



# TORNADO OUTBREAK *of* 2011

IN ALABAMA, GEORGIA, MISSISSIPPI,  
TENNESSEE, AND MISSOURI

## 3 Design and Construction Considerations

*During field investigations, the MAT focused on identifying building components and construction practices that performed either poorly or notably well during the tornadoes.*

Most buildings are not designed to withstand the extreme forces caused by the high wind speeds of severe or violent tornadoes (greater than 110 mph), and the vast majority fail when subjected to such conditions. However, the majority of tornadoes recorded in the United States are considered weak (EF1 or below), with maximum wind speeds of 110 mph. Wind speeds associated with EF0 and some EF1 tornadoes are less than or equal to the design wind speeds used in the majority of the United States,<sup>1</sup> and properly designed and constructed structures should perform well under these conditions. In addition to high wind, tornadoes produce large quantities of fast moving wind-borne debris, which contributes to and sometimes causes building failures by penetrating the building envelope and allowing wind inside the structure.

<sup>1</sup> Design wind speeds are higher in hurricane-prone regions of the United States, along the eastern and southeastern coast, than in other areas.

This chapter discusses the effects of wind loading on structures; the types and patterns of wind-borne debris observed in tornadoes; and the Federal, State, and local regulations that govern the areas affected by the tornadoes and the regulatory role in disaster mitigation efforts.

## 3.1 Effects of Wind Loading on Structures

Effects of wind on a building include internal pressurization, increased lateral forces, uplift, and external pressures. Internal pressurization occurs when wind enters a building and lateral forces act either inward, created by the wind blowing directly on the face of a building, or outward, due to suction forces created when low pressure conditions occur inside the building. Most buildings are designed as *enclosed structures* with no large or dominant openings in the envelope that allow wind to enter. However, a breach in this normally enclosed building envelope due to broken windows, failed entry doors, or a failed garage door causes a significant increase in the net effective wind loads acting on the building under strong wind conditions. In such cases, the increased wind load may initiate a partial failure or cause a total failure of the primary structural system. A schematic diagram illustrating the increased loads due to a breach in the building envelope is shown in Figure 3-1.

Internal pressurization due to a breach of the building envelope (i.e., broken windows, failed garage door, missile impact in roof structure, etc.) may contribute to significant structural failures. Maintaining the integrity of the building envelope by limiting the size and number of openings created by the wind event in the building significantly improves the performance of elements in the structural system.

Primary structural systems are those that support the building against lateral and vertical loads. Many buildings observed by the MAT had structural systems that provided continuous load paths for high winds, but that were not sufficient for the extreme lateral and vertical uplift forces generated by tornadic winds. The MAT gathered information to determine whether the observed damage could have been prevented in buildings located in the peripheral areas of the wind field, those not in the direct path of the vortex of the violent tornadoes. Figure 3-2 shows a continuous load path in a CMU wall.

Winds moving around a structure create vertical and lateral forces that act on the building and cause several different failure modes (Figure 3-3). Uplift is a force caused by the wind accelerating around and over buildings and is affected by the geometric changes in the building shape (Figure 3-4).

Model building codes incorporate provisions that take into account the effects of internal pressurization on *partially enclosed buildings*, which are buildings with large permanent openings, by requiring higher design wind loads. Residential structures, considered enclosed structures, are typically not designed to withstand instantaneous wind load increases such as those that occur after an envelope breach.

Some of the damage to buildings noted by the MAT was considered non-structural since only architectural and decorative finishes on the exterior were damaged (Figure 3-5). Engineering

standards such as ASCE 7-05, *Minimum Design Loads for Buildings and Other Structures* (2005), identify these elements as components and cladding and provide guidance for determining wind loads acting on them. ASCE 7-05 is the reference standard for the 2009 I-Codes.

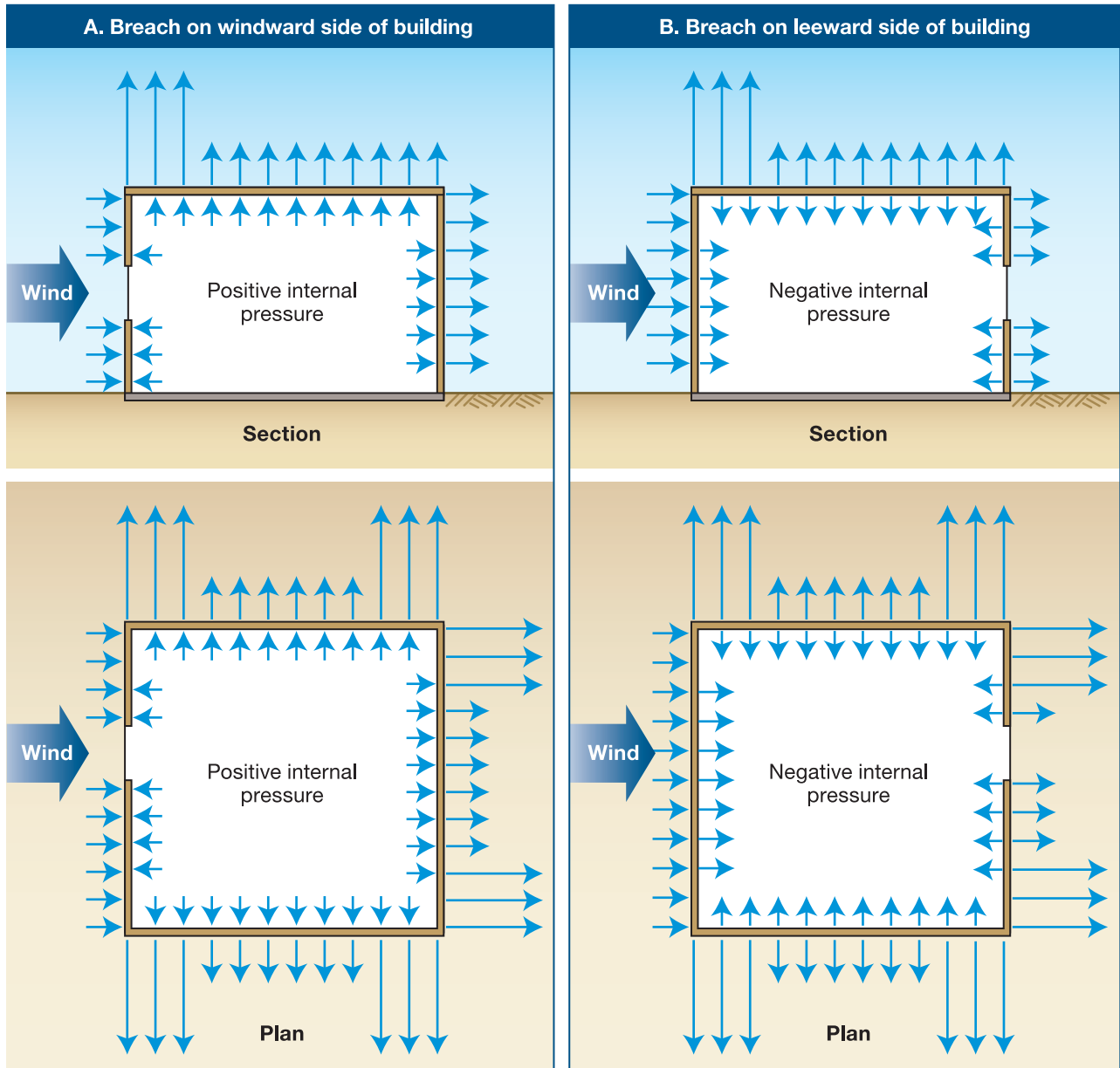
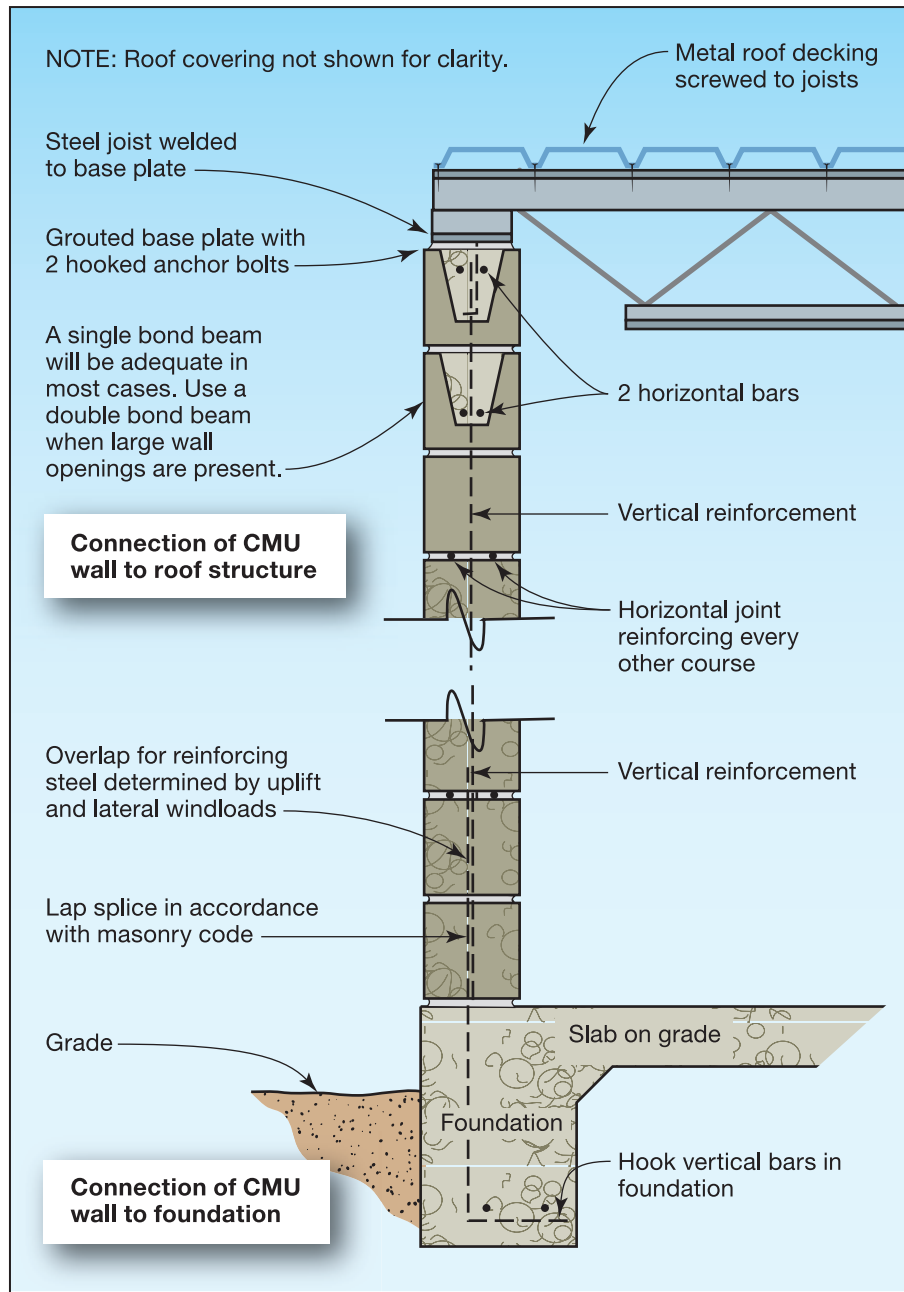


Figure 3-1: Effects of a breach in a building envelope when the breach is on the windward (a) or leeward (b) side of a building, shown in plan and section views

SOURCE: [HTTP://WWW.WBDG.ORG/RESOURCES/ENV\\_WIND.PHP](http://www.wbdg.org/resources/env_wind.php)

**Figure 3-2:**  
**Load path continuity in**  
**CMU wall**  
 SOURCE: FEMA 577, FIGURE 4-26



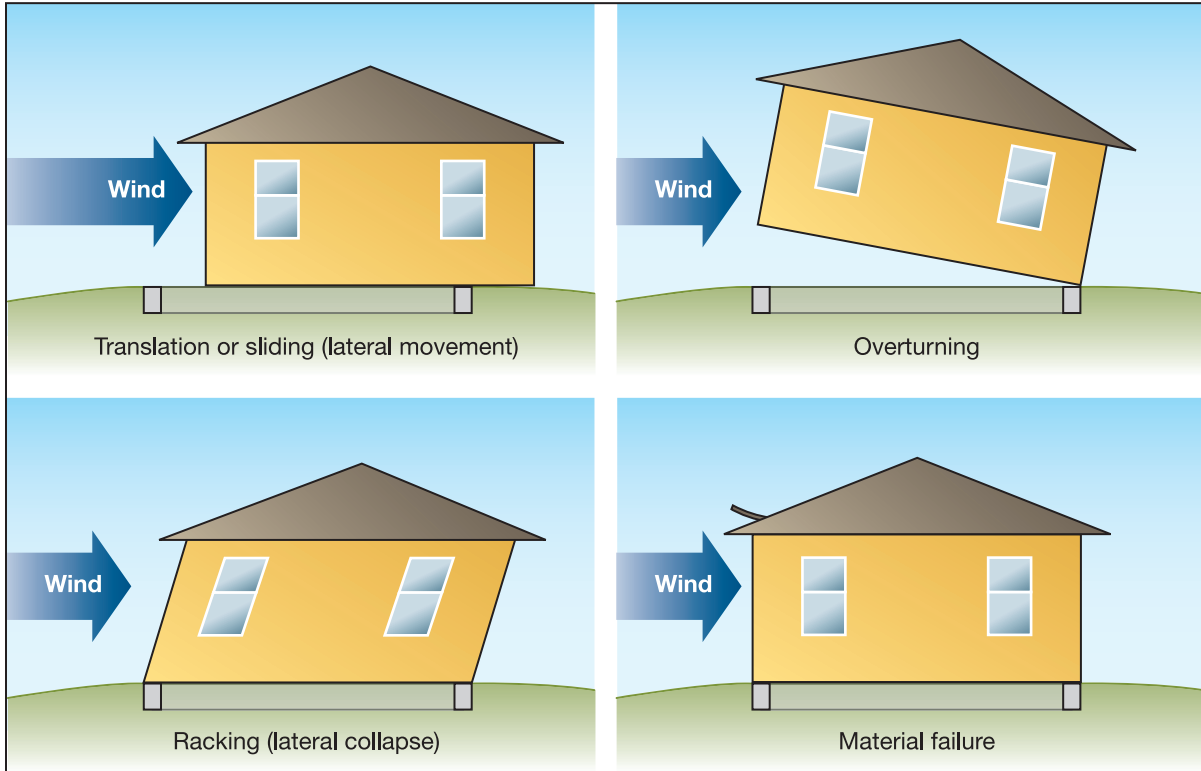


Figure 3-3: Building failure modes in high-wind event

SOURCE: FEMA 342, FIGURE 3-3

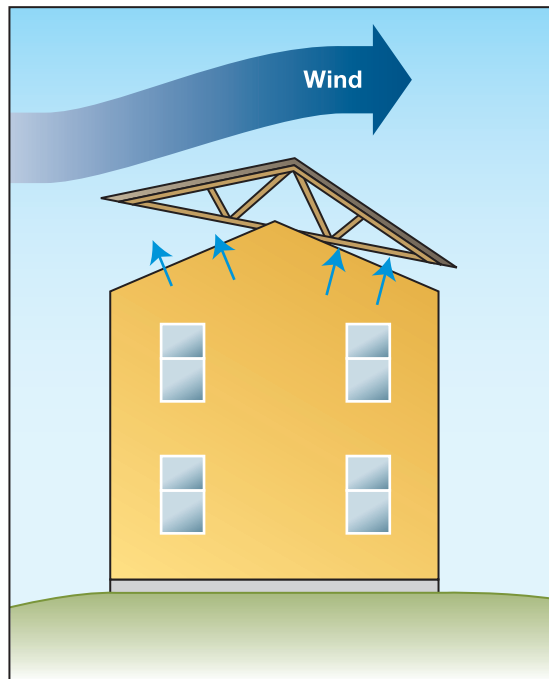


Figure 3-4: Uplift pressures acting on a building



Figure 3-5: Brick veneer blew off this high school cafeteria during the tornado in Phil Campbell, AL. Note that brick ties do not appear to be at the correct spacing, which may have contributed to the failure (shown in red circle in inset).

## 3.2 Wind-Borne Debris

Wind-borne debris, often referred to as missiles, can be generated in a wind storm, but is most common in tornadoes and can cause significant damage. Tornadoes generate some of the largest missiles and propel them with forces unequaled by any other wind storm. Wind-borne debris in tornadoes is a danger to life safety, buildings, and property. It can breach the envelope of a building, resulting in internal pressurization and structural failure, and it can kill or severely injure individuals who are unable to find shelter.

The funnel cloud of a tornado is composed of water vapor and debris carried by both the inflow winds and vortex winds of the storm (see Section 2.3). Smaller missiles (e.g., rocks, pieces of tree limbs, and pieces of shredded wood framing members such as those shown in Figure 3-6) can easily break common window glazing. This causes a rapid change in internal air pressure in a building, putting



stress on the roof-to-wall connections and wall-to-wall or wall-to-floor connections. Medium-sized missiles (e.g., appliances; furniture; heating, ventilation and air-conditioning [HVAC] units; long wooden framing members; and larger tree limbs, also shown in Figure 3-6) can become airborne and cause considerable damage. Large missiles (e.g., propane tanks, trees, and roof trusses such as those shown in Figure 3-7) are often observed as rolling debris, but may also become airborne and can cause major damage to the structural systems of buildings they strike. Section 3.2.1 describes the types, sizes, and quantity of missiles observed by the MAT.



**Figure 3-6:**  
Example of small- and medium-sized missiles commonly observed by the MAT (photograph taken near an apartment complex in Tuscaloosa, AL)



**Figure 3-7:**  
Example of medium- to large-sized wind-borne missiles (photograph shows roof trusses displaced from a nearby building in Tuscaloosa, AL)

### 3.2.1 Missile Types and Sizes

The missile types observed by the MAT varied greatly across the geographic area impacted by the tornados because of the varying intensities of the tornados and the differences in the built environment in affected areas. In residential areas where buildings were primarily wood-frame construction with asphalt shingle roofs, most of the missiles observed were wood framing members, household contents, and brick veneer pieces. Adjacent to wooded areas and in areas with a high tree density, the missiles also included small- to medium-sized pieces of wood from the trees. The missiles in residential areas caused significant damage to the glazing, roofing systems, and exterior cladding of buildings. In non-residential areas, the missiles and wind-borne debris were primarily pieces of wood from trees and building appendages (including awnings, etc.). Table 3-1 lists typical debris observed during the field investigation, its classification, and the typical associated damage.

**Table 3-1: Wind-Borne Debris and Rolling Debris Classifications**

Missile Size	Typical Composition of Missile	Associated Damage Observed
<b>Small</b>	Rocks, dirt clods, pieces of trees, fragments of buildings (e.g., pieces of wood framing members, bricks)	Broken glazing, broken doors, some damage to light roof coverings
<b>Medium</b>	Appliances, HVAC units, long wood framing members, steel decks, trash containers, furniture, road signs, large tree limbs, fencing	Considerable damage to building envelope and roof structures
<b>Large</b>	Structural columns, beams, joists, roof trusses, large tanks, trees, parts of buildings and appendages (e.g., awnings, decks)	Damage to structural systems

The intensity of the winds in the vortex of a tornado are capable of creating missiles out of nearly any object, from building sections to bits of timber, and projecting these objects with such force as to cause significant damage to buildings and threaten life. The following illustrates the range of missile sizes and resulting missile damage the MAT observed.

Figure 3-8 shows a 2x4 piece of wood that pierced the roof of Alberta Elementary School in Tuscaloosa, AL. The source of this missile was most likely a dislodged piece of the roof framing system from elsewhere at the school (see also Section 6.1.1).



**Figure 3-8:**  
Medium-sized missile that struck the roof of a school building (Tuscaloosa, AL)



Figure 3-9 shows a roof truss penetrating a home in Athens, AL, a town just north of Huntsville, AL. The truss most likely originated from the detached garage approximately 100 feet behind this home.



**Figure 3-9:**  
Large roof beam penetrated the roof of this home (Athens, AL)

Figures 3-10 and 3-11 show two instances of oriented strand board (OSB) as debris, one striking a school locker (Figure 3-10) and one impacting the roof of a home in a residential neighborhood (Figure 3-11). Poorly fastened trusses, rafters, and OSB have more potential to generate debris than material that is properly fastened.



**Figure 3-10:**  
OSB damaged the first floor locker in Joplin High School (Joplin, MO)

**Figure 3-11:**  
Small pieces of OSB debris  
penetrated the roof of a  
home (Harvest, AL)



Figure 3-12 shows metal sheathing blown from the roof of the Fultondale Fire Station in Fultondale, AL, and carried nearly 200 feet. Figure 3-13 shows a car in Joplin, MO, with its roof penetrated by a 2x6 framing member. The MAT also observed cars that had become rolling debris during the tornado events, similar to other large debris types.

Seeking refuge in a car during a tornado should only be a last resort.

**Figure 3-12:**  
Metal sheathing travelled  
200 feet as wind-borne  
debris and landed next to  
a building outside of the  
tornado swath  
(Fultondale, AL)







**Figure 3-13:**  
A 2x6 missile penetrated the roof and seat of a car in a residential neighborhood just outside the damage track of the violent tornado in Joplin, MO

### 3.2.2 Wind-Borne Missile Quantity

The missile quantity the MAT observed varied depending on the location of the site and the level of damage in the adjacent areas. Where buildings were totally destroyed, debris and missiles often covered the ground (Figures 3-14 and 3-15). In wooded areas and residential areas that were heavily wooded, passage along the streets was often impossible due to the volume of tree debris present. Many buildings were covered with small puncture marks where the façade was pelted with wind-borne debris. Figures 3-14 through 3-17 show examples of the volume of missiles generated by the tornadoes.



**Figure 3-14:**  
Wind-borne debris consisting of wood framing members and plywood sheathing near the Alberta Elementary School, Tuscaloosa, AL

**Figure 3-15:**  
Large quantity of wind-borne debris covering the lawn of a nursing home in Joplin, MO



**Figure 3-16:**  
Numerous missiles struck the outer wall of this non-residential building, including several that remained embedded (indicated by red circles) (Tuscaloosa, AL)







Figure 3-17:  
Large pile of small- and  
medium-sized wind-borne  
debris outside of Joplin  
High School (Joplin, MO)

### 3.3 Federal, State, and Local Regulations

This section provides background on the Federal, State, and local regulations that govern building construction in the affected areas. Building codes are the technical requirements for design and construction of buildings and structures and are adopted to protect public health, safety, and general welfare. Since the early 1900s and until 2000, model building codes in the United States were developed by three regional model code organizations: Building Officials and Code Administrators International (BOCA), International Conference of Building Officials (ICBO), and the Southern Building Code Congress International (SBCCI). Prior to 2000, there were four primary model building codes adopted throughout the country. These included:

- + National Building Code promulgated by BOCA
- + Uniform Building Code promulgated by the ICBO
- + Standard Building Code (SBC) promulgated by the SBCCI
- + Council of American Building Officials One and Two Family Dwelling Code, promulgated by BOCA, ICBO, and SBCCI

In the early 1990s, the three model code groups formed the ICC, with the intent of creating a single, common set of building, fire, and life-safety codes for the entire United States. The ICC publishes what are known as the *International Codes* (I-Codes), which include the IRC, IBC, and International Fire Code, to name a few. The IBC and IRC specifically address designing buildings for high-wind events such as hurricanes through prescriptive criteria, or they reference ASCE 7, but neither addresses designing for the wind speeds that occur in tornadoes. The IBC and IRC are described more fully in Section 3.3.1.

The adopted building codes and regulations for both residential and non-residential/industrial buildings differ considerably throughout the country. Often, they vary significantly even within a State; one such example is Alabama (described in Section 3.3.3.1 below). The adopted code in each of the affected States at the time of the 2011 tornado outbreak is described in Sections 3.3.3.1 through 3.3.3.5.

### 3.3.1 International Building Code and International Residential Code

The primary codes that address residential, non-residential, and critical facility construction are the IBC and IRC. To better address structural and architectural issues related to moderately high wind events, some State and local governments have adopted the I-codes (IBC and IRC). In addition, ICC 600, *Standard for Residential Construction in High-Wind Regions* (2008), provides guidance for residential construction. This standard specifies prescriptive methods for developing wind-resistant designs and construction details for residential buildings of masonry, concrete, wood-frame, or cold-formed steel-frame construction sited in high-wind regions.

The IBC is primarily a *performance code*, with some prescriptive provisions, that requires buildings and structures to be designed to meet the applicable requirements of the code and various referenced standards. The IRC addresses environmental loads such as high winds using a mostly *prescriptive approach*, so that many one- and two-family houses can be built without individual designs being prepared by architects and engineers. However, buildings and sites that fall outside the scope of the prescriptive limits, which include a maximum height and basic wind speed among other parameters, must be designed for the applicable loads.

Although the IBC and IRC editions published before 2009 do not address the threat of tornadoes, they address wind loading by referencing ASCE 7 (1998 edition or earlier). The current edition of ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures* (2010), has been incorporated into the 2012 I-codes.

### 3.3.2 International Codes and Storm Shelters

It is important to remember that the building codes and standards used in the United States before 2008 did not address life-safety protection from tornadoes or hurricanes. Although guidance from FEMA and others has existed since the late 1990s, it was not until the release of ICC 500 in 2008 that such criteria were introduced into building standards. The ICC 500 standard codifies much, but not all, of the extreme-wind shelter recommendations of FEMA 320 (1998, 1999, and 2008) and FEMA 361 (2000 and 2008). Following the release of the ICC 500, the 2009 IBC and IRC incorporated the standard by reference.

This means that if a building is constructed to the 2009 IBC and IRC, and there is a portion of the building designated to be a shelter, it must be designed to the criteria of the ICC 500, which has specific provisions on how to provide protection from extreme wind events and wind-borne debris associated with those events.

At this time, neither the ICC 500 nor the I-Codes require that shelters be designed or constructed within buildings.

In addition, ASCE 7 does not address tornadoes as part of the wind design considerations and requirements for buildings or other structures.

FEMA 361, which was updated at the same time ICC 500 was released in 2008, uses the same wind speed maps and design process, and references ICC 500 for general building criteria, inspection criteria, and testing standards for debris impact resistance. While the tornado hazard design criteria are the same or can be applied in the same manner for both FEMA 361 and ICC 500 (if an alternative design is not used), certain criteria in the design and construction of a safe room, such as those related to the hurricane hazard (both wind design and wind-borne debris impact criteria), the flood hazard siting criteria, and emergency management considerations are different. Safe rooms constructed in accordance with FEMA 320 (2008a) and FEMA 361 (2008c), meet all criteria of the ICC 500 for storm shelters. Since the two sets of criteria are similar, but not the same in all applications, FEMA uses the term *safe room* to differentiate construction consistent with its criteria from that of ICC 500, which uses the term *storm shelter*. Refer to the text box in Section 1.2 and Chapter 9 for more information regarding safe rooms, storm shelters, and hardened areas.

### 3.3.3 State and Local Codes and Regulations in Areas Visited by the MAT

An understanding of the codes in effect in the areas visited by the MAT is important to the damage assessment. If no codes were in place at the time of the tornado, the performance of structures was interpreted differently than in those locations where codes were in place. For locations where codes were in place before the event, the MAT was able to assess the performance related to specific design requirements in the code, and therefore the success of the code. This section of the report presents a brief history of code adoption in the communities visited by the MAT as well as a discussion of statewide code adoption in the five States visited by the MAT.

Building codes and the materials referenced in the codes change over time. As the building codes evolve, jurisdictions may choose to adopt the newest code, which then takes precedent over the historical code. Buildings that were built, and typically permitted, prior to the adoption of a new code do not need to meet the requirements of the newly adopted code. Therefore, in a single jurisdiction, some buildings may be built to an older code, while other buildings may be built to a newer code.

Tables 3-2 and 3-3 list the building codes in place during the past 5 years for commercial and residential buildings, respectively, in the communities affected by the tornadoes assessed in this report.

Table 3-2: Historical Codes for Commercial Buildings

State	Community	Commercial				
		December 2007	December 2008	December 2009	December 2010	December 2011
AL	Arab	NA	NA	NA	NA	IBC 2006
	Birmingham	IBC 2003	IBC 2003	IBC 2003	IBC 2009	IBC 2009
	Fultondale (Jefferson County)	IBC 2003	IBC 2003	IBC 2003	IBC 2003	IBC 2009
	Huntsville	NA	IBC 2003	IBC 2003	IBC 2003	IBC 2003
	Tuscaloosa	NA	NA	NA	NA	IBC 2009
GA	Ringgold	NA	NA	NA	NA	IBC 2006
MS	Smithville	NA	NA	NA	NA	IBC 2006
MO	Joplin	IBC 2000	IBC 2006	IBC 2006	IBC 2006	IBC 2006
TN	Cleveland	NA	NA	NA	NA	IBC 2006
	Hamilton County	IBC 2003	IBC 2003	IBC 2003	IBC 2003	IBC 2003

SOURCES: ARAB BUILDING DEPARTMENT 2012; CITY OF BIRMINGHAM, AL; CITY OF CLEVELAND, TN; CITY OF HUNTSVILLE, AL; CITY OF JOPLIN, MO; CITY OF TUSCALOOSA, AL; HAMILTON COUNTY, TN; ICC; JEFFERSON COUNTY, AL, 2011; RINGGOLD, GA; SMITHVILLE, MS  
 NA = data not available

Table 3-3: Historical Codes for Residential Buildings

State	Community	Residential				
		December 2007	December 2008	December 2009	December 2010	December 2011
AL	Arab	NA	NA	NA	NA	IRC 2006
	Birmingham	IRC 2003	IRC 2003	IRC 2003	IRC 2009	IRC 2009
	Fultondale (Jefferson County)	IRC 2003	IRC 2003	IRC 2003	IRC 2003	IBC 2009
	Huntsville	NA	IRC 2003	IRC 2003	IRC 2003	IRC 2003
	Tuscaloosa	NA	NA	NA	NA	IRC 2006
GA	Ringgold	NA	NA	NA	NA	IRC 2006
MS	Smithville	NA	NA	NA	NA	IRC 2006
MO	Joplin	IRC 2000	IRC 2006	IRC 2006	IRC 2006	IRC 2006
TN	Cleveland	NA	NA	NA	NA	IRC 2006
	Hamilton County	IRC 2003	IRC 2003	IRC 2003	IRC 2003	IRC 2003

SOURCES: ARAB BUILDING DEPARTMENT 2012; CITY OF BIRMINGHAM, AL; CITY OF CLEVELAND, TN; CITY OF HUNTSVILLE, AL; CITY OF JOPLIN, MO; CITY OF TUSCALOOSA, AL; HAMILTON COUNTY, TN; ICC; JEFFERSON COUNTY, AL 2011; RINGGOLD, GA; SMITHVILLE, MS  
 NA = data not available



### 3.3.3.1 Alabama



Alabama has not adopted a statewide building code for all residential and non-residential buildings.

The Alabama State Building Commission, which has jurisdiction over State-owned buildings, schools (public and private), hotels/motels, and theaters, adopted the 2009 IBC on September 1, 2010. The State made no amendments to the original 2009 IBC. Local amendments, however, are permitted.

The following codes were in effect for new construction for the sites visited at the time of the MAT investigation:

- +Arab, AL: 2000 SBC
- +Birmingham, AL: 2009 IBC, 2009 IRC
- +Fultondale, AL: 2009 IBC, 2009 IRC
- +Huntsville, AL: 2003 IBC, 2003 IRC
- +Tuscaloosa, AL: 2009 IBC, 2006 IRC

**Act 2010-746: Education Appropriations:** On April 30, 2010, Governor Riley signed House Bill 459, *Education Policy*, into law, thereby enacting Act 2010-746, which required any new contract awarded on or after July 1, 2010 for the construction of a new public school (grades kindergarten to twelfth) to include a Building Commission of Alabama-approved safe space or hallway. Pursuant to Act 2010-746, the Building Commission of Alabama adopted ICC 500 (2008) as the minimum building code for safe spaces. Safe spaces are required to comply with the building code requirements for tornado shelters. Compliance with the building code requirements for hurricane shelters is recommended, but not mandatory. Any renovations or additions to existing schools, or the addition of auxiliary buildings to an existing school, are not considered “a new public school” and are exempt.

**Act 2010-185: Alabama Energy and Residential Codes Board:** In 2010, Alabama adopted Act 2010-185, Residential Energy Board, which established the Alabama Energy and Residential Codes Board. The Board has the authority to establish an energy code for non-residential and residential construction; it also has the authority to establish a residential code for one- and two-family dwellings. Because of this authority to adopt such a residential code, the board can potentially affect high-wind load resistance for buildings in Alabama. For the residential building code, the Board has adopted the 2009 IRC with several amendments. This State code only applies to jurisdictions that newly adopt a code and those that have an existing code and intend to update it after the effective date of the State code. Additionally, there is no time limit for jurisdictions that currently implement codes to update to the new State code. However, when a jurisdiction does decide to update its code, it must, at a minimum, comply with the State code. Jurisdictions may amend the State code once they have adopted it to incorporate more stringent requirements.

### 3.3.3.2 Georgia



Georgia has adopted a statewide building code for all residential and non-residential buildings.

The State of Georgia has a statewide code for all residential and non-residential buildings. The Official Code of Georgia Annotated §8-2-20(9) (B) identifies 10 State minimum standard codes, which the Board of Community Affairs has adopted. The State codes consist of a base code and a set of amendments specific to Georgia. Eight of the 10 State minimum

standard codes are mandatory throughout Georgia. For residential construction, the base code currently in effect is the 2006 IRC with 2007, 2008, 2009, 2010, and 2011 State amendments. For non-residential construction, the base code is the 2006 IBC with 2007, 2009, and 2010 State amendments. The adopted IRC and IBC with the State amendments are 2 of the 10 “minimum standard codes.” For the areas the MAT visited, specifically Ringgold, GA, these codes are adopted for new construction.

### 3.3.3.3 Mississippi



Mississippi has not adopted a statewide building code for all residential and non-residential buildings.

Mississippi has not adopted a statewide building code, although it requires State buildings to meet the requirements set forth in the 1997 SBC, which is mandatory for all jurisdictions. Building code adoption and enforcement is primarily the responsibility of local jurisdictions.

In 2006, Bill 31-11-33 created the Mississippi Building Code Council. The Mississippi Building Code Council requires that five coastal counties—Jackson, Harrison, Hancock, Stone, and Pearl River—enforce, on an emergency basis after a disaster event, all of the wind and flood mitigation requirements prescribed by the 2003 IBC and 2003 IRC. None of these counties were affected by the storms described in this report.

After the April 25–28 tornado events, the Town of Smithville, MS, adopted the 2006 IBC and 2006 IRC at their May 24, 2011 meeting. To enforce the codes, the town contracted professional services to conduct building inspections. The 2006 IRC applies to residences that either are being totally rebuilt or have minor repairs being made following the storm damage. Non-residential structures have to comply with the 2006 IBC.

### 3.3.3.4 Tennessee



Tennessee has adopted a statewide building code for all residential and non-residential buildings.

Of the affected areas the MAT visited in Tennessee, only the City of Cleveland in Bradley County and Hamilton County (including the City of Chattanooga as an incorporated city within this county) have local building codes per the State’s definition. Cleveland has adopted the 2006 IBC and

2006 IRC, each with local amendments. Hamilton County (including the City of Chattanooga) has adopted the 2003 IBC and 2003 IRC. The rest of the affected areas did not have a locally adopted building code and would fall under the 2009 IRC statewide requirement for new residential construction and residential construction undergoing a change of use.

Tennessee adopted the 2006 IBC as a statewide code in 2008, but excluded Chapter 11 (Accessibility and Electrical Components) and Chapter 27 (Equipment and Systems). On October 1, 2010, the State adopted the 2009 IRC with several amendments. The 2009 IRC applies to new construction and residential buildings for which the use is going to change. Cities and counties are allowed to opt out of the residential building code requirements via passage of a resolution to exempt the city or county by a two-thirds vote. Additionally, if a region of the State already has a residential building code enforcement program in place that is current within 7 years of the latest edition, they can file to become an exempt jurisdiction and are permitted to continue to operate under their current building codes. Currently, most highly populated areas in Tennessee fall under this category and are therefore exempt from enforcing the 2009 IRC. Local jurisdictions reserve the right to amend the code, if adopted.

The metropolitan area of the City of Nashville and Davidson County adopted both the 2006 IBC and the 2006 IRC with local amendments. Since they have a residential building code in place with their enforcement of the 2006 IRC and local amendments, they did not fall under the requirement to enforce the 2009 IRC as of October 1, 2010.

Tennessee has not adopted a standard regarding safe rooms.

### 3.3.3.5 Missouri



Missouri has not adopted a statewide building code for all residential and non-residential buildings.

Like Mississippi, building codes in Missouri are adopted and enforced at the local level, though the 2000 IBC and 2000 IRC are effective statewide for State buildings. The State of Missouri Division of Facilities Management, Design and Construction have published a *Designer Information Packet* (2007)<sup>2</sup> for State buildings.

As a note, the City of St. Joseph, MO, passed an ordinance prior to the tornadoes requiring manufactured home communities to provide storm shelters for their residents. All storm shelters in the city are required to meet Americans with Disabilities Act requirements and the design criteria set forth by the current version of FEMA 361 (2008a).

The City of Joplin has actively adopted building codes since 1961. Joplin adopted the 2006 IBC and IRC in 2008. After the May 22, 2011 tornado event, the Public Works Department passed an ordinance requiring measures beyond code requirements to ensure safety in high-wind events. The new ordinance changes the required spacing of foundation anchor bolts from 6 feet on-center to 4 feet on-center; the bolts must also line up with the rebar required in concrete block cells. The

<sup>2</sup> Available online at the Missouri Office of Administration Web site, [http://oa.mo.gov/fmdc/dc/fmdc\\_dip/index.htm](http://oa.mo.gov/fmdc/dc/fmdc_dip/index.htm)

new ordinance also requires additional hurricane fasteners on every rafter end and on trusses; where fastening had been required by previous code on every other truss every 4 feet, the code was amended to include fastening on every truss member.