Building a Storm Resistant Safe Room

An Online Continuing Education Course for Engineers

Course Number: S-3008

Credit: 3 Hours / 3 PDH / 3 CPD

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Introduction


NOAA

Every year, tornadoes, hurricanes, and other extreme windstorms injure and kill people, and cause millions of dollars worth of property damage in the United States. Even so, more and more people build homes in tornado- and hurricane-prone areas, possibly putting themselves into the path of such storms.

Having a safe room built for a home or small business can help provide "near-absolute protection" for the occupants from injury or death caused by the dangerous forces of extreme winds. Near-absolute protection means that, based on current knowledge of tornadoes and hurricanes, the occupants of a safe room built according to this guidance will have a very high probability of being protected from injury or death. Knowledge of tornadoes and hurricanes is based on substantial meteorological records as well as extensive investigations of damage to buildings from extreme winds. It can also relieve some of the anxiety created by the threat of an oncoming tornado or hurricane. All information contained in this course is applicable to safe rooms for use in homes as well as in small businesses.


NASA

Should building a safe room be considered for a home or small business to provide near-absolute protection for the building's occupants during a tornado or hurricane? The answer depends on answers to many questions, including:

- Is the building located in a high-risk area?
- How quickly can safe shelter be reached during extreme winds?
- What level of safety is needed?
- What is the cost of a safe room?

This course will help answer these and other questions, in order to decide how best to provide near-absolute protection for building occupants or employees. It includes the results of research that has been underway for more than 30 years, by Texas Tech University's Wind Science and Engineering (WISE; formerly known as the Wind Engineering Research Center or WERC) Research Center and other wind engineering research facilities, on the effects of extreme winds on buildings.

This course provides safe room designs that will show building owners and builders/contractors how to construct a safe room for homes or small businesses. Design options include safe rooms located underneath, in the basement, in the garage, or in an interior room of a new home or small business. Other options also provide guidance on how to modify an existing home or small business to add a safe room in one of these areas. These safe rooms are designed to provide near-absolute protection for building occupants or employees from the extreme winds expected during tornadoes and hurricanes and from flying debris, such as wood studs, that tornadoes and hurricanes usually create.

TORNADO OCCURRENCE AND RESULTANT LOSSES ARE INCREASING

In 1950, the National Weather Service (NWS) started keeping organized records of tornadoes occurring in the United States. Since that time, 2011 was the deadliest year (550 deaths), including the deadliest single tornado strike, which occurred in Joplin, Missouri (160 deaths). The average number of fatalities for 2009-2011 was 206 deaths per year.

In addition to deaths, tornadoes cause injuries and devastating losses of personal property. Insurance claim losses from a single tornadic event of $1 billion and higher are becoming more frequent. The tornado that struck Joplin, Missouri resulted in an estimated $4.9 billion in insured losses.

This photograph from FEMA's photo library shows the vivid reality of how lives are impacted by tornadoes. (Lafayette, TN - February 5, 2000)

Although hurricanes and earthquakes generally generate higher losses per event, since 1953, tornadoes (and related weather events) have caused an average of 57 percent of all U.S. insured catastrophic losses.

SOURCE: A.M. BEST, CNN

In August 2008, the International Code Council® (ICC®), with the support of the National Storm Shelter Association (NSSA), released a consensus standard on the design and construction of storm shelters. This standard, the ICC/*NSSA Standard for the Design and Construction of Storm Shelters* (ICC-500), codifies much of the extreme-wind shelter recommendations of the early editions of the Federal Emergency Management Agency (FEMA) Document No. 320 and

FEMA 361, *Design and Construction Guidance for Community Safe Rooms* (first edition, July 2000). FEMA 361 contains detailed guidance for the design and construction of community safe rooms, which also provide near-absolute protection, the level of protection provided in the residential safe rooms of this course. The ICC-500 provides the minimum design and construction requirements for extreme-wind storm shelters and is expected to be incorporated into the 2009 International Building Code® (IBC®) and International Residential Code® (IRC®). It is important that those involved in the design, construction, and maintenance of storm shelters be knowledgeable of both FEMA guidance and ICC standards that pertain to sheltering from extreme winds.

The safe room designs presented in this course meet or exceed all tornado and hurricane design criteria of the ICC-500 for both the tornado and hurricane hazards.

The National Association of Home Builders (NAHB) Research Center has evaluated these designs for construction methods, materials, and costs for the earlier editions of this course. Engineers at Texas Tech University, engineering consultants, and FEMA have confirmed the design requirements for the expected forces from wind pressure and the impact of typical flying debris. When installation and foundation requirements are addressed by a local design professional, these designs will meet or exceed the design requirements set forth in the ICC-500 for residential and small community shelters (less than 16 persons) for both tornado or hurricane hazards. The safe rooms in this course have been designed with life safety as the primary consideration.

Planning a Safe Room

With a better understanding of the risks from a tornado or hurricane, building owners can work with builders/contractors to build a safe room to provide near-absolute protection for occupants or employees from these extreme windstorms. This section describes how extreme winds can damage a building, explains the basis of the safe room designs presented in this course, and identifies where safe rooms can be built in a home or small business.

Building Damage

Extreme winds can cause several kinds of damage to a building. An understanding that tornado and hurricane winds are not constant is first needed to understand what happens when extreme winds strike. Wind speeds, even in these extreme-wind events, rapidly increase and decrease. An obstruction, such as a home, in the path of the wind causes the wind to change direction. This change in wind direction increases pressure on parts of the home. The combination of increased pressures and fluctuating wind speeds creates stress on the home that frequently causes connections between building components to fail.

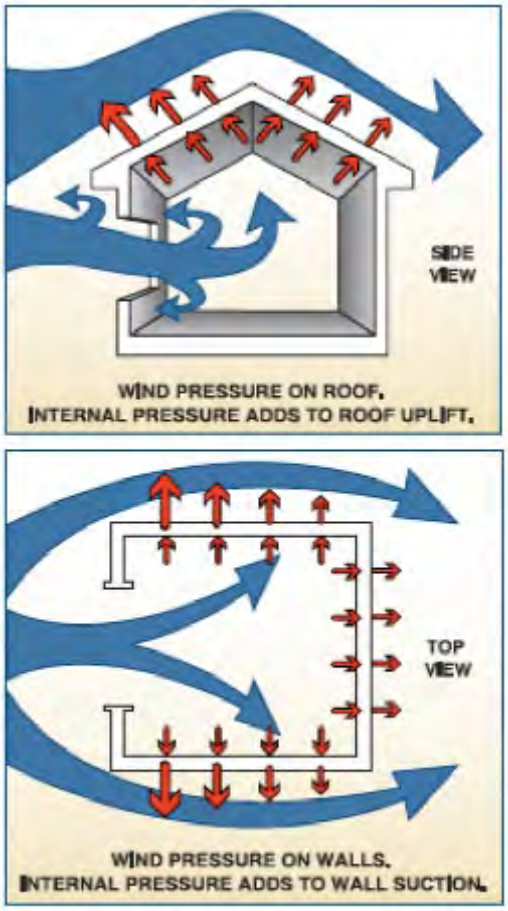


Figure II-1. Effect of extreme winds on building roof and walls

For example, the roof covering, roof deck, or wall siding can be pulled off and the windows can be pushed into or suctioned out of a building. Figure 1 shows how extreme winds can affect a building and helps explain why these winds cause buildings to fail. When wind is allowed to enter a building through a broken window, door, or roof section, that wind will act on the inside of a building much like air will act when forced into a balloon; it will push (or pull) on the walls and roof of the building from the inside. These forces within the building, added to the wind forces that are still acting on the outside of a building, often result in failure of the building because it was not designed to resist the forces acting on both the inside and the outside of the building.

Buildings that fail under the effects of extreme winds often appear to have exploded, giving rise to the misconception that the damage is caused by unequal atmospheric or wind pressures inside and outside the building. This misconception has led to the myth that, during an extreme-wind event, the windows and doors in a building should be opened to equalize the pressure. In fact, opening a window or door allows wind to enter a building and increases the risk of building failure.

2" x 6" missile penetrating a refrigerator, Midwest tornadoes of May 3, 1999

Damage can also be caused by flying debris (referred to as windborne missiles). If wind speeds are extreme enough, missiles can be thrown at a building with enough force to penetrate or perforate windows, walls, or the roof. For example, an object such as a 2" x 4" wood stud weighing 15 pounds, when carried by a 250-mph wind, can have a horizontal speed of 100 mph, which is enough force to penetrate or perforate most common building materials used in homes today. Even a reinforced masonry wall, which typically has hollow cells between reinforced cells, will be perforated unless it has been designed and constructed to resist debris impact during extreme winds. Because missiles can severely damage and even perforate windows, walls, and roofs, they threaten not only buildings but the occupants as well.

Palm tree pierced by plywood missile, Hurricane Andrew

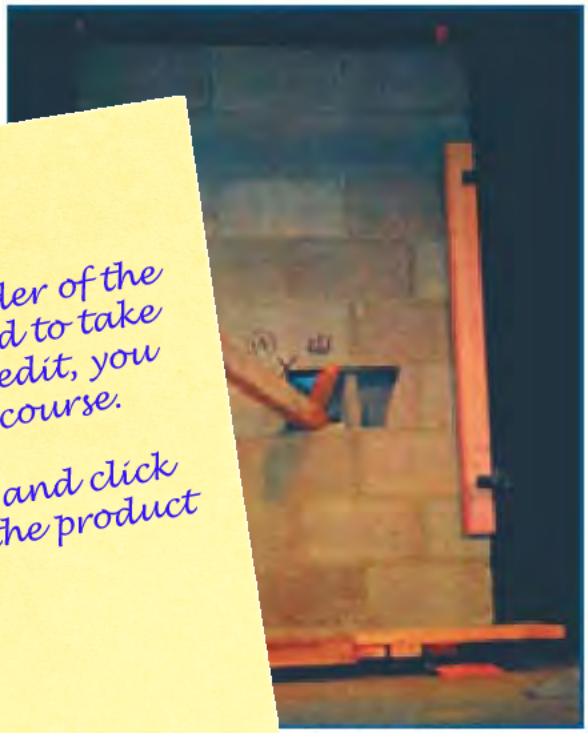
DEFINITION

In this course, missiles may be said to **penetrate** but not **perforate** the walls or roof of a safe room. For example, if a missile **penetrates** an exterior element of the safe room, this means the missile broke or damaged the exterior surface, but has not entered the safe room protected area. It is quite common for smaller missiles such as small stones, branches, and other lighter missiles to penetrate or imbed themselves into the exterior of the safe room and this is acceptable. However, the safe room walls, roof, and protected openings must not allow a missile to **perforate** these systems and allow the missile to enter into the safe room. When any portion of the safe room exterior is damaged such that a missile or portion thereof, enters the protected area, the safe room exterior has been perforated and this is not acceptable.

Basis of Safe Room Design

Missile (debris) launcher, Wind Engineering Research Center (WERC), Texas Tech University

The purpose of a safe room is to provide a space where building occupants or employees can survive a tornado or hurricane with little or no injury. For tornado-prone areas, the safe room should be located in an area that can be reached as quickly as possible from all parts of the home or small business. In hurricane-prone areas, the safe room should not be built where it can be flooded during a hurricane. The safe room should be readily accessible from all parts of the home or small business and should be free of clutter. To provide near absolute protection for the occupants during extreme windstorms, the safe room must be adequately anchored to the home's foundation to resist overturning and uplift. The connections between all parts of the safe room must be strong enough to resist failure, and the walls, roof, and door must resist perforation by windborne missiles.



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masonry wall, WERC,
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