# JLC Report

## New Code Requirements for Tornado Safe Rooms Kick In as Demand Spikes

The 2011 tornado season has been one for the record books. A multi-state outbreak in late April killed at least 322 people in several southeastern states, with 238 of the deaths taking place in Alabama alone. A month later, a massive storm swept through Joplin, Mo., claiming an additional 151 lives. Even Massachusetts — a state not ordinarily viewed as particularly tornado-prone — was struck by an early-June twister that killed three. As of midsummer — with the storm season past its peak but by no means over — the nationwide death toll for 2011 stood at 537, making it the deadliest year since 1936.

The severity of a given tornado is often described in terms of the Fujita scale, or F-Scale, which ranges from F0 (characterized by wind speeds from 40 to 72 mph, capable of damaging chimneys and pushing over shallow-rooted trees) to F5 (wind speeds from 261 to 318 mph, causing near-total destruction of most buildings). Safe rooms — also known as storm shelters — are designed to allow homeowners to survive a direct hit by even an F5 storm. They've been in fairly common use for at least a decade (see "Hunkering Down in Tornado Alley," *Notebook,* 10/99), but this year's grim casualty figures have set off what a recent *New York Times* article described as a "storm shelter gold rush," with companies that sell and install the protective structures struggling to meet surging demand. "Everyone would like to have one, and they want them yesterday," one sales executive was quoted as saying.

At the same time, code officials and builders in states that have recently adopted the 2009 IRC — which includes a first-ever standard for safe-room construction — are coming to terms with what that standard might mean for them.

***A short history of safe rooms.*** According to the National Storm Shelter Association (NSSA), the concept of an above-ground storm shelter was


FEMA/Tim Burkitt

The wreckage of this home, in the aftermath of a tornado that struck Tuscaloosa, Ala., on April 27, demonstrates the tendency of some interior rooms to remain largely intact even when the rest of a structure has been demolished.

■ OSHA has announced a three-month delay in the implementation of a new directive prohibiting residential builders from using alternative fall-protection methods, effectively requiring all workers exposed to fall hazards to use some sort of conventional fall protection, such as safety nets or body harnesses and retractable lanyards (see "OSHA Moves to Limit Alternative Fall Protection," *JLC Report,* 3/11). The directive, which was to have been phased in on June 16 of this year, will now become effective on September 15. During that interval, employers who meet the old alternative fall-protection standard — but fall short of the revised standard now technically in effect — will be issued what amounts to a warning letter. (Employers who fail to meet the older standard will be cited.) According to OSHA, the enforcement delay was established to "provide employers the additional time and flexibility they need to alter their work practices in accordance with the requirements of the new directive."

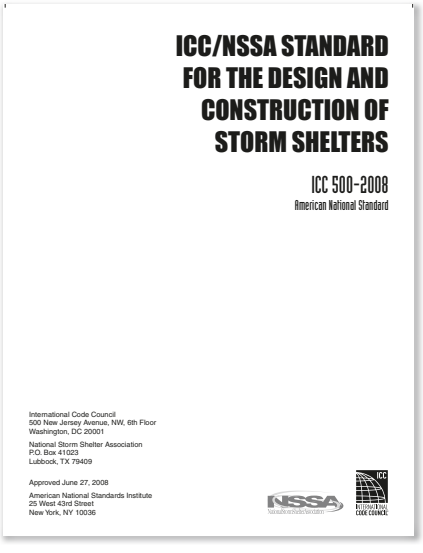
■ The owners of as many as 800 Florida homes containing contaminated Chinese drywall are expected to share a $55 million settlement funded by Banner Supply, a Miami-based building materials supplier. Banner had earlier signed an agreement releasing Knauf Group — the tainted drywall's manufacturer — from all liability associated with the product, after being assured by Knauf that tests had shown the drywall to be safe. Banner now claims that the tests had in fact shown the drywall to be defective and says it will pursue "all available remedies" to recover damages from Knauf.

first proposed in 1974 by Texas Tech University researchers, who had conducted a comprehensive study of structural damage resulting from a 1970 tornado in the city of Lubbock, Texas. Noting that many small, windowless interior rooms had survived largely intact, the TTU team concluded that a securely anchored, structurally strengthened room equipped with a secure door could serve as a reliable refuge from even a severe storm, while doubling as a closet or bathroom under normal conditions.

A few such shelters were actually built over the next two decades. But the concept didn't gain much traction until the late 1990s, when an NBC documentary on a deadly 1997 tornado that nearly obliterated the small community of Jarrell, Texas, showcased the TTU research. Soon thereafter, FEMA drew on assembly tests performed at TTU to put together a landmark publication called "Taking Shelter from the Storm," which contained detailed prescriptive plans for a variety of site-built residential shelters constructed from poured concrete, concrete block, and multiple layers of plywood reinforced with sheet metal.

FEMA/Jace Anderson

A series of tornadoes in the area of Joplin, Mo., on May 22 left almost unimaginable destruction. Deep-rooted trees that were not blown down, like the one visible in this photo, were in many cases stripped of their bark by the force of the wind.




ICC/NSSA 500, jointly developed by the International Code Council and the National Storm Shelter Association and released in 2008, is now part of the 2009 IBC and IRC.

"FEMA 320" — as the publication was designated — was an instant success. (A related publication, "FEMA 361," provided design and construction guidelines for larger community shelters.) The agency has since distributed more than a million printed copies of the residential guide — now in its third edition — and an unknown number of shelters have built to its specifications. (The current edition is available as a free download at fema.gov/plan/prevent/saferoom/fema320.shtm.) Texas Tech engineering professor and NSSA executive director Ernst Kiesling ventures the rough guess that as many as 2 to 3 million U.S. homes may now include storm shelters.

***Shelter performance and the code.*** That figure includes both site-built and manufactured shelters. While the former typically adhere closely to FEMA's prescriptive specs, manufactured shelters — which may be shipped broken down and assembled at the building site, or transported as preassembled units — are much more varied. Steel, plastic, or fiberglass shelters designed for underground installation are one option. Another is above-ground shelters. Usually made from steel or precast concrete, these units can be bolted to an existing home's garage slab or placed almost anywhere in new construction.

In 2001, the NSSA issued its own industry standard, which subjects manufactured shelters to rigorous strength and impact tests. Vertical shelter walls, for example, must be able to withstand a 100-mph strike by a 15-pound 2x4 fired from a specially designed air cannon, simulating what's thought to be the maximum credible impact from a wind-driven piece of debris.

Although the NSSA standard is purely voluntary — shelter manufacturers are under no obligation to seek NSSA approval of their products — most companies do seek the organization's seal of approval. "They want the element of prestige," says TTU engineer Larry Tanner. "The association has a compliance officer who conducts audits to make sure that everything manufacturers do is tested and approved. I can tell you that the organization has tossed out a number of members who did not comply."

Until quite recently, however, neither the FEMA prescriptive standards nor the NSSA industry standard were referenced by the ICC family of building codes. Purchasers of NSSA-approved manufactured shelters had a high degree of assurance that their shelters would perform as expected in an actual storm, but there was no comparable testing or inspection of site-built shelters.

According to Tanner, site-built shelters that receive FEMA funding — usually in the form of state-administered grants to homeowners in areas that have been declared federal disaster areas — are required to adhere strictly to the agency's

prescriptive specifications. Where no federal money is involved, however, builders have been free to build whatever they wanted, and to use the words "storm shelter" or "safe room" any way they chose.

All that began to change in 2008. Late that year, the ICC published a new standard for storm shelters, which was subsequently included in both the 2009 IRC and the 2009 IBC. Officially called "ICC/NSSA 500: 2008 Standard for the Design and Construction of Storm Shelters," it was developed in cooperation with the NSSA, and closely tracks the existing FEMA 320 and 361 guidelines. Its inclusion means that builders in jurisdictions subject to the 2009 IRC or IBC can no longer designate a part of a home as a storm shelter or safe room unless the space meets the ICC 500 benchmark.

Although the new standard — unlike the FEMA documents on which it's based — is written in code language, it's purely performance-based, rather than prescriptive. As a result, it's not clear how individual building-code jurisdictions will enforce it. For the time being, Ernst Kiesling suggests, building inspectors could refer to the FEMA prescriptive specifications, even though they differ slightly from the new ICC standard in some respects.

***Bang for the buck.*** In principle, bringing site-built storm shelters under the umbrella of the code should increase the likelihood that a new residential shelter will survive, should it someday be put to the ultimate test. And FEMA has set a high bar: Its prescriptive designs, the agency says, offer "near-absolute protection" from extreme winds. (Although ICC 500 is closely modeled on the FEMA guidelines, it does not make the same specific claim.)

One often-cited benefit of the "near-absolute protection" standard is that it provides not only physical safety but also a high degree of peace of mind. "If I've spent thousands of dollars on a shelter, I don't want to have to wonder whether a storm is a 3F or a 5F," Kiesling says.

But that degree of protection doesn't come cheap. A typical ICC 500–compliant storm shelter will set the purchaser back at least $5,000, and although post-disaster FEMA grants to states that have suffered serious tornado damage may offset part of the cost, such shelters are too costly for many homeowners.

Tim Reinhold, chief engineer at the Insurance Institute for Business and Home Safety and a member of the ICC committee that developed the storm-shelter standard, notes that many victims of the recent tornado in Tuscaloosa, Ala., didn't even have homeowner's insurance. "If you can't afford insurance, you're not going to go out and spend $5,000 on a storm shelter," he says.

During the early 2000s, Reinhold was one of a team of researchers at Clemson University that received funding from FEMA to investigate low-cost methods for providing homeowners with some degree of storm protection. The approach they ultimately came up with — which relied on what they called the "strong area" concept — falls well short of a FEMA 320 safe room, but it's both cheaper and easier to retrofit into an existing home. Stripped to its essentials, it involved constructing a strong plywood box in a closet or other interior room, securely tied to the foundation and provided with its own roof — one independent of the truss roof of the home itself, which is easily destroyed by even a mid-level tornado.

**Figure 8. End View of Safe Area Roof Showing Attachment of 2x8 Ceiling Protection**

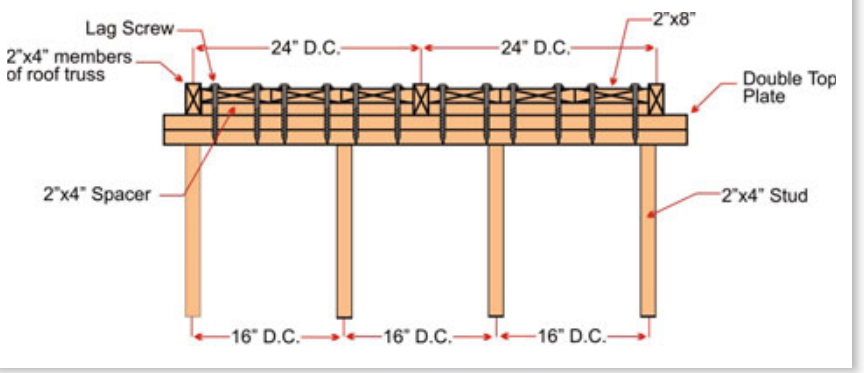
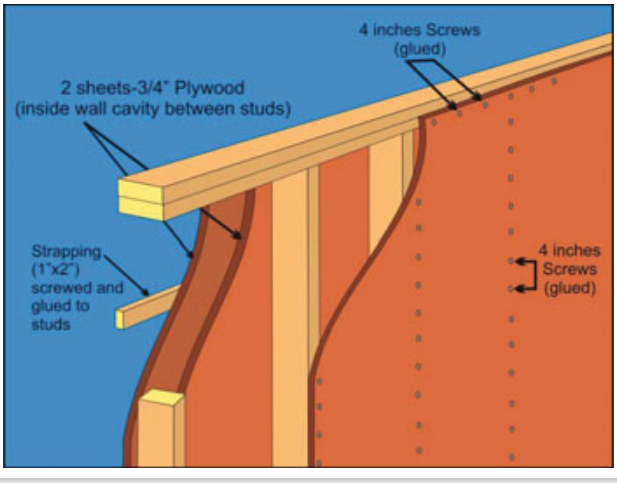



**Figure 15. Layout of Sheathing and #8 Screw Fastener Schedule for Single Surface Sheathing Application (stud plate ties assumed)**




These drawings from a 2003 FEMA-funded study show how to construct a relatively inexpensive in-home storm shelter that offers more limited protection than the ones required by the 2009 I-codes. While these low-cost shelters can still be built legally, they can no longer be designated as "safe rooms" or "storm shelters."

According to Reinhold, the team members found it relatively easy to design a structure strong enough to withstand tornado winds. A bigger challenge, he says, lay in providing walls tough enough to resist worst-case strikes by windborne missiles. The team ultimately concluded that it made sense to accept some degree of vulnerability to missile strikes in return for reduced cost. The most robust of the prescriptive "strong area" designs developed at Clemson were estimated to offer about 75 percent as much protection as a FEMA 320 safe room, at an estimated material cost of $1,200 (in 2003 dollars). The Clemson report, "In-Home Protection Against High Winds Building Guide," is available at bluesky-foundation .net/studyguides/Building_Guide.pdf (keep in mind that it has not been updated since 2003).

***Saving more lives.*** The rationale behind the "strong area" approach is that truly powerful tornadoes are so rare — F4- and F5-rated events account for only about one percent of all storms — that expanded use of less protective but cheaper shelters could potentially keep many more people safe than the all-but-indestructible shelters specified by FEMA 320 and ICC 500. "The analogy I use is that you can make a small improvement in highway safety by putting a few people in armored personnel carriers, or you can make a bigger one by putting a lot of people in Volvos," Reinhold says.

And in fact, nothing in the recent code change prevents builders or homeowners from pursuing the strong-area approach, or any other method they might develop on their own. But — and this is a crucial point — the words "storm shelter" or "safe room" can no longer be used to describe anything less than a fully ICC-500 compliant structure.

***Cautionary tale.*** The experience of Lawrence, Kan., builder Mike Hultine hints at the sort of trouble that could await builders unfamiliar with the new requirements.

In 2008, Hultine's company built a fourplex residential unit that included a range of features meant to appeal to older buyers, including an accessible "no step" design. Because eliminating steps also meant doing away with a basement — the traditional Kansas tornado refuge — Hultine made what he thought was the reasonable decision to include a simple aboveground storm shelter, consisting of a steel-reinforced concrete vault where the adjoining corners of the four garage units met. Standard wood-framed partition walls subdivided the vault's interior into four individual units, each of which could be accessed through an 18-gauge steel fire door in the concrete wall.

A real estate flier on the fourplex described each of the units as having a "concrete storm shelter/safe room for your peace of mind." Since ICC 500 had not yet been published, that description was legally unobjectionable. Even so, Hultine soon found himself embroiled in a dispute with a homeowner who — after watching a Weather Channel program that discussed storm shelters — demanded that the shelter be upgraded with FEMA-approved doors.

Hultine has refused to do so. "My door supplier gave me a price of $22,000 for the four doors," Hultine says. "My intention was never to misrepresent what I was doing, but I can't afford that. I'll never build another shelter unless someone specifically requests one."

The estimate from Hultine's door supplier may have been too high. TTU's Larry Tanner, who is familiar with the project, notes that approved doors should be available for as little as $2,000 each. The FEMA 320 guidelines (although not ICC 500) also approve the use of conventional 20-gauge or heavier steel doors, provided that they're strengthened by the addition of a 14-gauge steel plate on each side, hung on heavy-duty hinges, and have a cylindrical deadbolt lock at the level of each hinge. (That relatively inexpensive retrofit solution was rejected by the customer, leading Hultine to wonder whether his real objective was to settle for the cash value of the higher-priced door.)

It's also clear that the shelter's compartmentalized design contains a fundamental flaw: since the individual true shelter units are separated from one another only by studs and drywall, failure of the occupants of one compartment to close and bolt their door would leave those in the remaining three potentially exposed to storm-driven missiles on that side.

Even so, Hultine's back-of-an-envelope shelter design is almost certainly much safer than the standard basement he'd considered originally — and which, as Tanner observes, offers less reliable protection than many believe. "The floor system overhead tends to go away with the rest of the house," he says. "Once that happens, the whole basement can fill up with cars, propane tanks, and other debris." — *Jon Vara*