COLUMBUS
INTERNATIONAL CODE COUNCIL 2017

The Future of Hazard Resilience: Building Codes and Best Practices

Presenter: John Ingargiola

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ICC INTERNATIONAL CODE COUNCIL®

The Future of Hazard Resilience: Building Codes and Best Practices

Michael Mahoney, Senior Geophysicist / National Earthquake Hazards Reduction Program (NEHRP)

John Ingargiola, Lead Physical Scientist /
PTS A/E Building Science Program Area Manager

FEMA nehrp Building Science Branch

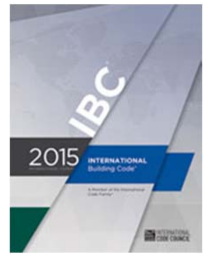
Agenda

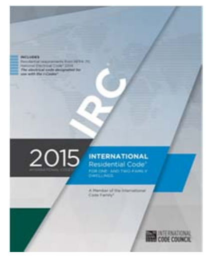
- **History of Seismic Building Codes**
- **Performance Goals of the Building Code**
- **First Generation of Performance Based Seismic Design**
- **FEMA's Next Generation Performance Based Seismic Design Project**
- **Increasing Seismic Resilience**
- **Flood, Wind and Snow Codes, Standards, and Publications**
- **Know Your Code**
- **New FEMA Policies and Directives**
  - Disaster Risk Reduction Minimum Codes and Standards
  - Public Assistance Required Minimum Standards Policy
  - Public Assistance Deductible (Draft)
- **Financing Assistance For Disaster Resistant Codes Activities**
- **Other Initiatives**
- **Resources**

FEMA

FEMA Supports Code Development

- FEMA's Strategic Goal is to support disaster resilience and ability of local communities to withstand and recover rapidly from disaster events.
- FEMA policy is to work with model codes to ensure they address natural hazards to meet national minimum standards.
- *International Codes* are now in use in some form by all 50 states.
  - NEHRP Provisions for eq.
  - NFIP Regulations for flood.
  - ASCE/SEI 7 for wind.





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FEMA and the Model Codes

- FEMA's goal is to reduce the risk of losses due to natural hazards, including earthquakes, flood and wind.
- Model building codes are the most effective way to ensure adequate construction at a local level.
- To meet this goal, FEMA was one of the first federal agencies to work within the model code development process and with all three legacy organizations.
  - For flood, this dates back to 1984; FEMA worked with the three legacy organizations to get NFIP criteria adopted into their codes.
  - For seismic, FEMA developed the *NEHRP Recommended Seismic Provisions* in 1985; adopted by BOCA and SBCCI in 1991.
  - For wind, criteria is primarily taken from ASCE/SEI 7, but FEMA is involved in the ASCE/SEI committees.

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Why are Feds Involved in Codes?

- OMB Circular A-119
  - Requires federal agencies to use available building codes when possible.
  - Encourages agencies to participate in the code development process.
- National Technology Transfer & Advancement Act (P.L. 104-113)
  - Use technical standards developed by voluntary consensus standards bodies if compliance would not be inconsistent with applicable law;
  - Consult with voluntary, private sector, consensus standards bodies and, when such participation is in the public interest and is compatible with agency missions, participate in the development of technical standards.

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FEMA Policy on Codes

- Until recently, the level of FEMA recovery funds were tied to the local building code in place and enforced at the time of the disaster, even if they are inadequate.
- New FEMA policy now requires adoption of the 2015 IBC as a requirement for receiving federal assistance.
  - More on this later from John.
- For new replacement structures, Executive Order 13717 requires that federally-funded structures be built to a seismically acceptable building code (specifically the 2015 IBC, which is based on ASCE/SEI 7-10).

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FEMA and ICC work together

- Development: FEMA participates in the model code development process along with other national organizations and experts.
- Outreach: FEMA, ICC, and other partner organizations work together to promote building codes by sharing best practices and available resources.
- Training: FEMA and ICC provide training options to educate and promote the adoption, enforcement, and use of building codes with communities.
- Partnership: FEMA, ICC, and other partner organizations work together to help ensure building codes are adopted, enforced, and promoted nationwide.

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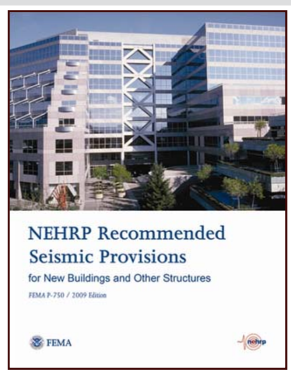
NEHRP and Earthquake Codes

- NEHRP leads federal government's earthquake role.
  - NEHRP's primary goal is to reduce earthquake losses.
  - To do this, one NEHRP focus is on better practices (codes).
- NEHRP products link research to building design practice to improve construction:
  - The first product to address seismic design was FEMA's *NEHRP Recommended Seismic Provisions*.
  - Updated versions continue to be primary seismic input into IBC.



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Code and Standards Development

- Research on Building and Infrastructure Performance
  - FEMA Mitigation Assessment Team, Learning from Earthquakes (LFE) investigations, NIST Construction Safety Team Act, etc.
  - Translating and incorporating research results
  - Coordination with local, state, federal agencies and practitioners
- Tracking Knowledge Voids
  - Building Science Helpline
  - Participation at Conferences, Course Deliveries and Industry Discussions
- Committee Participation via Proposal Submittals
  - ASCE/SEI 7, ASCE/SEI 24, ASCE/SEI 41, NEHRP Recommended Seismic Provisions, ICC-500, ASTM, etc.
  - Participation at Code Adoption Hearings
- Promotion of Disaster-Resistant Code Successes
  - Loss Avoidance Studies

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Seismic Codes, Standards and Publications

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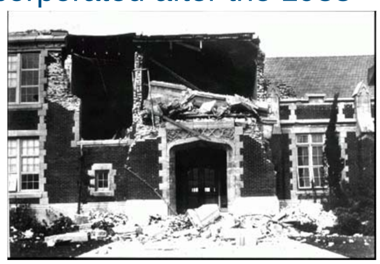
History of Seismic Building Codes

- California building practice adopted lessons from the 1906 San Francisco, but seismic codes did not exist.
- The first California building code was developed and adopted in 1927, shortly after the 1925 Santa Barbara earthquake to address lessons learned.
- Significant improvements, especially for unreinforced masonry structures, were incorporated after the 1933 Long Beach earthquake.



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History of Seismic Building Codes

- Incremental improvements made through the 1960's and incorporated into the SEAOC Blue Book, which was the basis for the ICBO Uniform Building Code.
- 1971 San Fernando earthquake lessons completely revised the reinforced concrete provisions of the code.
- 1994 Northridge earthquake showed issues with steel moment frame construction; FEMA developed recommendations that were published in FEMA 350-354 and in steel industry standards and model codes.

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Recent Building Code History

- The mid-1990's, there was recognition that having three regional model codes made a national perspective difficult. They merged into a single national model code.
  - One of the issues complicating a merger was how to address seismic provisions.
    - IBCO's SEAOC Blue Book vs. BOCA and SBCCI using FEMA *NEHRP Recommended Provisions*.
  - FEMA funded an effort to merge these two resource documents.
    - Our work was recognized by ICC as making the merger possible.
  - International Code Council (ICC) was formed in 1994 to formally merge the three model code organizations.
  - ICC then promulgated the International Codes, which were first published in 2000 and have been updated every three years since.

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Consensus Standards

- Consensus standards are the best way to get material adopted directly into the building code.
  - As a result, most technical design material has been removed from the building code.
- The main consensus standard is ASCE/SEI 7, *Minimum Design Loads for Buildings*.
- FEMA has worked with ASCE/SEI since late 1980's to ensure that ASCE/SEI 7 addresses seismic, wind and other loads.
  - Flood is under ASCE/SEI 24.
- ASCE/SEI 7 seismic is equivalent to the *NEHRP Recommended Seismic Provisions*.

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ASCE 7-16: Tsunami Loads and Effects

- Now includes Chapter 6: Tsunami Loads and Effects
  - Based on 2500-year Maximum Considered Tsunami
  - Only applies to the five US Western States – Washington, Oregon, California, Alaska and Hawaii
  - Only applies to Risk Category IV (Essential Facilities) and III (High Occupancy Buildings).
  - Will only apply to Risk Category II (General Stock) if adopted by the local jurisdiction, and for buildings over a set height.
  - Will not apply to all other Risk Category II, including light framed residential or commercial buildings.
    - Based on the assumption that communities have access to the NOAA tsunami warning system and an effective evacuation plan.
  - Replaces the design criteria in FEMA P-646 on tsunami vertical evacuation refuge, which is currently being updated.

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Resource Documents

- Resource documents translate research results into a form useable by standards and model codes.
- The original resource document was the SEAOC *Blue Book*, basis for the Uniform Building Code (UBC).
- *NEHRP Recommended Seismic Provisions* was first developed in 1985 to be a national seismic resource document.
- Updated every 5 years under contract by NIBS/BSSC.
- The 2015 edition (FEMA P-1050) is the basis for changes to ASCE/SEI 7-16 and 2018 IBC.
  - 2020 update cycle is underway.

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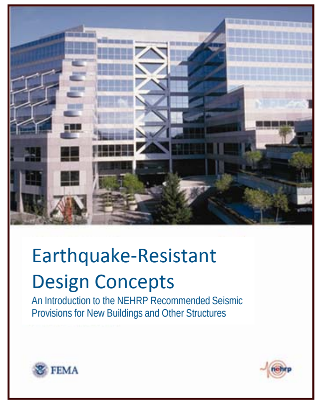
Introduction to Seismic Design

- FEMA P-749 introduces:
  - Seismic design concepts
  - How they fit into the building code
  - *NEHRP Recommended Seismic Provisions*
- Sections include:
  1. Building Regulatory Process/Seismic Risk
  2. Seismic Risk and Performance
  3. Design and Construction Procedures and Seismic Performance
  4. Buildings and Nonstructural Components
  5. Design Requirements
  6. Future Directions



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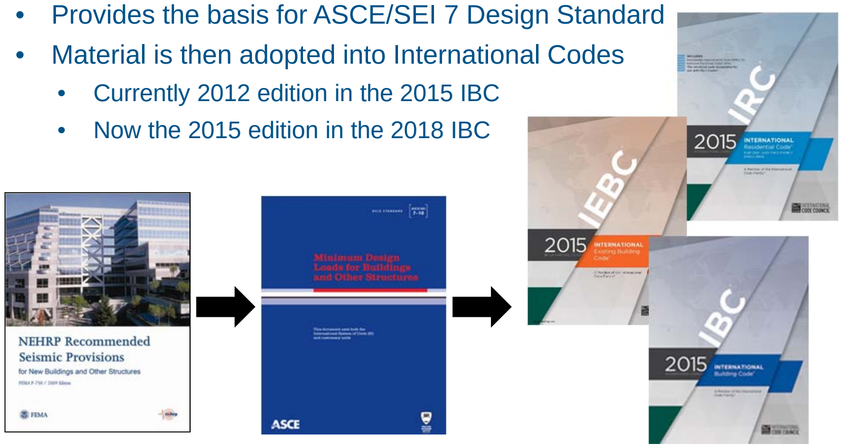
Code Development Process

Building Codes and Standards

- Begins with NEHRP Recommended Seismic Provisions
- Provides the basis for ASCE/SEI 7 Design Standard
- Material is then adopted into International Codes
  - Currently 2012 edition in the 2015 IBC
  - Now the 2015 edition in the 2018 IBC



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FEMA Code Support Activities

- FEMA supports an expert team to propose changes and monitor the model building code change process.
  - Code Support Committee (CSC).
  - Originally formed in 1996 to assist the new ICC in developing seismic portions of the IBC and IRC.
  - CSC is responsible for working within the model codes and standards process to ensure seismic safety.
  - CSC is restricted to seismic issues and to work based on the *NEHRP Recommended Seismic Provisions*.
  - Intended to provide a forum for resolving seismic issues before reaching the code hearings floor.
  - CSC also provides technical support and training to States for code update and adoption upon request.
  - FEMA and CSC members have provided written and oral testimony at previous state level code adoption hearings.

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MCE Seismic Design Maps

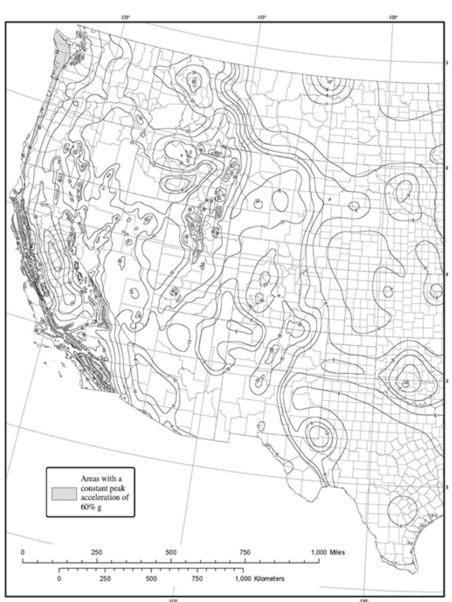

Fig. 11.8-1 Geometric mean MCE-based PGA, %g, Site Class B for the Conterminous U.S.

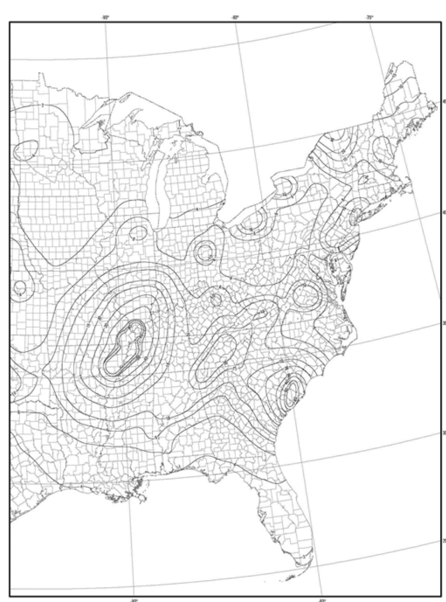

Fig. 11.8-1 (continued) Geometric mean MCE-based PGA, %g, Site Class B for the Conterminous U.S.

MCE Seismic Design Maps

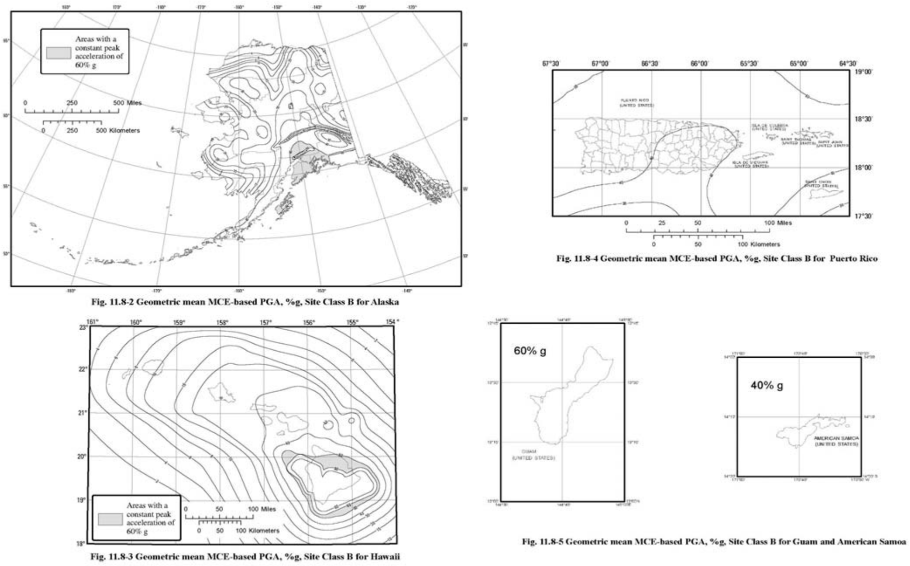

Fig. 11.8-2 Geometric mean MCE-based PGA, %g, Site Class B for Alaska

Fig. 11.8-4 Geometric mean MCE-based PGA, %g, Site Class B for Puerto Rico

Fig. 11.8-3 Geometric mean MCE-based PGA, %g, Site Class B for Hawaii

Fig. 11.8-5 Geometric mean MCE-based PGA, %g, Site Class B for Guam and American Samoa

USGS Map Website Tool

Seismic Design Maps and Tools for Buildings

http://earthquake.usgs.gov/hazards/designmaps/buildings.php

- USGS provides maps, data, and tools for seismic design of buildings:
- U.S. Seismic "DesignMaps" Web Application for design values from the 2009 and 2015 NEHRP Recommended Seismic Provisions and 2010 and 2016 ASCE/SEI 7 Standard, which will be identical to those in the 2012, 2015 and 2018 International Building Code.
- USGS tool allows for input of either lat-long or zip code and outputs the ASCE/SEI 7 / IBC design formula with ground motion coefficients already entered and formula answer already provided.
- USGS considering ending the graphic user interface tool. If so, it would be picked up by ASCE (for a fee) and possibly ATC.

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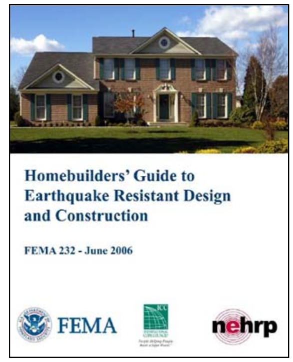
International Residential Code - Seismic

- IRC is intended to be a simplified code for 1 – 2 family residential buildings.
  - No standards are referenced.
- FEMA 232 is a design guide that also serves as a IRC commentary.
  - Also provides a series of “above code recommendations”
  - Sample design of typical home
  - Co-sponsored by ICC.



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Improving Seismic Resilience Using Performance Based Seismic Design

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Seismic Performance Goals of IBC

- Intended that structures will be damaged when they experience a design level earthquake!
  - It is normally too expensive to provide complete protection for the vast majority of buildings.
- The code's Life Safety goal is that they be designed to withstand damage without collapse, allowing exit.
  - However, damage may be so bad that repair may not be practical.
  - Code has higher performance levels for critical buildings, but all this does is increase the input design loads, not really effective.

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Overall Performance Goals of the IBC

- Section 101.3 of the International Building Code describes the Intent of the code:
  - "**The purpose of this code is to establish the minimum requirements to provide a reasonable level of safety, public health and general welfare** through structural strength, means of egress facilities, stability, sanitation, adequate light and ventilation, energy conservation, and safety to life and property from fire and other hazards attributed to the built environment and to provide a reasonable level of safety to fire fighters and emergency responders during emergency operations.
- Model building codes are intended to be life safety codes; to protect the occupants, not the building itself.

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Seismic Performance Goals of IBC

- It is intended that structures will be damaged when they experience a design level earthquake!
  - It is felt normally too expensive to provide complete protection (damage prevention) for the vast majority of buildings.
- The code's Life Safety goal is that they be designed to withstand damage without collapse, allowing exit.
  - However, damage may be so bad that repair is not practical.
- IBC Table 1604.5 specifies Risk Categories I to IV.
  - IV is essential facilities (hospitals, emergency response, etc.).
  - III is high hazard to life (high occupancy, hazmat, utilities, etc.)
  - II is all other occupied structures, I is low hazard (ag, storage)

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Seismic Performance Matrix

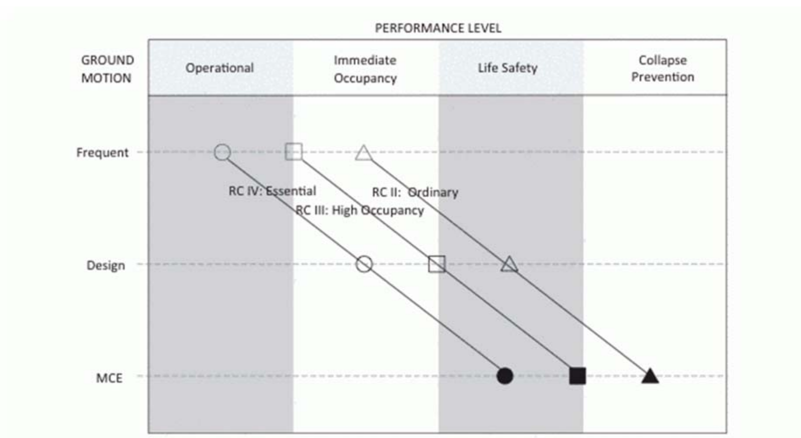

FIGURE C11-11 Expected Performance as Related to Risk Category (RC) and Level of Ground Motion

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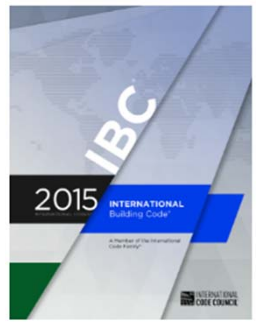
Seismic Importance Factor

Importance Factors by Risk Category of Buildings and Other Structures (ASCE/SEI 7-10, Table 1.5-2)

Risk Category / Seismic Importance Factor, I_e

I = 1.00; II = 1.00; III = 1.25; IV = 1.50

- Importance Factor, I_e, only increases the design strength, but strength alone is not enough for resilience.
- Resilience is a combination of building strength and stiffness for most, <u>but not all</u>, types of structures.
- Risk Category IV criteria include both strength and stiffness.



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PBSD in the IBC

- The IBC already allows the use of PBSD:
- Section 104 of the IBC:

  "The provisions of this code are not intended to prevent … or to prohibit any design or method of construction … provided that any such alternative has been approved.

  "An alternative… design shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code."
- One can build anything, whether in the code or not, providing:
  - Demonstrate the design provides equivalent public protection for: Safety, health, fire spread, structural stability, and sanitation
  - The burden is on the designer to demonstrate equivalence.

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Examples of PBSD under the IBC

The “Paramount”, San Francisco, CA
Introduction of New Technology

- 40-story residential building completed 2002
- Structural system is a precast-hybrid concrete moment-resisting frame (system was not one of permitted structural systems at time)
- Code did not adopt this system until 2007

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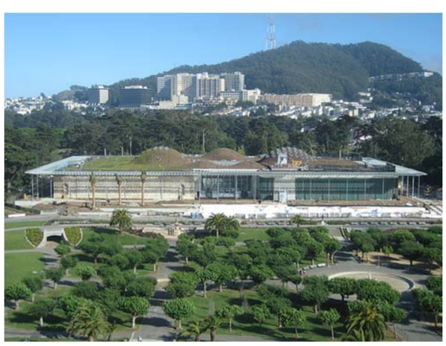
Slide courtesy of R. Hamburger

Examples of PBSD under the IBC

California Academy of Sciences, San Francisco
Obtain more economical structure



- Foundations are inadequate to withstand code-specified seismic forces without rocking
- Justified by use of non-linear analysis

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Slide courtesy of R. Hamburger

Examples of PBSD under the IBC

1 Rincon Hill, San Francisco, CA

Obtain other features

- 56 story condominium tower, completed in 2007
- Seismic-force resisting system uses “bearing walls” without backup moment frame
- Prohibited by code for buildings in excess of 240 feet high

FEMA Slide courtesy of R. Hamburger

Examples of PBSD under the IBC

Obtain Better Performance

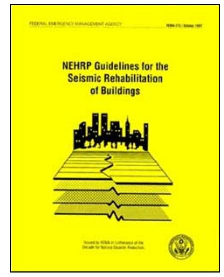
Christ the Light Cathedral, Oakland, CA

Salt Lake City Emergency Operations Center

FEMA Slide courtesy of R. Hamburger

First Generation of PBSD

- First generation of PBSD started with FEMA's existing buildings seismic retrofit design guidelines.
  - This was needed as seismic retrofit to new building code level protection was deemed too expensive and not necessary.
  - FEMA 273 (1997) was the first design guide to be based on PBSD.
  - FEMA 356 (2001) updated FEMA 273 and allowed it to be adopted into an approved standard.
  - ASCE 41-06 (2007) incorporated FEMA 356 and became the first consensus standard to include PBSD. Later adopted by reference into the IBC and then the IEBC.



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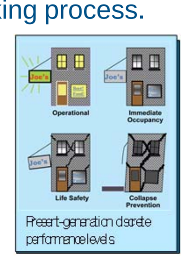
First Generation PBSD

- Issues with the first generation of PBSD:
  - Unable to account for variability and uncertainty.
  - Unacceptable performance can occur with the failure of a single connection, unable to assess building performance globally.
  - Can not explicitly assess performance of nonstructural building components, yet they are responsible for as much as 80 percent of earthquake losses.
  - Performance level descriptions confusing to building owners, they need to be more relevant for their decision-making process.



Present-generation discrete performance levels

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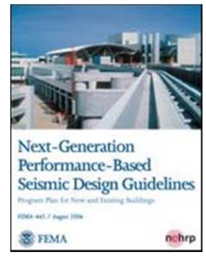
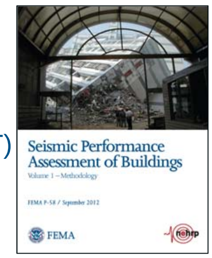
Performance Based Seismic Design

- PBSD is a process for an owner to assess performance in way they can understand:
  - Dollars - Casualties - Downtime
- Phase 1 developed a Seismic Performance Assessment Methodology.
  - 15 year effort based on the FEMA 445 Action Plan.
- FEMA P-58 was published in 2012.
  - Volume 1: Methodology
  - Volume 2: Implementation Guide
  - Volume 3: Supporting Data CD
  - Performance Assessment Calculation Tool (PACT) for the large amounts of data involved.
    - Recently released an updated PACT 3.0.





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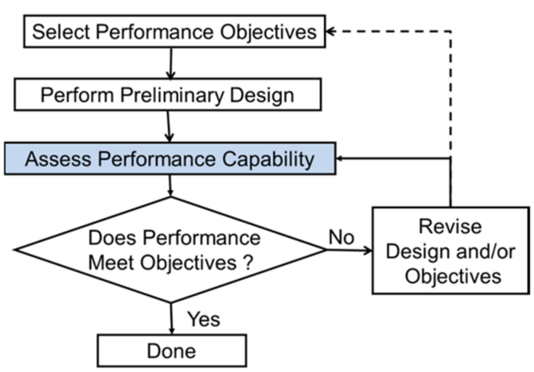
Performance Based Seismic Design Process



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Next Generation Performance Metrics

- Provide probable consequences of performance and explicit consideration of uncertainties, in terms of:
  - Casualties
  - Repair costs
  - Repair time
  - Unsafe placarding

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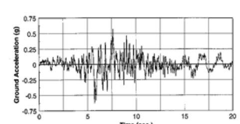
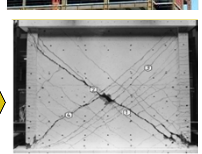
Performance Assessment Process

- Input ground motion from either:
  - Scenario ground motion,
  - Time-based probabilistic ground motion,
  - Specific earthquake magnitude.
- Input type of building:
  - Structural system and components
  - Nonstructural components
- Assign damage states and fragility to each building component.
- Output damage for each component for each of a large number of runs.





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Analyze Building Response

- Model the building structure.
- Analyze performance:
  - Nonlinear Response History Analysis
  - Simplified Linear Analysis (similar to ASCE-41 LSP)
- Predict median:
  - Story drifts
  - Floor accelerations
  - Floor velocities
  - Residual drift

FEMA

Calculate Performance

- PBSD uses a Monte Carlo process.
- Includes hundreds to thousands of “spins”
- Each “spin” is termed a “realization”
- Each realization provides a unique set of:
  - Demands
  - Damage
  - Consequences

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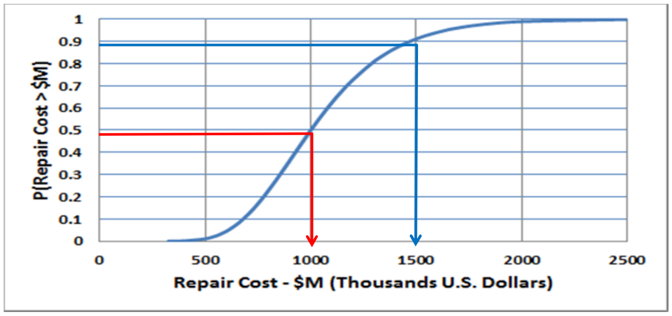
Scenario or Intensity Assessments



- 50% probability that repair cost will not exceed $1M
- 90% probability repair costs will not exceed $1.5M

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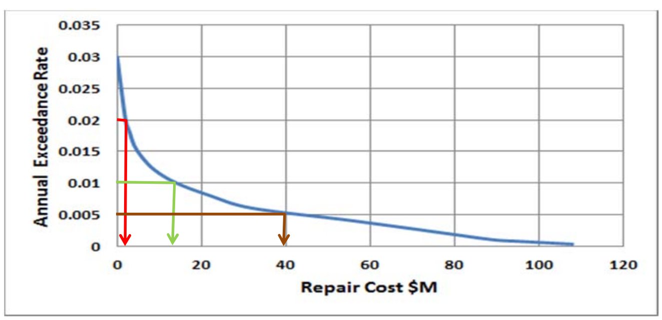
Time-based Assessment



- 50-year loss $2,000
- 100-year loss $14,000
- 200-year loss $40,000
- Average annual loss $540

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Probable Performance of XYZ Building for M7.2 Earthquake on the Hayward Fault

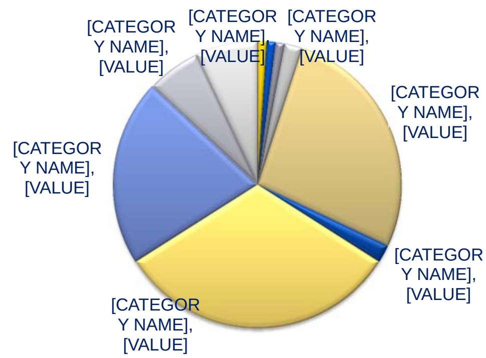
Casualties: 0

Probability of Unsafe placard: 10%

Median repair costs: $820,000 allocated as shown

Probable maximum loss (90^{th} percentile): $1,500,000

Median repair time: 8 weeks



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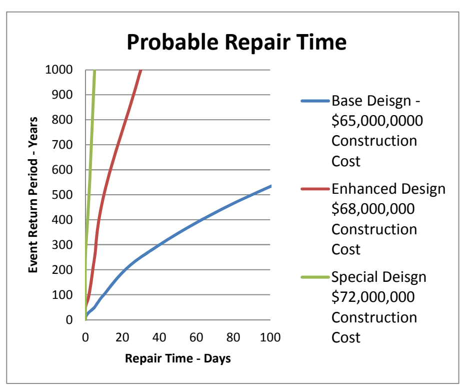
Probable Repair Time Required for XYZ Building for Various Sizes of Earthquakes

Base design: designed to code

Enhanced design: designed as an essential facility

Special design: uses technology like base isolation or dampers



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Possible Uses of PBSD and PACT

- Evaluation of design alternatives. How is building performance changed if it is mitigated by:
  - Use of an alternate framing system
  - Adding components to make the structure stronger/stiffer
  - Adding damping or seismically isolate the building
  - Changing the building cladding
- Provide far more accurate Probable Maximum Loss (PML) computations for insurance and finance industries.
- Conduct comparisons between code-conforming buildings to better validate or improve the model building codes.

FEMA

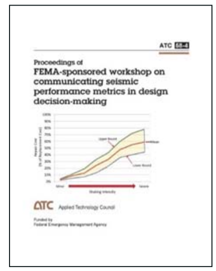
Phase 2 of the PBSD Project

- The goal of Phase 2 is to use FEMA P-58 Assessment Methodology developed under Phase 1 to develop Design Guidelines to assist design professionals to:
  - Develop efficient performance-based designs.
  - Quantify performance of typical code-conforming buildings.
  - Provide guidance on simplified design of buildings to achieve different performance objectives.
- A second but equal goal of Phase 2 is to develop User Guides to assist building owners and decision makers in selecting appropriate performance objectives.
- All Phase 2 deliverables are due in early 2018.

FEMA

Phase 2 – Stakeholder Interaction

- In 2013, we conducted a Workshop on Communicating Seismic Performance Metrics in Design Decision-Making.
  - 45 participants involved in design, construction, and management of buildings.
  - Included owners, developers, lenders, insurers, institutions, corporations, building officials, civic managers, and design professionals.
- For Phase 2 we followed-up with a similar Stakeholder Workshop for validation.
- An extensive program of follow-up interviews with stakeholders was then conducted to get more accurate data.



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Workshop Findings

- Probability concepts not well understood by stakeholders.
- Downtime and repair cost metrics were of most interest.
- Value in the breakdown of what is contributing to loss.
- Safety is of interest, but casualty metrics caused a great deal of concern over liability and disclosure.
- Nobody believes what current PML analyses are saying.
- Realistic maximum loss information of interest… if cheap.
- There is little market for enhanced performance.
- Early adopters include: institutions with assets at fixed locations; companies sensitive to business interruption.

FEMA

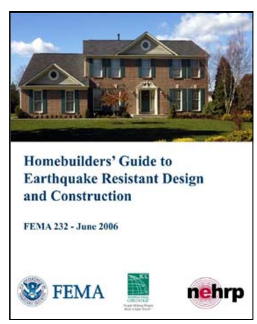
Summary: Increasing Seismic Resilience

- One option to increase resilience is to use building code provisions to require normal construction (Risk Category II and III) to meet the requirements of Risk Category IV.
  - This would increase strength and stiffness requirements and would generally improve building performance.
  - However, this would vary based on the building construction type and would be much less effective for some building systems.
  - Would do little to improve performance of non-structural components.
- However, the above would not improve the resilience of Risk Category IV structures; one option would be that new RC IV structures be designed using the FEMA P-58 procedure for enhanced performance.

FEMA

Summary: Increasing Seismic Resilience

- Residential structures are designed and built using a different code; the International Residential Code (IRC).
  - The IRC only addresses Risk Category II
    - Can't be used to recommend RC IV.
  - Earthquake resilient residential construction could use the "above-code recommendations" in FEMA 232 *Homebuilders Guide to Earthquake Resistant Design and Construction,* especially those for wall sheathing found in Chapter 5.
  - These will serve to stiffen the structure, resulting in less deflection and less damage in an earthquake.



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Flood, Wind, and Other Hazards Codes, Standards, and Publications

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Building Science Branch

Codes, Standards & Publications – Flood

- **2015 I-Code Summary of Changes to Flood Provisions**

  2015 I-Codes: Summary of Changes to Flood Provisions

  The following summarize the changes to the 2012 I-Codes that appear in the 2015 edition.

  International Building Code

  1. 104.2.1. Added specific section for determination of Substantial Improvement and Substantial Damage.

- **2018 I-Code Changes**
  - IRC:
    - Concrete slabs in V and CAZ
    - Decks and patios in V and CAZ
    - Stairways and ramps in V and CAZ
  - IBC and IRC: definition existing structure/building
  - IBC and IFC: Group I-2, emergency generators and <u>temporary connections</u>
- **ASCE/SEI 24-20 Development**

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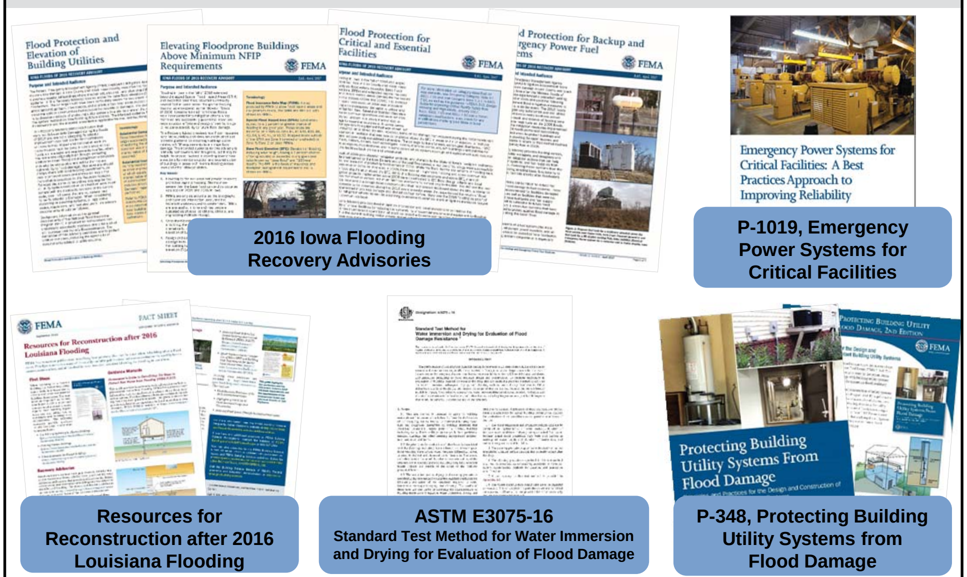
Recent Publications – Flood



- 2016 Iowa Flooding Recovery Advisories
- P-1019, Emergency Power Systems for Critical Facilities
- Resources for Reconstruction after 2016 Louisiana Flooding
- ASTM E3075-16 Standard Test Method for Water Immersion and Drying for Evaluation of Flood Damage
- P-348, Protecting Building Utility Systems from Flood Damage

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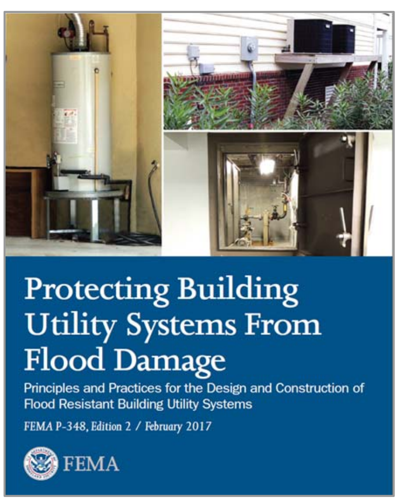
FEMA P-348, 2nd Edition (2017)



Purpose

- Intended to help address new construction and Substantially Improved structures where NFIP compliance is required
- Also, to provide guidance on best practices for existing buildings where NFIP compliance is not required

Target Audience – Intended Users

- People responsible for designing, constructing, operating, or maintaining residential and non-residential buildings
- Local officials responsible for enforcing floodplain management regulations and building codes.

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FEMA P-348, 2nd Ed. – Features

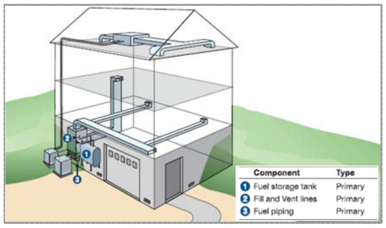
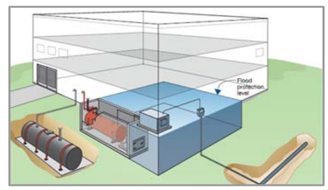


Table 2-1. Summary of I-Code and standard references for building utility systems in flood hazard areas.

Code/ Standard	HVAC	Electrical	Plumbing	Fuel Systems and Tanks	Conveyances
2015 IBC	1612.4, ASCE 24	1612.4, ASCE 24	1612.4, ASCE 24	1612.4, ASCE 24	1612.4, ASCE 24, 3001.2
ASCE 24-14	7.1; 7.4	7.1; 7.2	7.1; 7.3	7.1; 9.7	7.1; 7.5
2015 IRC	R322.1.6; M1301.1.1; M1401.5; M1601.4.10; M1701.2; M2001.4; M2201.6	R322.1.6	R322.1.6; P2601.3; P2602.2; P2705.1; P3001.3; P3101.5	R322.1.6; G2404.7; R322.1.6; R322.2.4; R322.3.7	R322.1.6
2015 IMC, IPC, IFGC	IMC: 301.16; 401.4; 501.3.1; 602.4; 603.13; 1206.9.1; 1210.8.6; 1305.2.1		IPC: 309.1; 309.2; 309.3	IFGC: 301.11	
2015 UMC, UPC	UMC: 305.2; 603.9; 607.2		UPC: 301.4		

- Improved photographs, schematics, and graphics
- Updated to reflect latest versions of the International Code Council® codes and building standards (ASCE 24)
- Expanded sections to address specific mitigation measures both residential and non-residential building utility systems and equipment
- Details in determining the best mitigation option for a particular building type and condition



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ASTM Flood Resistant Material Standard

- *E3075 – Standard* ***Test Method*** *for Water immersion and Drying for Evaluation of Flood Damage Resistance* (December 2016) – establishes procedures
- **Standard Practice** for Determining the Flood Damage Resistance Rating of Materials and Assemblies – includes valuation criteria

December 2016	October 2017	October 2018	2021
• Test Method published by ASTM (E3075)	• Standard Practice reviewed at Committee Week	• Standard Practice balloted for Main-Committee review	• Standard Practice referenced by the International Residential Code (IRC)

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Technical Bulletins

- Update of TBs 1, 4, 5, 8, 9, and 10 ongoing
- Update of TBs 2, 3, 6, 7, and 11 to begin in 2018
- Coordinating with Floodplain Management, Insurance, and other stakeholders

Send comments/suggestions to Jonathan.Westcott@fema.dhs.gov

TB No.	Title (Date)
0	User's Guide to Technical Bulletins (2009)
1	Flood Opening Requirements for Foundation Walls and Walls of Enclosures (2008)
2	**Flood Damage-Resistant Materials Requirements (2008)**
3	Non-Residential Floodproofing – Requirements and Certification (1993)
4	Elevator Requirements (2010)
5	Free-of-Obstruction Requirements (2008)
6	Below-Grade Parking Requirements (1993)
7	Wet Floodproofing Requirements (1993)
8	Corrosion Protection for Metal Connectors in Coastal Areas (1996)
9	Design and Construction Guidance for Breakaway Walls (2008)
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 (2001)**

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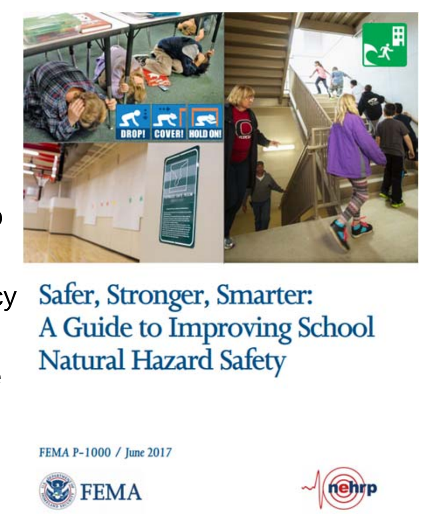
FEMA P-1000

- Focuses on operational guidance and physical protection
- Provides up-to-date info that schools can use to develop strategies for natural hazards
- Reviews natural hazards of concern to schools
- Guidance on developing an Emergency Operations Plan
- Emphasizes engagement of the whole community



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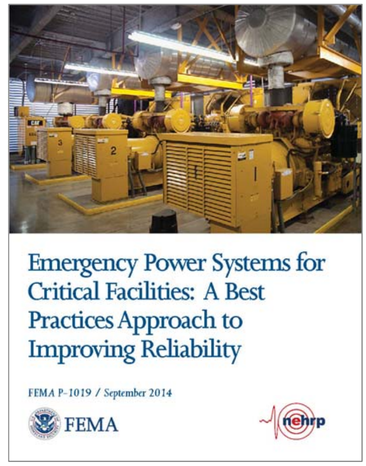
FEMA P-1019

- Developed based on MAT observations and recommendations
  - Hurricane Sandy
- Includes guidance and best practices to improve reliability
- Considers multiple hazards
- Can be used in hazard assessments and emergency planning
- Includes information on
  - Critical Facilities
  - Emergency Power Systems
  - Natural Hazards



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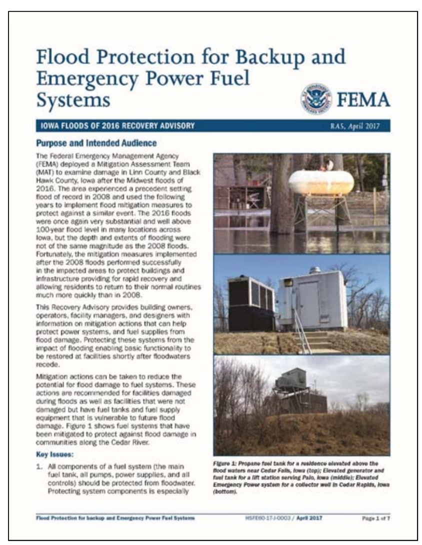
Post-Disaster Recovery – Flood, Wind & Other Hazards

- Iowa (DR-4289) Recovery Advisories
- Virginia (DR-4291) Residential Flood Retrofit Training
- Louisiana (DR-4277) Flood Code Provisions Training
- North Carolina (DR-4285) E-279 Training
- SDE – LA, NC, and FL
- Tennessee (DR-4293) Wildfires Investigations
- Georgia (DR-4297) BARA Training



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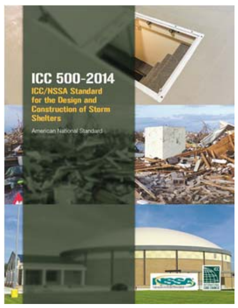
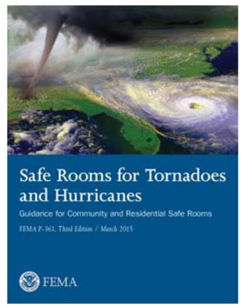
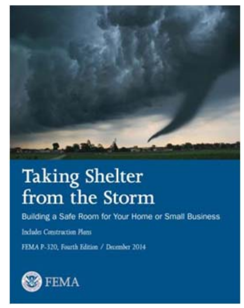
Codes, Standards and Publications - Wind

- New Editions of ICC 500 Storm Shelter Standard and FEMA Safe Room Guidance
  - ICC 500 (Second Edition) released in December 2014
  - FEMA P-361 (Third Edition) released in March 2015
  - FEMA P-320 (Fourth Edition) released in December 2014







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ICC 500 Purpose

- The purpose of this standard is to establish minimum requirements to safeguard the public health, safety, and general welfare relative to the design, construction and installation of storm shelters constructed for protection from high winds associated with tornadoes and hurricanes….
- 2009 or later editions of IBC and IRC incorporate the ICC 500 standard by reference
  - Where these codes are adopted, ICC 500 compliance is triggered for storm shelter or safe room construction
  - *A properly designed and constructed FEMA safe room is considered to be an ICC 500 storm shelter*

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2015 IBC Code Requirement for ICC 500 Storm Shelters

423.3 Critical emergency operations. In areas where the shelter design wind speed for tornadoes per Figure 304.2(1) of ICC 500 is 250 MPH, 911 call stations, emergency operation centers and fire, rescue, ambulance and police stations shall have a storm shelter constructed in accordance with ICC 500

FEMA

2015 IBC Code Requirement for ICC 500 Storm Shelters

423.4 Group E occupancies. In areas where the shelter design wind speed for tornadoes is 250 MPH per Figure 304.2(1) of ICC 500, all Group E Occupancies with an aggregate occupant load of 50 or more shall have a storm shelter constructed in accordance with ICC 500. The shelter shall be capable of housing the total occupant load of the Group E occupancy.

Exceptions:

- Group E day care facilities.
- Group E occupancies accessory to places of religious worship.
- Buildings meeting the requirements for shelter design in ICC 500.

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Know Your Codes

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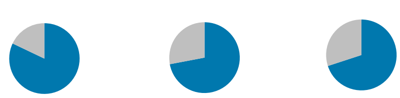
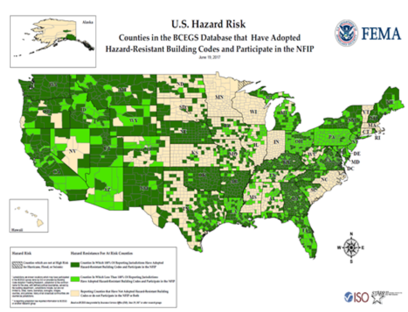
Building Science Branch

Know Your Codes

- What codes and standards are used for new and existing construction in your jurisdiction/state?
- Do you have a statewide, mandatorily adopted and enforced building code?
- Are there any amendments in your code that weaken the disaster-resistant provisions?
- Is your state or jurisdiction in the process of adopting new codes and standards?
- Is the public involved in making the codes?
  - In your State?
  - In your Jurisdiction?



Seismic	Flood	Wind
82%	72%	70%



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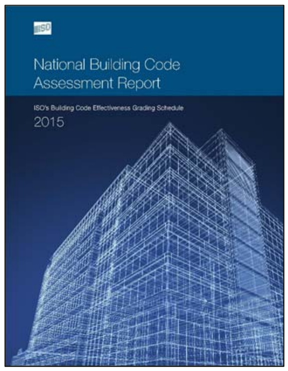
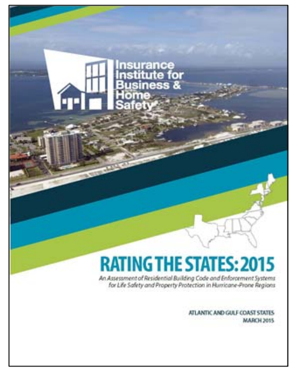
State-Based Building Code Assessments

- Resources are available to review the building code adoption and enforcement metrics of your state.



ISO's National Building Code Assessment Report (2015)



IBHS's Rate the States (2015)

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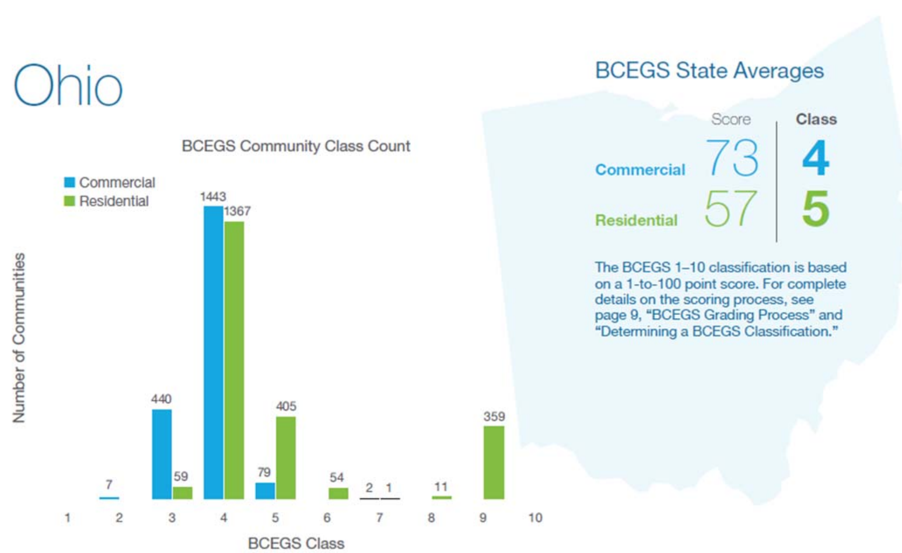
BCEGS Data Example: Ohio



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BCEGS Data Example: Ohio

By the Numbers

14 FEMA/National Flood Insurance Program Community Rating System (CRS) communities in the state

6,796 Average population serviced per certified building code official in the state

State Facts

313 Miles to the nearest ocean coast from Ohio, yet remnants of Superstorm Sandy (2012) and Hurricane Ike (2008) caused $1.610 billion of total insured losses

Top Natural Hazards

Building Code Adoption History (as of 6/30/15)

ICC Code Release	Commercial Date Adopted	Residential Date Adopted
2003	3/1/05	1/1/04
2006	7/1/07	Not adopted
2009	11/1/11	1/1/13
2012	Not adopted	Not adopted
2015	Not adopted	Not adopted

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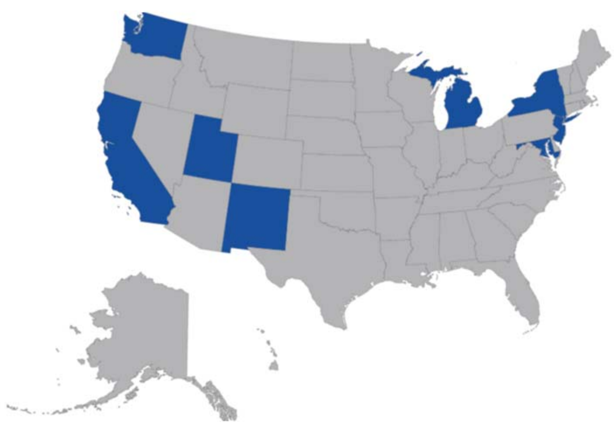
States Adopting the 2015 I-Codes & Maintaining Disaster Resistant Provisions

- California
- Maryland
- Michigan
- New Jersey
- New Mexico
- New York
- Utah
- Washington



NATIONWIDE TOTAL IS APPROX. 5,200 JURISDICTIONS

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Primary Hazard-Resistant Provisions

Primary Hazard-Resistant Chapters	IBC	IRC	IEBC
Earthquake	16, 17, 18, 19, 21, 22, 23	3, 4, 6	3, 4, 6, 7, 8, 9, 10, 11, 13, Appendices: A1, A2, A3, A4, A5
Wind	4, 15, 16, 17, 21, 23	3, 6, 7, 8, 9	4, 6, 7, 8, 9, 10, 11, 13
Flood	1, 8, 11, 14, 16, 18, Appendix G	1, 3, 4	1, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14

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Resources
(http:// www.fema.gov/building-code-resources)

- Flood
  - Flood Resistant Provisions of the 2015 International Codes
  - Highlights of ASCE 24 Flood Resistant Design and Construction
  - Reducing Flood Losses Through the International Codes: Coordinating Building Codes and Floodplain Management Regulations
  - Flood Resistant Design CodeMaster (S.K. Ghosh & Associates)
- Wind
  - Wind Provisions in the 2015 IBC, IEBC, and IRC
  - Highlights of ICC 500-2014, ICC/NSSA Standard for the Design and Construction of Storm Shelters
- Earthquake
  - NEHRP Recommended Seismic Provisions for New Buildings and Other Structures, 2015 Edition, FEMA P-1050

FEMA

New FEMA Policies and Directives

FEMA Building Science Branch

Disaster Risk Reduction Minimum Codes and Standards

FEMA

Disaster Risk Reduction Minimum Codes and Standards
FEMA Policy 204-078-2

POLICY STATEMENT
FEMA will encourage and, to the extent permitted by law, require the integration and use of nationally recognized voluntary consensus-based building codes and standards[1] consistently across FEMA programs.[2]

SCOPE
This policy applies to all FEMA offices and programs, including the provision of disaster and non-disaster grant programs.[3] This policy itself does not impose legally enforceable rights and obligations on the public; it requires FEMA programs to establish such rights and obligations regarding minimum codes and standards as described in the policy below.

FEMA Building Science Branch

Requirement A: Use the Latest Codes

- The latest code edition from the International Code Council (or its equivalent) must be used.
- Regulations, policies, grants, etc. must require the use of hazard-resistant standards from the most recent ICC codes.
- Adopt policies to ensure adherence to:
  - The Federal Earthquake Risk Management Standard (FERMS)
  - Wildland-Urban Interface Federal Risk Mitigation (WUIFRM)

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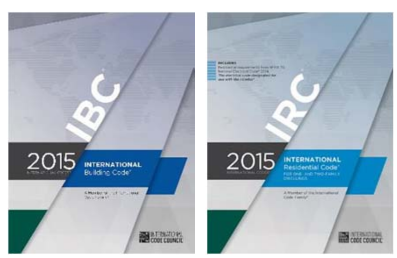
Which Codes and Standards?

- National Model Building Codes from the International Code Council (ICC) or equivalents for other disciplines
- Nationally recognized consensus standards



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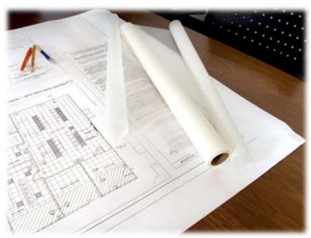
What Kinds of Work are Covered?

- Demolition
- Replacement
- Repair
- Removal
- Design
- Relocation
- Addition
- Construction Practices
- Construction
- Alteration
- Retrofit
- Addition
- Equipment (HVAC, etc.)



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Requirement B: Encourage State/Local Adoption of Latest Codes

- IBC, IRC, and IEBC
- ASCE 7 (structural), ASCE 24 (flood), and ASCE 41 (seismic retrofit)
- ASHRAE (HVAC), IWUIC, National Green Building Standard
- Future disaster-resistance upgrades to above codes
- Integrating flood-resistant elements of codes into floodplain management ordinances
- Any other disaster-resistant codes

- Provide education and outreach on disaster resistant codes.

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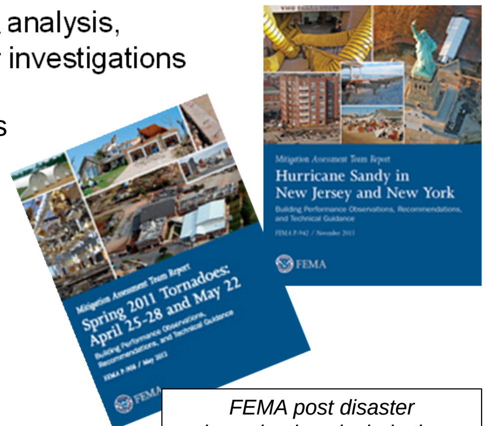
Requirement C: Codes Engagement

- Building Science Branch will inform code updates based upon FEMA analysis, research, and post-disaster investigations
- FEMA programs and offices will provide technical support for code updates



FEMA post disaster investigations include the FEMA Mitigation Assessment Team (MAT) program

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Policy Incorporated Into Latest Programs

Public Assistance (PA):

- "…will use…hazard-resistant standards referenced in the most recent edition of the model building code (IBC, IEBC, and IRC) as of the declaration date."
- In effect as of September 30th, 2016

FEMA

Public Assistance Required Minimum Standards Policy

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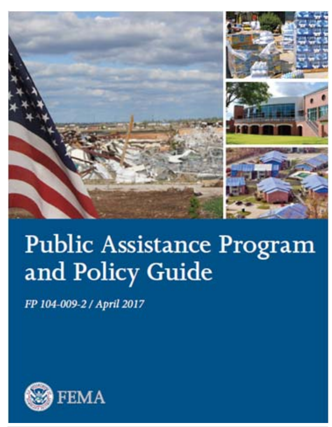
Building Science Branch

PA Required Minimum Standards Policy (PAPPG FP 104-009-2)

- Covers wind, seismic, and flood-prone areas
- Replacement/retrofit design and construction must account for any of the above hazards that may be relevant, regardless of which hazard caused the damage.
  - Example: A school replacement project caused by Matthew flood damage in Charleston would need to be designed for flood, wind, and seismic.



PA Required Minimum Standards Policy found in the Public Assistance Program and Policy Guide

FEMA

PA Required Minimum Standards Policy

- Applies to the following:
  - Substantial Damage
  - Substantial Structural Damage
  - Replacement
- Determination of whether policy has been triggered is made by local building official or (sub)recipient's licensed engineer

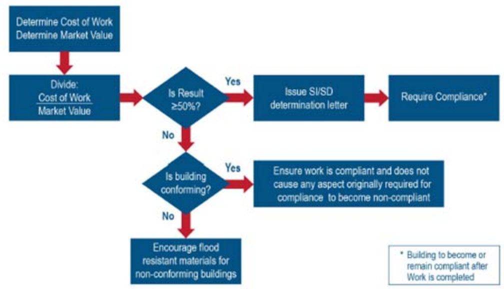


Figure 1. Process for Making SI/SD Determinations (adapted from FEMA P-758, Figure 4-1).

Process for making SI/SD determination found in FEMA P-758 and in the SD Job Aid.

FEMA

PA Required Minimum Standards Policy

- Required to use latest codes even if local jurisdiction has older, or no, building codes in effect
- Highest flood elevation governs design
  - 44 CFR § 9.11(d) or IBC/IRC/IEBC
- Failure to meet these expectations "may result in denial or de-obligation of FEMA funding".
- "FEMA may deviate from this policy in circumstances where utilization of the standards would create an extraordinary burden on the subrecipient or would be inappropriate for the facility."
- Costs of policy implementation are broken down under disaster cost share

FEMA

Resources - Substantial Damage Job Aid

Repairs ≥ 50% market value before damage occurred*

Resources:

- Job Aid: Understanding Substantial Damage in the I-Codes (2017)
  - Provides methodology for estimating whether a structure meets the requirements of SD
  - Step by step example provided
- Substantial Improvement/Substantial Damage Desk Reference (FEMA P-758)

Determinations can be made by:

- Floodplain Manager
- Local building official
- Registered design professional
- Other qualified individual

FEMA

Resources - Substantial Structural Damage Job Aid

Significant damage to the vertical elements of the lateral force-resisting system and/or the vertical gravity load-carrying components in accordance with the IBC or IEBC.

Resource:

- Job Aid: Understanding Substantial Structural Damage in the IEBC (2017).
  - Provides methodology for estimating whether a structure meets the requirements of Substantial Structural Damage (SSD)
  - Step by step example provided

School with Substantial Structural Damage to the Gravity System

Determinations can be made by:

- Local building official
- Registered design professional
- Other qualified individual

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Financial Assistance For Disaster Resistant Codes Activities

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Building Science Branch

Hazard Mitigation Grant Program

<u>Additional 5 Percent Initiative</u>

- What is it?
- Who is eligible?
- How to satisfy requirements of initiative?
- Potential eligible activities?
  - Adopting and enforcing the latest or previous edition of IBC/IRC
  - Improving the BCEGS score
  - Upgrading existing code to incorporate disaster resistant code provisions
  - Certifying/training community code officials in the latest codes
  - Licensing contractors and builders
  - Increasing public awareness of disaster resistant building techniques

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Hazard Mitigation Grant Program

- Post Disaster Building Code Enforcement and Eligible Post Disaster Grant
- Recipients and subrecipients must adopt disaster-resistant building codes or achieve an improved Building Code Effectiveness Grading Schedule (BCEGS) score
- HMGP will fund code enforcement costs after disaster
  - Can be obtained under 5% initiative or 5% set-aside

FEMA

Post-Disaster Building Code Enforcement Using Mutual Aid – EMAC

Emergency Management Compact Agreement

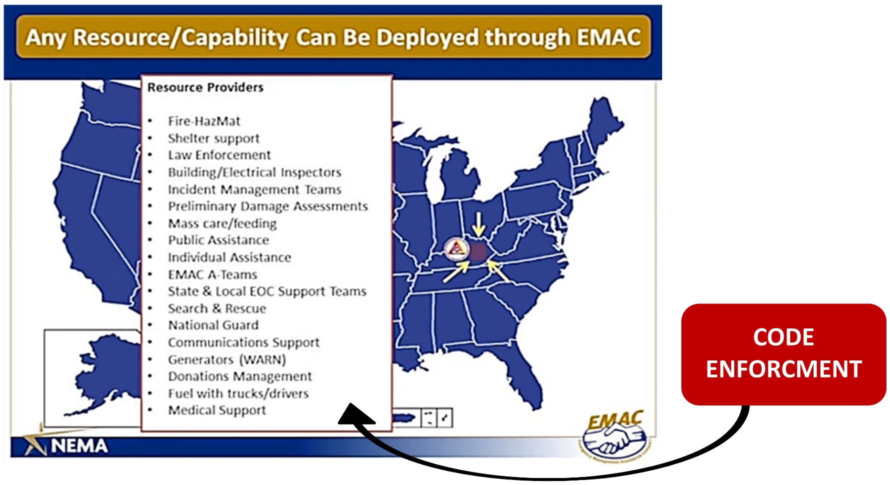
- All hazards – All disciplines mutual aid compact
- Offers assistance during governor-declared states of emergency
- Implemented within State Emergency Management Agencies
- Provides consistent & coordinated response across the nation
- Provides:
  - Tort Liability Protects
  - Worker's Compensation
  - License Reciprocity
  - REIMBURSEMENT

EMAC
Emergency Management Assistance Compact

What is your post-disaster code enforcement plan?

FEMA

Post-Disaster Building Code Enforcement Using Mutual Aid – EMAC



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Louisiana Pilot Program

Building Officials Association of Louisiana	Louisiana Floodplain Managers Association
Electrical Inspections	Substantial Damage Estimates
Gas Inspections	
Water/Sewer Inspections	
Structural	

PROGRAM GOALS

- *Homeowner Safety*
- *Accurate Damage Assessments/Estimates*
- *Code Compliance*

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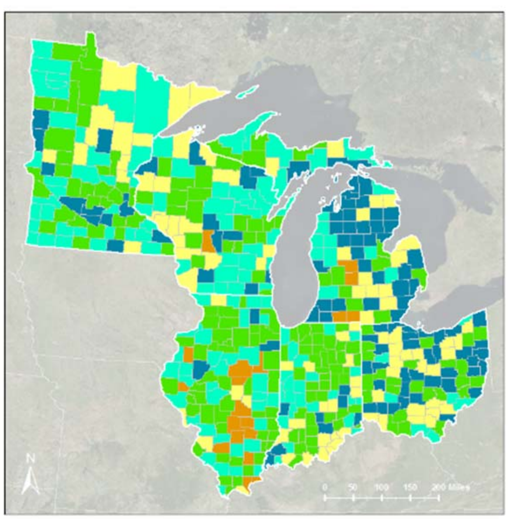
Other Initiatives

FEMA Building Science Branch

Local Mitigation Plans



FEMA Region V

Hazard Mitigation Plan
Building Code Reference

- All States -

Building Codes Mentioned in...	Total
Proposed Actions	104
Existing Capability	175
Both Capability and Action	139
No Data Found	87
No Plan Available	19

Legend

- Proposed Actions
- Existing Capability
- Both Capability and Action
- No Data Found
- No Plan Available

Those counties marked as "No Data Found" did not have building codes mentioned as an existing capability or as a proposed action. In those cases where plans mentioned building codes in other ways, such as a "theoretical action," these counties were tagged in this category.

Only multi-jurisdictional plans were reviewed. No single-jurisdiction or tribal plans were not referenced.

In circumstances where the county does not have a current plan, the most recent expired plan was used as reference.

If a county is labeled as "No Plan Available," they either do not have a mitigation plan, or a copy of the plan was not available online or through FEMA.

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Other Initiatives

- Moonshots
  - NFIP Policies
  - Mitigation Investment
- National Mitigation Investment Strategy (NMIS)
- ICC eLearning Modules on Building Science/Building Codes
- Advance Building Science Concepts Course at EMI

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Resources

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Building Science Branch

FEMA Region Building Science Resources

Safe Room Helpline:
Saferoom@fema.dhs.gov

Building Science Helpline:
FEMA-BuildingScienceHelp@fema.dhs.gov
www.fema.gov/building-science/

Building Science and Safe Room Helpline Phone:
(866) 927-2104

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FEMA Region Building Science POCs

FEMA Region	Name	Email
Region I (ME, VT, NH, RI, MA, CT)	John Grace	john.grace@fema.dhs.gov
Region II (NY, NJ, PR, US VI)	Clark Brewer & Nancy Pogensky	clark.brewer@fema.dhs.gov nancy.pogensky@fema.dhs.gov
Region III (DC, DE, MD, PA, VA, WV)	Legrande Brancheau & Charles Baker	legrande.Brancheau@fema.dhs.gov charles.baker@fema.dhs.gov
Region IV (AL, FL, GA, KY, MS, NC, SC, TN)	John Plisich & Derek Fellows	john.plisich@fema.dhs.gov derek.fellows@fema.dhs.gov
Region V (IL, IN, MI, MN, OH, WI)	Christine Gaynes	christine.gaynes@fema.dhs.gov
Region VI (AR, LA, OK, TX, NM)	John Bourdeau Jr.	john.bourdeaujr@fema.dhs.gov
Region VII (IA, KS, MO, NE)	Bob Franke & Jose Mateo	bob.franke@fema.dhs.gov jose.mateomorel@fema.dhs.gov
Region VIII (CO, MT, ND, SD, UT, WY)	Sean McGowan, Brooke Conner, & Christina Aronson	sean.mcgowan@fema.dhs.gov brooke.conner@fema.dhs.gov christina.aronson@fema.dhs.gov
Region IX (CA, NV, AZ, HI, Pacific Islands)	Michael Hornick & Clayton Pang	michael.hornick@fema.dhs.gov clayton.pang@fema.dhs.gov
Region X (AK, ID, OR, WA)	Tamra Biasco	tamra.Biasco@fema.dhs.gov

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FEMA Region Earthquake POCs

FEMA Region	Name	Email
Region I (CT, MA, ME, VT, NH, RI)	Paul Morey	paul.morey@fema.dhs.gov
Region II (NJ, NY, PR, US VI)	Scott Duell	scott.duell@fema.dhs.gov
	Sonny Beauchamp (Caribbean District)	sonny.beauchamp@fema.dhs.gov
Region III (DC, DE, MD, PA, VA, WV)	Stephanie Nixon	stephanie.nixon@fema.dhs.gov
Region IV (AL, FL, GA, KY, MS, NC, SC, TN)	Noriko Boston	noriko.boston@fema.dhs.gov
Region V (IL, IN, MI, MN, OH, WI)	William Heyse	william.heyse@fema.dhs.gov
Region VI (AR, LA, NM, OK, TX)	Bart Moore	bart.moore@fema.dhs.gov
Region VII (IA, KS, MO, NE)	Richard Leonard	richard.leonard2@fema.dhs.gov
Region VIII (CO, MT, ND, SD, UT, WY)	Sean McGowan	sean.mcgowan@fema.dhs.gov
Region IX (AS, AZ, CA, FM, GU, HI, MH, MP, NV)	Michael Hornick	michael.hornick@fema.dhs.gov
Region X (AK, ID, OR, WA)	Tamra Biasco	tamra.Biasco@fema.dhs.gov

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