TORNADO SHELTER DOORS:  
PERFORMANCE REQUIREMENTS, DEMONSTRATION  
Presented to  
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by  
Ernst W. Kiesling, PE, Ph.D., Research Professor  
National Wind Institute, Texas Tech University  
Executive Director  
National Storm Shelter Association (NSSA)  
Collaborator, Principal Investigator  
Larry Tanner, PE, Director  
Debris Impact Facility, Texas Tech University  

What's the problem?  
- Inadequate, untested doors are sometimes installed in residential above ground site-built tornado shelters  
- Buyers might be unaware of the consequences of installing inadequate door  
  - Performance demonstration will create awareness  

What are the consequences?  
- Door becomes a weak link of shelter  
  - Door is vulnerable to failure from  
    - Debris impact  
    - Wind-induced pressure  
- Occupants are led to false sense of security and are at risk in a high intensity tornado  
  - Defeats an important reason for having a storm shelter  

Example: Mayflower, AR  
Brought new awareness to importance of appropriate door selection  

Mayflower: a "Perfect Storm" situation  
- Installation of an inadequate, untested door  
- Inward swinging, away from the stops  
- Debris impact at critical location  
  - Unusual missile though not thought to be extraordinary  
- Occupants in contact with door or close to it  

Consequences:  
- One occupant killed, apparently from head injuries  
- Second occupant injured with broken bones, lacerations  

Why do consumers buy untested doors?  
- Cost  
  - Tested door system (door, frame, hardware) might cost $2,000  
  - Lightweight look-alike available for less, say $750  
- Builder's allowance in new home might be insufficient  
- Availability, lead time to order  
  - Retail stores not likely to stock tested door systems  
    - Small market for expensive inventory  
    - Delivery time for special orders requires weeks  
  - Schools, commercial buildings usually designed by architects  
    - Specify doors as part of plans, well in advance of construction  
    - Lead time not the same challenge as in residential construction  
- Lack of information  
  - List of tested door systems not readily available
How will our demonstration help?

- Better informed users of shelter doors
  - Importance of using proven, tested doors
  - Visualization, understanding of failure modes
- List of tested door systems available
  - Manufacturers and models, hardware
  - Advocacy for clear labeling of tornado shelter doors

What will we do?

- Widely disseminate results
- Help distribute FEMA Fact Sheet re Residential Tornado Safe Room Doors
- Advocate manufacturers for clear labeling of tornado safe room doors
  - Hurricane rated doors comprise different family

How will we disseminate results?

- Publications
- Presentations at meetings
- Media presentations
- Websites – NSSA.cc; wind.ttu.edu
- Facebook

NSSA/TTU
Door performance demonstration

- Phase 1. Perform forensic analysis on failed Mayflower door
- Phase 2. Take high-speed videotape photos of successful and failed performance
  - Pressure, Debris Impact
  - Publish list of successful performance
- Phase 3. Show ways to improve performance of inadequate doors, already installed

Characteristics of Mayflower door

- Good quality hollow-core steel door, honeycomb core
  - 3' wide x 6'8" high x 1-3/4" thick
  - 18 gauge steel skin; 16 gauge edge channel x 1-11/16" x 5/8"
  - Lapped, projection-welded edges, 3" o.c. top and bottom, 5" o.c. on edges
- 8" concrete masonry walls; 18 gauge wrap-around frame, grout filled without wall anchorage
- Three Residential Grade dead bolts and a latch set

Demands on tornado shelter door

- Withstand wind-induced pressures
  - Inward or outward
- Withstand wind-borne debris
  - Prevent perforation
  - Prevent structural failure
- Important to test door system as it will be installed
  - Door
  - Frame
  - Hardware
**NSSA/TTU Test Progression**

- Demonstrate undesired and desired behavior
- Begin with demonstrating expected failures, progress to successful performance
  - Wooden door systems
  - Steel-clad wooden doors
  - Thin-clad hollow-core steel doors, lightweight internal stiffening
  - Some are good doors, not intended for tornado shelter application
  - Heavy steel-clad hollow core steel doors, ample internal stiffening
  - Will pass debris impact test and pressure test

**Demo 1: SPS wood framed 26 ga. metal clad**

**Door characteristics**
- Size: 3' x 6'8" x 1 ¾"
- SPS ¾" wood frame
- Hardware: Std. residential
  - Deadbolts (3)
  - Lockset
  - Hinges (3)

**Door failed under pressure**

**We Test for both pressure and Debris impact**

Typically test for pressure first followed by debris impact test.

**Demo 1: SPS wood framed 26 ga. metal clad**

**Demo 1: SPS wood framed 26 ga. metal clad slow motion**

**Demo 1: SPS wood framed 26 ga. metal clad full speed test**
Demo 2: Solid wood composite 6-panel door
Hurricane rated to Dade County TAS 301/203

Door characteristics
- Door failed under pressure
- Size: 3' x 6'8" x 1 ¾"
- Frame: 16 ga. Hollow metal (HM)
- Hardware: Std. residential
  - Deadbolts (3)
  - Lockset
  - Hinges (3)

Demo 2: Solid wood composite 6-panel door
Hurricane rated to Dade County Pressure Test

Door characteristics
- Door failed under impact
- Size: 3' x 6'8" x 1 ¾"
- Frame: 16 ga. Hollow metal (HM)
- Hardware: Std. residential
  - Deadbolts (3)
  - Lockset
  - Hinges (3)

Demo 2: Solid wood composite 6-panel door
Hurricane rated to Dade County Slow Motion

Door characteristics
- Door failed under impact
- Size: 3' x 6'8" x 1 ¾"
- Frame: 16 ga. Hollow metal (HM)
- Hardware: Std. residential
  - Deadbolts (3)
  - Lockset
  - Hinges (3)

Demo 3: Hollow Metal Door with Open-cell Styrofoam core, 16ga.

Door characteristics
- Door failed under impact
- Size: 3' x 6'8" x 1 ¾"
- Frame: 16 ga. Hollow metal (HM)
- Hardware: Std. residential
  - Deadbolts (3)
  - Lockset
  - Hinges (3)
Demo 3: Hollow Metal Door with Open-cell Styrofoam core, 16ga. Impact Test

Door characteristics
- Size: 3' x 6'8" x 1 ¾"
- Frame: 16 ga. Hollow metal (HM)
- Hardware: Std. residential Deadbolts (3) Lockset Hinges (3)

Door PASSED under impact

Demo 4: Hollow Metal Door with honey-comb core, 16ga. Impact Test

Recommendations to consumers
- Allow ample time (4 – 6 weeks) for procurement
- Find a supplier of commercial products, make it clear that you want a tornado storm shelter door system
  - Includes hardware: frame, latches, hinges
- Look for a manufacturer’s label or specification as tornado door system
- Expect to pay a significant price for the door

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For more information

Contact:
- Larry Tanner
  - Larry.Tanner@ttu.edu
  - 806 834-2320
- Ernst Kiesling
  - Ernst.Kiesling@ttu.edu
  - 806 834-1931