ICC-NSSA Storm Shelters Webinar

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Presenter

- Ernst W. Kiesling, P.E., PhD
- Executive Director, National Storm Shelter Association
- Research Professor, National Wind Institute, Texas Tech University
We will discuss

Three courses available on the website
www.ICCCampus.org

- SURVIVING TORNADOS AND HURRICANES
- ICC RESIDENTIAL SAFE ROOM DESIGN AND CONSTRUCTION
- COMMUNITY SAFE ROOM DESIGN AND CONSTRUCTION

Webinar Purpose

- Online Courses provide overviews of:
  - Nature of severe winds, particularly tornadoes and hurricanes
  - Wind characteristics
  - Design fundamentals for residential and community shelters
  - Standards for design, including NSSA/ICC 500, ASCE-7
  - FEMA guidelines including FEMA P320 and FEMA P361

Objectives

- Upon Completion, participants will be better able to:
  - Describe the basics of storm shelter design.
  - Differentiate between the wind characteristics of hurricanes and tornadoes.
  - Discuss standards and guidelines of safe storm shelter design.
  - Identify essential features of storm shelters, manufactured and site-built.
## Course Benefits

- Explain effects of high winds on structures
- Assess the need for a storm shelter
- Develop a preliminary cost estimate
- Apply the provisions of NSSA/ICC 500 and FEMA P361
- Give advice on choosing a producer to provide a safe shelter

## Genesis of ICC Online Courses

- **FEMA funded HMGP project**
  - Administered by Texas Department of Community Affairs
  - Conducted by National Storm Shelter Association (NSSA)
- **Conducted workshops on**
  - General information on storm shelters
  - Design of residential storm shelters
  - Design of community storm shelters
- **Subcontracted with FLASH to video workshops**
  - FLASH subcontracted with International Code Council (ICC)
    - Digitize material on videotapes
    - Place on ICC Online server
    - Produce this webinar

## Overview of ICC Online Courses

- **Structural design criteria**
- **Siting**
- **Size limitations**
- **Construction materials**
- **Anchorage**
- **Access/egress**
Benefits of Shelters

- Save lives
- Reduce anxiety
- Produce economic benefits
  - Increase resale value
  - Avoid costs of evacuation from hurricanes
  - Decrease business interruptions

Design as a Process

- Understand benefits of storm shelters
- Perform risk assessment
- Perform design functions as per standards and guidelines
- Estimate costs
- Establish criteria for selecting shelter producers

Design Requirements

- Storm shelter must:
  - Possess structural integrity to withstand wind induced pressures
  - Possess hardness to prevent perforation from windborne debris
  - Be aesthetically compatible with surroundings
  - Be economical
Effects of High Winds

Wind induced pressures produce tendency to:
- Overturn
- Slide
- Fail at connections
- Wind induced pressures are generally outward
- Openings created by and doors or broken windows cause ballooning effect

<table>
<thead>
<tr>
<th>Tornadoes</th>
<th>Annually: 1,000</th>
<th>Injuries: 1,500</th>
<th>Deaths: 80</th>
<th>$1.1 billion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hurricanes</td>
<td>Annually: 2</td>
<td>Injuries: 60</td>
<td>Deaths: 17</td>
<td>$5.2 billion</td>
</tr>
</tbody>
</table>

Explosion from APC? No!

House Failure due to Wind Pressures

Tornadoes and Hurricanes:
- Tornadoes: 1,000 annually, 1,500 injuries, 80 deaths, $1.1 billion
- Hurricanes: 2 annually, 60 injuries, 17 deaths, $5.2 billion

International Code Council
Shelter types

- Indoor, Outdoor
- Aboveground, belowground
- Site-built, Manufactured
- Materials
  - Concrete
  - Steel
  - Fiberglass
  - Timber

Multiple Purposes

- Storm Protection
- Closet, bathroom, pantry, hobby room, ...
- Storage of valuables, fire protection
- Protection from intruders

Risk Assessment

- Perform risk assessment
- Teach homeowner to perform risk assessment
  - Elements include location, frequency/intensity
  - Examples of damage scale for Fujita rating
  - Explanation of Saffir-Simpson Hurricane scale
Risk Table

<table>
<thead>
<tr>
<th>NUMBER OF TORNADOS</th>
<th>WIND ZONE</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Low Risk</td>
<td>LOW RISK</td>
</tr>
<tr>
<td>Moderate Risk</td>
<td>LOW RISK</td>
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<tr>
<td>High Risk</td>
<td>LOW RISK</td>
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<td>HIGH RISK</td>
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</tbody>
</table>

Low Risk
Need for an extreme-wind safe room is a matter of homeowner or small business owner preference.

Moderate Risk
Safe room should be considered for protection from extreme winds.

High Risk
Safe room is the preferred method of protection from extreme winds if the home or small business is in a hurricane-susceptible region.

Cost Estimate

- Primarily for site-built shelters
- Design parameters that affect cost
  - Type
  - Size
  - Location
  - Quality of finish
  - New construction or retrofit
- Designs best suited for given application

Materials costs

- Basic information provided on cost of materials such as:
  - Reinforced concrete masonry (CMU)
  - Reinforced concrete construction
  - Wood frame with plywood/steel sheathing
  - Reinforced insulating concrete forms (ICF)
Shelter type selection

- Several issues affect choice of shelter type:
  - Suitable location in the house, basement, or garage
  - Mobility issues of family members
  - Single use or multi-purpose such as closet, pantry, recreational room
  - Flood threat

We Have Standards To Guide Design

- FEMA 361
- FEMA 320
- ICC-500
- ASCE 7-05
- I-Codes

NSSA/ICC 500 – 2008

- Only ANSI approved Consensus Standard
- Adopted by some states, e.g., Alabama
- Covers all types and sizes of shelters
- Comprehensive on pressure and debris impact testing
- Being revised in 2014
### FEMA P320-2008
- Primarily for residential shelters
- Contains prescriptive designs
  - Debris impact tested
  - Engineered to meet design criteria
  - FEMA’s “best seller”
- Being revised 2014

### FEMA P361
- Covers community and residential shelters
- Comprehensive guideline, not a standard
- Contains extensive commentary helpful to designers
- Must be followed to qualify for FEMA grants
- Deals with human factors issues

### Differences Between NSSA/ICC 500 and FEMA P361
- Differences in debris impact criteria for hurricanes
- FEMA P361 disallows building in floodplain
- Differences being reconciled in 2014 revisions
Testing Requirements

- ICC 500 is explicit; referenced in FEMA P361
- Failure criteria
- Test procedures prescribed in ICC 500
  - Walls
  - Doors
  - Roofs
  - Protective devices
- Examples are given

Launcher

Some Test Results
Door Tests Important

- Static pressure tests required
- Dynamic pressure tests can be circumvented by proper static pressure tests
- Cyclic testing may be required for hurricane applications
- Single specimen may be used for both pressure and impact tests

Door Test Requirements

- Debris impact magnitudes and locations are specified
- Double doors with or without mullions must be tested
- Alcove or baffled entry systems might need testing
  - For primary or secondary impacts
  - Shelter floor area must be defined and marked

Community Shelters

- Appropriate design fundamentals
- Provisions of ICC 500 and FEMA P361
- Design through practical examples
Rating Scales

**Tornadoes**
- Enhanced Fujita Scale
  - EF 1 – EF 5
  - 28 indicators vs. 4 for F scale
  - EF scale yields slightly lower wind speeds than F scale
  - Process for establishing scale is interactive

**Hurricanes**
- Saffir-Simpson Scale
  - Five categories 1-5
  - Maximum wind speeds generally less than for tornadoes
  - Wind speeds usually measured

Community Shelters

- An example of community shelter in Alabama
- State law, Governor’s support
- Elements of ICC 500 and FEMA P 361 are emphasized
- Applications are demonstrated through practical examples

Storm Shelter Fundamentals

- Types of wind hazards for tornadoes and hurricanes.
- Effects of high winds on buildings.
- Types of storm shelters available.
- Features of a storm shelter.
- FEMA Designer Checklists
Types of Wind Hazards:

- Tornado
- Hurricane

Community Shelter Examples
Shelter Characteristics

- **Space requirements**
  - **Residential shelters**
    - One or two family dwellings
    - Having an occupant load not exceeding 16 persons
    - Occupant density
      - Tornado – minimum 3 or 5 sq. ft. per person
      - Hurricane – 7 or 10 sq. ft. per person
  - **Community shelters**
    - Occupant density
      - Tornado – 5 sq. ft. per person
      - Hurricane – 20 sq. ft. per person
- Adjustments needed for wheelchair, bedridden persons

Wind Loads on Structures

- ASCE 7 is standard for determining wind loads
- Wind-induced pressure is a function of $V^2$
- Loads applied to all components
  - Walls
  - Roofs
  - Doors
  - Opening protective devices, e.g., shutters, skylights
- Wind speed design maps are given in ICC 500 for
  - Tornadoes
  - Hurricanes

Other Load Considerations

- **Enclosure classification**
  - Enclosed with venting
  - Partially enclosed
- **Atmospheric Pressure Change (APC)**
  - Accounted for by enclosure classification and Internal Pressure Coefficient (0.31 or 0.55)
**Common Wall Materials**

- Reinforced brick cavity
- Reinforced CMU’s or ICF’s
- Reinforced Concrete
- Wood frame with steel and plywood wall sheathing

**Door Testing Critical**

- Using tested doors is critical
  - ICC 500 Standard specifies test protocol
  - Second door or escape hatch is required

- Door(s) must swing outward in community shelters
  - Adds safety from debris impacts
  - Causes concern among some concerning debris blockage

**Effects of Building Characteristics**

- Effective variables
  - Height
  - Shape
  - Roof design
    - Gable
    - Pitched
  - Location, exposure category

- Failure tendencies
Permitting Process

- Application
- Plan Review
- Construction
- Inspection/approval
- Other details

General Design and Drawings

- FEMA Designer Checklist
- Framework for Using Checklist

- FEMA 361, Appendix B.1 for Refuge Areas, not safe rooms
- Plans and submittals
- Structural considerations
- Non-structural considerations, e.g., ventilation
  - Passive
  - Mechanical

Occupant Density, Sizing

- ICC 500 & FEMA P 361 explicit and consistent
- Shelter use and occupant needs taken into account
Structural Isolation

- Shelter is designed to withstand wind induced pressures and debris impacts
- Connections to other buildings or components should be minimal
- Revisions in NSSA/ICC 500-2014 will be specific

Flood Considerations

- Shelters/safe rooms shall not be built in flood-prone areas!
- FEMA 361 gives extensive guidance
- Emergency access as well as drowning must be considered.
- Storm surge must be considered in coastal areas

Summary of Online Courses

- Courses emphasize principles of storm shelter design
- Point to basic design criteria
- Identify design standards and guidelines available
- Are not intended to be used as design manuals
Contact Information

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