

Based on the 2015 International Codes®

# Course description

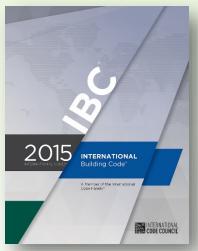
- The ICC 500 is a standard for the design and construction of storm shelters for protection from tornados and hurricanes. This course will review where storm shelters are required by the International building codes. There will also be an overview of the technical requirements, or the how to, requirements in the ICC 500.
- The needs of the type of shelter differ because of the differences between tornadoes and hurricanes. Some of the biggest differences is the amount of warning time to get to a shelter, the time the occupants will stay in the shelter and the differences in the forces from the wind and debris on the shelter. This class will explain those differences and the why behind the requirements.

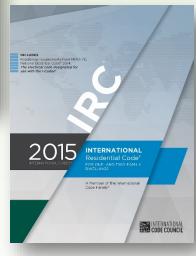


### Goal

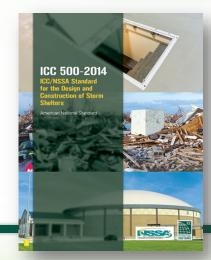
...determine the minimum technical requirements for storm shelters in.

- 2015 IBC.
- 2015 IRC.
- ICC 500-2014: Standard for the Design and Construction of Storm Shelters









## **Objectives**

- Upon completion of this seminar, you will be better able to:
  - Identify where the ICC 500 is scoped in the codes
  - Determine the extent to which storm shelter standard provisions apply.
  - Identify scoping and technical requirements



## Presentation organization



Title slides indicating topic/main code section



Performance requirements – Main ideas/ Philosophy



Code definitions or tables

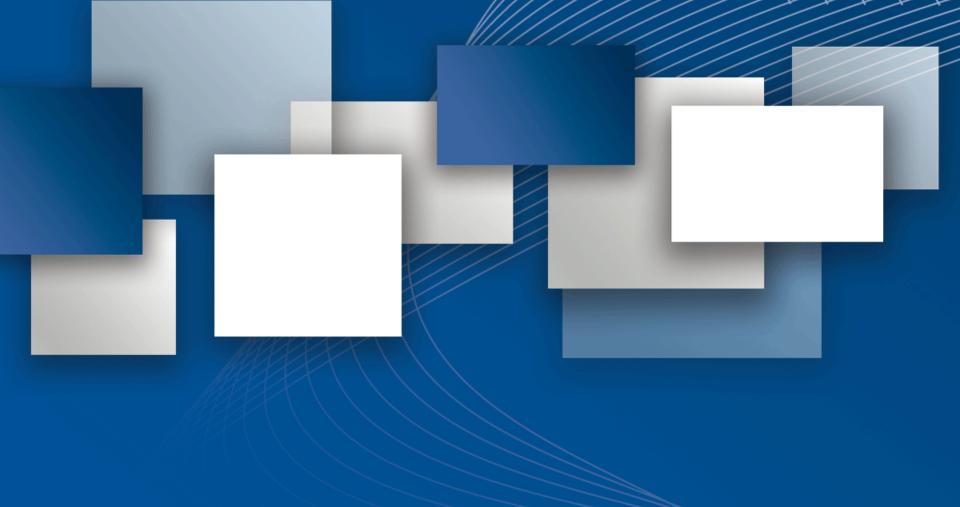


Example



Quick questions on what we learned





Scoping

# All referenced standards IBC Section 102.4

Considered part of the code to the extent referenced

Conflicts – codes rule







## **IBC Definitions**

[BS] STORM SHELTER. A building, structure or portions thereof, constructed in accordance with ICC 500 and designated for use during a severe wind storm event, such as a hurricane or tornado.

Community storm shelter. A storm shelter not defined as a "Residential storm shelter."

**Residential storm shelter.** A storm shelter serving occupants of *dwelling units* and having an *occupant load* not exceeding 16 persons.





#### SECTION 423 STORM SHELTERS

**2015 423.1 General.** In addition to other applicable requirements in this code, storm shelters shall be constructed in accordance with ICC 500.

2018 423.2 Construction. In addition to other applicable requirements in this code, storm shelters shall be constructed in accordance with ICC 500. <u>Buildings or structures that are also designated as emergency shelters shall also comply with Table 1604.5 as Risk Category IV structures.</u>





**2015 423.1.1 Scope.** This section applies to the construction of storm shelters constructed as separate detached buildings or constructed as safe rooms within buildings for the purpose of providing safe refuge from storms that produce high winds, such as tornados and hurricanes. Such structures shall be designated to be hurricane shelters, tornado shelters, or combined hurricane and tornado shelters.

2018 423.1 General. This section applies to the construction of storm shelters constructed as separate detached buildings or constructed as rooms or spaces within buildings for the purpose of providing protection from storms that produce high winds, such as tornadoes and hurricanes during the storm. Such structures shall be designated to be hurricane shelters, tornado shelters, or combined hurricane and tornado shelters. Design of facilities for use as emergency shelters after the storm are outside the scope of ICC 500 and shall comply with Table 1604.5 as a Risk Category IV Structure.





2015 423.3 Critical emergency operations. In areas where the shelter design wind speed for tornados in accordance with Figure 304.2(1) of ICC 500 is 250 MPH, 911 call stations, emergency operation centers and fire, rescue, ambulance and police stations shall have a storm shelter constructed in accordance with ICC 500.

**Exception:** Buildings meeting the requirements for shelter design in ICC 500.

2018 IBC has removed the exception as unnecessary.





**423.4 Group E occupancies.** In areas where the shelter design wind speed for tornados is 250 MPH in accordance with Figure 304.2(1) of ICC 500, all Group E occupancies with an aggregate occupant load of 50 or more shall have a storm shelter constructed in accordance with ICC 500. The shelter shall be capable of housing the total occupant load of the Group E occupancy.

#### **Exceptions:**

- 1. Group E day care facilities.
- 2. Group E occupancies accessory to places of religious worship.
- 3. Buildings meeting the requirements for shelter design in ICC 500.



2018 IBC has created a separate section for capacity.
2018 IEBC will require storm shelters in additions to schools.



- **2018 423.4.1 Required occupant capacity.** The required occupant capacity of the storm shelter shall include all of the buildings on the site and shall be the **greater** of the following:
- 1. The total occupant load of the classrooms, vocational rooms and offices in the Group E occupancy.
- 2. The occupant load of any indoor assembly space that is associated with the Group E occupancy.

#### **Exceptions:**

- 1. Where a new building is being added on an existing Group E site, and where the new building is not of sufficient size to accommodate the required occupant capacity of the storm shelter for all of the buildings on the site, the storm shelter shall at a minimum accommodate the required occupant capacity for the new building.
- 2. Where approved by the code official, the required occupant capacity of the shelter shall be permitted to be reduced by the occupant capacity of any existing storm shelters on the site.





**2018 423.4.2 Location.** Storm shelters shall be located within the buildings they serve or shall be located where the maximum distance of travel from not fewer than one exterior door of each building to a door of the shelter serving that building does not exceed 1,000 feet (305 m).





**TABLE 1604.5** 

RISK CATEGORY OF BUILDINGS AND OTHER STRUCTURES

**Risk Category IV** - Buildings and other structures designated as essential facilities, including but not limited to:

Designated earthquake, hurricane or other emergency shelters.

**1604.10 Loads on storm shelters.** Loads and load combinations on storm shelters shall be determined in accordance with ICC 500.





1604.5.1 Multiple occupancies. Where a building or structure is occupied by two or more occupancies not included in the same *risk category*, it shall be assigned the classification of the highest *risk category* corresponding to the various occupancies. Where buildings or structures have two or more portions that are structurally separated, each portion shall be separately classified. Where a separated portion of a building or structure provides required access to, required egress from or shares life safety components with another portion having a higher *risk category*, both portions shall be assigned to the higher *risk category*.

**Exception:** Where a *storm shelter* designed and constructed in accordance with ICC 500 is provided in a building, structure or portion thereof normally occupied for other purposes, the *risk category* for the normal occupancy of the building shall apply unless the *storm shelter* is a designated emergency shelter in accordance with Table 1604.5.





## **IRC**

#### SECTION R323 STORM SHELTERS

**R323.1 General.** This section applies to storm shelters where constructed as separate detached buildings or where constructed as safe rooms within buildings for the purpose of providing refuge from storms that produce high winds, such as tornados and hurricanes. In addition to other applicable requirements in this code, storm shelters shall be constructed in accordance with ICC/NSSA-500.







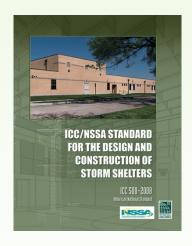
## **Application**

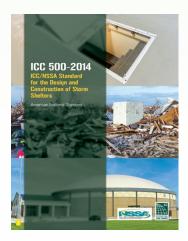
The purpose of the Storm Shelter standard is to provide design and construction requirements for 'safe rooms' that provide refuge from hurricanes and tornadoes.



## History/Development

- Started in 2002 as joint project for ICC and the National Storm Shelter Association (NSSA)
- First edition in 2008
- 5 year cycle
- Balances committee
- Open consensus process
- ICC has a commentary for this standard







# Types of storms

#### **Tornado**

#### Hurricane







## Hurricanes

- A cyclonic wind circulation of the atmosphere around a low pressure center surrounded by strong winds and thunderstorms.
- Form over warm water near the equator.
- Regionally know as hurricanes, typhoon or tropical cyclone





# The Saffir-Simpson Hurricane Wind Scale

Category	Sustained winds (mph)	Damage
One	74-95 mph	Very dangerous winds will produce some damage
Two	96-110 mph	Extremely dangerous winds will cause extensive damage
Three	111-130 mph	Devastating damage will occur
Four	131-155 mph	Catastrophic damage will occur
Five	greater than 155 mph	Catastrophic damage will occur



### **Hurricane facts**

#### **Hurricanes:**

- Hundreds of miles wide.
- Form only over warm ocean water.
- Last for days and sometimes well over a week.
- Produce rain and flooding in addition to powerful winds.
- Independent, self sustaining storm systems.
- Winds ranging from 74 to about 200 mph
- The hurricane season for the North Atlantic is June 1 through November 30.



### **Tornadoes**

- Storm systems that form on land due to pressure differences.
- Characterized by large rotating air columns, commonly shaped like funnels.
- Can reach speeds over 300 mph before dissipating.
- Most tornado deaths are from flying debris.





## The Fujita Scale

Scale	Estimated wind Speed (mph)	Average Damage Path Width (meters)	Potential damage
F0	40–72	10–50	Minor damage.
<b>F1</b>	73–112	30–150	Moderate damage.
F2	113–157	110–250	Considerable damage.
F3	158–206	200–500	Critical damage.
F4	207–260	400–900	Severe damage.
F5	261–318	1100 ~	Total Destruction.
F6	319+		Theoretical category. Immeasurable damage.

Note: the size of a tornado is not necessarily an indication of its intensity.



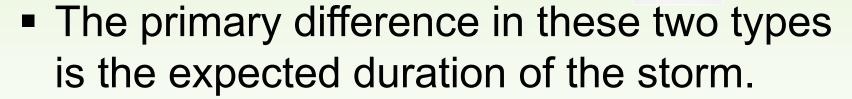
### **Tornado facts**

#### **Tornadoes**

- Rarely over a mile wide
- Usually form over land
- Usually last minutes, rarely a few hours
- Cause damage via wind and debris
- Dependent on a large storm to develop and keep going
- Winds range from 65 to about 300 mph
- Often have a condensation funnel.
- The tornado season runs from later winter through mid summer, however, tornadoes can happen all year.
- The strongest tornadoes have faster winds than the strongest hurricanes.

## Types of shelters

- Shelters used for hurricanes
- Shelters used for tornadoes



- Hurricane shelters 24 hours
- Tornado shelters 2 hours



# Types of shelters

# What requirements differ between hurricane and tornado shelters?

- Occupant density
- Sanitation
- Water supply
- Ventilation
- Emergency power
- Size/speed of flying debris





# Types of shelters

#### Community shelters

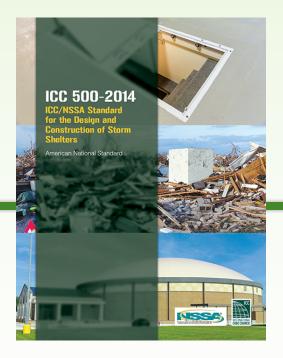
 Any shelter that is not a residential shelter

#### Residential shelters

- Limited to 16 occupants maximum
- •Limited to residence or small group of residences







#### ICC 500 - 2014

**Chapter 1: APPLICATION AND ADMINISTRATION** 

**Chapter 2: DEFINITIONS** 

Chapter 3: STRUCTURAL DESIGN CRITERIA

Chapter 4: SITING

Chapter 5: OCCUPANCY, MEANS OF EGRESS, ACCESS AND ACCESSIBILITY

**Chapter 6:** FIRE SAFETY

Chapter 7: SHELTER ESSENTIAL FEATURES AND ACCESSORIES.

Chapter 8: TEST METHODS FOR IMPACT AND PRESSURE TESTING.

**Chapter 9:** REFERENCED STANDARDS





# Application and Administration

# Scope, applicability and provisions for compliance

- For tornado and hurricane shelters
- Can be a separate structure or within another building
- Provides minimum requirements via alternative compliance paths
- Construction not addressed should comply with IBC



## **Occupancy Section 104**

- Shelters used for other purposes shall be the IBC Group for those occupancies.
- Dedicated facilities with >=50 occupants is Group A-3
- Dedicated facilities with <50 occupants is Group B</li>

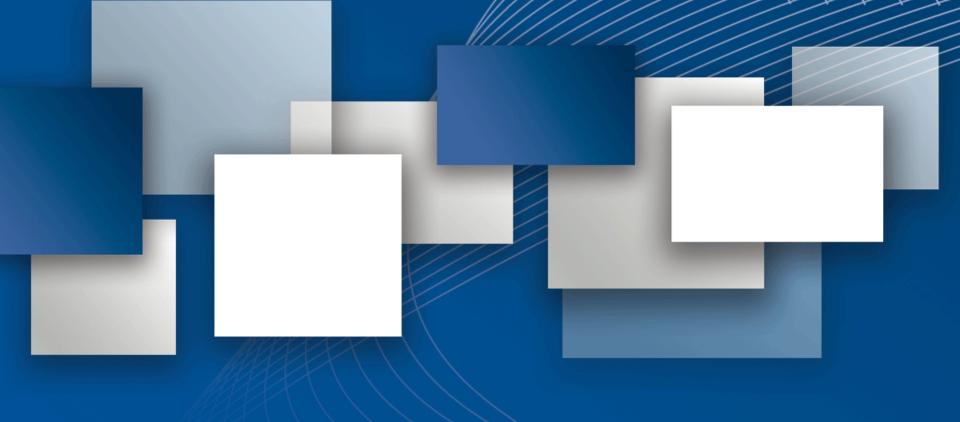


# Inspections, foundations, design loads

- The code official will inspect.
- Peer review
- Special inspections/Observations
- Construction drawings
- Labeling (FEMA P-361)







# **Chapter 2 Definitions**



Same as IBC Definitions.

**STORM SHELTER.** A building, structure or portions thereof, constructed in accordance with this standard, designated for use during a severe wind storm event, such as a hurricane or tornado.

**Community storm shelter.** Any storm shelter not defined as a "Residential storm shelter."

**Residential storm shelter.** A storm shelter serving occupants of dwelling units and having an occupant load not exceeding 16 persons.





### AREAS OF CONCENTRATED FURNISHINGS.

Fixed furniture or partitions

### AREAS OF UNCONCENTRATED FURNISHINGS.

Moveable furniture

### AREAS OF OPEN PLAN FURNISHINGS.

Moveable furniture and no walls











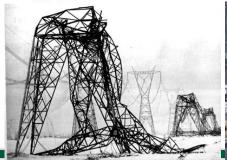
#### HAZARDS.

**Collapse.** Debris from wind damage to adjacent, taller structures that could fall onto the shelter.

**Laydown.** Nearby structures such as towers or large trees that could fall onto the shelter, if the shelter is within the laydown radius of the structure.

**Rollover.** Vehicles and small buildings, such as temporary classroom buildings, that could roll over due to extreme winds and impact the shelter.









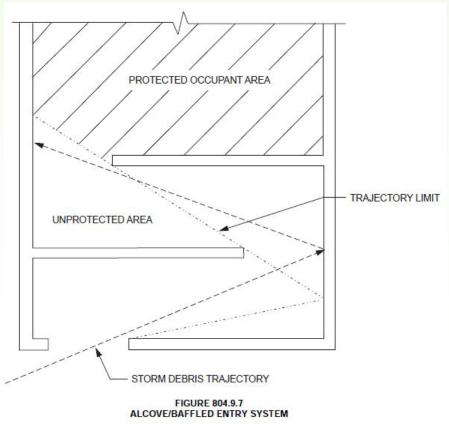


**IMPACT-PROTECTIVE SYSTEM.** A system or device such as a shutter, door or other device mounted on the inside or outside of the exterior wall of a shelter that has been demonstrated by testing to be capable of withstanding the impact of test missiles as detailed in this standard.

**REBOUND IMPACT.** The rebound impact by a test missile, or fragments thereof, on a portion of the shelter protective envelope after the test missile has impacted another surface of the shelter protective envelope.





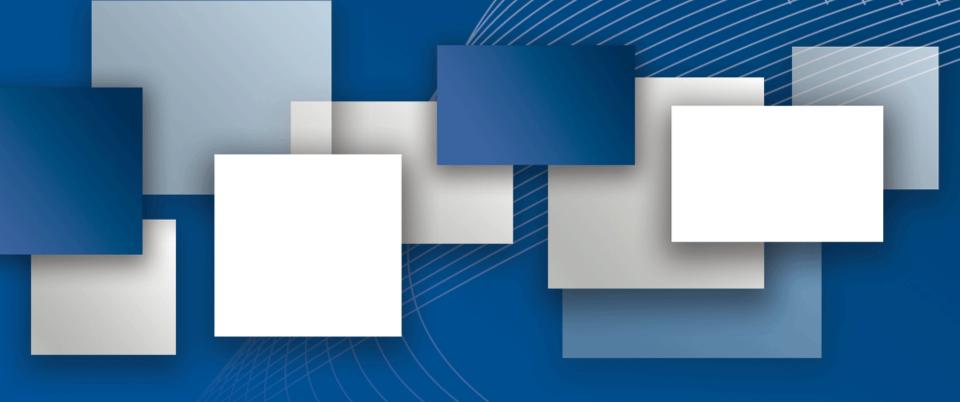


PROTECTED OCCUPANT AREA.

SHELTER ENTRY SYSTEM, ALCOVE. SHELTER ENTRY SYSTEM, BAFFLED.

SHELTER ENVELOPE. The protective walls, roofs, doors and other protected openings that are designed to meet the requirements of Chapter 3 to provide protection to occupants during a severe windstorm.





Chapter 3 – Structural Design Criteria Chapter 6 - Fire Safety



## **Application**

 Provides design requirements to resists high wind pressures and flying debris.







### **Application**

- Provide construction requirements for:
  - The main wind resisting structural system
  - Components and cladding.
  - Basic occupant life safety and health requirements



### **Structural Features**

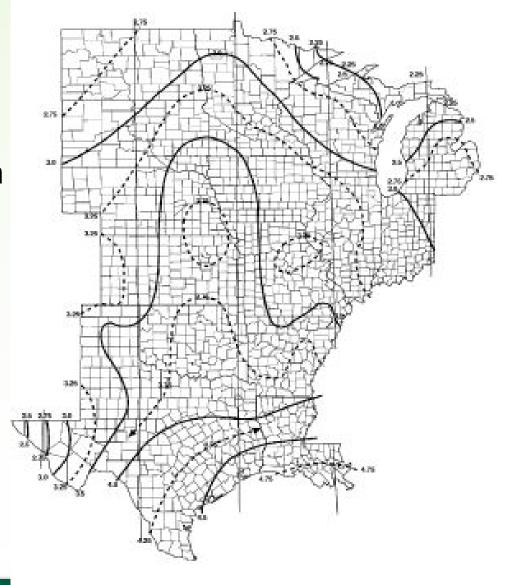
- Water loads
- Wind loads
- Debris
- Other concerns





#### Water loads

- Rain loads
  - 6" per hour in addition to rate in maps
- Hydrostatic loads
- Flood loads





#### Wind loads

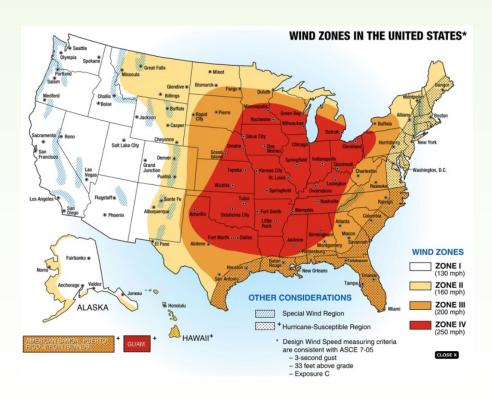
- Wind load contour maps
- Hurricanes



- Atlantic coast and Gulf of Mexico
- Hawaii, Puerto Rico, Guam and Virgin Islands
- Tornado



- Mid-west and eastern states
- Alaska, American Samoa, Guam, Hawaii, Puerto Rice, Virgin Islands





#### Wind loads

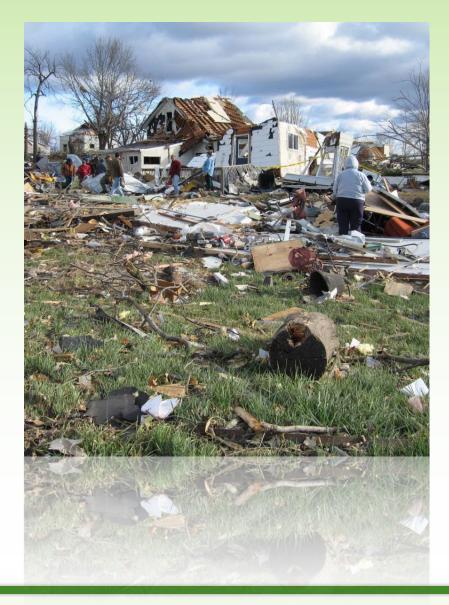
- Modifications to ASCE 7 Method 2
  - Wind directional factor, K<sub>d</sub>
  - Importance factor, I
  - Exposure category
  - Topographic effects, K<sub>zt</sub>
  - Enclosure classification
  - Atmospheric Pressure Change, APC





#### **Debris**

- Research based on compact, rod and plate type missiles.
- Test methodology for testing walls, doors, shutters, and windows for impact from flying debris
- The debris missiles expected for tornadoes is considerably higher than hurricanes





#### Other structural issues

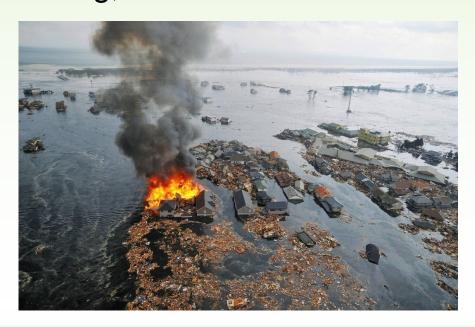
- Component design and testing;
- Weather protection;
- Enclosure within a 'host' building;
- Connection of the shelter to foundations or slabs;
- Penetration of the shelter envelope by systems and utilities.

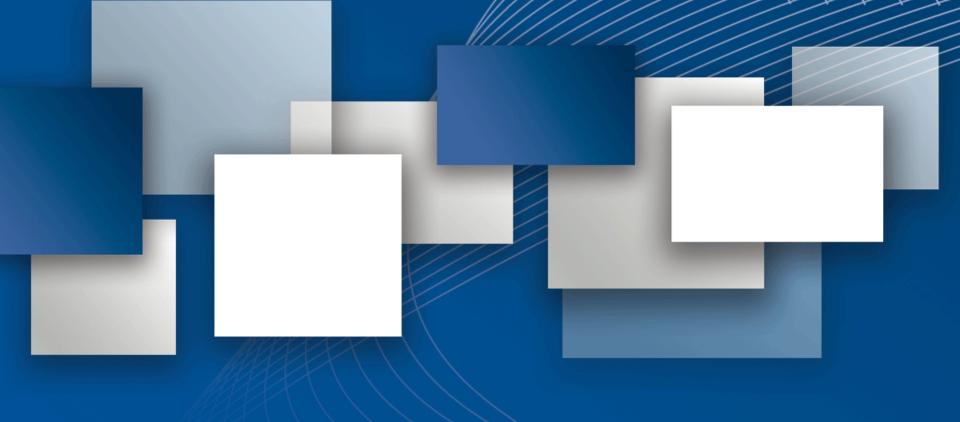


#### Other structural issues

Because fires often break out during or after a storm, where IBC requires fire barriers and horizontal assemblies with a fire-resistance-rating, where this is also a shelter wall or ceiling, it must be at least 2 hours.







# Chapter 4 Siting

#### **Travel distance**

- IBC says commercial tornado shelters at schools have to be within the building or less than 1000' from an exterior door of the building to the door of the shelter (IBC Section 423.4.2)
- ICC 500 says residential shelter have to be within the building or less than 150' from an exterior door of the home to the door of the shelter (ICC 500 Section 403)



## Flood provisions

- Both commercial and residential shelters have to be elevated to limit the chance of flooding
- Option differ based on if this is a tornado or hurricane, commercial or residential
- Hurricane shelter will consider storm surge and costal wave effects
- Considerations may include
  - 2' above the 100 year flood elevation and
  - Above the 500 year flood elevation
  - Above the highest recorded floor elevation



## Safety provisions

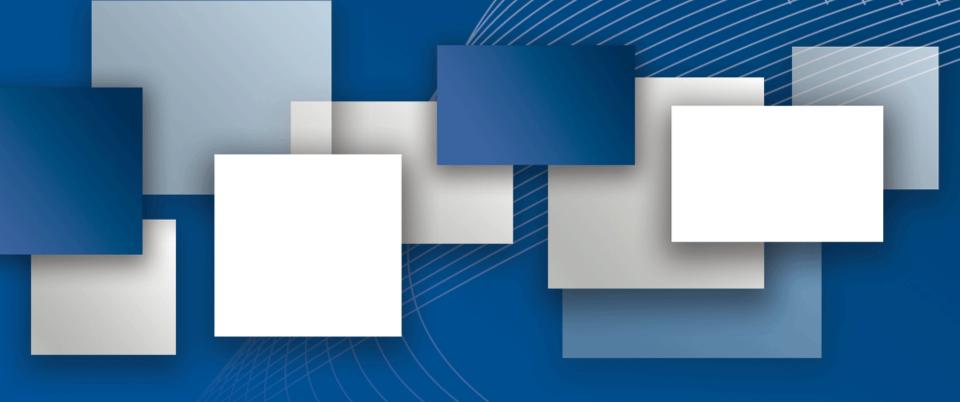
 Shelters must be protected from the possible release of any high hazard materials in the building

Shelters must not be located in Costal V zones

on in the Floodway.







Chapter 5 - Occupancy, Means of Egress and Accessibility
Chapter 7 - Shelter essential features and accessories



## **Application**

- Basic occupant life safety and health requirements include:
  - Accessibility
  - Means of egress
  - Lighting
  - Sanitation
  - Ventilation
  - Fire Safety
  - Minimum required floor space per occupants



#### **Essential Features**

- Occupant density
- Number of doorways
- Emergency escape
- Ventilation
- Potable water and sanitation
- Emergency features
- Location
- Accessibility





## **Occupant Density**

- Community shelters
  - Hurricanes
    - 20 sq.ft. per person
    - Wheelchair 20 sq.ft.
    - Bedridden 40 sq.ft.
  - Tornadoes
    - 5 sq.ft. per person
    - Wheelchair 10 sq.ft.
    - Bedridden 30 sq.ft.





## **Occupant Density**

- Residential shelters
  - One- and two- family residential shelters
    - Hurricanes 7 sq.ft. per person



- Tornadoes 3 sq.ft. per person
- Larger residential shelters
  - Hurricanes 10 sq.ft. per person



Tornadoes 5 sq.ft. per person



## Number of doorways & Emergency Escape

 Number of exits for primary occupancy during normal use, not the occupant load of the shelter



When a community shelter has a single exit, a 2<sup>nd</sup> emergency escape
 opening is required



#### Ventilation

- Minimum ventilation openings required
- Based on:
  - Tornado or hurricane shelter
  - Residential or community
  - Occupant load of community shelter greater than 50



## Potable water and sanitation facilities

- Toilet facilities higher for hurricane shelters due to length of stay
- Can use toilets within shelter if they can be converted for emergency mode
- Toilets can be chemical toilets.
- Hurricane shelters must have supply and storage for potable and waste water.



## **Emergency features**

#### Tornado shelters



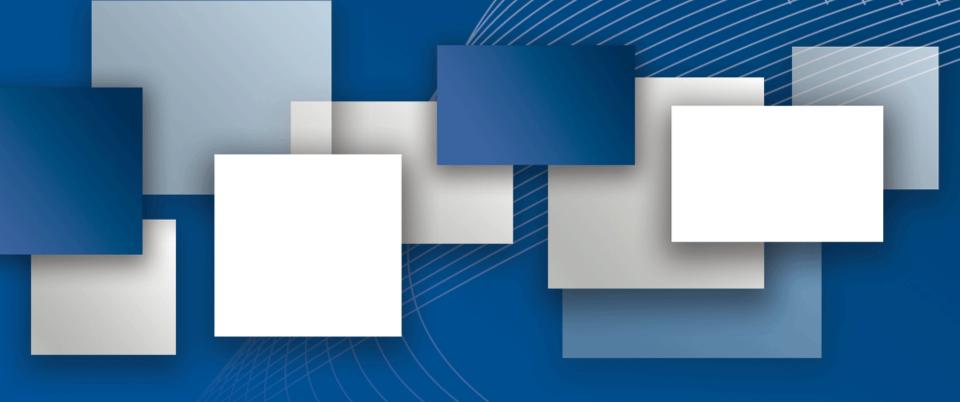
- Fire extinguishers, first aid kits
- Community shelter must have emergency lighting
- Hurricane shelters
- Fire extinguishers, first aid kits, emergency lighting
- Community shelters with greater than 50 occupants must have standby power and lighting



## **Location & Accessibility**

- Community shelters must be on an accessible route
- Residential shelters can be accessed by a stairway, ladder or alternating tread device

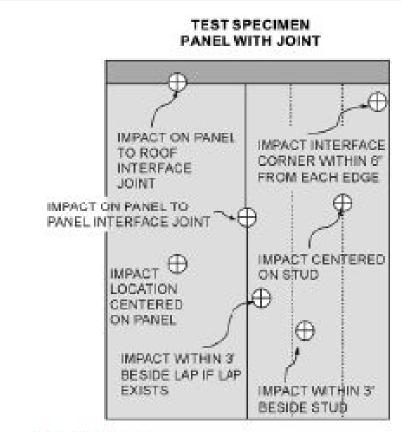




Chapter 8
Test methods for impact and pressure testing

## **Testing Protocol**

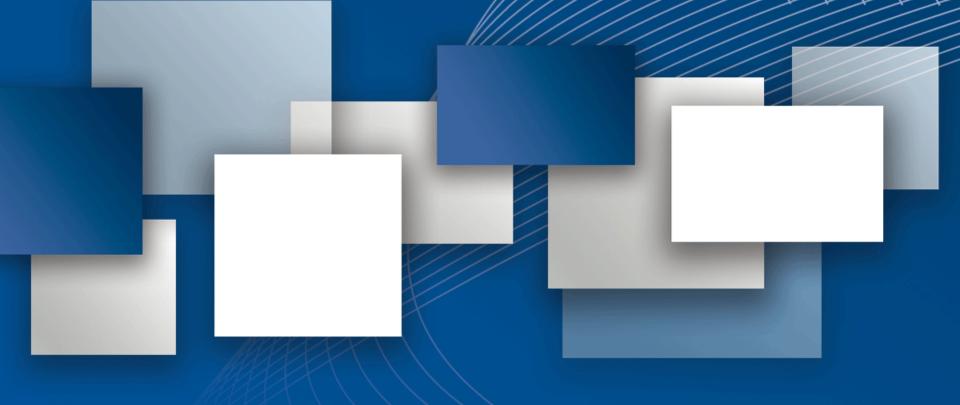
- Impact testing
- Pressure testing



For SI: 1 inch - 25.4 mm.

FIGURE 804.9.1(2)
PANEL OR FRAMED WALLS/ROOF





## Chapter 9 Referenced standards

#### Referenced Standards

- The full name of any standards referenced in the text, the edition and information on the promulgator are found in Chapter 6.
- If you look up a standard, you will also see the section where that standard is referenced.



## Summary

- Building codes require that buildings be able to withstand a "design" wind event.
  - Most tornado-prone regions, the building code design wind event is a wind event with 90 mph winds.
  - Hurricane-prone areas, design wind events in the code range from 90 to 150 mph.
- A tornado or extreme hurricane can cause winds much greater than those on which local code requirements are based.
- Having a home built to "code" does not mean that your home can withstand wind from an extreme weather event.



## Summary

- Home or small business owners should assess their risk and determine the best type of safe room for their needs.
- A safe room is the preferred method of wind protection in high-risk areas.
- IBC Section 423 does not require storm shelters in most occupancies, but does require compliance with ICC 500 if someone wants to build a shelter.
- Storm shelters are required in schools and buildings housing people we need for emergency response after the storm



## Summary

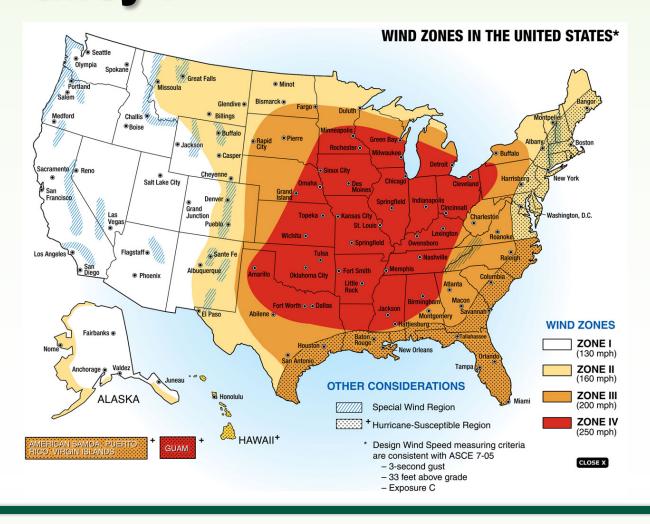
- Having a shelter can reduce injury and death.
- Evacuation plans must be made known and practiced.







## Is your area in tornado alley?







## Would a tornado shelter be required?







## Would a hurricane shelter be required?







#### Your comments?



- What in this section might you be able to use in your own work?
- What could you best share with others in as part of a collaborative effort?

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