Education Modules to Stimulate Public Awareness for Storm Shelters

Hector Estrada, Tomás Quintero

Civil Engineering Program
Texas A&M University – Kingsville

Ernst Kiesling

Department of Civil Engineering
Texas Tech University

Abstract

Safe rooms, or in-home storm shelters, are fast becoming integral components to households in extreme-wind prone areas such as tornado alley and the hurricane susceptible coastlines of the United States. The main purpose of these storm shelters is to protect its human occupants during extreme-wind events, not to protect possessions. For this reason, shelters tend to be relatively small, thereby occupying only a fraction of the floor plan of the home. Because of their size, their assimilation into new and existing constructions is relatively simple and inexpensive. While human losses to extreme-wind events are lower (under 100 per year[7]) than those associated with highway traffic accidents (over 40,000 per year[6]), the uncertainty and devastation associated with these natural disasters make them among the most terrifying experiences known to man. A safe room, though, has the potential for alleviating people's anxieties when they find themselves in the path of a storm.

This paper represents the culmination of a summer research internship at the Wind Science and Engineering Center at Texas Tech University. The primary objective of this research was to produce ideas to help publicize the concept of storm shelters. Effective terminology, illustrations, and other media were employed in the development of these shelter awareness modules.

Introduction

When disaster strikes, the news media is quick to report of any damage, significant or otherwise, inflicted on a community's infrastructure, emphasizing the victims of the disaster. Car wrecks, terrorist acts, building fires: each of these types of tragedies penetrates the American consciousness and arouses a fearful emotional response. It is natural disasters, however, that incite the most fear in people. While human losses to extreme-wind events are lower (under

100 per year[7]) than those associated with highway traffic accidents (over 40,000 per year[6]), the uncertainty and devastation associated with these natural disasters make them among the most terrifying experiences known to man. A safe room, though, has the potential for alleviating people's anxieties when they find themselves in the path of a storm. Safe rooms, or in-home storm shelters, are fast becoming integral components to dwellings in extreme-wind prone areas such as tornado alley and the hurricane susceptible coastlines in the United States. This suggestion is one of the foremost principles championed by researchers at Texas Tech University.

In the summer of 2004, a group of students along with a fellow professor from Texas A&M University – Kingsville, heretofore referred to as TAMUK, were invited to work at Texas Tech University's Wind Science and Engineering Centre (Center) in Lubbock, TX. Each student was assigned a different project, including research in aspects of wind engineering related to atmospheric science and embarking on storm chases throughout the Midwestern United States. Two students and the professor became involved in research related to different aspects of storm shelters, including the development of presentation modules to increase public awareness of the potential benefits of storm shelters.

The project that this paper addresses concerns the storm shelter awareness modules that Mr. Tomás Quintero and Dr. Hector Estrada, both of TAMUK, developed under the guidance of Dr. Ernst Kiesling. The primary objective of this research was to produce ideas to help publicize the lifesaving characteristics of storm shelters. These ideas were manifested primarily through PowerPoint presentations. These presentations seek to educate various audiences about the importance and benefits of storm shelters. The presentations developed were focused to two core audience groups: the General Public and Builders and Contractors. These groups, it was decided, are ultimately those that stand to benefit the most from learning about lifesaving characteristics and other benefits of storm shelters, in both tornado alley and hurricane-prone regions of the United States. In each presentation, a variety of photographs were featured that clearly indicated the depth of the destruction inherent in extreme wind events, their risk factors, shelter design requirements, successful applications, and benefits of widespread shelter use.

What we sought to convey in these presentations is that extreme wind events, though their occurrence is rare, are to be thought of as life-threatening incidents. Also, because of their high unpredictability, these events incite severe anxiety to those threatened. In fact, each year, over <u>three billion</u> person-hours are spent under severe weather watches[4]. Though one may live in Oklahoma or Kansas and not be affected by a tornado one year, he or she may very well become a victim in any year to come, and in some cases you may become a victim more than once in a lifetime as depicted in Figure 1. Regardless of circumstances, a safe room has the potential for easing people's restlessness and saving their lives when they find themselves in the path of a storm.

Genesis of Shelter Development

Post-storm documentation studies conducted by Texas Tech University revealed that occasionally a small interior room of a residence remained standing even when surrounding buildings were destroyed. It was reckoned that such rooms could be designed to offer a very high degree of occupant protection if additional stiffening and hardening were provided to increase structural integrity and debris impact resistance. Hence, the concept of the In-Residence shelter was born. The first publication of the concept appeared in the *Civil Engineer* magazine[5] in 1974.

Because of limited resources and manpower, development efforts continued at a low level for a number of years. Few people outside the research community knew of the concept. Some people were skeptical that protection from tornadoes could be provided aboveground. Public interest exploded with a Dateline NBC program following the 1997 Jarrell, TX tornado. The program documented the total destruction of a residential sub-division outside Jarrell and then featured photos of debris impacts on shelter components and illuminated the concept of the above-ground storm shelter. FEMA further popularized the concept by publishing FEMA 320, a prescriptive shelter design standard[2]. The booklet served well in quality control in the large number of shelters built under an incentive grant program initiated in Oklahoma after the Oklahoma City area tornadoes, (see Figure 1). In order to qualify for an incentive grant, homeowners were required to build according to the prescriptive designs of FEMA 320 or to have shelters tested for debris impact resistance and to have designs stamped by a professional engineer. Quality issues surfaced, especially in manufactured shelters, which are not covered in FEMA 320. A group of conscientious manufactures formed the National Storm Shelter Association and established its purpose: to foster quality in the shelter industry.

In announcing the shelter incentive grant program in OK City, FEMA Director Witt and President Clinton said schools ought also to have shelters. Little was available to guide designs of public or "community" shelters. Then a document entitled "National Performance Criteria for Tornado Shelters" was developed. It was incorporated into FEMA 361[3]. While FEMA was written for tornado criteria, the designs are being used (conservatively) for hurricanes as well.

Overview of Extreme Wind Events

Extreme wind events are a product of the Earth's natural processes. Unfortunately, these events can be difficult to predict, and once born, they are difficult to judge in terms of intensity, duration, and path. Extreme wind events are defined as storms, hurricanes, and tornadoes. Each of these not only consists of wind, but they also have the potential to carry with them a great deal of precipitation. It may be argued that hurricanes are the most threatening natural disaster due to the intense wind speeds they harbor as well as the great deal of precipitation that accompanies them. Unlike tornadoes, hurricanes cover a large area ranging from small, five-mile diameter, to a larger than 100-mile diameter. The damage produced by hurricanes is far more widespread than that of tornadoes or other storms. However, the most terrifying of all the extreme wind events are tornados because of the unpredictability of their path and the horrific destruction they produce.

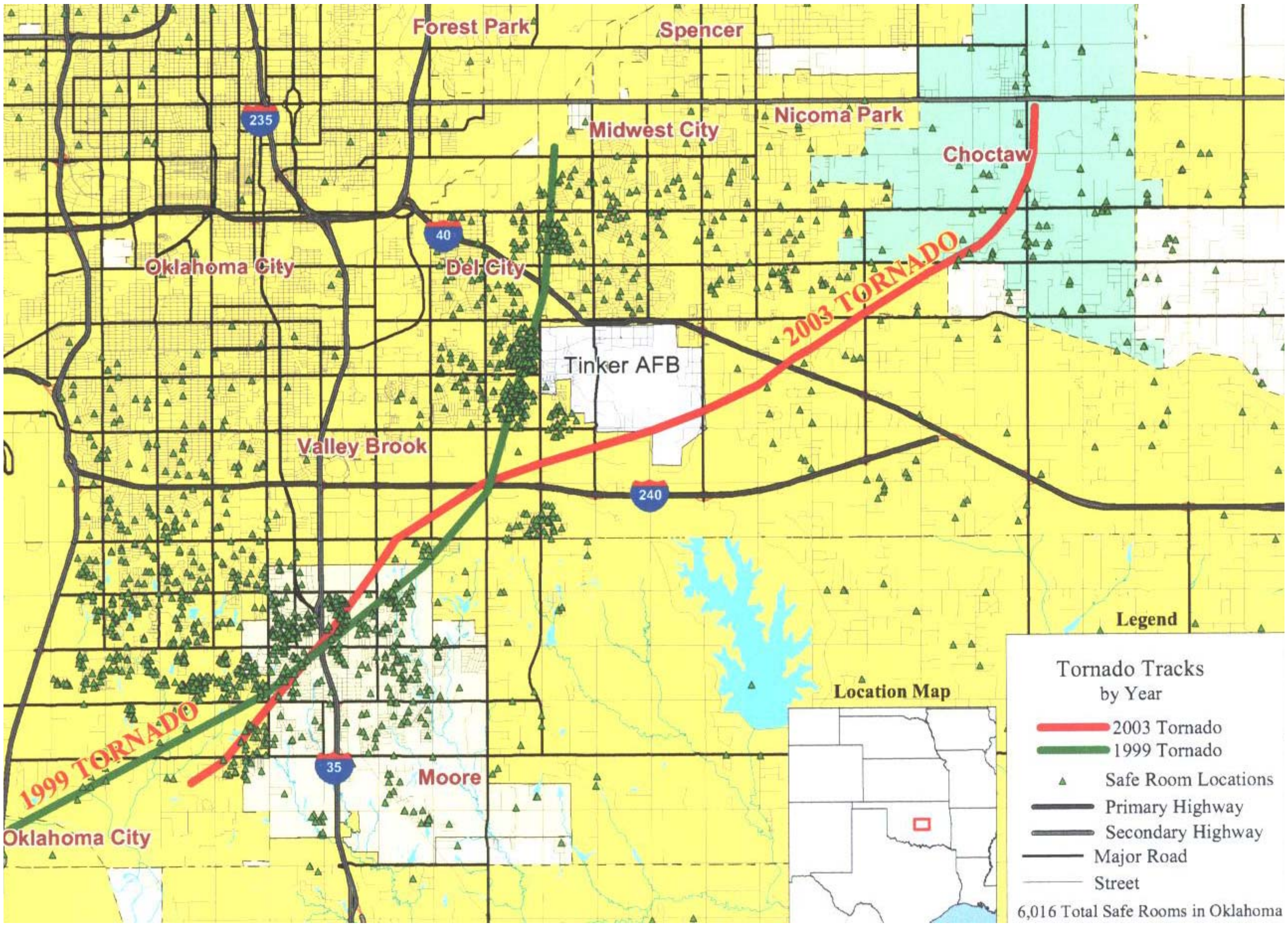

Figure 1: May 8, 2003 Tornado and Location of Shelters Constructed Under the Oklahoma Safe Room Initiative, FEMA, Mitigation Division, Washington, DC.

Intensity scales, such as the Saffir-Simpson damage scale for hurricanes and the Fujita scale for tornadoes, provide scientists and engineers with a relative standard with which to base calculations. Current engineering design load literature, ASCE 7-02[1] in particular, features calculations and instances in structural design that have resulted from the observations and studies of wind events. Wind forces are not the only concern during an extreme wind event; wind-borne debris is far more destructive. In the event of a tornado, for example, a simple piece of timber has the potential to be carried in mid-air at speeds up to 100mph. At this speed, the timber's momentum is larger than that of a speeding bullet. This power has the potential to rip through most household walls, including masonry walls. Obviously, a person would not survive the impact of this type of flying debris.

Life Threatening Risk Factors

There are two main threats to life during an extreme wind event: intense wind pressures and flying debris. The wind produces intense wind pressures, which may lead to breaching of the building envelope (the exterior surface of the building). The building envelope serves two purposes during an extreme wind event: a) to keep out the rain accompanying the storm and b) to keep the building from inflating (or deflating) as a result of the external wind pressures. This last case is the most critical because as the building envelope is breached, say from the wind direction, the building is pressurized, thus causing it to break apart (see Figure 2). Flying debris also pose a significant threat to buildings and the lives of those who find themselves in the path of a storm. As discussed in the last section, debris primarily in the form of timber shards acts as missiles, and may pack momentums larger than those of most bullets. The debris is usually a result of buildings breaking up. These debris strike adjacent buildings causing damage to the building envelope, leading to internal wind pressure damage as shown in Figure 2.

Figure 2: The effect of internal pressure after the building envelope is bridged.

Required Characteristics of Effective Storm Shelters

The main objectives of storm shelters are to avoid catastrophic loss of life, reduce anxiety and suffering, keep people safely at home, protect critical contents, and reduce economic losses. The main advantages of having a storm shelter in the home are: life saving habitat, dependable storm protection, avoidance of costly physical injuries, increased home security, peace of mind, and immediate attention to damage repair. To be effective, a storm shelter must: have structural integrity to withstand forces imposed by severe winds, have impact-worthiness to protect occupants from wind-borne debris (missiles), be stable during a storm, and be economical. To obtain these characteristics, construction quality must be ensured.

As previously discussed, storm shelters must resist severe pressures from wind. These pressures must be resisted by the entire structure. The structural integrity of the system is dependent on the strength of individual components, which are typically designed according to available design codes. Analytical structural analysis and design techniques are sufficiently mature to ensure structural integrity of shelters when subjected to extreme loading. However, the impact-worthiness of common residential building components to wind-borne debris does not lend itself to analytical solution and there are no specifications available for this design. The only available methods for assessing the reliability of these materials are performance testing. This testing is performed by impacting a wall system with a 15 pound piece of timber traveling at 100 mph. The stability of a shelter is guaranteed by properly anchoring the system to the foundation. A properly constructed shelter following the available information can withstand even the most severe of all tornadoes, an F5, with wind speeds in excess of 250 mph. One shelter case that was reported survived the May 3, 1999 tornado in Oklahoma City (see Figure 1). This was the only home with a storm shelter struck by the tornado[8]. The family survived the tornado unscathed (see Figure 3).

Figure 3: Beth Bartlett, her mother Norma Bartlett, two dogs and two cats weather out the tornado of May 3, 1999 in their safe room.

Storm Shelter Information Dissemination

Educational resources represent the cornerstone on which the nation was developed. As a public service, these resources should be readily available to all who aim to benefit from them. The material created at the Wind Science and Engineering Center in Lubbock, TX consists primarily of PowerPoint Presentations, (see Figure 4). These presentations may be adapted to suit a variety of audiences, from science classes at the elementary and secondary level, to informational college lecture sessions. For the former instance, special PTO/PTA meetings may be held to inform concerned parents and others about the importance of storm shelters in their respective communities. Pamphlets and other informational literature should be readily available at common outlets such as grocery stores, bus stops, and cafés and restaurants. Public Service Announcements offer another alternative through which windstorm information and precautions can be provided for the public. Local television news stations can also play an integral part in the dissemination process by creating exposés on the importance of sheltering.

For those interested in additional information, the resources used to produce the majority of these public awareness modules are available at no cost. FEMA 320[2] is available at www.fema.gov/mit/saferoom, or a hardcopy may be obtained by calling 1-888-565-3896 and requesting booklet # 320. FEMA 361[3], a much more detailed document elaborating on design specifications for shelters, can be obtained from the same sources. The National Storm Shelter Association (NSSA) standard may be downloaded from www.NSSA.cc.

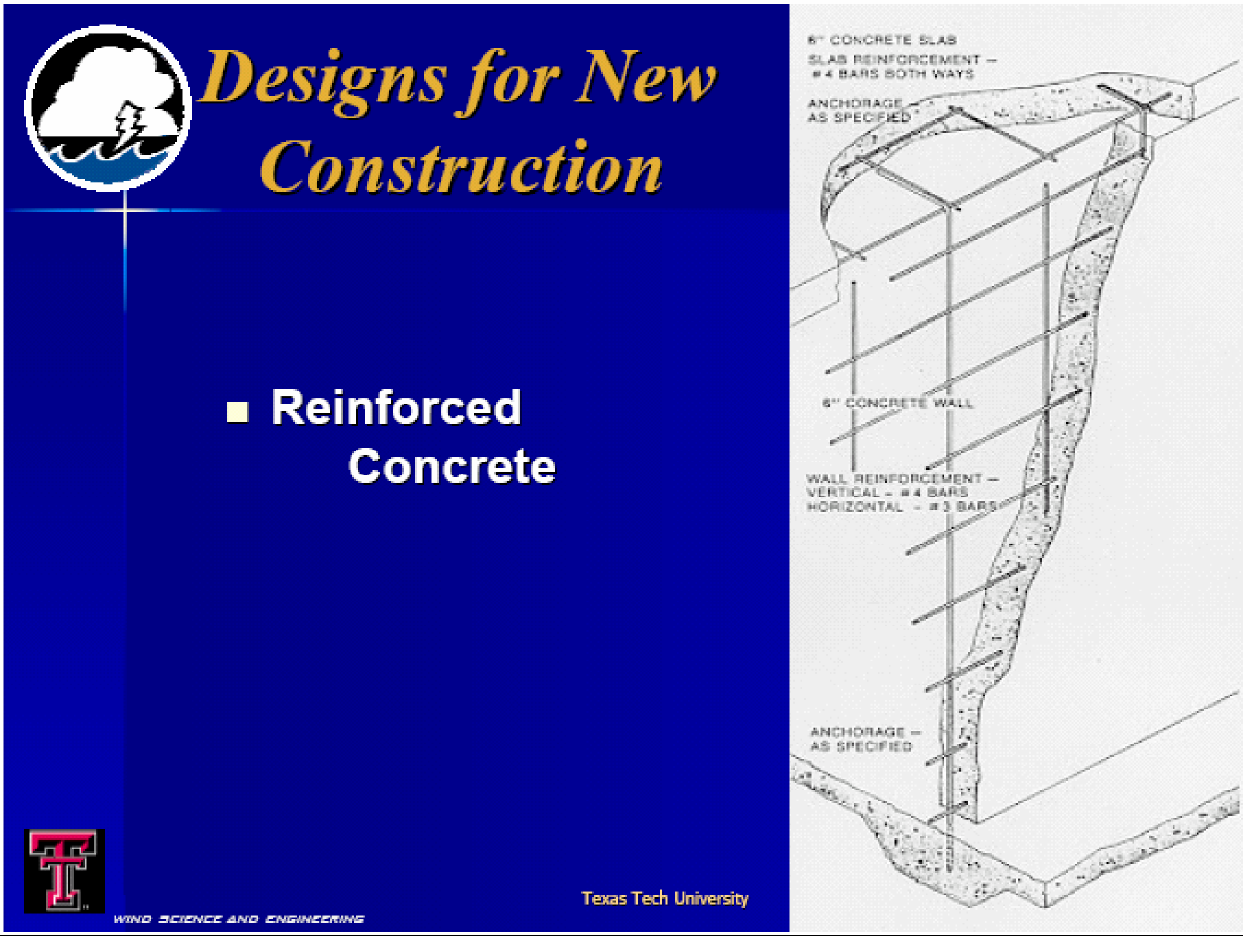

Figure 4: Typical slide depicting a reinforced concrete shelter design.

Conclusions

This paper presents work that was performed at the Wind Science and Engineering Center at Texas Tech University, in Lubbock, Texas as part of an IGERT Multidisciplinary Program in Wind Science and Engineering. This work involved developing materials for effective use in promoting public awareness of the benefits of storm shelters. This presentation is intended as part of this effort, and it is hoped that the participants of the 2005 ASEE Gulf-Southwest Annual Conference will come away with a better appreciation for storm shelters.

Acknowledgments

The first two authors are grateful for the financial support provided by the National Science Foundation through the IGERT Multidisciplinary Program in Wind Science and Engineering at Texas Tech University.

BIBLIOGRAPHY

1. ASCE, ASCE 7-02 Standard (2002). *Minimum Design Loads for Buildings and Other Structures*, American Society of Civil Engineers (ASCE), New York, New York.
2. *FEMA 320: Taking Shelter From the Storm: Building a Safe Room Inside Your House*, 2nd Ed. (August 1999). Washington, DC: Federal Emergency Management Agency.
3. *FEMA 361: Design and Construction Guidance for Community Shelters* (July 2000). Washington, DC: Federal Emergency Management Agency.
4. Kiesling, E.W., (2003). "Comparison of Storm Shelter Design Guides," Proceedings of the11th International Conference on Wind Engineering, June 2-5, 2003, The Wind Science and Engineering Research Center at Texas Tech University, Lubbock, TX, PP 2905-2911.
5. Kiesling, E. W., and D. E. Goolsby, (1974). "IN-Home Shelters for Extreme Winds," Civil Engineering, Vol.44, September 1974.
6. National Highway Traffic Safety Administration web page, URL: http://nhtsa.gov/people/Crash/LCOD/index.htm, accessed February 2005.
7. National Oceanic and Atmospheric Administration, (2003). "2003 Annual Summaries," National Environmental Satellite Data Information Service/National Climatic Data Center.
8. Ridley, W. L., K. M. Simmons, and D. Sutter. (2003). "Tornado Protection: An Analysis of Market and Policy Actions after the May 1999 Tornadoes," Proceedings of the11th International Conference on Wind Engineering, June 2-5, 2003, The Wind Science and Engineering Research Center at Texas Tech University, Lubbock, TX, PP 1513-1519.
9. *Surviving the Storm: A Guide to Hurricane Preparedness* (n.d.). [Brochure]. Washington, DC: Federal Emergency Management Agency.

BIOGRAPHICAL INFORMATION

HECTOR ESTRADA
Dr. Hector Estrada is an Associate Professor and Head of Civil Engineering at Texas A&M University-Kingsville.

TOMAS QUINTERO
Mr. Tomás Quintero is a current senior student in Civil Engineering at Texas A&M University-Kingsville.

ERNST KIESLING
Dr. Ernst Kiesling currently serves as a Professor of Civil Engineering at Texas Tech University. Many discoveries in Wind Engineering can be attributed to his efforts.