Retrofit for Wind Resiliency
Wind Design

Designing new buildings for wind is (relatively) easy – lots of updated codes and guidance
Retrofit is Hard

Priority: Where do we spend our next available dollar?
Scope: What exactly should we do with that dollar?
Retrofit – Where do we start?

Hurricane Charley, 2004: New windward door undamaged, two older doors blown off tracks
Building Opening Protection

Tyndall AFB, Hurricane Michael 2018
Building Openings

Tyndall AFB, Hurricane Michael 2018
Other Failure Modes – Load Path

Tyndall AFB, Hurricane Michael 2018
Other Failure Modes – Roof Components

Plainview, AL
Spring 2011 Tornadoes
Other Failure Modes - Attachments

Building attachments which become wind-borne debris – HVAC, Communications Equipment, lightning protection systems, canopies, etc.

Tyndall AFB, Hurricane Michael 2018
Failure Modes Inform Retrofit Choices
FEMA Hazus Tool

Uses a probability based approach to calculate annualized losses for a variety of natural hazards

Contains over 9,900 different wind damage curves

Combines building science, insurance claims data and expert experience
Quantitative Assessment Tool

- Allows comparison of pre-and post-retrofit performance

- Damage curves have been used to calculate building damages for a variety of natural hazards.

- These are commonly referred to as fragility curves in seismic design and depth-damage functions for flooding analysis.

- Damage curves provide a comparison of increasing magnitudes of a natural hazard event compared with a percent of the building that is predicted to be damaged by a specific event.

- CDM Smith created an initial screening tool that allows users to enter the type of building and then, using minimal inputs, conduct a quick comparison using Hazus curves associated with retrofits.

Let’s go to the tool
Using the Tool

Our approach:
• Allow users to easily select a Hazus wind curve based on building and location characteristics for an existing building condition and allow users to evaluate retrofit options for the building
• Input information on the value of the building, contents in the building, and value of the building’s function.
• Input the location specific probabilities of a series of wind speeds
• The tool creates a comparative analysis of the existing building vulnerability and the post-retrofit vulnerability
• It creates a visual tool to better understand the impact of various retrofits and based on the cost and lifespan of the mitigation a benefit-cost analysis of the retrofit measure
• Multiple buildings or retrofit scenarios can be compared in a summary table
• One quick format – asks questions in a logical progression
• Easy to use in the field and do the analysis and calculation quickly
Example – Comparing Retrofits

Roof Deck Attachment Improvements

Opening Protection Improvements

Damage averted with retrofit
And sometimes we get it right
Some Useful Background Information
Mitigation Assessment Team (MAT)

Building performance field studies after significant disasters

Consensus conclusions and recommendations:

• Improve codes/standards/materials
• Identify gaps in knowledge, testing, research
• Promote best practices and successes
• Tailored to building owners, design community, code organizations, local/state officials and FEMA
Flood & Wind Program

- Address MAT gaps/research needs
- Conduct problem-focused studies and leverage work partners
- Develop state-of-the-art guidance/best practices
- Feed new knowledge into codes/standards development
- Provide training, education and outreach to stakeholders
FEMA Building Performance Evaluation

A cornerstone of FEMA’s Building Science Branch is the Mitigation Assessment Team (MAT) Program

- Post-storm investigations since 1992
- **17 MAT reports** (hurricanes, tornadoes, floods and manmade)
- Use of observations:
  - In hazard mitigation manuals and best practice documents
  - Recommendations for building code/standard changes
  - Enhance FIMA programs
FEMA Building Performance Evaluation

Objectives of the MAT Studies

- Conduct *forensic engineering analyses* to determine causes of building failure and success
- Provide *recommendations* that communities, states and organizations/agencies can follow to reduce future damage and protect lives and property
- Strive to increase damage resistance through *improvements in construction codes and standards, designs, methods, and materials* used for new construction and post-disaster repair and recovery
- Support FEMA/FIMA Strategic Plans and NDRF
- Emphasis on building back safer and stronger
FEMA Building Performance Evaluation

MAT Composition and Duties

• Deployed in response to all types of natural & man-made disasters
• Representatives of FEMA HQ and FEMA Regional Offices
• State and local officials
• Public- and private-sector experts
  • Team comprised of national experts in flood, wind engineering, building codes, and coastal construction
  • ICC Representative
• Experienced in mitigation solutions for coastal flood and wind events

■ Assigned Task: study and document building performance; develop recommendations and reconstruction guidance
Guidance & Tools Development

- Building Science Supports Mitigation
  - Substantial Damage Estimator*
  - MH Foundation Guide
  - Retrofitting Guide*
  - Regional Training*
  - Coastal Construction Manual*

- Design and Construction Guidance for Community Safe Rooms Technical Bulletins*
- Revisions to Technical Bulletins (TB1, TB5, and TB8)*
Technical Publications

Wind Hazard
FEMA P-320 – Taking Shelter From the Storm
FEMA P-361 – Design and Construction Guidance for Community Safe Rooms
FEMA 549 – Hurricane Katrina in the Gulf Coast
FEMA P-804 – Wind Retrofit Guide for Residential Buildings
Wind Retrofits

FEMA P-804

- How to improve wind resistance of existing residential buildings
  - Written for Mississippi and across Gulf Coast
  - Content applies to all regions

- Use this guidance to retrofit existing buildings for improved performance during high-wind events
Technical Publications

**Flood Hazard**

FEMA P-55 – Coastal Construction Manual


FEMA P-348 – Protecting Building Utility Systems From Flood Damage

FEMA P-550 – Recommended Residential Construction for Coastal Areas

FEMA P-936 – Floodproofing Non-Residential Buildings

Unnumbered – Reducing Flood Losses Through International Codes
Flood Retrofitting Resource

FEMA P-936

- Aid to building owners and design professionals
  1. Existing non-residential buildings in riverine areas subject to shallow flooding (1 to 3 feet) and in coastal areas not subject to wave action
  2. Certain core areas of critical and other facilities
  3. Buildings subject to frequent, low-level flooding
Protecting Building Utility Systems from Flood Damage

FEMA 348
- Published end of January 2017
- Covers primarily Zone A Flood Hazards
- Regulatory Framework
- Chapter 4: Mitigation Measures for Residential Buildings
- Chapter 5: Mitigation Measures for Non-Residential Buildings
  - HVAC, plumbing, electrical, fuel systems, elevators and escalators
Partial List of RMS Publications and Trainings

- **FEMA P-424**: Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds, December 2010
- **FEMA P-543**: Design Guide for Improving Critical Facility Safety from Flooding and High Winds
- **FEMA 577**: Design Guide for Improving Hospital Safety in Earthquakes, Floods and High Winds
FEMA and Building Codes & Standards

- Return on investment
- Technology transfer
- Emerging Issues
  - Building Codes in the NFIP
  - Energy, Green, Climate Adaptation
- FEMA Strategic Priority- Enable Disaster Risk Reduction Nationally
  - Standards Development
  - Building code monitoring
  - Building code adoption tracking
Support for FEMA Hazard Mitigation Assistance Programs

- Grant Review
  - Benefit Cost Analysis and Engineering/Technical Feasibility Review
- Multifamily Housing
  - Ongoing Guidance Development and FEMA Policy Recommendations
- Efficiency Mechanisms
  - Development of a tool to evaluate increased flood heights due to wildfire damages
- Freeboard Benefits for Nonresidential Buildings
  - Research and paper to support FEMA’s FFRMS rule making
  - Required development of an automated tool to run FEMA’s Benefit-Cost Analysis Flood Module 119k times to evaluate potential trends
  - Reviewed by DHS and OMB economists
  - Discussed in a White House report on resiliency