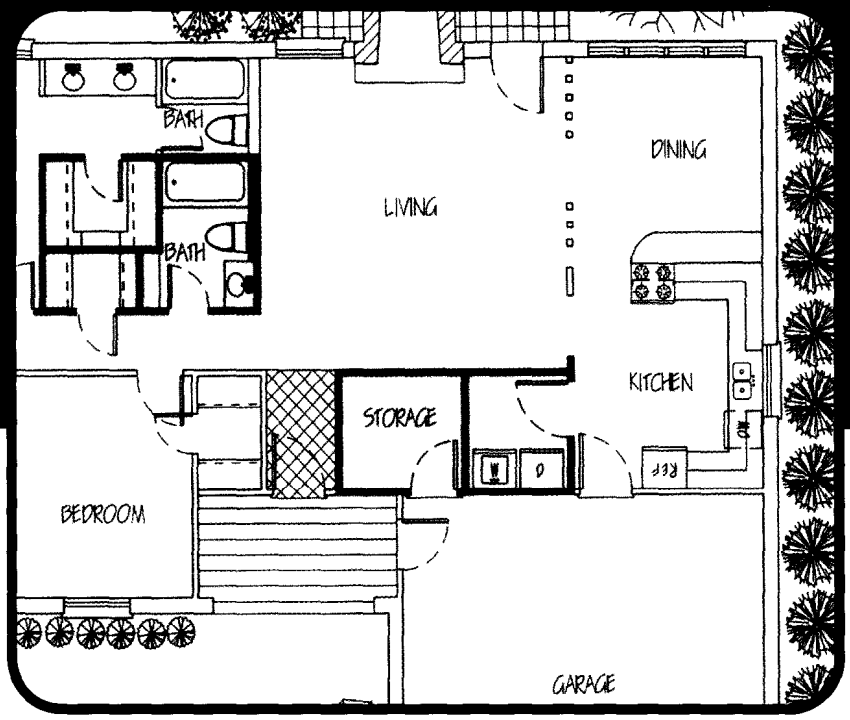


Building Codes and Storm Shelter Safety

by James E. Waller, P.E., and Ernst W. Kiesling, P.E., Ph.D.

Nearly 1,100 tornadoes were reported to have occurred throughout the U.S. during the first six months of this year. During May 2–11 alone over 400 tornadoes occurred in 19 states, resulting in numerous deaths and injuries and property loss claims that it is estimated will reach $1.55 billion. Since a large number of tornadoes occur during the summer and fall months, it is expected that 2003 will be a record year for tornadoes. Weather forecasters have also predicted that an unusually high number of hurricanes will hit coastal areas of the U.S. during coming hurricane seasons (James E. Waller, "Surviving Nature's Wrath and Human Shortsightedness," *Southern Building*, September/October, 2002).

Considering the "climate," it is not surprising that in-residence storm shelters are becoming an increasingly attractive option. In response, ICC recently initiated a program to develop a standard which will respond to the public's need for storm shelter quality assurance.

50 Years Hindsight

In May of 1953 (the third deadliest year for tornadoes in the U.S.) tornadoes claimed 519 lives. Three alone—which struck Waco, Texas; Flint, Michigan; and Worcester, Massachusetts—resulted in 324 deaths and 2,744 injuries. As a result, the first Texas Tornado Warning Conference was convened on June 24, 1953. Organized by Texas A&M University and the U.S. Weather Bureau (forerunner of the National Oceanic & Atmospheric Administration's National Weather Service), this conference would lead to the establishment of an integrated weather radar system in the U.S. (*NOAA Magazine*, May 5, 2003). Today, the entire North American continent is covered by a network of Doppler radar sites which inform us of every weather phenomenon of interest or concern. In the future, these systems will be replaced with phased array radars, which will significantly reduce scan times and increase severe weather warning lead times (*NOAA Magazine*, June 24, 2003).

National television coverage of the 1997 Jarrell, Texas, tornado and its aftermath damage, and of high-speed 2x4s impacting common residential wall assemblies during tests conducted at Texas Tech University first sparked interest in the construction of in-residence storm safe rooms and shelters. The U.S. Federal Emergency Management Agency responded by publishing FEMA 320, "Taking Shelter From the Storm"—a prescriptive design guide for above-ground residential shelters—the following year to inform the public of the extreme forces and violent debris impacts that qualified above-ground shelters would have to resist during F5 tornadoes. After the multiple Oklahoma/Kansas super-cell thunderstorms produced 70 tornadoes on May 3, 1999, resulting in many casualties and over $1 billion in property damage, a large segment of the population became acutely aware of the benefits of in-home storm protection, and a new industry was born.

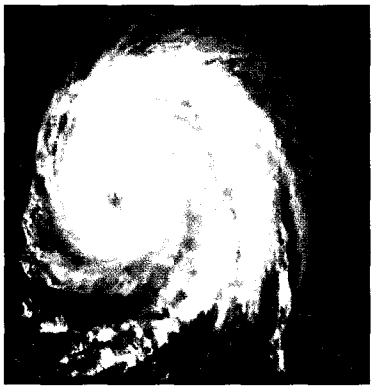
A 1999 Oklahoma shelter incentive grant program jump-started the shelter industry. Since then, it is estimated that approximately 300,000 tornado shelters and safe rooms have been built in the U.S. Unfortunately, not all of these shelters meet construction or life-safety standards. Quality issues that surfaced during this period made it apparent that the storm shelter industry was in dire need of self-governance, and the National Storm Shelter Association (NSSA) was formed to create quality assurance standards for the industry. In April, 2001, NSSA published the "Standard for the Design, Construction, and Performance for Storm Shelters" and created the mechanisms for enforcing the compliance of member producers. The NSSA document was the first comprehensive standard applicable to all types of storm shelters.

It should also be noted that great strides have been made to improve the structural stability and continuity of new residential buildings by creating "continuous load paths" from roofs to foundations. The *International Residential Code*® contains specific provisions for achieving structural continuity, which may be expected to result in a significant improvement in the ability

of residential buildings to resist wind forces. Coupled with the fact that the impact of wind-borne debris on storm shelters is such a critical issue with respect to the protection of occupants during damaging storms, enforcement of these provisions is of utmost importance.

ICC Committee on Storm Shelters

In February 2003, the ICC Committee on Storm Shelters (IS-STM-CC) was formed to develop a national consensus standard for storm shelters, using the NSSA standard as the foundation document by agreement with the association. Reference to this standard by the *International Codes*™ and adoption by regulating authorities will provide the basis for legally enforcing the production and construction of high-quality storm shelters. Building designers and code enforcement officials should expect qualified storm safe room and shelter manufacturers to make detailed design and construction documents available for review for compliance with the NSSA standard. Pending completion of the ICC standard, NSSA will continue to update its standard and make it available on the association website, which is located at *www.nssa.cc*.



Assurance of compliance with storm shelter standards may also require inspection of the assembled, installed or constructed shelter. Typical developer/builder residences are constructed from stock plans. Construction of a residence usually proceeds as an uninterrupted sequence from site grading and foundation layout to finishing, carpeting and closing on the house. General contractors are reluctant to interfere with predetermined schedules to facilitate installation of specialty substructures such as storm safe rooms. As soon as the building is "dried-in," the subcontractors are expected to be framing partitions; roughing-in mechanical, plumbing and electrical; and installing and finishing drywall.

This creates a number of difficulties with respect to the in-home safe room assembly/inspection process. The exterior surfaces of in-residence storm safe room walls are usually expected to be finished with drywall so as to match the location and finish of other interior partition walls. Electrical rough-in of safe rooms is also typically required. When a safe room is installed following completion of interior partitions, several problems are typically encountered.

- When a safe room must be installed in a closet space, installation costs are significantly increased due to a lack of space available to perform the installation by normal means.
- Occupiable space is reduced by the combined thicknesses of the stud walls and shelter walls, and finishing costs are typically duplicated by drywall and painting requirements for safe room interiors.
- Similarly, electrical rough-in will probably be duplicated by rough-in of the shelter walls.
- Installation and inspection of shelter exterior cladding is severely hampered by previously installed partitions.
- Installation and anchorage of the shelter may be severely hampered by the existence of a carpeted floor slab.

The optimum conditions for the satisfactory inclusion of a storm safe room inside a residence are best achieved when there are pertinent pre-construction agreements between the homeowner/purchaser, building designer (if applicable), building contractor, shelter subcontractor, other relevant subcontractors and the building department's inspection office. For example, there should be agreements that the safe room walls will serve as interior partitions around the safe room; that assembly and finishing of the safe room and safe room door framing must be coordinated with the framing, electrical, drywall and painting sub-contractors; and that inspections of the safe room installation, if required by the local building department, require visual access to multiple sides of the safe room before the space is closed up by other construction. In short, economical, efficient construction of in-residence storm safe rooms is best facilitated when considered during the planning stage, rather than being an afterthought.

Alternate Methods of Quality Assurance

Since pre-construction agreements may not always be in place for new residences and many existing homes are being retrofitted with in-residence storm safe rooms, alternate solutions must be evaluated. Inspections might need to be coordinated with shelter installation. More than one inspection may be required if compliance is an issue, but having an NSSA seal and Certificate of Installation may be considered adequate evidence of compliance with an appropriate standard. (An NSSA Certificate of Installation—which bears the manufacturer's name and shelter serial number, the NSSA seal number affixed to the shelter, the name and address of the purchaser, and the date of sale or installation—certifies that the shelter complies with the requirements of the NSSA standard.)

Future Trends and Needs

Predictions of increases in severity of tornadoes and hurricanes are prevalent in the media. On the first day of the 2003 hurricane season, veteran weather forecaster William Gray announced: "Regardless of whether a major hurricane makes landfall this year, it is inevitable that we will see hurricane-spawned destruction in coming years on a scale many, many times greater than we have in the past" (CNN.com Weather, "Hurricanes Predicted to Double," June 1, 2003). The public is beginning to realize that evacuation may often be the least desirable option when a severe storm hits.

Tornado shelters designed to comply with the NSSA standard or based on the prescriptive designs of FEMA 320 provide safe designs for F5 tornadoes. However, shelters meeting these standards far exceed strength, stability and debris impact requirements for hurricane wind speeds. Although tornadoes are

frequently spawned by hurricanes which have made landfall, it would be neither economical nor desirable to require hurricane shelters to meet F5 tornado standards. It is important, however, to recognize that debris impact criteria adopted by jurisdictions in hurricane regions for protecting the building envelopes from becoming breeched, thereby allowing full internal pressurization, may be woefully deficient for the protection of people from death and injury while occupying hurricane shelters.

The near-term construction of large numbers of shelters in hurricane regions suggests the importance and urgency of creating and adopting shelter design standards that are appropriate for the wind loads and debris impacts expected from hurricanes in coastal regions of the U.S. The storm shelter industry has continued to grow in spite of the relatively low level of tornado and hurricane activity of the preceding two years. In addition to individual family decisions to have in-home shelters installed, several residential developments have built or installed storm shelters in virtually all units and severallarge developments are committed to including storm shelters in every home. Those developers are encouraged to provide high-quality shelters and to implement quality verification measures such as those embodied by the NSSA member quality assurance prgram. ◆

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