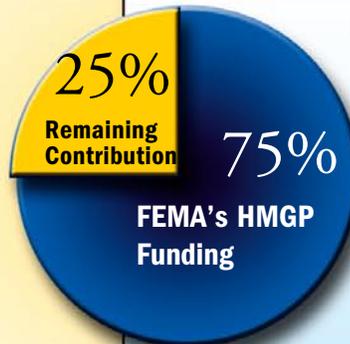


A Proactive School District

As a result of the May 3 event, the damaged counties received a Presidential disaster declaration and financial assistance from the Federal Emergency Management Agency. Because the event clearly evidenced that additional protection was needed for Kansas' school children, work began to find a way to construct tornado shelters in Kansas schools.

FEMA's Hazard Mitigation Grant Program (HMGP), as well as supplemental appropriations from Congress, provided funding for damage-prevention projects after the tornadoes.

After the May 3 tornadoes, The Kansas Division of Emergency Management (KDEM), which administers FEMA's mitigation programs in the State of Kansas, and the Kansas Hazard Mitigation



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.

Kansas Hazard Mitigation Team

The purpose of a state hazard mitigation team is to assess hazard mitigation needs, develop and implement statewide hazard mitigation policies, promote coordination of mitigation programs at all levels of government, and pursue alternative mitigation funding strategies.



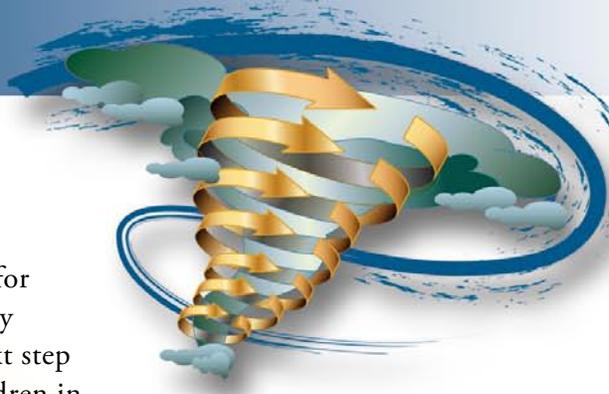
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Kansas Hazard Mitigation Team Members include:

Adjutant General's Department
Kansas Department of Agriculture
Kansas Department of Commerce and Housing
Kansas Department of Health and Environment
Kansas Department of Transportation
Kansas Legislative Research Department
Kansas State Historical Society
Kansas Water Office
Kansas Wildlife and Parks
Kansas Biological Survey
Kansas Forest Service
Kansas Geological Survey
Kansas Highway Patrol

Kansas Insurance Department
Kansas State Fire Marshal's Office
Kansas League of Municipalities
Kansas Association of Conservation Districts
Kansas Association of Counties
Kansas Rural Water Association
State Conservation Commission
State Association of Kansas Watersheds
Federal Emergency Management Agency
National Weather Service
U.S. Army Corps of Engineers

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Team (KHMT) determined that the best use of mitigation funds would be to construct tornado shelters in Kansas schools. This was good news for the Wichita Public School District and the Sedgwick County Emergency Management Office because they had also recognized this need. The next step was the development of a proactive program to provide shelters for children in Wichita schools. In subsequent planning for a major facilities bond issue, the community decided that shelters were a desirable improvement and should be included in new school construction and renovation.

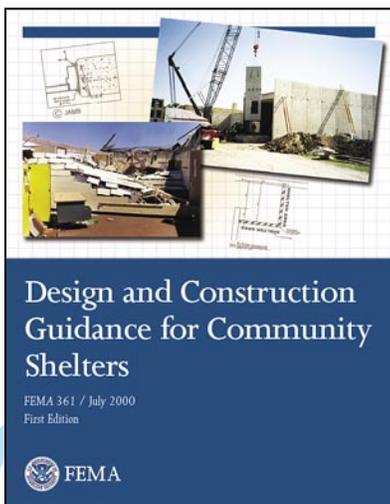
The Wichita Public School District currently has 24 safe room projects under construction, which will serve approximately 7,800 of the District's 49,000 students for approximately 180 operating school days per year. In addition, the facilities will be used extensively by the community for precinct voting locations, church worship services, and various community outreach organizations such as the Boy Scouts and Girl Scouts.

To encourage shelter construction in schools, Sedgwick County Emergency Management works closely with the Wichita Public School District to evaluate areas of refuge in the schools. Each evaluation identifies the safest areas within a school and leads to recommendations for increasing occupant safety. The school district then determines the most appropriate and feasible means of creating the shelter—constructing a new school, constructing a new addition, or retrofitting an existing area. All new approved shelter construction carried out in the Wichita program meets the criteria presented in FEMA publication 361, *Design and Construction Guidance for Community Shelters*. In addition, all shelter construction projects are inspected by a trained team that assists in determining the best location for shelter areas, identifying areas that need improvement, and determining how to resolve any structural concerns.

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, and the special inspections and quality control required.



For a new school designed to serve approximately 600 students, the Wichita Public School District would have an approximate budget of \$6.5 million. If a shelter is to be included in the school, the total budget is increased by 2.5 to 3.5 percent. For new school additions, the budget is estimated at \$115 per square foot, and if the addition is to include a shelter, an additional \$40 per square foot is included.



FEMA 361

Case Studies

WICHITA, KANSAS

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Hallway originally designated as the safest refuge area in Park Elementary.

Showcase School Shelters

Park Elementary

Park Elementary, in the Wichita Public School District, contains the first shelter in the Wichita School District to have been specifically designed to meet the criteria established in FEMA 361. **The shelter was ready for use on March 25, 2002, and 3 months after completion it had already been used three times during high-wind events.** As in many other schools, the hallways in Park Elementary were the originally designated refuge areas.

The new shelter in Park Elementary serves as a multipurpose room: cafeteria and gymnasium. The shelter walls are constructed of precast concrete panels, and precast concrete double-tee beams are used for the structural roof members. The roof is covered with a 4-inch reinforced concrete slab. These structural members were designed to withstand the high wind pressures and debris impact forces associated with a tornado. In addition, to transfer loads from the roof to the walls and from the walls to the foundation, connections must be designed to withstand the additional forces a tornado can impose on a structure.



Interior of Park Elementary multipurpose shelter, which is used as both a cafeteria and a gymnasium.



Exterior of Park Elementary multipurpose shelter.



Connection between precast concrete wall panels and roof. Special inspections are necessary during construction for all shelters. For shelters built with wall panels, special attention is required to ensure that the connections between the wall panels and the roof and foundation are properly made.



Crane placing precast concrete wall panels.



Pouring the 4-inch concrete roof deck.

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Exterior of McCollom Elementary School shelter addition.



Exterior of Kensler Elementary School shelter addition.

Showcase School Shelters

Kensler and McCollom Elementary Schools

Kensler and McCollom Elementary Schools have almost identical classroom and corridor shelter additions. A unique aspect of these shelters is the installation of two windows in each of the classroom shelters.

To prevent debris from breaching the building envelope, each window is protected by shutters with six-point connections (three hinges and three deadbolts). To ensure that debris impacts do not knock the window frames out of the wall, all window frames are welded to steel plates embedded in the precast concrete wall panels.



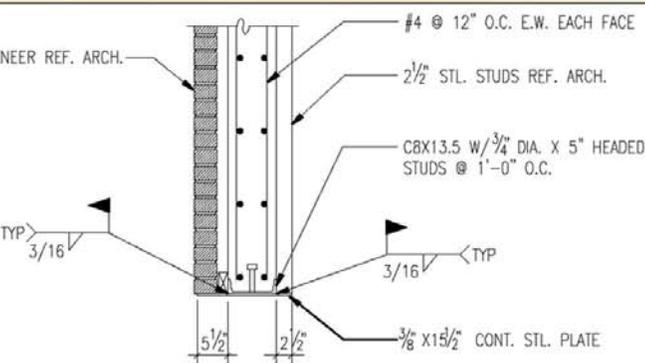
Protective Shutter



All doors, including doors that serve as protective window shutters, must have sufficient points of connection to their frames to resist design wind pressure and impact loads. Each door should be attached to its frame with six points of connection (three connections on the hinge side and three on the latch side).



Perimeter door with six-point connection at McCollom Elementary. Like the windows, all perimeter doors in the shelter are also welded to embedded steel plates and have six points of connection.



10 WINDOW HEAD & JAMB DETAIL
S0.2 3/4"=1'-0"

Detail of steel plate embedded in precast concrete wall panels. Note: Construction drawings are provided here only as illustrative examples. Shelter design and construction should be based on conditions and needs at the shelter site.

Steel plates embedded in precast concrete wall panels at Kensler Elementary.

FEMA Mitigation Case Studies

Showcase School Shelters

Jefferson Elementary School

The shelter in Jefferson Elementary, like the one in Park Elementary, is a multipurpose room constructed with precast concrete wall panels and precast concrete double-tee beams. Once again, hallways were the originally designated refuge areas.

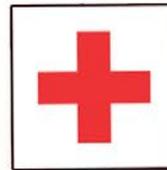
A unique feature of the Jefferson Elementary shelter is the protective alcove at the shelter entrance. Because Jefferson's shelter was constructed before the publication of FEMA 361, doors strong enough to withstand the design wind and debris impact loads had not been identified. The alcove entrance design minimizes the potential for wind and debris damage to the exterior door and latching system. The shelter is identified as a place of refuge by a sign at the entrance, which reads "Tornado Safer Area." Adequate signage is critical for users if they are to readily find and enter the shelter.



Jefferson Elementary shelter protective alcove located at the shelter entrance.



An emergency cabinet houses the weather radio and a first-aid kit.



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

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

FEMA Mitigation Case Studies

Original shelter at Blessed Sacrament (a tunnel that connected the school to the church).



Showcase School Shelters

Private Schools

Private, non-profit schools that are open to the public are also eligible to apply for grants using HMGP funds and supplemental appropriations for mitigation. Several private schools in Kansas have also chosen to construct shelters.

For example, at the Blessed Sacrament school in Wichita, professional architectural services were donated for the shelter design. The original shelter at Blessed Sacrament was a tunnel that connected the school to the church. As a shelter, the tunnel was not large enough and was not accessible to individuals with mobility disabilities. A new, larger shelter was constructed in the basement of the school.

A unique feature of the shelter at Blessed Sacrament is the passive ventilation chimney. Ventilation for a shelter should comply with the building codes or ordinances adopted by the local jurisdiction. Passive means of ventilation (as opposed to a forced-air system) may be used as long as the building code requirements for normal use are met.

FEMA recommends that the shelter space serve as a functional space for the school during normal operation. In addition to being more cost-effective, shelter space that is used regularly is less likely to become a storage area cluttered with old desks, books, and other materials. Additionally, if the space is used regularly, it is more likely to receive regular maintenance that will help ensure longevity. For example, shelters have been or are being constructed at Holy Cross, Kapaun Mount Carmel, and Trinity High Schools. Holy Cross' shelter is the library; Kapaun Mount Carmel's shelter is in a basement room; and Trinity High School's shelter is a stand-alone weight training facility. A tornado shelter space can be adapted for almost any use that a school might need.



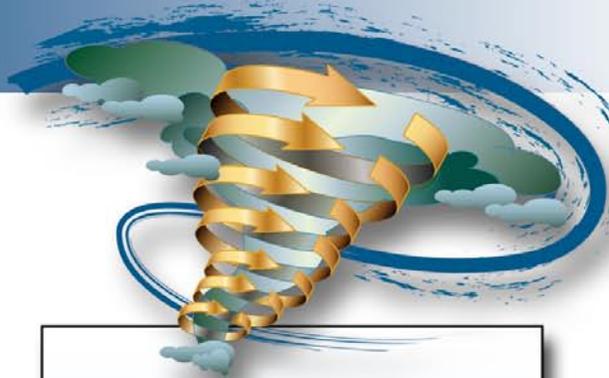
Blessed Sacrament's new tornado shelter under construction.



Passive ventilation chimney for underground shelter at Blessed Sacrament.



Holy Cross' library shelter is the first school shelter known to be constructed to meet FEMA 361 criteria in the state of Kansas.



Shelter Operations Plan

A successful shelter requires a successful operations plan, which must cover the process or steps to be followed before, during, and after a tornado watch and/or warning. A shelter operations plan should include the following:

Before the tornado watch or tornado warning:

A shelter management team should be established, and the responsibilities of each member should be clearly defined.

Shelter maintenance procedures and schedules should be established and followed.

Drill procedures and a drill schedule should be established and followed.

When a tornado watch is issued and in effect, the shelter management team should be on alert and should:

Monitor weather conditions.

Inspect the shelter and access routes to the shelter to make sure the area is ready for occupants.

When a tornado warning is issued, the shelter management team should be activated and begin performing the following tasks:

Alert the students and staff and direct them to go to the shelter.

Take a head count in the shelter.

Secure the shelter.

Monitor the storm from within the shelter.

After the tornado warning has expired, the shelter management team must:

Determine whether conditions warrant allowing shelter occupants to leave.

Clean the shelter and restock any emergency supplies.

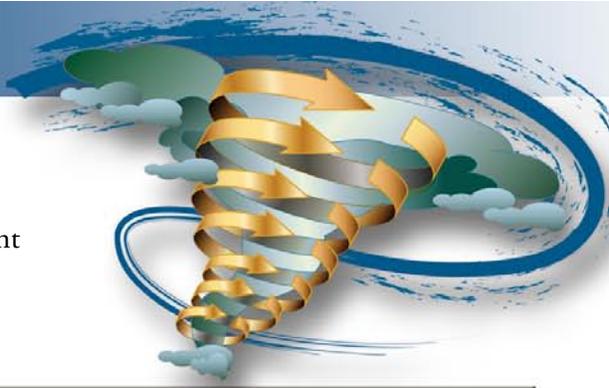


A tornado watch is issued by the National Weather Service when a tornado is possible in the area.

A tornado warning is issued by the National Weather Service when a tornado has actually been sighted or is indicated by radar.

I really like the design. It is very comfortable. Last spring we had occasion to use the storm shelter during a severe thunderstorm. We had students in the shelter. The noise level was very low. The kids didn't even know a storm was happening. This room will be good for the community to use also.

— Norma Jean Glenn, parent, speaking about the Park Elementary multipurpose safe room



An excerpt from the shelter operations plan developed by the Kapaun Mount Carmel Catholic High School that lists the responsibilities of the shelter management team members.

Kapaun Mount Carmel Catholic High School

Severe Weather Safe Room Entrance Strategy

Safety Goal: To have all Kapaun Mount Carmel students, faculty, and staff in the Safe Room located underground in the new Science and Technology Wing (the South Wing of the building).

The Kapaun Mount Carmel Catholic High School Emergency Committee shall consist of the following:

NOTE: Multiple positions may be held by one person as long as that person can adequately complete the assigned tasks.

Site Emergency Coordinator

- Maintain a current Shelter Operations Plan
- Oversee the activation of the Shelter Operations Plan
- Provide signage
- Notify local authorities
- Implement emergency procedures
- Maintain log of events

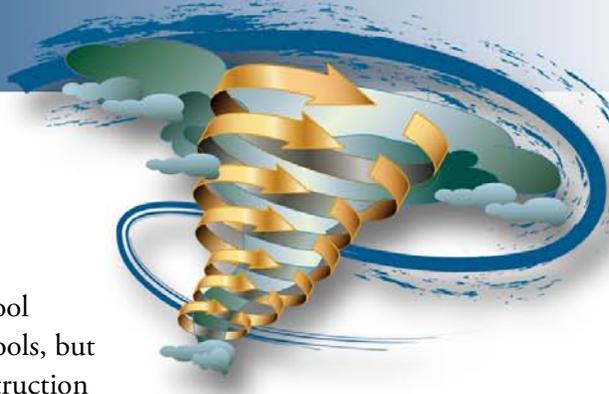
Safety Manager

- Ensure that all staff/students are thoroughly familiar with the Shelter Operations Plan
- Conduct training programs that include, at a minimum:
 - the various warning signals used, what they mean, and what responses are required
 - what to do in an emergency (where to report)
 - identification, location, and use of common emergency equipment such as fire extinguishers
 - shutdown and startup procedures
 - evacuation and sheltering procedures (routes, locations of safe areas)
 - conducting drills and exercises (at least three annually) to evaluate the Shelter Operations Plan and to test the capability of the emergency procedures
 - ensuring staff/students with special needs have been consulted about their specific limitations and then determining how best to provide assistance to them during an emergency
 - conducting an evaluation after a drill, exercise, or actual occurrence of an emergency situation, in order to determine the adequacy and effectiveness of the Shelter Operations Plan and the appropriateness of the response by the students and staff

Emergency Security Coordinator

- Ensure that the shelter is opened for occupancy during a drill or emergency event
- Control the movement of students and faculty to the shelter site
- “Lock down” the shelter
- Assist with the care and handling of injured persons
- Prevent unauthorized entry into hazardous or secured areas
- Assist with fire suppression, if necessary

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Summary

In carrying out a proactive school shelter initiative, the Wichita Public School District has not only taken decisive action to protect the children in its schools, but also led by example, spurring the implementation of a broader shelter construction program that involves private and public schools in other areas of the state.

The District has shown that a successful school shelter initiative involves the education of both individuals and organizations, including:

- the **legislature and school boards**, concerning the benefits of funding school shelter projects
- **local school and building officials**, concerning the structural, logistical, and human requirements for successful shelters
- the **private sector**, such as architects and engineers, concerning the design and construction of shelters
- **school staff**, to ensure that shelters are maintained and emergency procedures established and practiced
- **students**, so that they understand the hazards posed by severe wind events and know where and how to seek shelter

The KDEM and FEMA have taken great care to ensure that the shelters built for Kansas schools meet the design and construction criteria and operational guidelines presented in FEMA 361. These criteria and guidelines are based on the results of laboratory testing and engineering analysis, and on real-world experience with the performance of buildings during tornadoes and other severe-wind events. Shelters built to FEMA 361 standards meet the needs for structural strength, accessibility, reliability, and the comfort of shelter occupants.

The success of this school shelter program is based largely on the foresight of the Wichita Public School District and the cooperative efforts of school district officials, the State of Kansas, the private sector, and the Federal Government—efforts that have enabled the design and construction of economical, attractive shelters that make efficient use of valuable school space while providing for the safety and comfort of students. By following the guidance presented in FEMA 361, the participating schools have ensured that school children are afforded an unparalleled level of protection from the hazards associated with severe winds and windborne debris.

I hope some day that every Kansas school has a tornado safe room. The reality is we live in Tornado Alley and it just makes sense to do what we can to protect our children. Weather prediction and warning advancements now provide us the advantage of time to take shelter. But, all the warning time in the world doesn't do any good unless there is a refuge area for our children to go.

— Maj. Gen. Greg Gardner, Adjutant General of Kansas
Director of Emergency Management & Homeland Security