Course Objectives

At the conclusion of this course, participants will be able to:

- Provide an overview of FEMA P-499, Home Builder's Guide to Coastal Construction
- Identify wind and flood hazard mitigation techniques for new and existing construction

Instructors

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Course Schedule

I. Course Welcome, Introduction, and Risk Discussion (15 minutes)
II. Structural Analysis and Design and FEMA P-499 Technical Fact Sheets (105 minutes)
   Break (15 minutes)
III. Wind and Flood Retrofit Guide (90 minutes)
IV. Conclusion and Q&A (15 minutes)

Course Materials – New Construction

The Home Builder’s Guide to Coastal Construction (FEMA P-499)
- Provides guidance on avoiding storm damage
- Includes 37 Technical Fact Sheets aimed at improving the performance of buildings subject to flood and wind forces in coastal environments

Coastal Construction Manual (FEMA P-55)
Provides guidance on designing and constructing residential buildings in coastal areas to be more resistant to the effects of natural hazards. Provides information on current issues and techniques related to:
- Planning
- Siting
- Designing
- Constructing
- Maintaining homes in coastal environments
Course Materials – Existing Construction

Wind Retrofit Guide for Residential Buildings (FEMA P-804)
- Provides guidance for improving the performance of houses in the United States. Proposes three “Mitigation Packages”:
  - Basic
  - Intermediate
  - Advanced
Each package builds on the retrofits of the previous package for increasing levels of wind-hazard resistance for existing houses.

Course Materials – Existing Construction

Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures (FEMA P-259)
Provides guidance for selecting and implementing flood retrofitting measures that are feasible and cost effective. Flood retrofitting measures include:
- Elevation
- Relocation
- Barriers (floodwalls and levees)
- Dry floodproofing
- Wet floodproofing

Why Develop Hazard-Resistance Guidance?

- The damage caused by coastal wind and flood events during Hurricane Sandy illustrates the continued importance of adopting and enforcing effective building codes.
- Thousands of existing homes remain vulnerable to the effects of coastal high-wind and extreme flood events.

According to the FEMA NJ Disaster Declaration page as of March 4th, 2013, 59,447 applications have been approved for Individual Assistance!
Why Develop Hazard-Resistance Guidance?

Local and national FEMA staff have concluded additional technical guidance is needed to:

- Facilitate development of residential wind and flood retrofit projects
- Strengthen new residential construction to mitigate damage from natural hazards
- Provide prescriptive solutions and implementation guidance

Hurricane Sandy (2012)

- Made landfall in Brigantine, NJ on October 29, 2012
- Affected 24 states including entire east coast from Florida to Maine
- New Jersey and New York were hardest hit
- Damage is estimated to be more than $71 Billion

MAT deployed in 4 sub-teams:

- Coastal
- Hospitals and Other Critical Facilities
- High-Rise, Police, Fire, Municipal and Schools
- Historic
Recovery Advisories

Sandy MAT Recovery Advisories – Brief, focused advisories to help address key observations in a timely manner
1. Improving Connections in Elevated Coastal Residential Buildings
2. Reducing Flood Effects in Critical Facilities
3. Restoring Mechanical, Electrical, and Plumbing Systems in Non-Substantially Damaged Residential Buildings

Recovery Advisories

Sandy MAT Recovery Advisories – Brief, focused advisories to help address key observations in a timely manner
4. Reducing Operational Interruptions to Mid- and High-Rise Buildings During Floods
5. Designing for Flood Levels Above the Base Flood Elevation After Hurricane Sandy
6. Protecting Building Fuel Supplies from Flood Damage
7. Reducing Flood Risk and Flood Insurance Premiums for Existing Buildings

http://www.fema.gov/building-science/hurricane-sandy-building-science-activities-resources

Let’s Talk Risk...

REMEMBER THIS!
Facts do not cease to exist because they are ignored
~Aldous Huxley
Let's Talk Risk…

Risk – Potential losses associated with a hazard, defined in terms of expected probability and frequency, exposure, and consequences

Hazards associated with risk:
• Flood
• Wind
• Other Hazards (Seismic, Wildfire, Snow)

Let’s Talk Risk…

“Floods are an act of God, but flood losses are largely an act of man”
~ Gilbert F. White

Flood Facts
• #1 U.S. Natural Disaster
• $2.7B Annual Losses (10-year average)
• 5.5M Flood Insurance Policies

Let’s Talk Risk…

The math tells the risk story. If you live in a floodplain for 30 years, you have a 26% chance of seeing a design event, the “100-year flood.”
Let’s Talk Risk...

Why is this house here?

Let’s Talk Risk...

How about these houses?

Let’s Talk Risk...

The homes are still here because:

- They were built high enough
- The Katrina house was built above the Camille elevation not just to the base flood elevation (BFE)
- The Bolivar Peninsula houses were built 3 feet or so above BFE

Both storms exceeded the BFE in many places
Let’s Talk Risk…

Risk Communication is typically accomplished with:
- Community meetings
- Maps and mailers
- Web sites
- Television ads and videos

Usually it is “under-addressed” and treated as a formality of a home purchase.

“Flooding like that is unlikely. Don’t worry about it…”

Let’s Talk Risk…

Identify the wind risk
Event: Hurricane Sandy
Location: Coney Island
Let's Talk Risk…

IBHS Research Center in South Carolina

Let's Talk Risk…

Where can we get wind information?
The Applied Technology Council Windspeed By Location Web site
http://www.atcouncil.org/windspeed/

Let's Talk Risk…

Search Results
Okay. I agree, but what do you want me to do about it?

How Should We Address Risk?

If it looks like a floodplain, it probably is.
Mother nature does not see lines on a map

Consider going above the minimum!

Following a disaster, no one ever says that they wish they had done less
How Do We Prevent Failures?

- Design building components that withstand the stresses
- Select and install connectors that withstand the forces
- Use the load path concept
- Use sound, durable materials

What Makes a Successful Building?

- The building foundation must remain intact and functional
- The envelope (walls, openings, roof, and lowest floor) must remain structurally sound and capable of minimizing penetration by wind, rain, and debris
- The lowest floor elevation must be sufficient to prevent floodwaters from entering the elevated building envelope during the design event

What Makes a Successful Building?

- The utility connections (e.g., electricity, water, sewer, natural gas) must remain intact or be restored easily
- The building must be accessible and usable following a design-level event
- Any damage to enclosures below the design flood elevation (DFE) must not result in damage to the foundation, the utility connections, or the elevated portion of the building

In short—leave them something to come home to!
Questions

Any questions on the course schedule or content?

FEMA Building Science

Flood/Wind Building Science Helpline:
FEMA-BuildingScienceHelp@fema.dhs.gov
(866) 927-2104
http://www.fema.gov/building-science
Unit II Objectives

- Provide an overview of FEMA P-499, Home Builder’s Guide to Coastal Construction, and other technical resources

Background & General Information

The Home Builder’s Guide to Coastal Construction
- Provides guidance on avoiding storm damage
- Includes 37 Technical Fact Sheets aimed at improving the performance of buildings subject to flood and wind forces in coastal environments
Background & General Information

FEMA P-499
- Developed by FEMA in association with the National Association of Home Builders Research Center and other trade associations
- ASCE 7-10
- 2009 International Residential Code
- Lessons learned since previous version (Hurricane Katrina, Hurricane Ike, etc.)
- FEMA 55, Coastal Construction Manual
- Latest NFIP Regulatory Requirements

Background & General Information

Updated FEMA P-499
Organized into 10 Categories
- General
- Planning
- Foundations
- Load Paths
- Wall Systems
- Openings
- Roofing
- Attachments
- Repairs
- Guide

General Category Sheets

Summary of Coastal Construction Requirements and Recommendations for Flood Effects (1.2)
- Recommendations for exceeding NFIP regulatory requirements concerning coastal construction
- Guidance updated based on:
  - Latest NFIP requirements
  - IRC 2009
  - Best practices
General Category Sheets

Using a Digital Flood Insurance Rate Map (DFIRM) (1.3)

- Explains the purpose of FIRMs, highlights features that are important to coastal builders, and explains how to obtain FIRMs and FISs
- Defines the flood hazard zones:
  - Zone V (1% chance)
  - Zone A (1% chance)
  - Zone AO (1% chance)
  - Zone X (within 0.2% chance)

Flood Zone Criteria

Coastal A Zone Terminology: Building Codes vs. Mapping

LiMWA: Limit of Moderate Wave Action (1.5-foot wave height)
MoWA: Zone of Moderate Wave Action (CAZ)
MiWA: Zone of Minimal Wave Action
General Category Sheets

Update includes:
- Area of Moderate Wave Action (MOWA)
- Sample FIRM with explanations of terms

Lowest Floor Elevation (1.4)
- Outlines the benefits of exceeding the NFIP minimum elevation requirements; identifies common construction practices that violate the NFIP regulations, which result in higher flood insurance premiums; and discusses the NFIP Elevation Certificate
- Update includes:
  - Enhanced best practices
  - Guidance on latest FEMA Elevation Certificate

V Zone Design and Construction Certification (1.5)
- Outlines the Zone V requirements of the NFIP to verify the design of the foundation, lowest floor elevation, and foundation anchorage requirements
- Update includes:
  - Revised Example Zone V Certificate
  - Updated to the 2009 IRC requirements
  - Refers to ASCE 7-05 and 24-05
General Category Sheets

Designing for Flood Levels Above the BFE (1.6)
- Outlines design and construction practices that reduce the likelihood of flood damage in the event that flood levels exceed the BFE
- Discusses:
  - FIRM and flood risk
  - Consequences of flood levels exceeding the BFE
  - Potential impact on flood insurance premiums

General Category Sheets

Designing for Flood Levels Above the BFE (1.6)
- Adding freeboard to the BFE
  - ASCE 24-05 requires 0 to 2 feet of freeboard depending on the building importance
  - 2009 IRC requires 1 foot of freeboard in Zone V and Coastal A Zones
- General Recommendation
  - Older FIRM — ASCE 24-05, plus 3 feet
  - New FIRMs — freeboard elevation specified by ASCE 24-05

General Category Sheets

- Coastal Building Materials (1.7)
- Flood-resistant, wind-resistant, decay- and corrosion-resistant materials
- Guidance and best practices on selecting building materials to use for coastal construction
- Update includes:
Flood-Resistant Materials

- Lumber: pressure-treated or naturally decay resistant, including redwood, cedar, some oaks, and bald cypress
- Concrete: a sound, durable mix, and when exposed to saltwater or salt spray, made with a sulfate-resisting cement, with a 28-day compressive strength of 5,000 psi minimum and a water-cement ratio not higher than 0.40
- Masonry: reinforced and fully grouted
- Structural steel: coated to resist corrosion
- Insulation: plastics, synthetics, and closed-cell foam, or other types approved by local building officials

High Wind-Resistant Materials/Methods

- Shingles rated for high winds
- Double-hemmed vinyl siding
- Deformed-shank nails or screws for sheathing attachments
- Wind-resistant glazing
- Reinforced garage doors
- Metal flashing connectors used throughout structure (from roof framing to foundation)
- Wider framing members

Corrosion-Resistant Materials/Methods

- Use hot-dipped galvanized or stainless steel hardware
- Use stainless steel if located within 3,000 feet of the ocean
- Protect reinforcing steel from corrosion by with proper coverage
- Avoid joining dissimilar metals, especially those with high galvanic potential (e.g., copper, steel)
- Ensure metal-plate-connected trusses are not exposed to the elements
Non-Traditional Building Materials and Systems (1.8)
- Guidance on non-traditional building materials and techniques and their appropriate application in coastal environments
- Looks at construction techniques other than traditional wood framing or traditional masonry construction

Non-Traditional Building Materials and Systems (1.8)
- Engineered Wood Products
- Structural Insulated Panels (SIPs)
- Insulating Concrete Forms (ICFs)
- Prefabricated Shear Walls and Moment Frames
- Sprayed Closed-Cell Foam Insulation
- Advanced Wall Framing
- Modular Houses

Moisture Barrier Vulnerabilities
Locations and Causes of Common Water Intrusion Problems
The single most common and costly siting mistake is the failure to consider future erosion and slope stability.
What Should You Do About Siting?

• Consult local and State agencies, universities, and consultants for detailed, site-specific erosion and hazard information
• Look for historical information on erosion and storm effects
• Determine the homeowner’s risk tolerance for storm and erosion damage

Beware of common siting problems:
• Small lots between a road and an eroding shoreline
• Near the edge of a bluff
• Near a tidal inlet with a dynamic shoreline
• Immediately behind and close to an erosion control structure
• Too close to rivers
• Storms can cause erosion that greatly exceeds long-term erosion projections
• Long-term erosion rates do not accurately reflect the potential impacts of short-term erosion
Foundations Category Sheets

- Review coastal foundation successes and failures
- Identify foundations suitable for coastal soil and flood conditions
- Identify foundation characteristics necessary for success
  - Provide guidance on erosion and scour
  - Integrate FEMA 550 guidance
- Include lessons learned / recommendations from Hurricane Katrina and Ike Mitigation Assessment Team (MAT) Reports
- Can also help with structures in riverine floodplains

Hydrostatic Loads

- Occur in standing or slowly moving water
- Include buoyant or flotation forces
- Act laterally and vertically on walls and floors (act normal to any surface)

Hydrodynamic Loads
Wave Load Categories

- Non-breaking waves
- Breaking waves
- Broken waves
- Uplift

Debris Impact Parameters

Foundation Failures
Foundations Category Sheets

Foundations in Coastal Areas (3.1)
- Guidance on foundation types suitable for coastal environments
- Update:
  - Integrates ASCE 24-05 guidance
  - Coastal A Zone
  - Includes lessons learned / recommendations from Hurricane Katrina and Ike MAT Reports

Foundations in Coastal Areas
- Foundations used for inland construction are generally not suitable for coastal construction
- Foundations in coastal areas must elevate buildings above the BFE and withstand flood forces, high winds, scour and erosion, and floating debris
- Deeply embedded pile or pier foundations are required for many coastal areas

Foundation Construction: Top Issues
- Soil properties: Verify
- Pile alignment: According to design
- Foundation embedment/support: Below expected depth of erosion and scour
- Proper materials
- Construction methods: Don’t compromise strength of foundation
- Connections and bracing
Foundation Construction: Materials

- Use flood-damage-resistant materials
- Don’t substitute without designee’s approval
- Use field-treat cut or drilled wood to prevent decay

Open Foundations

Closed Foundations

Closed foundations are not recommended in Coastal A Zones and not allowed in Zone V
Recommended Foundation Types by Flood Zone

<table>
<thead>
<tr>
<th>Recommended Type</th>
<th>Y to Z</th>
<th>D to E</th>
<th>A to E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Wood</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reinforced block</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Masonry block</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Foundation Construction: Reinforcement

Concrete/Masonry Reinforcement:
- Use proper size/number/splice
- Provide cover
- Don’t reinforce slabs-on-grade

Bracing
- Strive to establish a design that is stable without bracing
- Use bracing only to add rigidity to the design for the comfort of occupants
- Three types:
  - Grade beams
  - Diagonal bracing
  - Knee bracing
- Orient bracing parallel to wave and current direction
- Verify behavior and strength of structure perpendicular to waves
Grade Beams

Bracing Options

Foundations Category Sheets

Pile Design and Installation (3.2)
- Pile types
- Size and embedment
- Installation
- Verification
Localized Scour

![Diagram of Localized Scour](image)

Local Scour

![Image of Local Scour](image)

Allowable Loads, Wood Piles (CCM Example Building)

<table>
<thead>
<tr>
<th>Diameter and Embedment</th>
<th>Installation Method</th>
<th>Compression (pounds)</th>
<th>Tension (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>d = 12 inches, d = 10 feet</td>
<td>Driven</td>
<td>4,400</td>
<td>2,204</td>
</tr>
<tr>
<td></td>
<td>augered</td>
<td>1,000</td>
<td>540</td>
</tr>
<tr>
<td>d = 12 inches, d = 20 feet</td>
<td>driven</td>
<td>11,816</td>
<td>6,630</td>
</tr>
<tr>
<td></td>
<td>augered</td>
<td>6,000</td>
<td>3,206</td>
</tr>
<tr>
<td>d = 15 inches, d = 10 feet</td>
<td>driven</td>
<td>9,004</td>
<td>4,500</td>
</tr>
<tr>
<td></td>
<td>augered</td>
<td>4,400</td>
<td>2,204</td>
</tr>
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<td>d = 15 inches, d = 20 feet</td>
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</tr>
<tr>
<td></td>
<td>augered</td>
<td>6,000</td>
<td>3,206</td>
</tr>
</tbody>
</table>

Table 10.7
Foundations Category Sheets

Wood Pile-to-Beam Connections (3.3)
- Guidance related to typical wood pile-to-beam connections
- Update includes:
  - Built-up beams
  - Connectors must meet IRC corrosion protection requirements and be compatible with the wood variety selected for construction

Foundations Details

What not to do

What to do

Foundation Construction: Support for Framing

Don’t notch more than 50 percent
**What's Wrong With This Picture?**

**Recommended Fixes to Misaligned Piles**

**Foundations Category Sheets**

**Reinforced Masonry Pier Construction (3.4)**

- Guidance related to masonry pier construction where site conditions indicate that piers are an acceptable foundation
- Update includes:
  - Proper connection to the floor beam
  - Corrosion protection of reinforcement
  - Pros and cons of grade beams
Foundations Category Sheets

Zone A Enclosures

Load Paths Category Sheets
Load Paths

- Load paths must be continuous
- Each path contains strong links
- Load paths always end in supporting soils
- A building contains hundreds of load paths

Missing Connections = Missing Load Path

Not All Nails Are Created Equal

- WFCM – Table A3.10, Roof edge zone, 8d nails at 4 inches o.c. edge and in field
- Make sure the nail size is stated as the minimum diameter

- WFCM – Table A3.10, Roof edge zone, 8d nails at 4 inches o.c. edge and in field
- Make sure the nail size is stated as the minimum diameter
All Loads Must Be Directed to the Foundation

- Total load on a building must be resisted by the foundation
- Total load determines number of piles or columns, or size of footings
- Lateral and uplift loads must be considered
- Load must be transferred to foundations through proper connections

Shear Walls

- Exterior wall sheathing can be used for uplift resistance
- Sheathing will perform two functions: uplift and shear
- From APA (Engineered Wood Association) technical bulletin on combined uplift and shear resistance of structural panels

Fact Sheet 4.1: Load Paths
Load Paths Category Sheets

Load Paths Category Sheets

Masonry Details — Reinforcement

Load Path Category Sheets

Load paths start at the top and work down

A

B

C
Connections — Details A and B

Connections — Detail C

Corrosion is Common
**Advantages of housewrap vs. building paper**

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Housewrap</th>
<th>Building Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Non-woven</td>
<td>Non-woven</td>
</tr>
<tr>
<td>Weather resistance</td>
<td>Better</td>
<td>Less</td>
</tr>
<tr>
<td>Air permeability</td>
<td>Lower</td>
<td>Higher</td>
</tr>
<tr>
<td>Water vapor transmission</td>
<td>Better</td>
<td>Less</td>
</tr>
<tr>
<td>Breathability</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Reflects water</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Heat-resistant</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Vents</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Nails</td>
<td>Not</td>
<td>Yes</td>
</tr>
<tr>
<td>Seal</td>
<td>Roof</td>
<td>Roof</td>
</tr>
<tr>
<td>Finish</td>
<td>Waterproof</td>
<td>Waterproof</td>
</tr>
</tbody>
</table>

**Housewrap problems:**
- Wrapping is incomplete
- Lapping is improper
- Integration with flashing is improper

**Wall-to-wall flashing detail**

**Deck-to-wall flashing detail**

**Roof-to-wall flashing detail**
Wall Systems Category Sheets

Siding Installation in High-Wind Regions (5.3)
- Guidance related to design and installation tips for various types of siding that will enhance wind resistance
- Update includes:
  - Detailed methods for wind resistance
  - Sustainable design

Vinyl Siding

High Wind Vinyl Siding
- Double Nailing Hem
- Greater Locking Area
- Thicker Vinyl
Wall Systems Category Sheets

Attachment of Brick Veneer in High-Wind Regions (5.4)

- Guidance on practices for installing brick veneer that will enhance wind resistance
- ACI 530/ASCE 5/TMS 402: Building Code Requirements for Masonry Structures
- Brick Industry Association Technical Notes
- Construction Guidance
- Tie Installation

Brick Veneer

Lack of Ties
Openings Category Sheets

Window and Door Installation (6.1)
- Give adequate resistance to water intrusion
- Do not depend solely on sealants
- Be integral with secondary weather barriers
- Be adequately attached to the wall

Doors, Windows, Shutters, Skylights
- Strength
  - Sufficient to resist positive and negative design wind pressures (ASTM E 1233)
- Missile impact
  - Impact-resistant glazing or shutters or "partially enclosed" building design
- Corrosion resistance
  - Aluminum, wood, vinyl frames
  - Stainless steel attachments
- Anticipate leakage

Openings Category Sheets

Protection of Openings—Shutters and Glazing (6.2)
- Provide general information about the selection and installation of opening protection in windborne debris regions
- Update includes:
  - Revised guidance based on latest opening requirements in codes (IRC) and standards (ASCE 7)
Openings Category Sheets

Sheathing “Do’s”
- Sheathing Type
- Sheathing Layout
- Fastener Type
- Fastener Spacing
- Roof Venting
- Metal Roofing

Roofing Category

FEMA Wind and Flood Hazard Mitigation
Half-day course, ICC ABM 2013
Asphalt Shingle Installation Tips

Select the most appropriate shingle type based on site conditions

<table>
<thead>
<tr>
<th>Shingle Type</th>
<th>Nail Type</th>
<th>Nailing Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic/Aluminum</td>
<td>316</td>
<td>Standard nailing</td>
</tr>
<tr>
<td>Roofing/Aluminum</td>
<td>316</td>
<td>Standard nailing</td>
</tr>
<tr>
<td>GFI/Steel/Aluminum</td>
<td>316</td>
<td>Standard nailing</td>
</tr>
</tbody>
</table>

Drive the roof nails properly

Roofing Category Sheets

Minimizing Water Intrusion through Roof Vents in High-Wind Regions (7.5)

- Guidance for minimizing water intrusion through roof vent systems that can lead to interior damage and mold growth in high-wind regions
  - Soffit vents
  - Ridge vents
  - Gable end vents
  - Off-ridge vents
  - Gable rake vents
  - Turbines

Soffits – Wind and Water Resistance
Roofing Category Sheets

Metal Roof Systems in High-Wind Regions (7.6)
- Guidance for designing and installing metal roof systems that will enhance wind resistance
- Metal roofing options
  - Standing-seam hydrostatic (i.e., water-barrier) systems
  - Hydrokinetic (i.e., water-shedding) panels
- Metal shingles
- Construction guidance

Attachments Category Sheets

Enclosures and Breakaway Walls (8.1)
- Guidance related to enclosures and breakaway walls below BFE
- Update includes:
  - Obstruction considerations and the NFIP Flood Insurance Manual
  - Lattice versus solid breakaway walls
  - Lessons learned / observations from Hurricane Ike

Note: In Zone V, space below the BFE must be free of obstructions (breakaway walls and open lattice are OK)

Breakaway Walls – Details are Important
Breakaway Walls

Failure begins at connection between bottom plate of wall and floor

Breakaway Wall Guidance

- New Technical Bulletin 9-08 (three design approaches)
  - Prescriptive
  - Simplified
  - Performance-based
- Walls must resist wind and seismic loads
- Must resist at least 10 psf; if resistance is more than 20 psf, wall must be certified
- Materials: wood-frame or masonry
- Obstructions: wall must not be obstructed by utilities, bracing, or other structures

Breakaway Wall Guidance

  - Recommends use of louvers or lattice over solid breakaway walls
  - Probably less damage, less debris
  - Cheaper flood insurance premiums
- May 2009 FIMA changed; now rates buildings with one solid breakaway wall or garage door, and all other walls, louvers, or lattices as without obstruction
- Consider flood openings in breakaway walls
Obstructions

The NFIP is concerned with the increasing size and obstruction potential of stairs.
Attachments Category Sheets

Attaching risers to, or placing risers near, interior or landward pilings will help protect utilities.

Don’t attach utilities to breakaway walls and partitions.

Condenser Supports are Vulnerable

Cantilevered platform and unit fastened to platform.

Common Practice

Recommended Practice

Repairs Category Sheets

Repairs, Remodeling, Additions and Retrofitting – Flood (9.1) and Wind (9.2)

- Provides guidance related to best practice recommendations for repairs, remodeling, and additions
- Proposes opportunities for retrofitting
- Update includes:
  - Split fact sheet into “Flood” and “Wind”
  - Latest Code and Substantial Improvement/Damage requirements
  - Detailed wind retrofits (i.e., gable end)
Substantial Damage and Substantial Improvement

Resources Category Sheets

References and Resources (G.2)

- Lists references and resources relevant to topics covered in FEMA P-499
- Update includes material from:
  - American Wood Council
  - Brick Industry Association
  - Metal Construction Association
  - National Roofing Contractors Association
  - Masonry Society
  - Timber Pile Council
  - Vinyl Siding Institute

NFIP Technical Bulletins

1. Openings in Foundation Walls and Walls of Enclosures (2008)
7. Wet Floodproofing Requirements (1993)
10. Ensuring that Structures Built on Fill In or Near Special Flood Hazard Areas are Reasonably Safe from Flooding (2001)
11. Crawlspace Construction for Buildings Located in Special Flood Hazard Areas are Reasonably Safe from Flooding (2001)
Unit Objectives

At the conclusion of this unit, participants will be able to:

- Identify wind risks for a particular site or area
- Describe the process used to evaluate a building for vulnerability to wind events
- Evaluate the suitability of retrofitting measures for individual residential structures
- Understand the retrofitting process the homeowner must go through

Unit Materials

Why Develop the WRG?

- Thousands of existing homes remain vulnerable to the effects of coastal high-wind events
- Lack of formal guidance on what should be done to wind retrofit homes
- Information is needed about which wind-resistant measures are the most effective in existing buildings

Wind Hazards in Coastal Regions

Remember: The hurricane-prone region extends much farther inland than what is typically considered coastal areas
Notice the light yellow shading

Wind Hazards: ASCE 7-05

- ASCE 7-05, defines the windborne debris region as:
  - Areas within 1 mile of the coastal mean high water line where the basic wind speed is equal to or greater than 110 mph
  - Areas where the basic wind speed is equal to or greater than 120 mph
  - Extreme winds produce windborne debris that may perforate the building envelope. As the building envelope is punctured, wind damage increases.
Building Codes

- Properly designing and constructing a building to locally adopted building codes provides the minimum level of protection for the wind hazard at a particular site for new construction.
- Older houses may not be as wind resistant as houses built to current codes and standards.

Building Codes

- Over time, building codes have increasingly included design and construction practices that are more resistant to high winds.
- Building codes are typically updated to incorporate lessons learned after natural disasters.

Wind Retrofit Guide Packages

- Developed to improve wind resistance of existing residential buildings.
  - **Basic** – most basic package for a residential wind-retrofit project.
  - **Intermediate** – second tier of mitigation package options; builds on Basic Package.
  - **Advanced** – most comprehensive package of retrofits; builds on Basic and Intermediate Mitigation Packages.
### Basic Package (Section 4.1 of WRG)

#### Improvements with Roof Covering Replacement (4.1.1)
- Securing the roof deck and replacing the roof covering (4.1.1.1)
- Installing and improving secondary underlayments (4.1.1.2)
- Improving roof coverings (4.1.1.3)

#### Improvements without Roof Covering Replacement (4.1.2)
- Securing roof deck attachment/providing secondary water barrier using foam adhesive

### Additional Required Retrofits

- Strengthening vents and soffits (4.1.3)
- Strengthening overhangs at gable end walls (4.1.4)
- Window and entry door protection from windborne debris, garage door protection from wind pressure, and garage door glazing protection from windborne debris (if located in the windborne debris region) (4.2.1)

### Basic Package: Detail on Soffit Retrofit
Intermediate Package (Section 4.2 of WRG)

- Opening protection from windborne debris (4.2.1)
- Windows (4.2.1.1)
- Entry Doors (4.2.1.2)
- Garage Doors (4.2.1.3)
- Bracing gable end walls over 4 feet tall (4.2.2)
- Strengthening connections of attached structures (4.2.3)

Intermediate Package: Detail on Gable Retrofit

Advanced Package (Section 4.3 of WRG)

- Developing a Continuous Load Path Opening (4.3.1)
- Protecting Openings for Design Pressures (4.3.2)
Advanced Package: Continuous Load Path Guidance

Recommended Protection

- To improve building performance in a hurricane-prone region, FEMA, the building industry, and the insurance industry conduct post-disaster investigations.
- In general, buildings that performed poorly did not have:
  - Roof and wall coverings capable of resisting high winds
  - Protection for openings to resist high winds, windborne debris, and wind-driven rain
  - Structural systems that provide a continuous load path for all forces to be passed from the roof and building exterior surfaces to the ground through the foundation

Recommended Protection

When deciding which Mitigation Package to implement, consider the following factors:
- Is the house a good candidate for a wind retrofit project?
- Which Mitigation Packages are cost effective for the desired level of protection?
- How much risk of wind-related damage is acceptable to the homeowner?
Evaluating Existing Homes

To execute a successful retrofit on any home, its existing condition should be evaluated to determine:

- Age and condition
- Overall structural integrity
- Weaknesses in the envelope, structure, and foundation
- Whether the home can be retrofitted to effectively improve resistance to wind-related damage
- Most effective retrofit project

Evaluating Existing Homes

- Evaluators should provide recommendations to homeowner based on findings
- Acceptable evaluators include:
  - Building science professionals
  - Building officials
  - Evaluators certified through other acceptable wind retrofit programs, such as IBHS Fortified for Existing Homes

Evaluating Existing Homes

The homeowner should provide available documentation to the evaluator regarding:

- Foundation of the building
- Existing roof covering
- Secondary water barrier (if previously installed on roof)
- Termite inspection within past 12 months (if applicable)
- Windows, entry doors, impact-rated products
Evaluating Existing Homes

The homeowner should provide available documentation to the evaluator regarding (continued):

- Foam products applied to underside of roof deck
- The condition of the building or prior work done to the building, such as plans or previous inspection reports

Having all available information prepared for the evaluator can greatly increase the accuracy and timeliness of the evaluation.

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Evaluating a Home

The purpose of the evaluation is to determine:

- Whether the home is a good candidate for any of the wind retrofit packages
- Repairs that must be performed before undertaking a wind retrofit project
- Applicability of the wind retrofit packages from a construction standpoint
- Whether prescriptive retrofits can be performed on the home or a specific engineering solution should be developed

---

Basic and Intermediate Package Evaluations

- Evaluations for the Basic and Intermediate Packages should require minimal disturbance to the building
- The evaluator should verify whether the home already has components of any of the retrofit projects included in the Mitigation Packages (e.g., already has opening protection)
Advanced Package Evaluations

- A continuous load path is an important part of a building’s ability to resist wind-related damage
- Providing a continuous load path is part of the Advanced Package—not Basic or Intermediate
- Structural connections that create a continuous load path from the roof to the foundation need to be evaluated for the Advanced Package
  - This may require some destructive investigations to conduct a proper evaluation

Evaluation Outcome

- The outcome of the evaluation should be a report describing the evaluator’s findings and including:
  - A description of the existing condition of the building and a recommendation for one or more of the packages
  - Enough details to allow a basic cost estimate to be prepared
- Based on the findings of the evaluation process, the report should result in one of three determinations

Evaluation Outcome

**Determination 1**

- The prescriptive solutions in the Wind Retrofit Guide may be used for the retrofit projects

The report should identify which projects can be implemented using prescriptive solutions
Evaluation Outcome

Determination 2

- Some of the construction elements of the retrofit projects for the package are already present in the home

The report should identify which items of the selected Mitigation Package already exist and how the remainder of the items can be addressed.

Evaluation Outcome

Determination 3

- The prescriptive solutions in the Wind Retrofit Guide cannot be used because there are existing building conditions that differ from those assumed in the Guide

A registered design professional should develop a solution for retrofits to any building elements for which prescriptive solutions cannot be used.

Evaluation Outcome

- Homes falling under one of the first two determinations are typically the most cost-effective candidates
- Homes that receive the third determination require a design professional to develop a solution that meets the intent of the prescriptive solution
Costs and Benefits

Factors to consider to understand the costs and benefits:

<table>
<thead>
<tr>
<th>Costs</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>The total cost for the wind retrofit project</td>
<td>Damage resistance</td>
</tr>
<tr>
<td>Compliance with codes and local building departments</td>
<td>Wind hazard insurance plans and premiums</td>
</tr>
<tr>
<td>Effects of construction</td>
<td>Federal assistance through HMA programs</td>
</tr>
</tbody>
</table>

Predicted Mitigation Improvements

Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures

- Intended to help homeowners, engineers, and architects select and implement flood retrofitting measures
- Focus is on residential structures
- Contains current issues, modern techniques, and engineering concepts in floodproofing
- Includes drawings, photographs, design equations, example problems, and case studies
### Retrofitting Methods

- **Elevation**
- **Relocation**
- **Dry Floodproofing**
- **Wet Floodproofing**
- **Floodwalls/Levees**

### Definition

**Retrofitting:**
Adjustments or additions to existing structures intended to eliminate or reduce the possibility of damage.

### Definition

**Elevation:** The raising of a structure to place the lowest floor at or above the designated design flood elevation (DFE) on an extended support structure or fill.
### Definitions

**Base Flood Elevation (BFE):** The water surface elevation resulting from the base, or 100-year flood, which is defined as the flood having a 1% chance of being equaled or exceeded in any given year.

**Design Flood Elevation (DFE):** Associated with the greater of the area subject to the base flood or the area designated as a flood hazard area on a community flood map or otherwise designated. The height (elevation) to which a flood protection measure is designed.

### BFE vs. DFE

<table>
<thead>
<tr>
<th>BFE</th>
<th>DFE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Residential Structures That Can Be Elevated

- Houses over a crawlspace
- Houses over basements
- Houses on piles, piers, or columns
- Slab-on-grade houses
  - Wood-frame
  - Masonry
Elevation Support Systems

Elevation on Solid Perimeter Foundation Walls

Before

Elevation on Solid Perimeter Foundation Walls

After
Elevation on Solid Perimeter Foundation Walls

Cross-section of elevated wood-framed house with extended masonry-enclosed area on top of an abandoned and filled-in basement

Elevation on Piers

Cross-section of elevated wood-frame house on new or extended pier foundation
Elevation on Posts

Elevation on Piles

Regional Elevation Example

Elevated Home, Burlington County, NJ
Relative Costs for Elevation

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Existing Foundation</th>
<th>Relative Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame</td>
<td>Basement, crawlspace, or open foundation</td>
<td>Highest</td>
</tr>
<tr>
<td>Frame</td>
<td>Concrete or poured slab foundation</td>
<td>Medium</td>
</tr>
<tr>
<td>Frame</td>
<td>Stilts on grade</td>
<td>Lowest</td>
</tr>
</tbody>
</table>

Relocation

Relocation: The moving of a structure to a location that is less prone to flooding and flood-related hazards such as erosion.
Select the Relocation Contractor

<table>
<thead>
<tr>
<th>Contractor Identification</th>
<th>Yes</th>
<th>No</th>
<th>Yes</th>
<th>No</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name and address</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact person</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Phone number</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-mail address</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Prepare the Existing Site

Figure 38-4. Existing pathway beneath the structure for moving support (i.e., one key of Wolf House Mound).

Preparing the Structure

Figure 38-6. Boards supported by cribbing, placed at critical lift points (i.e., over key of the House Mound).
Preparing the Structure

Preparing the New Site

Moving the Structure
Regional Relocation Example

Relocations in Gilboa (Schoharie County), NY

How Not to Move a House...

Relative Costs for Relocation

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Existing Foundation</th>
<th>Retrofit</th>
<th>Relative Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame</td>
<td>Crawlspace or open foundation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frame with masonry veneer</td>
<td>Basement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frame with masonry veneer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frame with masonry veneer</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Definition

Wet Floodproofing:
A flood retrofitting technique that involves modifying a structure to allow floodwaters to enter it in such a way that damage to the structure and its contents are minimized.

Wet Floodproofing Techniques

- Openings
- Flood damage-resistant materials
- Protect equipment
  - Elevate
  - Protect in place
- Modify surfaces for easy cleanup
- Emergency preparedness planning
- Operation and maintenance (O&M) plan adjustments
Flood Damage-Resistant Materials Selection: Considerations

- Interaction with adjacent materials
  - Some finish materials can have a negative reaction with structural materials when used in the same system
  - Examples: vinyl flooring over plywood subfloor, latex paint over wood structural walls
- Long-term exposure to contaminants
  - Biological contaminants: bacteria, fungi (mold)
  - Chemical contaminants: heavy metals, petroleum products, pesticides

Utility Systems

- Electrical systems
- Heating, ventilation, and air conditioning (HVAC) systems
- Fuel supply/storage systems
- Water systems
- Sewer systems
Relative Costs for Wet Floodproofing

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Category</th>
<th>Retrofit Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subfloor</td>
<td>Small</td>
<td>$5555</td>
</tr>
<tr>
<td>Subfloor</td>
<td>Medium</td>
<td>$5555</td>
</tr>
<tr>
<td>Subfloor</td>
<td>High</td>
<td>$5555</td>
</tr>
</tbody>
</table>

Table 3-6: Relative Costs of Wet Floodproofing

FEMA Building Science

Flood/Wind Building Science Helpline:
FEMA-BuildingScienceHelp@fema.dhs.gov
(866) 927-2104
http://www.fema.gov/building-science