Lessons Learned – Building Performance and Building Codes Following the 2017 & 2018 Hurricanes

FEMA Building Science Branch

Wednesday, May 22, 2019
Agenda

• FEMA Mitigation Assessment Team (MAT) Program

• 2017 Hurricane MAT - TX, USVI, PR, FL
  • General Observations
  • Lessons Learned/ Key Recommendations
  • Building Science SME Support

• 2018 Hurricane Michael MAT

• Summary
Mitigation Assessment Team (MAT)

• The Federal Emergency Management Agency (FEMA) Mitigation Assessment Team (MAT) Program is managed by the Building Science Branch at FEMA Headquarters.

• Following a natural disaster, the team conducts field assessments and makes technical observations on the performance of buildings subjected to the effects of the natural hazard event.
2017 Hurricanes

FEMA Mitigation Assessment Teams

- Harvey – TX
- Irma – USVI, PR, & FL
- Maria – USVI & PR

Source: www.rms.com
Hurricanes Irma & Maria – USVI

• Building Science Branch deployed a MAT to affected areas in the USVI starting in October and November, 2017.

• USVI MAT focus:
  • Assess performance of residential, nonresidential, and critical facilities
  • Performance of structures after Hurricane Marilyn (1995)
  • Photovoltaic (PV) facilities
  • Topographic Effects on Building Performance
  • Building Codes

2019 ASFPM Conference
General Observations: USVI MAT

- Shortcomings Observed
  - Island specific construction
  - Lack of building materials/resources
  - Lack of building official staff and resources
  - Ambiguity in Building Code
  - Implementation of Building Code (25% Damage Clause)
  - Implementation of new PA Building Code Policy
  - Unmitigated vulnerabilities in critical facilities (hospitals, fire stations, EOC)
  - Lack of adequate shelter/saferoom facilities
  - Much of the existing building stock remains vulnerable to wind damage
  - Mitigation efforts must remain multi-hazard
  - Incorporation of mitigation best practices
General Observations: USVI MAT

• Successes Observed
  • Mitigation Successes from FEMA-sponsored and locally supported wind-mitigation programs including:
    • Home Protection Roofing Program
    • Construction Information for a Stronger Home (Stronger Homes Guide)
  • Permitting and code enforcement is as important as the code itself
  • Success observed in building materials (concrete, masonry, steel, wood)
  • Use of flood-resistant materials allowed some homes/buildings to rapidly recover
    • From flooding
    • From wind-driven rain and water intrusion
  • Use of opening protection systems prevented wind-borne debris damage
Key Recommendations: USVI MAT

- Adopt the latest building code from ICC
- Improve permitting and code enforcement programs
- Vulnerability Assessments for Public Buildings and Critical Facilities
- Hazard-resistant design guidance needed for alternative energy systems
- Improve/construct life-safety hurricane shelter facilities (P-361/ICC 500)
Hurricanes Irma & Maria – Puerto Rico

- Wind and Flood Impacts to Residential Buildings and Critical Facilities
- Topographic Effects, Erosion, Landslides, Storm Surge, Riverine
- Implementation of Georges MAT Recommendations
- Adoption of I-Codes, Corrosive Protection, Flood Risk Education
- Performance of post-Georges Construction and Mitigation Projects
- New Secure Housing Program, Storm Shutters, Generators
- Alternative Energy Systems including Solar Rooftop solar systems and solar farms
General Observations: Puerto Rico MAT

• Shortcomings Observed
  • Informal construction
    • Lack of continuous load path
    • Unpermitted
    • Not designed IAW Building Code
  • Water intrusion through roofs and openings
  • Rooftop equipment attachment
  • Variable performance of ground-mounted PV

• Siting
  • Landslide
  • Erosion
  • SFHA
  • Topographic Wind Speed-Up

• Corrosion Failures
  • Connections and Structural Members
  • Tile Roof Attachment
General Observations: Puerto Rico MAT

• Successes Observed
  • Mitigation successes from FEMA-sponsored, locally supported mitigation programs:
    • New Secure Housing Program
    • Wind Retrofits (e.g., fire station shutters)
    • Rooftop solar water heaters
    • Flood damage resistant materials
Key Recommendations: Puerto Rico MAT

• Adopt the latest building code from ICC and update regularly.

• Publish prescriptive residential designs.

• Require construction documents to list critical parameters and load path connections

• Perform vulnerability assessments for public buildings and critical facilities

• Require design professionals and contractors to be licensed and registered.

• Develop hazard-resistant design guidance for alternative energy systems.

• Improve/construct life-safety hurricane shelter facilities (P-361/ICC 500).
Building Science SME Support – Puerto Rico MAT

- Support for Building Code update to 2018 I-Codes
  - Includes strengthening amendments based on PR MAT Recommendations
- Prescriptive Residential Designs
  - In collaboration with PR College of Architects and College of Engineers
- Best Available Refuge Area for Hurricane Shelters Job Aid
  - Assist PRDOH “Vivienda” with selection protocols
- Cost & Constructability Analysis for 2018 PRBC Update
  - from 2009 to 2018 IRC
- Guidelines for Wind Vulnerabilities Assessments for Critical Facilities
- Multi-Hazard Design Trainings

Topographic Wind Speed-Up Microzoning incorporated into 2018 PRBC
Hurricane Harvey – Texas

• Landfall as a Category 4 hurricane
• Winds of 130 mph near Rockport and Fulton, TX
• System remained over Texas for several days, resulting in constant rain from Houston to western LA
General Observations – TX MAT (Flood)

- Elevation matters - damage to non-conforming buildings was noticeably greater than damage to NFIP-compliant buildings.
General Observations – TX MAT (Floodproofing)

• Dry Floodproofing System Failures
• Overtopping Failure of Opening Protection
• Structural Failure of Flood Barrier
• Failure to Identify and Protect Lowest Point of Entry
• Failure to Maintain Structural Integrity of the Flood Barrier
• Seepage Issues
• Sanitary Sewer or Stormwater System Flows
• Flood Vulnerability Assessments
• Planning and Pre-Design Considerations
• Design Considerations
Lessons Learned: Hurricane Harvey MAT in Texas

- Roof-mounted equipment lacked adequate attachments
- Widespread flood damage was observed within and outside the regulatory floodplain
- Damage to non-conforming buildings was noticeably greater than damage to NFIP-compliant buildings
- Dry floodproofing measures failed under less than design flood conditions
- Dry floodproofed buildings sustained damage and experienced significant loss of function while repairs were completed
Hurricane Irma – Florida

- Landfall 1: Cudjoe Key Sep 10 at 9AM EDT (130 mph-Cat 4)
- Landfall 2: Marco Island Sep 10 at 3:30PM EDT (115 mph-Cat 3)
General Observations – FL MAT (Building Envelope)

- Roof Covering
- Soffits
- Wall Covering
- Opening Protective Systems
Lessons Learned – Irma MAT (FL)

- The MAT observed evidence of inadequate resistance to wind loads for roof coverings, soffits, and certain wall coverings of residential buildings.
- In some cases, improper materials and installation contributed to building envelope damages; increased inspections may be needed.
- Damage to non-conforming buildings was noticeably greater than damage to NFIP-compliant buildings.
- This team also focused on dry floodproofing and had similar lessons learned to the TX Harvey MAT.
Hurricane Michael MAT

- Monday 10/22 – helicopter recon
- Tue-Thur 10/23-25, Pre-MAT
- Mon – Thur 1/6-10, MAT
  - “Residential Wind”
  - “Critical Facilities”
  - “Coastal”
- 350+ sites
Preliminary Observations/Themes

• Building codes work…but WE CAN DO BETTER
  • Elevation, roof cover, soffits, and siding…significant water infiltration damage
  • Long-term damage impact with follow-on weather…still taking on water

• Mitigation works…but WE CAN DO BETTER
  • Protected an element not a facility…perform comprehensive vulnerability assessments

• Not just the building code / re-evaluate highly vulnerable siting

• Numerous opportunities to implement best practice
  • Enhanced nailing pattern, proper materials, rooftop equipment, ridge vents, FBC HVHZ, etc.
  • FEMA Building Science Publications (e.g., 55, 499, 804, RMS, etc.)
Preliminary Observations/Themes

• Extensive and significant operational impacts on Critical Facilities

• Poor performance of Critical Facilities, including designated shelters; highly vulnerable – especially since first responders shelter in place

• Perform comprehensive vulnerability assessments – facility AND service utilities

• Lack of a basic load path had significant adverse impacts

• Possibly modify existing testing fenestration standards for water intrusion

• Significant challenges with efficiently and effectively navigating floodplain management (SD) and other building code requirements
2017 Hurricane MAT Summary
2017 Hurricane MAT Themes

- Building codes work! AND hazard mitigation too!
- Codes and standards are the minimum requirement – performance reflects that
- A thorough vulnerability assessment is critical
- Redundancy, freeboard, additional level of protection is key
- Code officials expressed a need to reduce workload post-disaster
- Ensure seismic resistance is incorporated into all “new construction”
- Education of microzoning/topography and landslides into building code and guidance
- Performance of ‘homemade’ versus ‘tested’ (ASTM, ANSI, etc.) products
- Overestimating resources/implementation capacity
- Continued need to spread awareness of best practices
2017 Hurricane Building Science Branch Products

- Sixteen Recovery Advisories across the four MAT
- Four MAT Reports (FEMA P-2020 through P-2023)
- Building Code Adoption Technical Assistance
  - Puerto Rico
    - Fact Sheets 2009 versus 2018 IBC/IRC
    - Cost & Constructability Analysis for 2018 PRBC Update
    - Topographic Wind Speed-Up Microzoning Maps
- FEMA Flood Quick Reference Guide
- Community Education and Outreach Flyers for select Building Science Branch Publications
2017 Hurricane Building Science Branch Products

• Ongoing
  • PR Prescriptive Residential Designs Guide
  • Best Available Refuge Area Guidance
  • Wind Vulnerability Assessment Publication
  • Compendium
Questions?

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