Background and History

CONCEPTUAL PHASE

1970s

- After homes are destroyed by violent tornadoes, investigators continue to find small interior rooms that survive.
- Dr. Ernest W. Kiesling of Texas Tech University (TTU) conceives the idea of hardening a small interior room.
- To design this interior room, researchers study the wind forces (speed) and the type of airborne debris (called missiles) that must be stopped. Quick access to a shelter and cost are also important considerations.
- Based on observed tornado damage and engineering analysis, TTU determines that tornadic wind speeds, once estimated as high as 600 mph, have much lower wind speeds. A wind speed of 250 mph is used or shelter design.

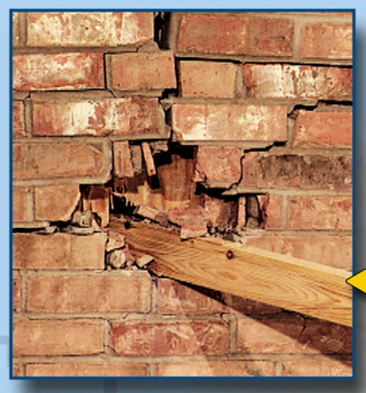
Xenia, OH, tornado, 1974. This is not a shelter but an interior room which survived the tornado even though the rest of the residence was destroyed.

TESTING PHASE

1980s

- Researchers Dr. Joseph E. Minor and Dr. Kishor C. Mehta develop preliminary shelter designs funded by the Defense Civil Preparedness Agency (a forerunner of FEMA).
- Dr. James R. McDonald develops a missile impact facility that can launch large missiles at high speeds. Walls, roofs and doors can now be consistently tested.
- TTU develops construction details for in-residence shelters that are available to the public.

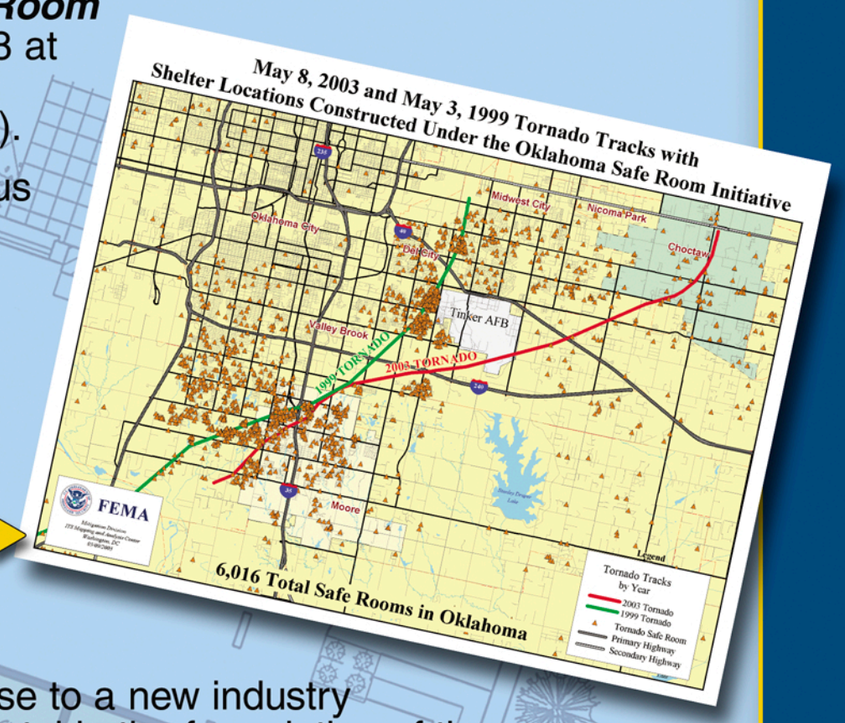
The new debris launch facility allows for a greater range of motion of the barrel and more accurate missile impact.



Design missile is 15 lb 2x4 traveling at 100-mph. Two laser timing gates provide verification of the recorded missile speed.

1990s

- FEMA studies the technical and economic feasibility of in-residence shelters. Pressure and impact tests are conducted for door structure and hardware. Additional safe room designs are developed and tested.
- In 1997, after the Jarrell, TX, tornado, a national news story brings attention to the in-residence shelter. Wind Engineering Research Center personnel receive over 1,000 requests for shelter plans within a week.
- The booklet, **FEMA 320, *Taking Shelter from the Storm, Building a Safe Room Inside Your House***, is published and introduced to the media in August 1998 at the FEMA National Tornado Forum. The second edition, published in August 1999 incorporates a design for a shelter using insulated concrete forms (ICF).
- In May 1999, an outbreak of tornadoes ravages Oklahoma City and numerous counties in Oklahoma and southern Kansas. Two people survive in an above-ground, reinforced concrete shelter located in the path of the tornado. The President urges families to consider incorporating in-residence shelters when they rebuild their homes.
- Documented efforts of public, private, and residential initiatives are viewable online at FEMA's Safe Rooms and Community Shelters website [**http://www.fema.gov/mit/saferoom**].



Map depicts two tornado tracks occurring in 1999 and 2003. Between this period 6,016 safe rooms were constructed to protect residents through the Oklahoma Safe Room Rebate Program.

CONTINUAL TESTING AND IMPLEMENTATION

NOW

- The success of the above ground in-residence concept in Oklahoma gives rise to a new industry of shelter manufacturers across the nation. Texas Tech University is instrumental in the formulation of the **National Storm Shelter Association (NSSA)** in order to provide an industry standard of quality consistent with Texas Tech and FEMA guidelines.
- In 2000, FEMA publishes **FEMA 361**, ***Design and Construction Guidance for Community Shelters***, which is used to design community shelters in apartment complexes and schools.
- FEMA publishes multiple case studies and best practices focusing on statewide safe room initiatives and community shelters in public schools, emergency communication operations centers, hospitals, and public areas.
- **FEMA 431, *Tornado Protection: Selecting Refuge Areas in Buildings***, published in 2003 presents guidance for building administrators, architects, and engineers to select the best available refuge areas.
- Several Federal, state, and local governments provide funding support and create educational initiatives for both residential and community shelters.
- Over 345,000 copies of **FEMA 320, *Taking Shelter from the Storm, Building a Safe Room Inside Your House***, have been distributed.
- FEMA is currently monitoring the International Code Council (ICC) Storm Shelter consensus standard that will provide design and construction guidance for residential and community shelters. This new standard should be available for adoption in the summer of 2006.

FEMA