

8 Preliminary Recommendations

The recommendations contained in this report are based solely on the BPAT's observations and conclusions. When these recommendations are implemented, they will facilitate future personal and property protection from extreme wind events.

8.1 GENERAL RECOMMENDATIONS

The May 3, 1999 tornadoes were disastrous in terms of lives lost and property destroyed, but out of this disaster comes the opportunity to reflect on the things that are important in peoples lives. Out of these reflections, Oklahoma and Kansas communities can commit to planning for future tornadoes through promoting sustainable construction and tornado-resistant communities.

As the people of Oklahoma and Kansas rebuild their lives, homes, and businesses and plan for future economic development, there are several ways they can reduce the effects of future tornadoes, including:

- Design buildings to the most current building codes and standards that provide greater protection against moderate tornado-generated winds.
- Provide safe refuge in the event of a severe or violent wind storm or tornado in the form of engineered shelters.

More specific recommendations are included in the following subsections. Mitigating future losses, however, will not be accomplished by simply reading this report; mitigation is achieved when a community actively seeks and applies methods and approaches that lessen the degree of damage, injuries, and loss of life that may be sustained from future tornadoes.

8.2 PROPERTY PROTECTION

Property protection recommendations have been divided into subsections on residential and non-residential building considerations, codes and regulations, and voluntary actions.

8.2.1 Residential and Non-residential Buildings

Proper construction techniques and materials must be incorporated into the construction of residential buildings to reduce their vulnerability to damage during moderately high wind events. Existing construction techniques proven to minimize damage in wind-prone areas are not always being utilized areas that are subject to tornadoes. Construction must be regulated and inspected to ensure that residential buildings meet the most current model building code requirements.

It is recommended that, for engineered buildings, the engineer review structural connections to ensure adequate capacity for moderate to severe uplift and lateral loads that may be in excess of loads based on the building codes currently in effect. To address the issues of construction that may be mitigated to improve building performance, the following recommendations are provided:

- Sheathing at areas of discontinuity should be fastened in a manner that will resist uplift forces with a factor of safety over the design wind pressure stipulated in applicable building codes and standards. Some current building codes reflect an increased fastener size intended to address high wind areas.
- The masonry industry should consider re-evaluating attachment criteria of masonry, specifically regarding product usage. Greater emphasis should be given to code compliance for the bond between the mortar and brick tie, the mortar and the brick, and to the spacing of brick ties.
- Garage doors are an extremely important residential building component. Failure of these doors led to catastrophic progressive failures of primary structural systems that could have been avoided. New garage doors should be installed with improved resistance to moderately high wind loads. Retrofits should be made to improve the wind resistance of existing garage doors, specifically double-wide garage doors. These retrofits and new doors may reduce the roof and wall damage that was observed in homes that experienced garage door failures.
- The Federal Government (HUD) should review its standards and enforcement program in an effort to improve the performance of manufactured homes in moderately high wind events, such as in inflow areas of severe to violent tornadoes and the tracks of moderate tornadoes. Specifically, the capacity of anchoring and strapping equipment and systems needs to be evaluated to eliminate the discontinuity between the Federal standard and the State and local installation and enforcement process.
 - Consideration should be given to permanently connecting the manufactured home unit to its foundation. The BPAT concluded

that newer manufactured homes on permanent foundations performed as well as conventional stick built homes in resisting lateral wind loads, as long as there was an adequate connection of the chassis and perimeter joists to the permanent foundation.

- For non-residential buildings, the BPAT recommends using threaded fasteners to attach joists and metal decking to supporting frames and walls. In many of the roof system failures observed by the BPAT, current welding practices were insufficient in carrying loads and weld failures were common.
- To reduce the number of missiles generated from roofs on essential facilities (e.g., hospitals) and buildings such as schools, aggregate ballast and paver surfacing should not be used. Enhanced wind design for the roof covering on essential facilities should be considered for those facilities located in tornado-prone areas.
- When wood construction is not utilized, reinforced concrete and partially reinforced masonry with adequate ties to foundations and roofs should be used in areas with a high probability of being hit by a tornado. Ties between concrete and other materials should be made with drilled-in fasteners or cast-in-place fasteners.
- Diaphragm action to resist shear forces must be maintained and reinforcement must be properly placed in concrete and masonry walls to reduce the possibility of collapse. Masonry walls should be engineered and constructed to support the specific architecture of the building.
- Precast concrete buildings should have anchors to prevent the uplift of hollow core planks and other precast elements. Better performance would have been obtained if drilled-in expansion anchors or through-bolts had been used to attach the walls to the floors. Use of powder-driven anchors to attach bottom plates of walls to concrete should be avoided unless they are very closely spaced to achieve sufficient pull-out resistance.
- Undamaged sections of brick veneer walls should be inspected, and where they can be deflected or pulled off, the air space behind the veneer should be grouted and reinforced, or be replaced.
- A brick veneer wall system should be designed as a "stand alone" system. Current construction practices for brick veneer need to be improved so that a flexible connection between the framed wall and the veneer does not result.
- It may be necessary to fasten brick ties with ring or screw-shank nails to prevent nail pull-out at brick ties.

- Architectural features should be appropriately designed, manufactured, and installed to minimize the creation of windborne debris. To accomplish this, the local community may want to further regulate these features to ensure code compliance.
- The installation of laminated glass in essential facilities should be considered because of the substantial protection that it offers from modest-energy missiles. Testing should be conducted in accordance with ASTM E 1886, based on load criteria given in SBCCI STD 12.

8.2.2 Codes and Regulations, Adoption, and Enforcement

To better address structural and architectural issues related to moderately high wind events, State and local governments should consider adopting the most current edition of their model building code. Other recommendations related to building codes and enforcement are provided below:

- Cities and appropriate local governments should adopt the 1997 UBC or the 1996 NBC as the model building codes. Amendments that require calculation of wind loads via ASCE 7-95 or the new ASCE 7-98 should also be adopted. Currently, the 1997 UBC & 1996 NBC reference ASCE 7-95, but allow their own UBC/NBC methods to be used; it is important to note that wind calculations from these methods will result in lower loads than calculations from ASCE 7-95 or 7-98. For buildings other than one or two family dwellings, state and local governments should adopt the latest codes that specify the most current engineering standards for wind loads for the design of structural components and cladding.
- Governments using a previous version of the 1995 CABO One- and Two-Family Dwelling Code should update to the 1995 version immediately. This will provide some guidance for designing for moderate wind loads.
- The International Building Code (IBC) and the International Residential Code (IRC) should be adopted upon their release in 2000. Although these codes do not directly address the threat of tornadoes, they address wind load issues using ASCE 7-98 for both non-residential and residential construction, respectively. Use of codes based on ASCE 7-98 will reduce future losses from moderately high wind loads.
- Greater emphasis should be given to code compliance, particularly for wall and roof covering wind loads and resistance. Homebuilders and code enforcement agencies should consider developing an active education and outreach program with contractors to emphasize the importance of code compliance for wind resistance.
- State and local governments should consider creating a task force with the different building code groups and construction industry groups to

determine if basic wind speed classifications should be reconsidered for tornado-prone areas.

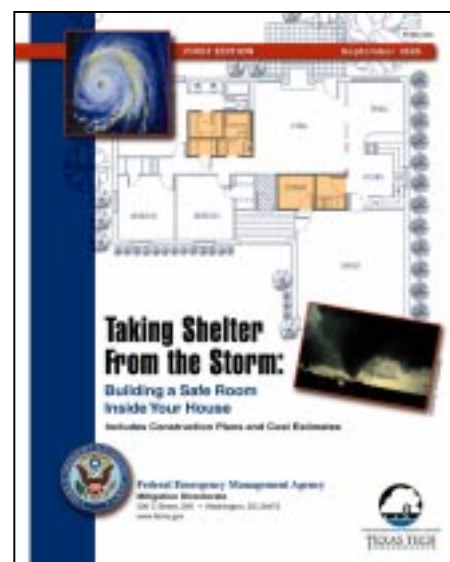
8.2.3 Voluntary Actions

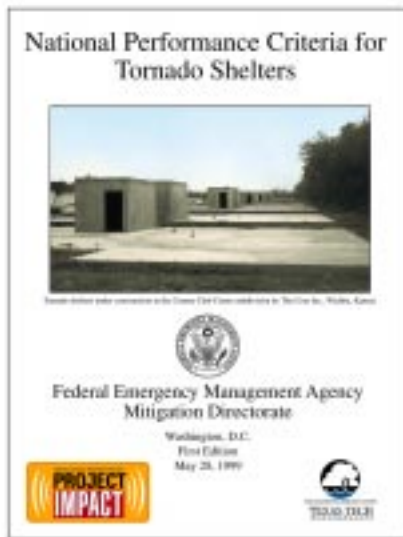
There are a number of voluntary actions that can be undertaken to reduce the risk of property damage in inflow areas of severe and violent tornadoes and in moderate tornado tracks. Some of these are included in the following recommendations.

- To improve tornado resistance, individuals, builders, communities should use existing hurricane-resistant technologies (straps, clips, etc.) to protect themselves, their property, and their homes.
- The design of wood frame structures should utilize connection devices such as anchors, clips, and straps to provide a continuous load path for all loads; gravity, uplift, and lateral.
- Communities should consider the need for adopting ordinances and regulations that promote disaster-resistant communities by incorporating tornado shelters into new construction and communities.
- Fire departments and Emergency Services Agencies should make a list of addresses with shelters, to assist in checking after a tornado to see if people are trapped inside shelters.

8.3 PERSONAL PROTECTION

Shelters are the best means of providing near absolute protection for individuals who are attempting to take refuge during a tornado. Whether a shelter is constructed by a homeowner for protection of his family or is constructed as a group or community shelter, all shelters should be designed and constructed in accordance with either FEMA 320 or The National Performance Criteria For Tornado Shelters. At a minimum, shelter doors should be constructed of 14 gauge hollow metal and be held by 3 hinges and 3 deadbolts with three points of contact. Ventilators should be constructed of heavy gauge steel or protected by heavy gauge shrouds or saddles to prevent their removal by the storm and the entrance of debris through the remaining openings. Below grade portions of the shelter should be waterproof. All shelters should provide access to persons with disabilities as necessary and in conformance with the ADA. Local officials must monitor the installation of shelters to ensure that the floor of all shelters is located at or above expected flood levels.





8.3.1 Residential Sheltering

People should be encouraged to have in-residence or nearby shelters. Although this report advocates that buildings may be strengthened to better resist high wind events, a shelter is still considered the only means of providing near absolute personal protection.

8.3.2 Group and Community Sheltering

The following recommendations are given regarding group and community shelters, and also address the reason people have congregated (i.e., residential, public areas, etc.):

- Many manufactured homes offer only minimal protection from severe wind storms and tornadoes. In the event of such storms, occupants of manufactured homes should exit their home and seek shelter in storm cellars, basements, or above-ground shelters. If shelters are provided in manufactured home parks, which is recommended, dispersed shelters, which can be accessed in a short time period are recommended.
- Prospective occupants of community shelters should be acutely alert to storm warnings in order to allow sufficient time for the travel distance to the community shelter. Custodians of the shelter should be similarly alert so that the shelter is unlocked at appropriate times. Community shelters should be ADA compliant and the admission rules permanently posted (i.e. “No Pets Allowed,” etc.).
- Essential facilities are critical to government response following a severe wind event or tornado. Site-specific evaluations should be made at essential facilities and other important facilities such as schools and daycare centers to determine the best locations for occupants during a storm. An assessment should be conducted to identify and provide signage to the designated refuge within or at the facility and evaluate the adequacy of the identified refuge to ensure people have a safe place to go and time to get there. All public use facilities must have a NOAA weather radio in continuous operation. Communities should consider enforcing this requirement by adopting as appropriate law or ordinance.
- Existing essential facilities that offer inadequate protection should have shelters retrofitted or a shelter added. New essential facilities should be designed with shelters. Interested states should form a committee to evaluate the need for tornado plans and shelters in essential facilities and other establishments serving the public (e.g., schools, hospitals, and critical facilities).

8.3.3 Place of Refuge

If a specifically designed tornado shelter is not available and refuge has to be taken in a residential or non-residential building, the following are recommended:

- State and local governments should develop education programs to assist homeowners and other property owners in developing a tornado safety plan similar to a fire safety plan. The plan should include the identification of a place of refuge and essential supplies. A tornado safety plan should include:
 - Seek refuge in a basement or below-grade crawl space, in an area away from the entry to the basement or crawl space. If the basement is partially above grade and has windows, seek shelter in a room within the basement that does not have windows.
 - If a residence does not have a basement or below-grade crawl space, seek refuge on the first floor in an interior bathroom or closet. If refuge is taken in a bathroom, lay in the tub.
 - In a non-residential building that does not have a basement, seek refuge on the first floor in a concrete stair tower, interior corridor, or a small room that does not have glass openings in doors or walls and is as far inward as possible from exterior walls. Avoid rooms that are more than 40 feet between walls or columns.
 - Wherever refuge is taken, lay on the floor if space permits, or kneel down. Cover up with pillows or heavy blankets for added protection.