

FEMA Earthquake Program New Products

2014 National Earthquake Program Managers Meeting

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FEMA, Building Science Branch



FEMA



National Earthquake Hazards Reduction Program (NEHRP)

- NEHRP was formed by Congress in 1977 to lead federal government “to reduce the risks of life and property from future earthquakes in the US...”
- Four primary agencies:
 - USGS: earth science research and hazard identification
 - NSF: basic research
 - NIST: applied research and standards development
 - **FEMA: implementation of program goals / products**
- Under NEHRP, FEMA’s goal is to reduce future losses.
 - However, NEHRP (unlike NFIP) has no regulatory authority
 - So we focus on: encourage better practices (codes), improve public awareness, and support State and local partners.



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FEMA's Role in NEHRP

- Support implementation of improved building codes and standards for new and existing buildings and lifelines
- Support state, regional, and local efforts to develop mitigation activities and response and recovery plans
- Application of earthquake loss estimation models (Hazus)
- Support for State and regional earthquake activities
- Support of multi-state consortia and earthquake partners
- Support State-related needs through our partners
- Increase public awareness of earthquakes and mitigation
 - A listing of ~100 FEMA Earthquake Program publications is at:
<http://www.fema.gov/plan/prevent/earthquake/pubindex.shtm>



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FEMA Earthquake Guidance Products

- Under NEHRP, FEMA is responsible for translating research results into practice:
 - Develop and disseminate technical and non-technical guidance documents based on new data.
 - Maintain consensus seismic resource document, such as the *NEHRP Recommended Seismic Provisions*
 - Provide input into national consensus standards; ASCE/SEI 7, ASCE/SEI 41
 - Support inclusion of FEMA design guidance and loss reduction concepts in the nation's model building codes



Lessons Learned From Recent Earthquakes

- FEMA and NEHRP are capturing Lessons Learned from recent earthquakes in Chile, New Zealand and Japan.
- All three countries have building codes similar to US and experienced damage in buildings similar to US.
 - Chile has raised issues about reinforced concrete walls, specifically boundary confinement and axial strength.
 - Christchurch raised issues about effectiveness of URM seismic retrofitting methods and zoning.
 - All three raised issues on protection of non-structural components.



Seismic Performance Goals of IBC

- Ordinary Structures
 - provide a low probability of collapse for any earthquake every likely to be experienced
 - protect life safety against non-structural hazards
- High (and Hazardous) Occupancy Structures
 - provide increased margin (relative to Ordinary Structures) for collapse avoidance (1.25)
- Essential Facilities
 - increase probability that facility will remain useful for post-disaster recovery (1.5)



Seismic Performance Goals of IBC

- It is intended that structures will be damaged when they experience a design level earthquake.
 - Normally too expensive to provide complete protection.
- Their life safety goal is only that they be designed to withstand damage without collapse to allow for evacuation of occupants!



Status of the Model Building Codes

- FEMA provides key input into the nation's model building codes through the NEHRP Recommended Seismic Provisions and ASCE/SEI 7:
 - 2012 International Building Code.
 - 2012 International Residential Code
 - 2012 International Existing Building Code
 - 2015 ICC codes are almost complete.
- FEMA monitors the building code process to ensure they continue to provide adequate seismic protection.
 - The FEMA/NIBS Code Resource Support Committee (CRSC) testified on over 50 changes in the 2015 cycle to ensure that the I-Codes remain equivalent to the NEHRP Provisions.
 - CRSC can also help State adoption by testifying and training.
 - Memphis: recently adopted IBC but trying to modify IRC.



NEHRP Recommended
Seismic Provisions
for New Buildings and Other Structures
2012 Edition

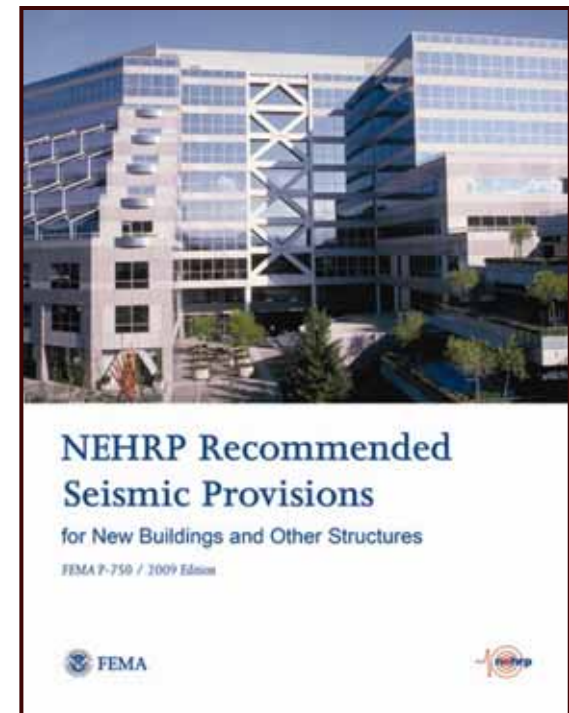
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NEHRP Recommended Seismic Provisions

- *NEHRP Recommended Seismic Provisions for New Buildings and Other Structures – FEMA P-750*
- Primary resource for ASCE/SEI 7-10 and the national model building codes IBC and IRC 2012.
- Reference standard for EO 12699.
- Recently completed two supporting publications:
 - FEMA P-751 Design Examples
 - FEMA P-752 Training Materials
 - Soon: FEMA P-753CD: Compendium



NEHRP Recommended Seismic Provisions

- *NEHRP Recommended Seismic Provisions* currently being updated for the 2015 edition (to be FEMA P-950).
 - Update being done by the BSSC's Provisions Update Committee (PUC); consists of 21 national subject matter experts and federal representatives from FEMA, NIST and USGS.
 - 11 Issue Teams and 3 Study Groups involving over 200 volunteer participants from engineering design, material industry, academia, and codes and standards development.
- *NEHRP Recommended Seismic Provisions* contains three parts:
 - Part 1: Major Changes (recommended changes to ASCE 7);
 - Part 2: Commentary (explanation of changes);
 - Part 3: Resource Papers (new material / issues)



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NEHRP Recommended Seismic Provisions

- Updates to the 2015 edition include:
 - Most recent USGS seismic hazard maps and related design maps
 - Revised site soil factors
 - Adoption of FEMA P-695 and P-795 for qualification of new systems and components
 - Simplified seismic design provisions for SDC B and procedure
 - New procedure for diaphragm design
 - A new Chapter 16 on nonlinear response history analysis (NRHA)
 - New material on Soil Structure Interaction (SSI)
 - A new strength-based foundation design methodology
 - Updates on modal response spectrum analysis (MRSA)
 - Damping and base isolation systems
 - Criteria for foundations on liquefiable sites



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| Region | City (Site Location) | 1997 UBC | | ASCE/SEI 7-10 | | | Proposed for 2015 Provisions | | |
|---------------------|-------------------------|----------|---------------------------------|--------------------|----------------------|----------------------|------------------------------|-----------------------|----------------------|
| | | Zone | 2.5 ^o C _s | S _s (g) | S _o (g) * | SDC _s *** | S _s (g) | S _o (g) ** | SDC _s *** |
| Southern California | Los Angeles | 4 | 1.10 | 2.40 | 1.60 | D | 2.11 | 1.69 | D |
| | Century City | 4 (NF) | 1.32 | 2.16 | 1.44 | D | 2.27 | 1.81 | D |
| | Northridge | 4 | 1.10 | 1.69 | 1.13 | D | 1.90 | 1.52 | D |
| | Long Beach | 4 (NF) | 1.43 | 1.64 | 1.10 | D | 1.83 | 1.46 | D |
| | Irvine | 4 | 1.10 | 1.55 | 1.03 | D | 1.34 | 1.07 | D |
| | Riverside | 4 | 1.10 | 1.50 | 1.00 | D | 1.50 | 1.20 | D |
| | San Bernardino | 4 (NF) | 1.32 | 2.37 | 1.58 | D | 2.54 | 2.03 | D |
| | San Luis Obispo | 4 | 1.10 | 1.12 | 0.78 | D | 1.17 | 0.94 | D |
| | San Diego | 4 (NF) | 1.43 | 1.26 | 0.84 | D | 1.70 | 1.36 | D |
| | Santa Barbara | 4 (NF) | 1.43 | 2.83 | 1.89 | D | 2.29 | 1.83 | D |
| | Ventura | 4 (NF) | 1.43 | 2.38 | 1.59 | D | 2.19 | | |
| | Weighted Mean | | 1.25 | 1.83 | 1.22 | | 1.82 | | |
| Northern California | Oakland | 4 (NF) | 1.43 | 1.86 | 1.24 | D | 2.06 | 1.65 | D |
| | Concord | 4 | 1.10 | 2.08 | 1.38 | D | 2.43 | 1.94 | D |
| | Monterey | 4 | 1.10 | 1.53 | 1.02 | D | 1.44 | 1.15 | D |
| | Sacramento | 3 | 0.90 | 0.67 | 0.57 | D | 0.61 | 0.54 | D |
| | San Francisco | 4 | 1.10 | 1.50 | 1.00 | D | 1.50 | 1.20 | D |
| | San Mateo | 4 (NF) | 1.28 | 1.85 | 1.23 | D | 1.97 | 1.57 | D |
| | San Jose | 4 | 1.10 | 1.50 | 1.00 | D | 1.50 | 1.20 | D |
| | Santa Cruz | 4 | 1.10 | 1.52 | 1.01 | D | 1.70 | 1.36 | D |
| | Vallejo | 4 (NF) | 1.19 | 1.50 | 1.00 | D | 1.64 | 1.31 | D |
| | Santa Rosa | 4 (NF) | 1.65 | 2.51 | 1.67 | D | 2.64 | | |
| | Weighted Mean | | 1.18 | 1.60 | 1.08 | | 1.69 | | |
| | | | | | | | | hazard level 6% ↑ | |
| Pacific Northwest | Seattle | | | 1.36 | 0.91 | D | 1.52 | 1.22 | D |
| | Tacoma | | | 1.30 | 0.86 | D | 1.48 | 1.18 | D |
| | Everett | | | 1.27 | 0.85 | D | 1.31 | | |
| | Portland | | | 0.98 | 0.72 | D | 0.97 | | |
| | Weighted Mean | | | 1.22 | 0.83 | | 1.31 | 1.05 | |
| Other WUS | Salt Lake City | | | 1.54 | 1.03 | D | 1.69 | 1.35 | D |
| | Boise | | | 0.31 | 0.32 | B | 0.33 | 0.34 | C |
| | Reno | | | 1.50 | 1.00 | D | 1.60 | 1.28 | D |
| | Las Vegas | | | 0.49 | 0.46 | C | 0.70 | | |
| | Weighted Mean | | | 0.85 | 0.65 | | 1.02 | | |
| CEUS | St. Louis | | | 0.44 | 0.42 | C | 0.50 | 0.47 | C |
| | Memphis | | | 1.01 | 0.74 | D | 1.12 | 0.89 | D |
| | Charleston | | | 1.15 | 0.80 | D | 1.55 | 1.24 | D |
| | Chicago | | | 0.13 | 0.14 | A | 0.13 | 0.14 | A |
| | New York | | | 0.28 | 0.29 | B | 0.32 | | |
| | Weighted Mean | | | 0.30 | 0.29 | | 0.32 | | |
| | | | | | | | | hazard level 10% ↑ | |

hazard level 3% ↑

hazard level 6% ↑

hazard level 7% ↑

hazard level 18% ↑

Earthquake Resistant Design Concepts

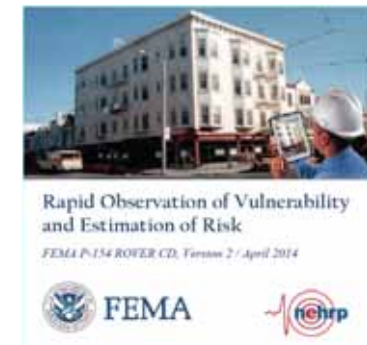
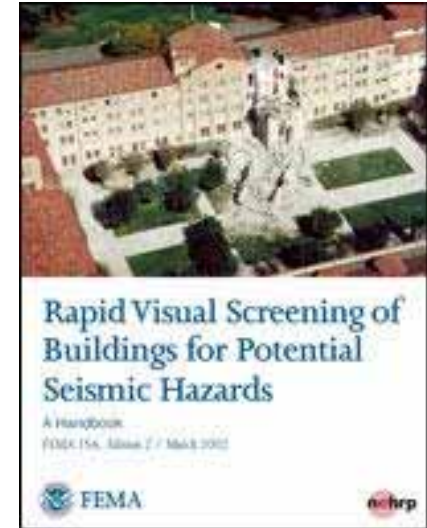
An Introduction to the NEHRP Recommended Seismic Provisions for New Buildings and Other Structures – FEMA P-749



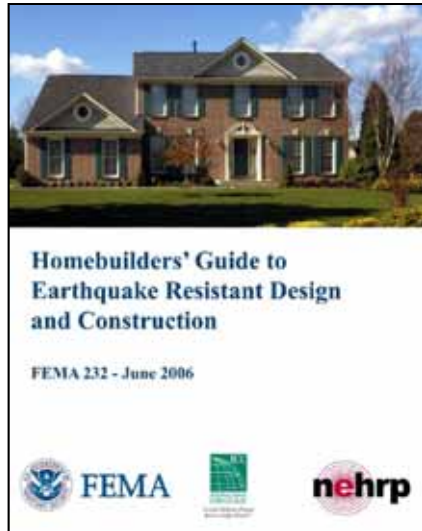
- Provides non-technical explanation of:
 - US building codes and standards.
 - Earthquakes and seismic risk.
 - Seismic design requirements.
- New training course is now available.
 - Training course is divided into six chapters.
 - Building Regulatory Process
 - Seismic Risk and Performance
 - Important Design and Construction Features
 - Structural and Nonstructural Components
 - Design Requirements
 - Future Directions
- Basis for a new NETAP building code training course.
 - Intended to be taught by an instructor

Existing Buildings Guidance

- Rapid Visual Screening (FEMA P-154)
 - Provides screening method and forms for windshield survey of buildings.
 - First level determination for at-risk buildings.
 - Currently being updated, new version fall 2014.
 - Includes FEMA 155 Supporting Documentation
 - NETAP training course also being updated.
- FEMA P-154 ROVER CD
 - Electronic version of FEMA P-154 RVS and ATC-20 post-earthquake safety evaluation of buildings
 - Version 2.0 ROVER web server due to FEMA soon.
 - ROVER user group – ROVER Ready Alliance

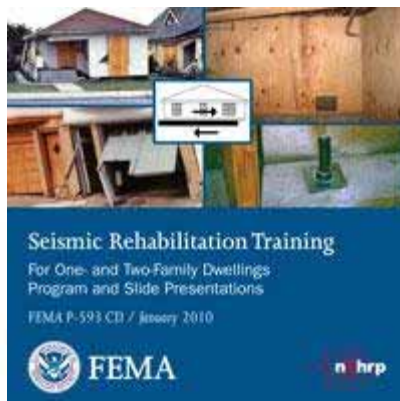


Residential Buildings Guidance



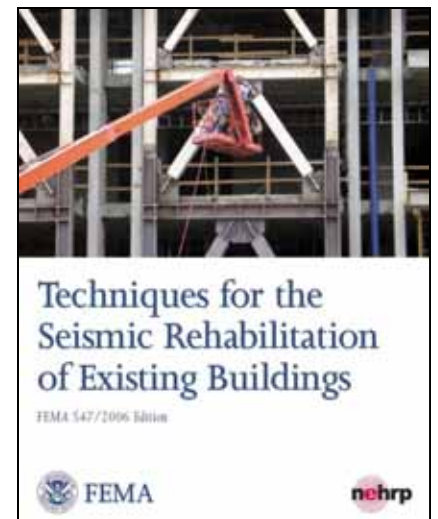
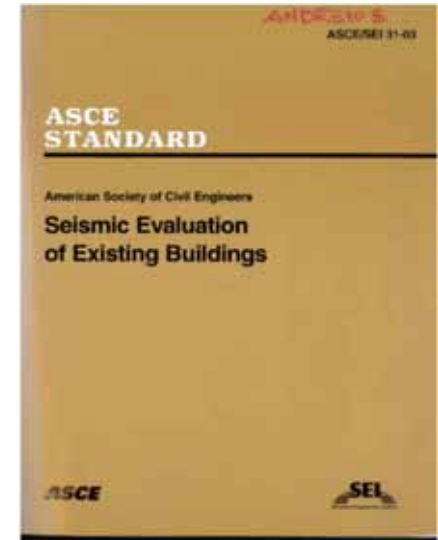
- Homebuilders Guide to Earthquake Resistant Design and Construction (FEMA 232)
 - Co-sponsored by the International Code Council.
 - Commentary for the seismic sections of the IRC.
 - Includes “Above Code Recommendations”
 - New FEMA P-232 CD contains:
 - PDF version of Guide
 - New training course (self- or instructor-taught)
 - New Spanish translation

- Seismic Rehabilitation Training for One and Two Family Dwellings (FEMA P-593)
 - PowerPoint training for retrofitting existing homes.
 - Basis for NETAP and ICC training courses.
 - A new California CEA version being developed.



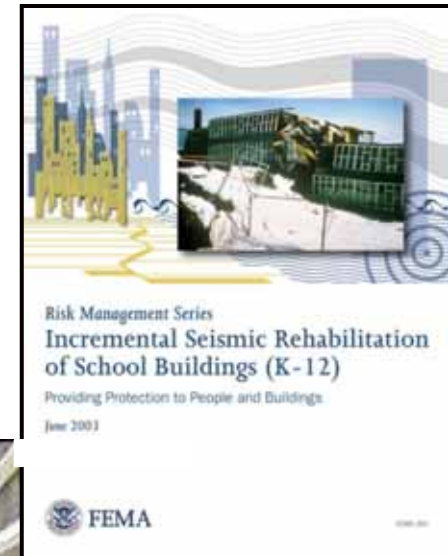
Existing Buildings Guidance

- ASCE Standard for Seismic Evaluation (FEMA 310 > ASCE-31)
- ASCE Standard for Seismic Rehabilitation (FEMA 356 > ASCE-41)
- ASCE 31 and 41 recently updated and combined together into a single consensus standard, ASCE 41-13.
- The new standard will be adopted by reference into the 2015 IEBC.
- FEMA 547 training on EERI website.



Existing Buildings Guidance

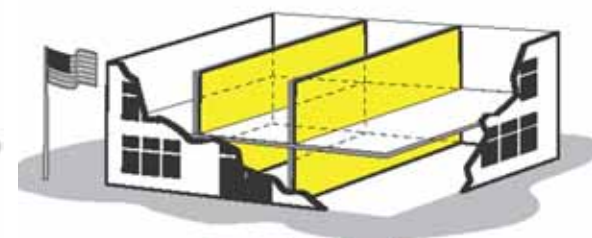
- Incremental Seismic Rehabilitation series
 - FEMA 395 – Schools (NETAP training course)
 - FEMA 396 – Hospitals
 - FEMA 397 – Offices
 - FEMA 398 – Apartments
 - FEMA 399 – Retail
 - FEMA 400 – Hotels
- Engineering Guideline for Incremental Seismic Rehabilitation (FEMA P-420)
 - Engineering-based companion design guide.



Roof Work



Exterior Wall Work



Interior Work

Existing Buildings Guidance

- Seismic Evaluation and Retrofit of Multi-Unit Wood-Frame Buildings With Weak First Stories.
 - Developed in coordination with the San Francisco CAPPs Project.
 - Targets “Marina District” and Northridge style soft story multi-unit wood frame residential structures.
 - Retrofit limited to weak story only.
 - Provides a calculation spreadsheet (Weak Story Tool) to account for strength of all walls present in the building, including non-structural.
- Available on FEMA & ATC websites.



Seismic Evaluation and Retrofit Of Multi-Unit Wood-Frame Buildings With Weak First Stories

FEMA P-807 / May 2012



FEMA

Nonstructural Retrofitting

- Nonstructural damage accounts for most earthquake damage and can result in loss of use of a building.
 - Piping failures closed ½ hospitals in the 1994 Northridge earthquake.
- Nonstructural components include:
 - Architectural building components.
 - Mechanical, electrical and plumbing components.
 - Furniture, fixtures and equipment.
- Types of nonstructural risk include:

Life safety



Property loss



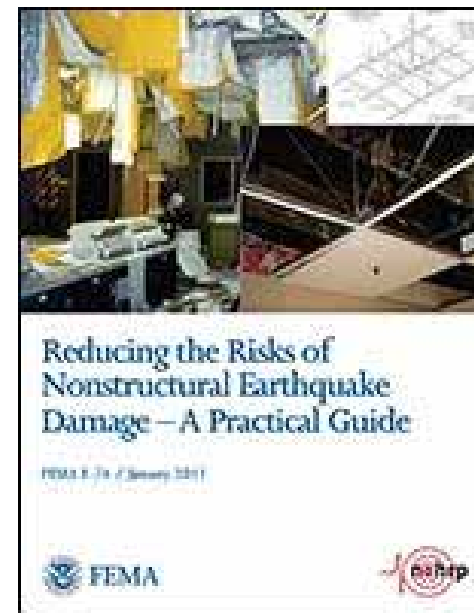
Functional loss



Nonstructural Mitigation Guide

- Nonstructural Design Guide (FEMA E-74)

- Web-based design guide. CD in publication.
- Provides design guidance for over 70 different nonstructural components.
- Provides examples of damage and plans or photos of the recommended mitigation technique for each component.
- Includes technical specifications, risk rating forms and sample inventory checklists.
- **Short web-based and longer NETAP-based technical training materials available.**
- New update to capture recent earthquake data from Chile (elevators), Christchurch (stairways) and Japan (ceilings).

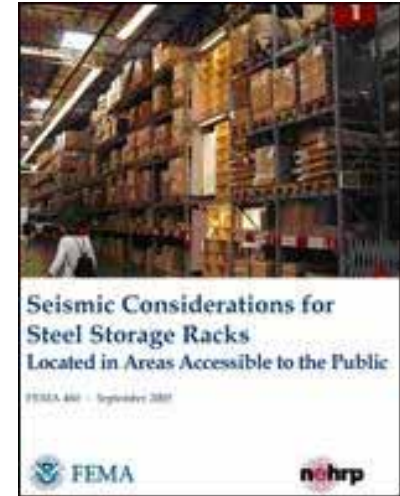


- <http://www.fema.gov/plan/prevent/earthquake/fema74/index.shtm>



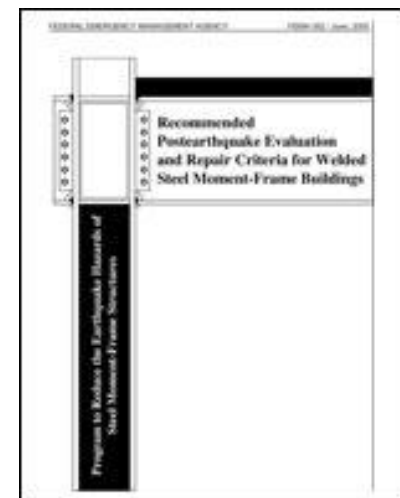
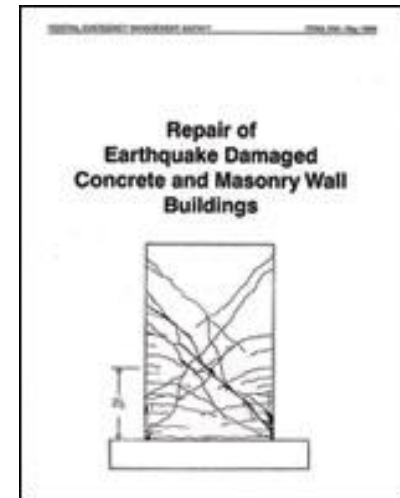
Nonstructural Installation Manuals

- Seismic Considerations for Storage Racks in Areas Accessible to the Public (FEMA 460)
 - Guidance for storage rack manufacturing, installation, use, and maintenance for “Big Box” stores.
 - Developed in response to State of Washington request following a fatality in a hardware store.
 - Responsible for subsequent update of MRI standard.
- Installation Manuals, details for seismic restraint of equipment.
 - Designed for use on construction sites.
 - Mechanical equipment - FEMA 412.
 - Electrical equipment - FEMA 413.
 - Piping installation - FEMA 414.



FEMA Mitigation Post EQ Publications

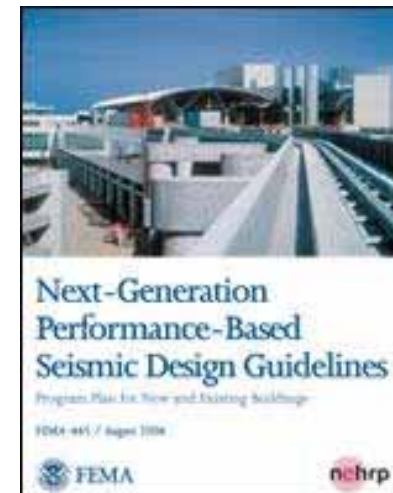
- Post Event Guidance for Concrete Buildings
 - Evaluation of Earthquake Damaged Concrete and Masonry Wall Buildings (FEMA 306 and 307)
 - Repair of Earthquake Damaged Concrete and Masonry Wall Buildings (FEMA 308)
 - New CD version with all three pubs now available.
- Post Event Guidance for Steel Buildings:
 - Evaluation and Repair Criteria for Steel Frame Buildings (FEMA 352)
 - Evaluation and Upgrade Criteria for Existing Steel Frame Buildings (FEMA 351)
 - Specifications and QA Guidelines for Steel Buildings (FEMA 353)



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Performance Based Seismic Design

- Current prescriptive building codes are designed to provide “life safety” level of protection.
 - For earthquake, this means the building will probably not collapse, but will still suffer damage resulting in loss of use, and may be significant enough to require demolition.
 - Code performance does not include any way of determining what will happen to the building, contents, and occupants.
- Performance criteria needs to allow an owner to determine performance of their building based on criteria they can understand:
 - Dollars Casualties Downtime
- Project based on FEMA 445 Action Plan



Performance Based Seismic Design

- The first phase of this project was a 10 year effort to develop a Performance Assessment Methodology using the Plan.
- This methodology is done and has been published as FEMA P-58.
 - Volume 1: Methodology
 - Volume 2: Implementation Guide
 - Volume 3: Supporting Data CD
- Phase 2 to use Assessment Methodology to develop PBSD Guidelines and Stakeholders Guide over 5 years.



Seismic Performance Assessment of Buildings

Volume 1 – Methodology

FEMA P-58 / September 2012



Performance Based Seismic Design

- Performing PBSD requires:
 - Characterizing building structural and nonstructural components,
 - Exposing these components to many earthquake ground motions,
 - Factoring in each component's fragilities for each run, and
 - Presenting all of this data in a meaningful way.
- FEMA P-58 includes a spreadsheet tool to handle this data, Performance Assessment Calculation Tool (PACT).
 - PACT contains default data, like framing systems, and a list of components based on occupancies
 - PACT requires input of building specific data and demands
 - PACT output includes loss curves and de-aggregation of data.



Seismic Rating of Residential Buildings

- First residential seismic rating system was developed for City of Los Angeles using Northridge HMGP funds.
 - ATC 50 extensively tested, but not implemented.
 - Includes a retrofitting guide (ATC 50-1).
- Based on a Simplified Seismic Assessment Form that calculates a Seismic Performance Grade.
 - The form provides a list of conditions that, if seismically retrofitted, would allow the owner to improve their seismic rating score.
- FEMA funded ATC take ATC-50 and convert it to national use to rate seismic performance of dwellings in any area.
- *Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings* (FEMA P-50).



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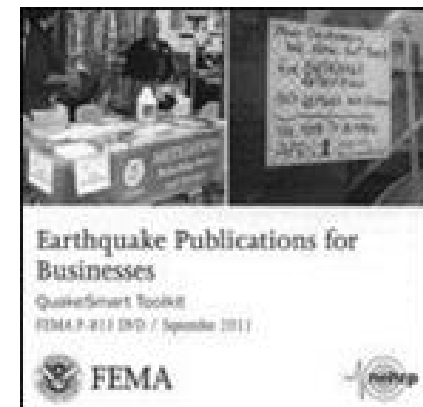
Seismic Rating of Residential Buildings

- The FEMA P-50 system assigns a rating score based on:
 - Foundation (type, slope, anchorage)
 - Framing and Configuration (irregularities, heavy roof or walls)
 - General Condition Assessment (evidence of deterioration)
 - Nonstructural Elements (chimney, water heater anchored, veneer)
 - Local Site Conditions (sloped lot, cut and fill pad, settlement)
 - Regional Seismic Score (S_{DS} , ground failure, liquefaction, faulting)
- Identifies items that can be retrofitted to improve scoring.
- FEMA P-50-1 is a retrofitting guide to provide assistance.
- FEMA P-50 and P-50-1 are a set and shipped together.
 - FEMA is only providing the tool, it is up to others to use.



QuakeSmart: Business Outreach

- QuakeSmart is FEMA's earthquake business outreach initiative.
- Encourages business owners to take three-step approach to mitigation – know your risk; make a plan; get it done.
- Mitigation helps businesses minimize damage, protect investments, and speed up the overall recovery.
- QuakeSmart: Earthquake Mitigation Toolkit for Businesses (FEMA P-811) compiles all of this material into one product.



New Training Materials

- FEMA P-909, Train-the-Trainer: Home and Business Earthquake Safety and Mitigation
 - Training and materials that prepare and equip individuals to conduct training courses and demonstrations to convey basic knowledge about earthquakes.
 - Also includes what people can do to increase earthquake safety and mitigate seismic risks in homes and workplace.
- IS-325, Earthquake Basics: Science, Risk, and Mitigation
 - A short independent study course presenting basic information about earthquake causation, potential seismic vulnerabilities in homes and workplaces, and structural and nonstructural mitigation techniques.
 - Available online through the FEMA EMI website.



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www.fema.gov

