Risk Management Series

Design Guide

for Improving School Safety in Earthquakes, Floods, and High Winds

FEMA P-424 / December 2010

FEMA

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Design Guide

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Foreword and Acknowledgments

Background

Our society places great importance on the education system and its schools, and has a tremendous investment in current and future schools. Nearly 50 million students were expected to attend approximately 99,000 public elementary and secondary schools in the fall of 2009, with an additional 5.8 million expected to attend private schools.[1] The sizes of these school facilities range from one-room rural schoolhouses to citywide and mega schools that house 5,000 or more students. The school is both a place of learning and an important community resource and center.

This publication is concerned with the protection of schools and their occupants against natural hazards. Architects and engineers deal with natural hazards in building design and construction and building codes have provisions for protection against natural hazards.

This manual addresses two core concepts: multi-hazard design and performance-based design. Neither is revolutionary, but both represent an evolution in design thinking that is in tune with the increasing complexity of today's buildings and that takes advantage of developments and innovations in building technology:

1 U.S. Department of Education, National Center for Education Statistics, Fast Facts, Back to School Stats, http://nces.ed.gov/fastfacts/display.asp?id=372, accessed April 19, 2010.

- **Multi-hazard design** recognizes the fundamental characteristics of hazards and how they interact, so that design for protection becomes integrated with all the other design demands.
- **Performance-based design** suggests conducting a systematic investigation to ensure that the specific concerns of building owners and occupants are addressed, rather than relying on only the minimum requirements of the building code for protection against hazards. Building codes focus on providing life safety, while property protection is secondary. Performance-based design provides additional levels of protection that cover property damage and functional interruption within a financially-feasible context.

This publication stresses that the identification of hazards and their frequency and careful consideration of design to resist these hazards must be integrated with all other design issues, and be included from the inception of the site selection and building design process. Although the basic issues to be considered in planning a school construction program are more or less common to all school districts, the specific processes differ greatly because each school district has its own approach. Districts vary in size, from a rural district responsible for only a few schools, to a city district or statewide system overseeing a complex program of all school types and sizes. Any of these districts may be responsible for new design and construction, renovations, and additions. While one district may have a long-term program of school construction and be familiar with programming, financing, hiring designers, bidding procedures, contract administration, and commissioning a new building, another district may not have constructed a new school for decades, and have no staff members familiar with the process.

Scope

This publication is intended to provide design guidance for the protection of school buildings and their occupants against natural hazards. It focuses on the design of elementary and secondary schools (K–12), as well as repair, renovation, and additions to existing schools. It is one of a series of publications in which multi-hazard and performance-based design are addressed (FEMA 577, *Design Guide for Improving Hospital Safety in Earthquakes, Floods, and High Winds*, and FEMA 543, *Design Guide for Improving Critical Facility Safety from Flooding and High Winds*).

This publication considers the safety of school buildings to occupants, and the economic losses and social disruption caused by building damage and destruction. The volume covers three natural hazards that have the potential to result in unacceptable risk and loss: earthquakes, floods,

and high winds. A companion volume, FEMA 428, *Primer to Design Safe School Projects in Case of Terrorist Attacks*, covers the manmade hazards of physical, chemical, biological, and radiological attacks.

This publication is intended to assist design professionals and school officials involved in the technical and financial decisions related to school construction, repair, and renovations.

Organization and Content of the Manual

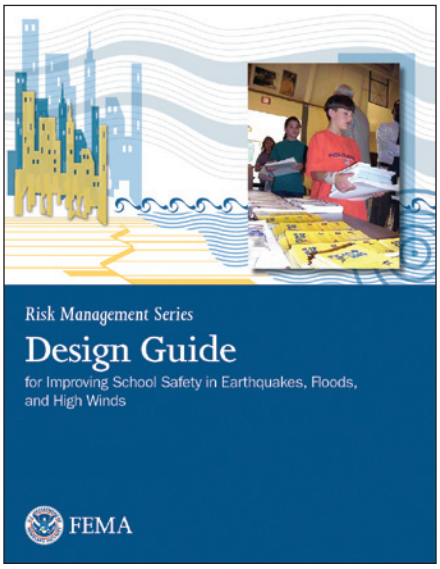
Chapters 1–3 present issues and background information that are common to all hazards. Chapters 4–6 cover the development of specific risk management measures for each of the three natural hazards addressed.

Chapter 1 opens with a brief outline of the past, present, and future of school design. Past school design is important because many of these older, and even historic, schools are still in use and may be exposed to the effects of earthquakes, floods, and high winds.

Chapter 2 introduces the concept of performance-based design, an approach to design that is driven by the desired performance of a new or retrofitted facility.

Chapter 3 introduces the concept of multi-hazard design and presents a general description and comparison of the hazards, including charts that show how the design to resist one hazard may interact with the design for other hazards.

Chapters 4, 5, and 6 outline how to address risk management concerns for protection of schools against earthquakes, floods, and high winds, respectively. Information is presented on the nature of each hazard and its effect on vulnerability, as well as and the consequences of building exposure. Procedures for risk assessment are followed by descriptions of current methods of reducing the effects of each hazard. These methods vary, depending on the hazard under consideration.



Appendix A contains a list of acronyms that appear in this manual.

This publication provides recommendations to create safe schools, but is necessarily limited. Readers should not expect to use the information directly to develop plans and

specifications. Rather, the information is intended to help designers and facility decision-makers, who may be unfamiliar with the concepts involved, to understand fundamental approaches to risk mitigation planning and design. With this understanding, they can then approach the implementation phase of detailed planning, which involves consultants, procurement personnel, and project administration.

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This publication will be revised periodically and FEMA welcomes comments and feedback to improve future editions.

Please send comments and feedback via e-mail to riskmanagementseriespubs@dhs.gov.

Design Guide

for Improving School Safety in Earthquakes, Floods, and High Winds

Table of Contents

Foreword and Acknowledgments i

Background i

Scope ii

Organization and Content of the Manual iii

Acknowledgments iv

Principal Authors iv

Contributors iv

1 An Overview of the School Design and Construction Process 1-1

11.1 Introduction 1-1

1.2 School Construction: The National Picture 1-2

1.3 Past School Design 1-2

1.4 Present School Design 1-8

1.5 Future School Design 1-9

1.6 The Design and Construction Process 1-11

1.7 References 1-14

2 Performance-Based Design 2-1

2.1 Background 2-1

2.2 Prescriptive vs. Performance-Based Design 2-3

2.3 The Performance-Based Design Process 2-4
2.4 Acceptable Risk and Performance Levels 2-5
2.5 Considerations For Achieving Continuous Operation Performance Level 2-8
2.6 Performance-Based Flood Design 2-10
2.7 Performance-Based High-Wind Design 2-11
2.8 Performance-Based Seismic Design 2-12
2.9 References 2-14

3 Multihazard Design 3-1
3.1 Introduction 3-1
3.2 The Hazards Compared 3-1
3.2.1 Location: Where do Hazards Occur? 3-2
3.2.2 Warning: How Much Warning is There? 3-4
3.2.3 Frequency: How Likely are They to Occur? 3-5
3.3 A Comparison of Potential Losses 3-6
3.4 Fire and Life Safety 3-10
3.5 Multihazard Design Interactions 3-11
3.6 References 3-18

4 Making Schools Safe From Earthquakes 4-1
4.1 Introduction 4-1
4.2 The Nature and Probability of Earthquakes 4-2
4.2.1 Earthquakes and Other Geologic Hazards 4-2
4.2.2 Earthquakes: A National Problem 4-4
4.2.3 Common Measures of Earthquakes 4-8
4.2.4 Determination of Local Earthquake Hazards 4-11
4.3 Vulnerability: What Earthquakes Can Do to Schools 4-13
4.3.1 Vulnerability of Schools 4-13

4.3.2 Earthquake Damage to Schools 4-16
4.3.3 Significant School Damage in U.S. Earthquakes 4-23
4.3.4 Consequences: Casualties, Financial Loss, and Operational Disruption 4-27
4.4 Scope, Effectiveness, and Limitations of Codes 4-28
4.4.1 The Background of Seismic Provisions in Building Codes 4-29
4.4.2 Seismic Codes and Schools 4-29
4.4.3 The Effectiveness of Seismic Codes 4-30
4.5 Evaluating Existing Schools for Seismic Risk and Specific Risk Reduction Methods 4-31
4.5.1 Rapid Visual Screening 4-31
4.5.2 Systems Checklist for School Seismic Safety Evaluation 4-32
4.5.3 Seismic Evaluation of Existing Buildings 4-37
4.6 Earthquake Risk Reduction Methods 4-38
4.6.1 Risk Reduction for New Schools 4-39
4.6.2 Risk Reduction for Existing Schools 4-49
4.7 The School as a Post-Earthquake Shelter 4-55
4.8 References and Sources of Additional Information 4-56
4.9 Glossary of Earthquake Terms 4-58

5 Making Schools Safe From Flooding 5-1
5.1 General Design Considerations 5-1
5.1.1 The Nature of Flooding 5-2
5.1.2 Probability of Occurrence or Frequency 5-4
5.1.3 Flood Characteristics and Loads 5-8
5.1.3.1 Hydrostatic Loads 5-10
5.1.3.2 Hydrodynamic Loads 5-11
5.1.3.3 Debris Impact Loads 5-13
5.1.3.4 Erosion and Local Scour 5-14
5.1.4 Design Parameters 5-15
5.1.4.1 Flood Depth 5-15

5.1.4.3 Flood Velocity—Riverine 5-19
5.1.4.4 Flood Velocity—Coastal 5-19
5.1.5 Flood Hazard Maps and Zones 5-20
5.1.5.1 NFIP Flood Maps 5-21
5.1.5.2 NFIP Flood Zones 5-22
5.1.5.3 Coastal A Zones 5-25
5.1.6 Floodplain Management Requirements and Building Codes 5-26
5.1.6.1 Overview of the NFIP 5-27
5.1.6.2 Summary of the NFIP Minimum Requirements 5-28
5.1.6.3 Executive Order 11988 and Critical Facilities 5-30
5.1.6.4 Model Building Codes and Standards 5-31
5.2 Schools Exposed to Flooding 5-33
5.2.1 Identifying Flood Hazards at School Sites 5-33
5.2.2 Vulnerability: What Flooding Can Do to Existing Schools 5-34
5.2.2.1 Site Damage 5-34
5.2.2.2 Structural Damage 5-36
5.2.2.3 Nonstructural Damage 5-39
5.2.2.4 Utility System Damage 5-41
5.2.2.5 Contents Damage 5-44
5.3 Requirements and Best Practices in Flood Hazard Areas 5-45
5.3.1 Evaluating Risk and Avoiding Flood Hazards 5-45
5.3.2 Benefits and Costs: Determining Acceptable Risk 5-46
5.3.3 Site Modifications 5-48
5.3.4 Elevation Considerations 5-50
5.3.5 Dry Floodproofing Considerations 5-56
5.3.6 Flood Damage-Resistant Materials 5-59
5.3.7 Access Roads 5-61
5.3.8 Utility Installations 5-61
5.3.9 Potable Water and Wastewater Systems 5-63
5.3.10 Storage Tank Installations 5-64
5.3.11 Accessory Structures 5-64

5.4 Risk Reduction for Existing Schools 5-64
5.4.1 Introduction 5-64
5.4.2 Site Modifications 5-65
5.4.3 Additions 5-67
5.4.4 Repairs, Renovations, and Upgrades 5-68
5.4.5 Retrofit Dry Floodproofing 5-69
5.4.6 Utility Installations 5-70
5.4.7 Potable Water and Wastewater Systems 5-72
5.4.8 Other Damage Reduction Measures 5-72
5.4.9 Drainage Improvements 5-73
5.4.10 Emergency Measures 5-74
5.5 Schools as Emergency Shelters and Safe Rooms 5-75
5.6 Checklist for Vulnerability of Floodprone Sites and Schools 5-77
5.7 References and Sources of Additional Information 5-83
5.8 Glossary of Flood Protection Terms 5-86

6 Making Schools Safe From High Winds 6-1
6.1 General Design Considerations 6-1
6.1.1 Nature of High Winds 6-3
6.1.2 Probability of Occurrence 6-4
6.1.3 Wind/Building Interactions 6-6
6.1.4 Building Codes 6-12
6.1.4.1 Scope of Building Codes 6-13
6.1.4.2 Effectiveness and Limitations of Building Codes 6-14
6.2 Schools Exposed to High Winds 6-17
6.2.1 Vulnerability: What High Winds Can Do to Schools 6-17
6.2.1.1 Types of Building Damage 6-17
6.2.1.2 Ramification of Damage 6-21
6.2.2 Priorities, Costs, And Benefits: New Schools 6-25
6.2.2.1 Priorities 6-25
6.2.2.2 Cost, Budgeting, and Benefits 6-26

6.2.3 Priorities, Costs, and Benefits: Existing Schools 6-28
6.2.3.1 Priorities 6-28
6.2.3.2 Cost, Budgeting, and Benefits 6-29
6.2.4 Evaluating Schools for Risk from High Winds 6-31
6.2.4.1 New Buildings 6-31
6.2.4.2 Existing Buildings 6-32
6.2.4.3 Portable Classrooms 6-33
6.3 Requirements and Best Practices in High-Wind Regions 6-34
6.3.1 General School Design Considerations 6-35
6.3.1.1 Site 6-35
6.3.1.2 School Design 6-37
6.3.1.3 Construction Contract Administration 6-42
6.3.1.4 Post-Occupancy Inspections, Periodic Maintenance, Repair, and Replacement 6-43
6.3.1.5 Site and General Design Considerations in Hurricane-Prone Regions 6-44
6.3.2 Structural Systems 6-46
6.3.2.1 Design Parameters for Structural Systems 6-46
6.3.2.2 Design Parameters for Structural Systems in Hurricane-Prone Regions 6-52
6.3.3 Building Envelope 6-53
6.3.3.1 Exterior Doors 6-53
6.3.3.2 Windows and Skylights 6-57
6.3.3.3 Windows and Skylights in Hurricane-Prone Regions 6-60
6.3.3.4 Non-Load-Bearing Walls, Wall Coverings, and Soffits 6-63
6.3.3.5 Non-Load-Bearing Walls, Wall Coverings, and Soffits in Hurricane-Prone Regions 6-73
6.3.3.6 Roof Systems 6-74
6.3.3.7 Roof Systems in Hurricane-Prone Regions 6-86
6.3.4 Nonstructural Systems and Equipment 6-94
6.3.4.1 Exterior-Mounted Mechanical Equipment 6-94
6.3.4.2 Nonstructural Systems and Mechanical Equipment in Hurricane-Prone Regions 6-104
6.3.4.3 Exterior-Mounted Electrical and Communications Equipment 6-106

6.3.4.4 Lightning Protection Systems in Hurricane-Prone Regions 6-109

6.3.5 Municipal Utilities In Hurricane-Prone Regions 6-115

6.3.5.1 Electrical Power 6-116

6.3.5.2 Water Service 6-117

6.3.5.3 Sewer Service 6-118

6.3.6 Post-Design Considerations in Hurricane-Prone Regions 6-118

6.3.6.1 Construction Contract Administration 6-118

6.3.6.2 Periodic Inspections, Maintenance, and Repair 6-118

6.4 Remedial Work on Existing Facilities 6-119

6.4.1 Structural Systems 6-121

6.4.2 Building Envelope 6-122

6.4.2.1 Windows and Skylights 6-123

6.4.2.2 Non-Load-Bearing Walls, Wall Coverings, and Soffits 6-127

6.4.2.3 Roof Coverings 6-128

6.4.3 Exterior-Mounted Equipment 6-131

6.4.3.1 HVAC Units, Condensers, Fans, Exhaust Stacks, and Ductwork 6-131

6.4.3.2 Antenna (Communications Mast) 6-134

6.4.3.3 Lightning Protection Systems 6-134

6.5 Occupant Protection Best Practices in Tornado- and Hurricane-Prone Regions 6-135

6.6 Checklist For Building Vulnerability of Schools Exposed to High Winds 6-139

6.7 References and Sources of Additional Information 6-143

6.8 Glossary of High Wind Protection Terms 6-147

Appendix

Appendix A: Acronyms A-1

Figures

Chapter 1

Figure 1-1: One-room schoolhouse, Christiana, DE, 1923 1-3

Figure 1-2: High school, New York City, NY, 1929 1-3

Figure 1-3: Elementary school, Washington, DC, constructed in 1930 1-4

Figure 1-4: Typical finger plan school, 1940s 1-5

Figure 1-5: Compact courtyard plan, 1960s 1-5

Figure 1-6: Fountain Valley High School, Huntington Beach, CA, 1964 1-6

Figure 1-7: Open enclosure plan teaching area, with movable screens and storage, Rhode Island, 1970 1-6

Figure 1-8: Typical portable classrooms, 1980s, still in use 1-7

Figure 1-9: Elementary school, Fairfield, PA, 1980s 1-7

Figure 1-10: Private high school located in a remodeled industrial building, Palo Alto, CA 1-8

Figure 1-11: West High School, Aurora, IL, 2000 1-10

Figure 1-12: Elementary school, Oxnard, CA, 2000 1-10

Figure 1-13: Design and construction process flow chart 1-13

Chapter 2

Figure 2-1: Performance-based design flow diagram 2-4

Figure 2-2: Maximum level of damage to be tolerated based on performance groups and magnitude of design event 2-7

Figure 2-3: Relative magnitude and return period for seismic, flood, and wind events 2-8

Chapter 3

Figure 3-1: Areas where earthquakes are likely to occur on the U.S. mainland. The contour lines indicate the 2-percent probability of exceedance of ground motion accelerations within each contour area (or the "odds" [2-percent] that the accelerations will be exceeded in a 50-year period) 3-3

Figure 3-2: Basic wind speed map from ASCE 7 for Risk Category III and IV buildings and other structures. ASCE 7 is cited in the model building codes and used to select design wind speeds. 3-4

Chapter 4

Figure 4-1: School in Anchorage, AK, 1964, severely damaged by earthquake-induced landslide 4-3

Figure 4-2: States with seismic risk 4-5

Figure 4-3: Examples of national seismic hazard maps 4-12

Figure 4-4: Representative shapes of building code (or design) response spectra for different soils 4-12

Figure 4-5: Ductility 4-13

Figure 4-6: Collapse of portion of nonductile concrete frame school structure, Helena, MT, 1935 4-14

Figure 4-7: Modular classrooms pushed off their foundations; note stairs at left, Northridge, CA, 1994 4-14

Figure 4-8: Fallen filing cabinets and shelves, Northridge, CA, 1994 4-15

Figure 4-9: Fallen shop equipment, Coalinga, CA, 1983 4-15

Figure 4-10: Fallen light fixtures, library, Coalinga, CA, 1983 4-16

Figure 4-11: Fallen heavy lath and plaster ceiling across auditorium seating, Northridge, CA, 1994 4-16

Figure 4-12: Damage to the John Muir School, Long Beach, CA, 1933 4-17

Figure 4-13: Damage to shop building, Compton Junior High School, Long Beach, CA, 1933 4-17

Figure 4-14: A dangerous passageway between two buildings, Polytechnic High School, Long Beach, CA, 1933 4-18

Figure 4-15: A heavy corridor lintel ready to fall, Emerson School, Bakersfield, Kern County, CA, 1952 4-18

Figure 4-16: Overturned shop equipment and failed light fixtures, Kern County, CA, 1952 4-19

Figure 4-17: Destroyed exit corridor, Bakersfield, Kern County, CA, 1952 4-19

Figure 4-18: Typical school damage, Helena, MT, 1935 4-20

Figure 4-19: The student body president was killed here by falling brickwork, Seattle, WA, 1949 4-21

Figure 4-20: Another dangerous entry collapse, Seattle, WA, 1949 4-21

Figure 4-21: Collapse of roof over stage, Seattle, WA, 1949..... 4-22

Figure 4-22: Damage to library shelving, Seattle, WA, 1949 4-22

Figure 4-23: Severe structural damage to the West Anchorage High School, Anchorage, AK, 1964 4-23

Figure 4-24: Brittle failure at nonductile concrete column, West Anchorage High School, 1964..... 4-24

Figure 4-25: Ceiling damage, Northridge, CA, 1994..... 4-25

Figure 4-26: Damage to ceramic kiln, including fractured gas line, Northridge, CA, 1994 4-26

Figure 4-27: Line of suspended light fixtures fallen on teacher's station, Northridge, CA, 1994..... 4-26

Figure 4-28: Example of rapid visual screening information form 4-32

Figure 4-29a: Structural and nonstructural elements of a building..... 4-46

Figure 4-29b: Structural and nonstructural elements of a building..... 4-47

Figure 4-30: Suspended ceiling and light fixture bracing and support..... 4-47

Figure 4-31: Bracing tall shelving to the structure 4-48

Figure 4-32: Connection of nonstructural masonry wall to structure to permit independent movement 4-48

Figure 4-33: Bracing for existing unreinforced masonry parapet wall 4-48

Figure 4-34: Design strategies for seismic retrofit of existing buildings 4-51

Figure 4-35: Retrofit of B.F. Day Elementary School, Seattle, WA 4-52

Figure 4-36: Sections and plans of the B.F. Day School: existing at bottom, retrofitted at top. Note that the retrofit has also opened up the basement and first floor to provide large spaces suitable for today's educational needs 4-52

Chapter 5

Figure 5-1: The riverine floodplain 5-4

Figure 5-2: The floodplain along an open coast 5-5

Figure 5-3: Probability and magnitude 5-6

Figure 5-4: Hydrostatic loads on buildings 5-11

Figure 5-5: Hydrodynamic loads on a building or building element 5-11

Figure 5-6: Definition sketch – coastal wave height and stillwater depth 5-16

Figure 5-7: Velocity as a function of stillwater flood depth 5-20

Figure 5-8: Riverine flood hazard zones 5-23

Figure 5-9: Coastal flood hazard zones 5-24

Figure 5-10: Sample digital FIRM format used for modernized maps 5-24

Figure 5-11: Illustration of the Limit of Moderate Wave Action, which delineates the inland limit of areas referred to as Coastal A Zones 5-25

Figure 5-12: Flooding caused the failure of this road bed 5-35

Figure 5-13: School bus washed away by storm surge 5-36

Figure 5-14: Interior unreinforced masonry walls of the Port Sulphur High School in Louisiana were damaged by hydrostatic loads associated with Hurricane Katrina's storm surge (2005) 5-37

Figure 5-15: Concrete slab ruptured by hydrostatic pressure (buoyancy) induced by the floodwaters of Hurricane Katrina (2005) 5-38

Figure 5-16: Scour undermined the foundation of St. Paul Catholic School, Pass Christian, LA 5-38

Figure 5-17: This parquet wood gymnasium floor was damaged by dimensional changes due to saturation (Hurricane Katrina 2005). 5-40

Figure 5-18: Saturation damage extends above the water line in this grade school in Gurnee, IL 5-41

Figure 5-19: Although it was anchored and not displaced by floodwaters, this generator was out of service after being submerged (Hurricane Katrina, 2005) 5-43

Figure 5-20: Destroyed computers and peripheral equipment, Nichols Elementary School, Biloxi, MS 5-44

Figure 5-21a: Schematic of typical earthen levee 5-49

Figure 5-21b: Schematic of typical permanent floodwall 5-50

Figure 5-22: High school in Bloomsburg, PA, elevated on fill 5-53

Figure 5-23: A stemwall foundation elevates the Marion T. Academy above the flood level in Wilmington, DE. 5-54

Figure 5-24: School elevated on columns 5-54

Figure 5-25: Typical crawlspace with flood openings 5-55

Figure 5-26: Specially designed panels are mounted to block doors, windows, and other openings to keep water from entering the building. 5-58

Figure 5-27: Brick facing separated from masonry wall (Hurricane Katrina, 2005) 5-60

Figure 5-28: Equipment room with watertight door 5-62

Figure 5-29: A masonry floodwall with multiple engineered openings in Fargo, ND, during flooding in 2001 5-67

Figure 5-30: Utility component elevated above flood level 5-71

Figure 5-31: Gravel-filled containers form a barrier to protect the University of Iowa (2008) 5-75

Chapter 6

Figure 6-1: Large portions of the roof coverings blew off of this school. Estimated wind speed: Approximately 125 to 130 miles per hour (mph). Hurricane Katrina (Louisiana, 2005) 6-2

Figure 6-2: Hurricane-prone regions and special wind regions 6-3

Figure 6-3: Average number of tornadoes per year (1953-2005) 6-5

Figure 6-4: This high school was damaged by a strong tornado (Plainfield, IL 1990) 6-6

Figure 6-5: Basic wind speeds for Risk Category III and IV buildings and other structures 6-8

Figure 6-6: Wind pressure as a function of wind speed 6-9

Figure 6-7: Relative roof uplift pressures as a function of roof geometry, roof slope, and location on roof, and relative positive and negative wall pressures as a function of location along the wall 6-10

Figure 6-8: Aggregate Blow-off associated with building irregularities. Hurricane Hugo (South Carolina, 1989) 6-11

Figure 6-9: The irregularity created by the stair tower (covered with a metal roof) caused turbulence resulting in wind speed-up and roof damage. Hurricane Andrew (Florida, 1992) 6-11

Figure 6-10: Plan view of a portion of the building in Figure 6-9 showing the use of a corner uplift zone in lieu of a perimeter uplift zone on the low-slope roof in the vicinity of the stair tower 6-12

Figure 6-11: The single-ply roof membrane on this school was torn by a missile. The tear was still unprotected 6 days after it was damaged. A substantial amount of water can enter the building through such a tear, unless the deck is water tight (see Figure 6-13) or a secondary roof membrane is used as discussed in Section 6.3.3.8. Estimated wind speed: 105 to 115 mph. Hurricane Ivan (Florida, 2004) 6-15

Figure 6-12: Constructed in 1995, this school was used as a hurricane shelter. The large number of occupants moved from one area of the school to another as water entered various areas of the building due to envelope failures. Estimated wind speed: 105 to 115 mph. Hurricane Ivan (Florida, 2004) 6-17

Figure 6-13: Extensive roof covering and rooftop equipment damage occurred on this school. However, the cast-in-place concrete deck kept most of the water from entering the school. Hurricane Andrew (Florida, 1992) 6-18

Figure 6-14: The outer window panes were broken by aggregate from a built-up roof. Estimated wind speed: 104 mph. Hurricane Hugo (South Carolina, 1989) 6-18

Figure 6-15: Blow-off of metal wall panels allowed wind-driven rain to enter this school. Hurricane Frances (Florida, 2004) 6-19

Figure 6-16: Collapsed unreinforced CMU wall. Hurricane Marilyn (U.S. Virgin Islands, 1995) 6-19

Figure 6-17: The roof and all of the walls of a wing of this elementary school were blown away by a violent tornado. (Oklahoma City, 1999) 6-20

Figure 6-18: This elementary school was composed of several buildings. The building in the foreground collapsed and several others experienced significant structural damage. The buildings further up the hillside are residences. Hurricane Marilyn (U.S. Virgin Islands, 1995) 6-20

Figure 6-19: This portable classroom was blown up against the main school building. Depending upon the type of exterior wall, an impacting portable classroom may or may not cause wall collapse. Hurricane Marilyn (U.S. Virgin Islands, 1995) 6-21

Figure 6-20: This newly-constructed gymnasium had a structural metal roof panel (3-inch trapezoidal ribs at 24 inches on center) applied over metal purlins. The panels detached from their concealed clips. A massive quantity of water entered the school and buckled the wood gym floor. Typhoon Paka (Guam, 1997) 6-22

Figure 6-21: The entire metal deck and steel joist roof structure at this school's auto shop blew off. Estimated wind speed: 105 to 115 mph. Hurricane Ivan (Florida, 2004) 6-22

Figure 6-22: The metal straps between this portable classroom and the ground anchors were not taut. This classroom is susceptible to being blown off the piers and to overturning. See Figure 6-26 for a robust anchoring system 6-23

Figure 6-23: This old school was used as a hurricane shelter. Structural failure did not occur during this hurricane. However, portions of the roof covering were blown off, rooftop equipment was damaged, and many windows were broken by aggregate from the built-up roof (red arrow). Estimated wind speed: 130 mph. Hurricane Katrina (Mississippi, 2005) 6-24

Figure 6-24: This old school was scheduled to be used as a hurricane shelter. Sheltering people in schools that lack sufficient wind and wind-borne debris resistance presents risk of injury or death to occupants. Hurricane Andrew (Louisiana, 1992) 6-25

Figure 6-25: Lack of fasteners resulted in blow-off of the HVAC unit, which caused extensive interior water damage and interrupted facility use. Hurricane Marilyn (U.S. Virgin Islands, 1995) 6-28

Figure 6-26: The cementitious wood-fiber deck panels blew off the overhangs and caused a progressive lifting and peeling of the roof membrane. Strengthening (or replacing) inadequately attached roof decks during a reroofing project is both prudent and relatively economical. Estimated wind speed: 120 mph. Hurricane Katrina (Mississippi, 2005) 6-30

Figure 6-27: Unlike the portable classroom shown in Figure 6-22, with the thick T-shaped plates and taut turnbuckles, this portable classroom has a robust anchorage to the ground. Hurricane Francis (Florida, 2004) 6-33

Figure 6-28: Asphalt shingles and vinyl siding blew off of this portable classroom. This type of wind-borne debris can break unprotected glazing. Hurricane Francis (Florida, 2004) 6-34

Figure 6-29: This fallen tree caused minor damage to these portable classrooms. However, had the tree landed on the classroom at the left of the photograph, it could have caused injuries if the building had been occupied. Although portable classrooms are not occupied during hurricanes, they are frequently occupied during thunderstorms, which often topple trees. Estimated wind speed: 105 to 115 mph. Hurricane Ivan (Florida, 2004) 6-36

Figure 6-30: In most of the areas on this roof, the connection of the top nailer to the bottom nailer was the weakest link. However, in a few locations, the connection of the bottom nailer to the roof structure was the weak link (three of the blown-off bottom nailers are shown by the red lines). 6-39

Figure 6-31: Illustration of load path continuity 6-40

Figure 6-32: Dirt and vegetation surrounded this roof drain (red arrow) and impeded drainage. Roof drains should be checked at least annually and cleaned of debris if found. Drains should also be checked prior to hurricane landfall. Hurricane Ike (Texas, 2008) 6-44

Figure 6:33: Open walkways do not provide protection from wind-borne debris. Hurricane Katrina (Mississippi, 2005) 6-46

Figure 6-34: The structure on this school was composed of light gauge metal framing, with a proprietary composite deck system composed of light gauge corrugated metal deck and gypsum board. In addition to the gable end wall failure, the asphalt shingles and underlayment were blown off at the corner of the eave and ridge. Estimated wind speed: 140 to 160 mph. Hurricane Charley (Florida, 2004) 6-47

Figure 6-35: Even though the roof structure blew off, because of the strength and reliability of the screwed deck connections, the decking remained attached to the joists. Hurricane Charley (Florida, 2004) 6-48

Figure 6-36: View looking down at the top of a steel joist after the metal decking blew away. Only a small portion of the deck was well fused to the joist (circled area). Tornado (Oklahoma, 1999) 6-49

Figure 6-37: Looking down at a sidelap of a deck attached with powder-driven pins. The washer at the top pin blew through the deck 6-49

Figure 6-38: View looking along a sidelap of a deck attached with powder-driven pins. The right pin does not provide adequate uplift and shear resistance. 6-49

Figure 6-39: Portions of this waffled precast concrete roof deck were blown off. Typhoon Paka (Guam, 1997) 6-50

Figure 6-40: Twin-Tee roof panel lifted as a result of the combined effects of wind uplift and pre-tension. Tornado (Missouri, May 2003) 6-51

Figure 6-41: The wind speed was sufficient to collapse this school's canopy, but the speed was not high enough to blow the canopy debris very far. Hurricane Francis (Florida, 2004) 6-51

Figure 6-42: At the school shown in Figure 6-34, wind-borne debris ruptured the proprietary composite deck system composed of light gauge corrugated metal deck and gypsum board. Estimated wind speed: 140 to 160 mph. Hurricane Charley (Florida, 2004) 6-53

Figure 6-43: Door sill pan flashing with end dams, rear leg, and turned-down front leg 6-55

Figure 6-44: Drip at door head and drip with hook at head 6-55

Figure 6-45: Door shoe with drip and vinyl seal (left); neoprene door sweep (right) 6-56

Figure 6-46: Automatic door bottom 6-56

Figure 6-47: Interlocking threshold with drain pan 6-57

Figure 6-48: Threshold with stop and seal 6-57

Figure 6-49: Adjustable jamb/head weatherstripping 6-57

Figure 6-50: Two complete windows, including frames, blew out as a result of an inadequate number of fasteners. Typhoon Paka (Guam, 1997) 6-58

Figure 6-51: View of a typical window sill pan flashing with end dams and rear legs. 6-59

Figure 6-52: Protecting sealant retards weathering and reduces the exposure to wind-driven rain 6-59

Figure 6-53: Plywood panels (black continuous bands) installed after the glass spandrel panels were broken by roof aggregate. Estimated wind speed: 130 mph. Hurricane Katrina (Mississippi, 2005) 6-60

Figure 6-54: The red arrow shows a piece of laminated glass that was broken, but remained in the frame to protect the building's interior. The blue arrow shows unbroken laminated glass. The yellow arrows show granite wall panels. Estimated wind speed: 105 mph. Hurricane Katrina (Louisiana, 2005) 6-61

Figure 6-55: The exterior wall stopped just above the soffit (red arrows). After the metal soffit panels blew away, wind-driven rain blew into the attic space, which saturated the fiberglass batt insulation and caused the ceiling boards to collapse. Estimated wind speed: 130 mph. Hurricane Katrina (Mississippi, 2005) 6-63

Figure 6-56: The red arrows show the original location of a CMU wall that nearly collapsed following a rolling door failure. Estimated wind speed: 140–160 mph. Hurricane Charley (Florida, 2004) 6-64

Figure 6-57: Although uncommon for schools, precast wall panels were attached to the structural frame of this school. This type of wall typically offers excellent wind performance. Note the roof covering damage and displaced gas line. Estimated wind speed: Approximately 125–130 mph. Hurricane Katrina (Louisiana, 2005) 6-65

Figure 6-58: The four ties shown by the red arrows were not embedded into the mortar. Estimated wind speed: 105 mph. Hurricane Katrina, (Mississippi, 2005) 6-66

Figure 6-59: Water leaked inside along the base of the brick veneer walls (red arrow). Estimated wind speed: 115 mph. Hurricane Katrina (Louisiana, 2005) 6-67

Figure 6-60: Typical EIFS assemblies 6-67

Figure 6-61: EIFS blow-off near a wall corner. At one area, the metal fascia was also blown in 6-68

Figure 6-62: At this EIFS failure, the screws attaching the gypsum board (yellow colored material) were too far apart (red circle). Additionally, at the board joint, the screws were too close to the board edge (blue circle). In this area, the screws were spaced at 4½, 4, 6, 6, 9, and 9½ inches on center. Also, the adhesive between the gypsum board and MEPS was applied in rows rather than continuously over the gypsum board. Estimated wind speed: 120 mph. Hurricane Katrina (Mississippi, 2005) 6-68

Figure 6-63: The stucco wall failure was caused by inadequate attachment between the stud tracks and the building's structure. All of the metal stud framing within the red circle blew away. The arrow shows a bottom stud track that detached and pulled away from the building. Estimated wind speed: 110–125 mph. Hurricane Ivan (Florida, 2004) 6-69

Figure 6-64: The loss of metal wall panels allowed a substantial amount of wind-driven rain to penetrate into the classroom. Estimated wind speed: 105–115 mph. Hurricane Ivan (Florida, 2004) 6-70

Figure 6-65: Blow-off of metal fascia panels due to inadequate attachment of wood furring to the CMU wall. Estimated wind speed: 85–95 mph. Hurricane Ivan (Florida, 2004) 6-71

Figure 6-66: This cement fiber siding was attached with blind nails (red circle). Because of the high design wind speed, face nails should have been used (blue circle). Hurricane Francis (Florida, 2004) 6-72

Figure 6-67: Three of the panel ribs opened up (one to the right of the blue arrow and two to the left). The LPS conductor serving the air terminal (red arrow) ran underneath the ridge flashing. Estimated wind speed: 105–115 mph. Hurricane Ivan (Florida, 2004) 6-75

Figure 6-68: The blown off insulation (red arrow) may have initiated blow-off of the roof membrane. Estimated wind speed: 105–115 mph. Hurricane Ivan (Florida, 2004) 6-77

Figure 6-69: The orientation of the membrane fastener rows led to blow-off of the steel deck. Hurricane Marilyn (U.S. Virgin Islands, 1995) 6-78

Figure 6-70: The ink pen shows an opening that the wind can catch to cause lifting and peeling of the membrane. 6-79

Figure 6-71: The metal edge flashing on this building disengaged from the continuous cleat and the vertical flange lifted. Hurricane Hugo (South Carolina, 1989) 6-80

Figure 6-72: The coping blew off because of inadequate attachment of the cleats. Estimated wind speed: 92 mph. Hurricane Ike (Texas, 2008) 6-80

Figure 6-73: Both vertical faces of the coping were attached with exposed fasteners instead of concealed cleats. Typhoon Paka (Guam, 1997) 6-81

Figure 6-74: Because this gutter was not attached to the bracket, wind lifted the gutter along with the metal edge flashing that lapped into the gutter. Bracket fasteners are indicated by the red arrows. Hurricane Francis (Florida, 2004) 6-82

Figure 6-75: The original modified bitumen membrane was blown away after the gutter lifted in the area shown by the red arrow (the black membrane is a temporary roof). Hurricane Francis (Florida, 2004) 6-82

Figure 6-76: At this gutter, a fastener connected the bracket to the gutter. Note: To avoid leakage at the fasteners between the bracket and gutter, the bracket should extend near or to the top of the gutter so that the fastener would be above the waterline. Estimated wind speed: 95 mph. Hurricane Ike (Texas, 2008) 6-83

Figure 6-77: Sheet metal straps were attached to an existing gutter that lacked sufficient uplift resistance. 6-84

Figure 6-78: Blow-off of this downspout resulted in glazing breakage. Estimated wind speed: 105–115 mph. Hurricane Ivan (Florida, 2004) 6-85

Figure 6-79: If mechanically attached base flashings have an insufficient number of fasteners, the base flashing can be blown away. Hurricane Andrew (Florida, 2004) 6-85

Figure 6-80: The secondary membrane prevented significant leakage into the building after the copper roof blew off. Hurricane Andrew (Florida, 1992) 6-87

Figure 6-81: Although a missile cut into the SPF, the roof was still watertight. The ink pen (blue arrow) shows the relative size of the impact area. Estimated wind speed: 110 mph. Hurricane Ike (Texas, 2008) 6-88

Figure 6-82: Significant interior water damage and facility interruption occurred after the standing seam roof blew off. Hurricane Marilyn (U.S. Virgin Islands, 1995) 6-89

Figure 6-83: Brittle roof coverings, like slate and tile, can be broken by missiles, and tile debris can break other tiles. Estimated wind speed: 140–160 mph. Hurricane Charley (Florida, 2004) 6-90

Figure 6-84 These wire-tied tiles were installed over a concrete deck. The failure was attributed to lack of vertical restraint, which allowed the tiles to lift and then be broken when they slammed back down onto the deck. Typhoon Paka (Guam, 1997) 6-91

Figure 6-85: This mechanically attached single-ply membrane progressively tore after being cut by wind-borne debris. Hurricane Andrew (Florida, 1992) 6-91

Figure 6-86: A continuous peel-stop bar over the membrane may prevent a catastrophic progressive failure if the edge flashing or coping is blown off. (Modified from FEMA 55, 2000) 6-92

Figure 6-87: Several rubber walkway pads were blown off the single-ply membrane roof. Estimated wind speed: 130 mph. Hurricane Katrina (Mississippi, 2005) 6-93

Figure 6-88: Base flashing protected by metal wall panels attached with exposed screws. Estimated wind speed: 120 mph. Hurricane Katrina (Mississippi, 2005) 6-93

Figure 6-89: This gooseneck was attached with only two small screws. Emergency repairs had not been made at the time this photograph was taken, which was 5 days after the hurricane struck. A substantial amount of water was able to enter the school. Hurricane Francis (Florida, 2004) 6-94

Figure 6-90: Although this 18,000-pound HVAC unit was attached to its curb with 16 straps, it blew off the building during Hurricane Ivan. (Florida, 2004) 6-95

Figure 6-91: The gooseneck on this building remained attached to the curb, but the curb detached from the deck. Typhoon Paka (Guam, 1997) 6-97

Figure 6-92: Cowlings blew off two of the three fans. Note also the loose LPS conductors and missing walkway pad (red arrow). Estimated wind speed: 140–160 mph. Hurricane Charley (Florida, 2004) 6-98

Figure 6-93: Cables were attached to prevent the cowling from blowing off. Typhoon Paka (Guam, 1997) 6-98

Figure 6-94: These condensers were blown off their sleepers. Displaced condensers can rupture roof membranes and refrigerant lines. Estimated wind speed: 120 mph. Hurricane Katrina (Mississippi) 6-99

Figure 6-95: This condenser had supplemental attachment straps (see red arrows). Typhoon Paka (Guam, 1997) 6-99

Figure 6-96: Failure of vibration isolators that provided lateral resistance but no uplift resistance caused equipment damage. A damaged vibration isolator is shown in the inset. Estimated wind speed: 120 mph. Hurricane Katrina (Mississippi, 2005) 6-100

Figure 6-97: Guyed flue blew over (red arrow indicates one of the guys). Estimated wind speed: 92 mph. Hurricane Ike (Texas, 2008) 6-101

Figure 6-98: The school shown in Figure 6-63 also had an access panel blow off. Blown-off panels can puncture roof membranes, break glazing, and cause injury. Estimated wind speed: 85–95 mph. Hurricane Ivan (Florida, 2004) 6-101

Figure 6-99: The school shown in Figures 6-64 and 6-98 also experienced gas line rupture (shown by the lines dangling over the side of the building). Estimated wind speed: 85–95 mph. Hurricane Ivan (Florida, 2004) 6-102

Figure 6-100: At a periodic gas line support on this roof, a steel angle was welded to a pipe that was anchored to the roof deck. A strap looped over the gas line and was bolted to the support angle. Such a connection provides resistance to lateral and uplift loads. 6-102

Figure 6-101: These two condensate drain lines detached from their HVAC units. They had not been anchored to the roof. Estimated wind speed: 125 mph. Hurricane Katrina (Mississippi, 2005) 6-103

Figure 6-102: Equipment screen panels can puncture roof membranes, break glazing, and cause injury. Estimated wind speed: 105–115 mph. Hurricane Ivan (Florida, 2004) 6-104

Figure 6-103: This exhaust fan was impacted by wind-borne debris. Although it is often impractical to place all equipment such as fans in penthouses, doing so to the extent possible avoids debris damage. Estimated wind speed: 130 mph. Hurricane Katrina (Mississippi, 2005) 6-105

Figure 6-104: Leaf debris and ponding near a scupper (red and blue arrows). The yellow arrow indicates a piece of coping that blew off an upper roof shown in Figure 6-71. Estimated wind speed: 92 mph. Hurricane Ike (Texas, 2008) 6-106

Figure 6-105: Collapsed light fixtures caused by severe corrosion (see inset). Estimated wind speed: 105–115 mph. Hurricane Ivan (Florida, 2004) 6-107

Figure 6-106: The collapse of the antenna tower at this school caused progressive peeling of the roof membrane. Also note that the exhaust fan blew off the curb, but the high parapet kept it from blowing off the roof. Hurricane Andrew (Florida, 1992) 6-108

Figure 6-107: Common anchoring method for satellite dish. Estimated wind speed: 85–95 mph. Hurricane Ivan (Florida, 2004) 6-109

Figure 6-108: A satellite dish anchored similarly to that shown in Figure 6-106 was blown off this five-story building. Estimated wind speed: 140–160 mph. Hurricane Charley (Florida, 2004) 6-109

Figure 6-109: An air terminal (red arrow) debonded from the roof. Even though the school had a tough membrane (modified bitumen), the displaced air terminal punctured the membrane in two locations (blue arrows). Hurricane Charley (Florida, 2004) 6-110

Figure 6-110: View of an end of a conductor that became disconnected. Estimated wind speed: 130 mph. Hurricane Katrina (Mississippi, 2005) 6-110

Figure 6-111: This conductor connector was adhered to the coping. The conductor deformed the connector prongs under wind pressure, and pulled away from the connector. Estimated wind speed: 130 mph. Hurricane Katrina (Mississippi, 2005) 6-111

Figure 6-112: This conductor was attached to the coping with a looped connector. Estimated wind speed: 130 mph. Hurricane Katrina (Mississippi, 2005) 6-112

Figure 6-113: Plan showing conductor attachment 6-112

Figure 6-114: Use of intermittent membrane flashing strips to secure an LPS conductor, as illustrated in Figure 6-113 6-113

Figure 6-115: Adhesively attached conductor connector that does not use prongs 6-113

Figure 6-116: If conductors detach from the roof, they are likely to pull out from pronged splice connectors. Estimated wind speed: 90–100 mph. Hurricane Charley (Florida, 2004) 6-114

Figure 6-117: Bolted splice connectors are recommended to prevent free ends of connectors from being whipped around by wind. Estimated wind speed: 130 mph. Hurricane Katrina (Mississippi, 2005) 6-115

Figure 6-118: In lieu of permanent on-site emergency generators, portable generators can be an economical way to provide electrical power to schools used as hurricane recovery centers. Estimated wind speed: 108 mph. Hurricane Ike (Texas, 2008) 6-116

Figure 6-119: The tree shown by the red line nearly fell on the emergency generator (red arrow). Estimated wind speed: 110 mph. Hurricane Ike (Texas, 2008) 6-117

Figure 6-120: The roof and a portion of the EIFS on this 5-year-old building blew off. Water leaked into the floor below. The floor was taken out of service for more than a month. Estimated wind speed: 130 mph. Hurricane Katrina (Mississippi, 2005) 6-119

Figure 6-121 The cementitious wood-fiber deck panels blew off of much of the overhang at this school. Deck panel failure resulted in lifting and peeling of the roof system over a large area, exposure of the decking in the area shown by the blue arrows, and extensive interior water infiltration. Estimated wind speed: 105–115 mph. Hurricane Ivan (Florida, 2004) 6-121

Figure 6-122: The steel truss superstructure installed on this school as part of a steep-slope conversion blew away because of inadequate attachment. Hurricane Marilyn (U.S. Virgin Islands, 1995) 6-122

Figure 6-123: Wind pressure caused the window frames on the upper floors to fail (red arrow). Estimated wind speed: 130 mph. Hurricane Katrina (Mississippi, 2005) 6-123

Figure 6-124: On-site water-spray testing in accordance with ASTM E 1105 can be used to evaluate wind-driven rain resistance. Older window assemblies such as the ones at this school are often quite susceptible to leakage. Estimated wind speed: 125 mph. Hurricane Katrina (Mississippi, 2005) 6-124

Figure 6-125: This school has accordion shutters. Estimated wind speed: 105–115 mph. Hurricane Ivan (Florida, 2004) 6-125

Figure 6-126: A metal panel shutter. Hurricane Georges (Puerto Rico, 1998) 6-125

Figure 6-127: Polycarbonate shutters were temporary screwed to the doors and wall adjacent to the window opening. An advantage of polycarbonate is its translucence, which allows daylight to enter the building without removing the shutters. Hurricane Francis (Florida, 2004) 6-126

Figure 6-128: This school has roll-down shutters. The toggle in the red circle allows the shutter to be manually raised. Estimated wind speed: 130–140 mph. Hurricane Charley (Florida, 2004) 6-126

Figure 6-129: Collapsed unreinforced masonry parapet. Greensburg Tornado (Kansas, 2007) 6-127

Figure 6-130: View of a 5-foot by 5-foot negative pressure chamber used to evaluate roof system uplift resistance. 6-128

Figure 6-131: The built-up roof on this school was blown off after a few of the rotted wood planks detached from the joists. Estimated wind speed: 120 mph. Hurricane Katrina (Mississippi, 2005) 6-129

Figure 6-132: The nailer (red arrow) blew off an upper roof and landed on the roof below. The nailer was anchored to a brick wall. Some of the anchors pulled out of the brick, and some of the bricks blew away with the nailer. Estimated wind speed: 105–115 mph. Hurricane Ivan (Florida), 2004 6-130

Figure 6-133: Failed base flashing adhered directly to the brick parapet. Estimated wind speed: 105 mph. Hurricane Katrina (Louisiana, 2005) 6-130

Figure 6-134: During a reroofing project a slot was cut in the plywood deck in order to allow air to flow from the attic to a new continuous ridge vent. The cutting depth of the saw was not adjusted for the thickness of the deck. The top 1½ inch of each truss and a portion of the metal nailing plate was inadvertently cut. 6-131

Figure 6-135: To strengthen attachment of this HVAC unit, robust pipe anchors were attached to the deck and cables with turnbuckles installed. 6-132

Figure 6-136: At this school, the hood on this HVAC unit was inadequately attached. A strap between the hood and unit can be economically installed to avoid this problem. Estimated wind speed: 110 mph. Hurricane Ike (Texas, 2008) 6-132

Figure 6-137: These condensers were simply mounted on wood sleepers that rested on the roof surface. Note the damaged exhaust stacks and missing rain caps (red oval). Estimated wind speed: 105 mph. Hurricane Katina (Mississippi, 2005) 6-133

Figure 6-138: Two large openings (red rectangle and inset) through the roof were left after the ductwork blew away. Estimated wind speed: 130 mph. Hurricane Katrina (Mississippi, 2005) 6-134

Figure 6-139: The antenna collapsed and was whipped back and forth across the roof membrane. Hurricane Andrew (Florida, 1992) 6-135

Figure 6-140: Greensburg Tornado (Kansas, 2007) 6-136

Figure 6-141: A violent tornado showered the roof with missiles (Oklahoma, 1999) 6-136

Figure 6-142: Frequency of recorded EF3, EF4, and EF5 tornadoes (1950–1998) 6-137

Figure 6-143 : Unreinforced masonry walls and hollow-core concrete roof planks collapsed. Enterprise Tornado (Alabama, 2007) 6-139

Tables

Chapter 2

Table 2-1: Combinations of structural and nonstructural seismic performance 2-12

Chapter 3

Table 3-1: HAZUS-MH earthquake, hurricane, and flood losses (all values are in $1,000s—2002 valuation) 3-8

Table 3-2: HAZUS-MH estimated losses by percentage of school building and contents inventory 3-9

Table 3-3: Multihazard design system interactions 3-12

Chapter 4

Table 4-1: Known historic (1558–1989) earthquakes in 47 U.S. States 4-10

Table 4-2: School seismic safety evaluation checklist 4-33

Table 4-3: Roofing maintenance and repair/re-roofing 4-54

Chapter 5

Table 5-1: ASCE/SEI 24 provisions related to the elevation of schools 5-33

Table 5-2: Classes of flood damage-resistant materials 5-59

Table 5-3: Checklist for building vulnerability of floodprone schools 5-77

Chapter 6

Table 6-1: Number of #12 screws for base case attachment of rooftop equipment 6-96

Table 6-2: Checklist for building vulnerability of schools exposed to high winds 6-140