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PRECAST OFFERS Safe Haven

Standards for FEMA storm shelters—required in some parts of the country—have been revised and upgraded. Precast concrete helps meet these needs with quick, economic construction

— Craig A. Shutt

KICKAPOO HIGH SCHOOL
The new Kickapoo High School safe room, seen at the far right, connects seamlessly to the existing school building on both the exterior and interior. Photo: BKDC.

School administrators in many parts of the country, especially through the Midwest's "Tornado Alley," have added safe rooms to their buildings to protect faculty and children against the damaging impact that storms can create. The 2015 International Building Code (IBC) requires such rooms in certain educational facilities, leaving it up to districts to conform to those standards. Many designers have turned to precast concrete systems to meet the needs for safe, protected spaces with economical, functional, and attractive designs.

"It's only a matter of time until a major tornado strikes while a school is in session," says Brian M. Orr, a principal at Toth and Associates Inc. in Springfield, Mo. Toth has been designing safe rooms for 15 years and is on the technical steering committees for updates to Federal Emergency Management Agency (FEMA) publications P-320, P-361, and P-431 that govern requirements. The firm has designed more than 100 safe rooms that encompass more than 1 million ft^2 and protect nearly 150,000 occupants.

MORE STRINGENT STANDARDS

Toth notes that the latest edition of the FEMA standards make more stringent distinctions between a "FEMA safe room" and an "ICC (International Code Council) 500 storm shelter," which has fewer requirements. Safe rooms offer more versatility for schools, as they can be used for other functions, such as a gymnasium. The ICC 500-2014 upgraded a number of provisions for these rooms, and includes key structural features such as:

- Two-hour fire separation
- 100-mph missile impact resistance
- Resistance to pressure and uplift from 250-mph winds
- Tested and approved door assemblies or protected vestibules
- Design for collapse load of adjacent structures and a 100-lb/ft^2 rubble load.

Per the 2015 IBC, section 423.4, schools in an area that can encounter 250-mph shelter-design wind speeds are required to provide a safe room, Toth notes. That has become easier as more manufacturers, especially of windows and doors, are offering better products targeted to meet the

upgraded needs. "Prices have dropped tremendously on these products, with more variety in larger sizes. The options are much better to meet any type of room need."

Toth normally prefers to use precast concrete for the structural system of the rooms, regardless of their location or function. "Precast offers a structurally consistent material, and its applications continue to grow." Those include capabilities to produce 50-ft-tall walls and new aesthetic options. "Precast concrete safe rooms don't have to be square concrete boxes," he says. "There are many architecturally pleasing designs that can be created with finishes and inset brick."

The benefits of using precast concrete components are varied, he says. They include ease of construction, consistent high quality of fabrication from certified plants, design flexibility through long spans and tall walls, integrated insulation, fast fabrication and delivery due to proximity of plants to sites, and short required lead times.

Some administrators and designers have shied away from incorporating precast concrete safe rooms into their facilities, owing in part to their belief in various myths that exist about the spaces (see sidebar p. 35). Education and awareness are key to ensuring schools receive the best protection at the most economical cost.

'Precast offers a structurally consistent material, and its applications continue to grow.'

KICKAPOO HIGH SCHOOL SAFE ROOM
Kickapoo High School in Springfield, Mo., recently built a safe room that doubles as the school's performing-arts center. Photo: BKDC.

STATE-OF-THE ART PERFORMANCE SYSTEMS
The Kickapoo High School safe room and performing arts center features state-of-the art performance systems, an orchestra pit, and a fly loft for lowering sets. Photo: BKDC.

DUAL-USE ROOMS

Integrating a safe room into the building by allowing it to perform another function, such as a gymnasium, band room, or even larger classrooms, provides the best approach, he says. "Dual-use safe rooms give a sense of comfort and familiarity to younger children during severe weather events, reducing stress," he points out.

The thick, insulated concrete walls assist in dampening sound transmission, adding benefits to cafeteria and band room applications, he notes. "With FEMA-rated window assemblies now available, classrooms can be used and still provide natural light and bright, airy spaces."

'Dual-use safe rooms give a sense of comfort and familiarity to younger children.'

They also can be integrated into new additions with transition to the safe room occurring seamlessly both on the interior and exterior. Precast concrete aesthetic designs can aid this, especially if the existing school features a traditional brick façade, by using similar inset thin brick or using formliners and stains to replicate the brick size and color.

Safe rooms also can be created for other facilities besides schools, he notes. Toth has designed them for parks and recreation buildings, fire and police stations, community centers, city halls, and hospitals. All can serve as safe havens for people in the vicinity when danger strikes.

TOTAL–PRECAST
A total–precast concrete structural framing system was used to construct most of the performing-arts center at the Kickapoo High School. Photo: Prestressed Casting Co.

KICKAPOO HIGH SCHOOL

A recent example of how precast concrete components can create successful designs is the Kickapoo High School safe room in Springfield, Mo. The facility serves as a performing-arts center and was built adjacent to the existing high school, connecting to the main building. In addition to offering state-of-the-art theater systems, an orchestra pit, and a fly loft for lowering sets, it serves as the school's safe room.

The structural system consists of a total–precast design, with a structural-steel fly loft diaphragm, used to shorten the fly loft structure while maximizing the interior clear height. Buxton Kubik Dodd Creative in Springfield, Mo., was the architect of record, while Prestressed Casting Co. in Springfield fabricated the precast concrete components.

The $9.9-million project features load-bearing panels with 4 in. of insulation sandwiched between an interior 6-in. wythe (the FEMA requirement) and an exterior 4-in. wythe. The panels were erected horizontally in a stacked configuration on the east and west faces of the fly loft, while the remaining wall panels were erected in a vertical format, with many serving as load-bearing walls. The panels on the north and south faces of the fly loft, which were erected vertically, feature 8 in. of insulation sandwiched between two 8-in.-thick wythes of concrete for a 2-ft thickness. That design was necessary to provide the required structural support at that height.

PRECAST RISERS SPECIFIED

Designers also specified precast concrete risers for the seating, which were part of the FEMA structure. The limited space required the panels to be erected with a crane inside the space, backing out and erecting the wall diaphragm as they went, with no shoring.

"The logistics of setting the seating were complex," says Dave Robertson, vice president of sales at Prestressed Casting Co., the precast producer and erector. The facility was built in two phases due to the large orchestra pit in the center, with one side erected after the other, after which interior trades did stage work and the erectors returned with a larger crane to button up the center.

That work was sped up by providing a steel-troweled finish on the interior sides, so they needed only painting to be completed. Exteriors also received a smooth finish that was painted.

CHALLENGES FOR THE ERECTION OF THE WALL PANELS
Precast concrete risers were installed for seating sections, creating challenges for the erection of the wall panels in the tight location. Photo: Prestressed Casting Co.

"This safe room worked only because we had precast concrete available to us and could hold a lot of preliminary design discussions with the precast producer to see if this could even be done," Toth says.

Safe Room Myths

Construction of safe rooms is sometimes delayed due to misconceptions about how they function and what is required. Here are some of the key myths that Brian M. Orr, principal, Toth and Associates Inc. in Springfield, Mo., hears:

Myth: Safe rooms have to be underground.

Fact: Above-ground safe rooms designed to FEMA standards can withstand the forces of an EF-5 tornado and provide near absolute protection.

Myth: It's cheaper to build underground.

Fact: Safe rooms can be built above-ground for less cost than below-grade options, eliminating many issues related to Americans with Disabilities Act (ADA) accessibility requirements and the potential for flooding.

Myth: They are single-use spaces.

Fact: Safe rooms can serve many roles, integrating into a building's everyday functions. Their capabilities can create benefits, such as dampening sound from gyms, band rooms, or theaters.

Myth: They can't have natural light.

Fact: New window products meet FEMA standards and natural light and a traditional appearance.

Myth: Hallways can serve as a safe room.

Fact: Hallways act as wind tunnels and do not have FEMA-rated doors to protect against flying debris.

Myth: Hurricane shutters provide sufficient protection.

Fact: Shutters are not designed for the higher wind speeds that a tornado can produce, and doors and roofs remain at risk.

Myth: Thick walls are all that's needed.

Fact: Thick walls will protect against debris and projectiles, but the entire envelope and its connections must work together to provide consistent protection.

NEOSHO HIGH SCHOOL IN NEOSHO, MO.
Neosho High School in Neosho, Mo., built a long, narrow safe room along the adjacent highway, presenting a new, signature look to passersby. Photo: Toth and Associates.

NEOSHO HIGH SCHOOL

Another challenging project was the Neosho High School in Neosho, Mo. The building, two stories tall and more than 300 ft long, with an 8:1 length-to-width ratio, was placed along the side facing the highway that was most prominent, due to a flood plain and bus routing on the other side.

"We had a very limited footprint and a long, skinny building to design, which created issues for a safe room," Toth says. The design incorporates multiple interior shear walls that act as room dividers to break down the scale. As shear walls, they were funded by a FEMA grant, which would not have been the case for interior divider walls, he notes.

The erection was complicated by the tight site and the need to work around existing trees and other obstacles. "It was a difficult location, especially with an active site," says Robertson, whose firm also fabricated these components. Sapp Design Associates Architects in Springfield, Mo., was the architect of record.

STRUCTURE FEATURES
The structure features load-bearing precast concrete walls and double tees that rest on haunches built into the panels. Photo: Prestressed Casting Co.

To create a signature look on the highway side (and to face the administration offices across the highway), three colors of brick were inset into the panels. "The new look makes a world of difference for the school," says Toth. "Precast concrete was the only material that could reach the goals that were set in an economical way."

'Precast concrete was the only material that could reach the goals that were set in an economical way.'

Funding for these projects from FEMA is available up to $3 million depending on the design, Toth says. Grants typically are given on a 75/25 ratio for the basic FEMA-approved shelter components, but construction costs typically work out to closer to 60/40. FEMA does not share costs for interior or exterior finishes and mechanical systems such as air conditioning.

The work already has paid off. The Neosho High School safe room withstood a tornado in February with no casualties. A school in Goodman, Mo., was struck on an April evening by a tornado, avoiding casualties but wrecking part of the building. Toth now is working on a design for their safe room.

"Both Neosho and Kickapoo are great examples," says Toth. "They show how engineers and PCI-certified precaster producers can work together from the preliminary stages to create designs that meet the architect and owners' requirements while resulting in buildings that have a major impact on their campuses."