

# National Earthquake Hazards Reduction Program

*... a research and implementation partnership*

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## NIST Earthquake Risk Mitigation R&D Program Update

Advisory Committee on Earthquake Hazards Reduction  
10 November 2010



FEMA

NIST  
National Institute of  
Standards and Technology



USGS  
science for a changing world

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national **earthquake** hazards reduction program

# Presentation Outline

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- Program Management Philosophy
- Program Planning
- Projects



# Overarching Principle

## NEHRP Mission

To develop, disseminate, and promote knowledge, tools, and practices for earthquake risk reduction – through coordinated, multi-disciplinary partnerships among the NEHRP agencies and their stakeholders – that **improve the nation's earthquake resilience** in public safety, economic strength and national security.

*Fulfilling the mission requires NEHRP (and NIST) to support the advancement of performance-based design and engineering principles!*



# Program Management Philosophy (1/2)

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- Earthquake Risk Mitigation (ERM) R&D is one of 3 programs in Engineering Laboratory (EL) Disaster-Resilient Structures and Communities Strategic Goal area\*
  - EL long-range plan is to develop integrated strategic R&D roadmap for ERM R&D under Disaster-Resilient Structures and Communities Strategic Goal
  - Key first step is receipt of National Research Council (NRC) roadmap for all needed U.S. earthquake risk mitigation implementation activities
    - NIST work is expected to be part of this larger plan
    - NRC report development has encountered significant delays
  - NIST strategic Earthquake Risk Mitigation (ERM) R&D plan is also expected to follow philosophical approach outlined in ATC-57 (*see following slides*)
- \* With recent NIST realignment, the structure of Engineering Laboratory strategic goals and program will be reviewed and possibly realigned



# Program Management Philosophy (2/2)

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- 2007-2010 projects have largely focused on fulfilling needs identified in ATC-57 (see following slides)
- Consistent with ATC-57, 2007-2010 projects have targeted numerous gaps identified by practitioners and researchers working on FEMA-sponsored work (see following slides)
- 2010 Chile earthquake also had major impact on 2010-2011 plans (see following slides)
  - NIST accompanied EERI LFE and ASCE 7 teams in post-earthquake reconnaissance
  - NIST co-sponsored Chile earthquake reconnaissance discussion meeting with ASCE, PEER, that identified several key building code issues: <http://www.nehrp.gov/library/ChileMeeting.htm>



# Program Philosophy: The “ATC Roadmap”

- A “...gap between engineering and scientific knowledge and its practical application (for design and construction of economical, earthquake-safe structures) has dramatically widened ...”
- “The informational link between theory, research results, and practice is weaker than it should be.”

## Roadmap Elements



1. Technical support for seismic practice and code development.
2. Problem-focused, user-directed research to support development of performance-based seismic design concepts and guidelines.
3. Problem-focused research and technical resources (e.g., guidelines and manuals) development to improve seismic engineering practice.
4. Evaluated technology made available to practicing professionals in the design and construction communities.
5. Tools to enhance the productivity, economy, and effectiveness of the earthquake-resistant design and construction process.

# Program Philosophy: The “ATC Roadmap”

Four groups in U.S. society play key roles in shaping, promoting, and implementing the use and development of technology in the engineering design and construction professions:

- Private sector
- Academia
- Government
- Collaborative organizations



## Roadmap Philosophy

- Program should be user- and needs-driven
- Include appropriate evaluations and assessments – and abide by them
- Efforts of government, academic, and private sector participants should be balanced and formulated to achieve results on specific tasks
- Assess costs and benefits

# Implementing the ATC “Roadmap”



- Began implementation in 2007
- Developing combined **extramural** and **in-house** research capabilities and efforts
- Target ~ 50% of total funded effort in extramural efforts
- Awarded 5-year IDIQ contract to *NEHRP Consultants Joint Venture* in September 2007
  - Partnership of ATC and CUREE
  - All earthquake engineering research centers (MAE Center, MCEER, PEER Center) also tied to partnership
- Building new in-house research staff – collaborative with, but not overlapping, existing NIST Structures Group staff
- Use NEES sites for any experimental work that is undertaken



# Program Planning Resources (1/2)

Specific research needs are identified via interactions with earthquake professional community and review of resource documents, e.g.:

- Participation in BSSC PUC and ASCE 7/31/41
- Field reconnaissance (e.g., Chile, see <http://www.nehrp.gov/library/ChileMeeting.htm>)
- NEHRP *Recommended Provisions* research needs statements

## RESEARCH NEEDS IDENTIFIED DURING DEVELOPMENT OF THE 2009 NEHRP RECOMMENDED SEISMIC PROVISIONS FOR NEW BUILDINGS AND OTHER STRUCTURES

As part of its efforts to regularly update the *NEHRP Recommended Seismic Provisions for New Buildings and Other Structures*, the Building Seismic Safety Council (BSSC) is charged by the Federal Emergency Management Agency (FEMA) to identify research needed to advance the state of the art of earthquake-resistant design and to serve as the basis for future refinement of the *Provisions*. During the project to generate the 2009 edition of the *Provisions*, the various working groups identified specific needed research that was beyond the scope of the 2009 *Provisions* update. Please direct any feedback regarding these research issues to: [bssc@nibs.org](mailto:bssc@nibs.org).

## DESIGN AND ANALYSIS

Several items related to the design and analysis requirements of the 2009 *Provisions* require fundamental research based on the methodology outlined in *Quantification of Building Seismic Performance Factors*, FEMA P-695. In addition, specific issues requiring attention if defensible changes are to be made in current requirements include system irregularities (both vertical and horizontal), dual frame systems, strong-column/weak-beam requirements for special moment frames, and importance factors for Occupancy Category III and IV structures.

Among the design and analysis issues identified for attention are the following:

1. With FEMA P-695 now complete and benchmarking of the methodology with several existing system types identified in ASCE/SEI 7-05 Table 12.2-1 (including the requirement that  $C_d = R$ , which has specific consequences), Design Coefficients and Factors for Seismic Force-Resisting Systems, under way, efforts to simplify Table 12.2-1 are warranted. Envisioned is a table that would be more generically based on anticipated level of ductility (ordinary, intermediate, and special) for all material types (i.e., special, intermediate, and ordinary systems would have the same seismic design coefficient factors regardless of material type). Likewise, the need for the system to be dependent on Seismic Design Category and the need for height limits should be reviewed and verified. Finally, the  $R$  factor basis should be verified (i.e., whether seismic designs are best categorized as "life safety" or "collapse"). Clearly, however, the performance goals of nonstructural systems also need to be considered, refined, and modified as necessary to produce the desired results. The determination of the structural performance goals should be based, at least in part, on

**Source: FEMA P-750**



# Program Planning Resources (2/2)

Specific research needs are identified via interactions with earthquake professional community and review of resource documents, e.g.:

- PBSD workshop report (NIST GCR 09-917-2) →
- ATC 57 (see previous slides)
- ATC 73 – *Prioritized Research for Reducing the Seismic Hazards of Existing Buildings*



# Overview of Ongoing Projects

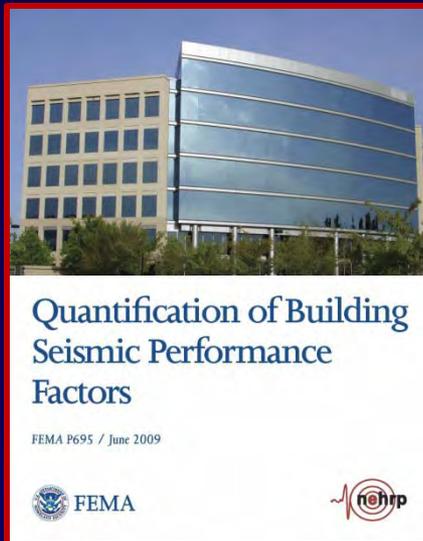
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- Ongoing NEHRP Consultants Joint Venture task orders and in-house projects are listed
- Proposed 2011 NCJV task orders will be approved & finalized before ACEHR meeting in Spring 2011



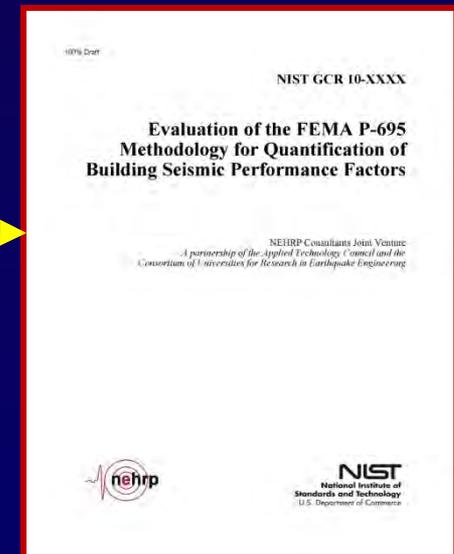
## Roadmap Element **1**

# Technical Support for Seismic Practice & Code Development



- **Task Orders 1 & 4:** *Quantification of Building System Performance and Response Parameters* (to be completed late 2010)
- **In-House Project:** *Improved Seismic Provisions for U.S. Building Codes* (2011 new start, based on Chile observations)

- **In-House Project:** *Seismic Performance of Buildings in the Central and Eastern U.S.* (2011 new start)
- **Task Order 11:** *Improved Structural Response Modification Factors for Seismic Design of New Buildings, Phase I*



## Roadmap Element **1**

# Technical Support for Seismic Practice & Code Development

- **Task Order 16:** *Cost-Benefit Analysis of Codes and Standards for Earthquake-Resistant Construction in Selected U.S. Regions, Phase 1* (discussed previously)
- **Task Order 17:** *Seismic Behavior and Design of Deep, Slender Wide-Flange Structural Beam-Column Members, Phase 1* (late 2010 startup)
- **Task Order 19:** *Comparison of Present Chilean and U.S. Model Building Code Seismic Provisions and Seismic Design Practices* (late 2010 startup)
- **Task Order 20:** *Ground Motion and Building Performance Data from the 2010 Chile Earthquake* (late 2010 startup)
- **Task Order 21/22:** *Analysis of Seismic Performance of Reinforced Concrete Buildings in the 2010 Chile Earthquake* (late 2010 startup)



## Roadmap Element

# Performance-Based Seismic Design Development

- **Task Order 6: Nonlinear Multi-Degree of Freedom Modeling** (report in formal publication review)
- **In-House: Nonlinear Seismic Analysis of Structures**

- Current focus: Develop an accurate & efficient nonlinear modal analysis methodology that accommodates nonlinear modal superposition using the force analogy and state space methods.
- Methodology will be peer reviewed in early 2011.



## Roadmap Element **2**

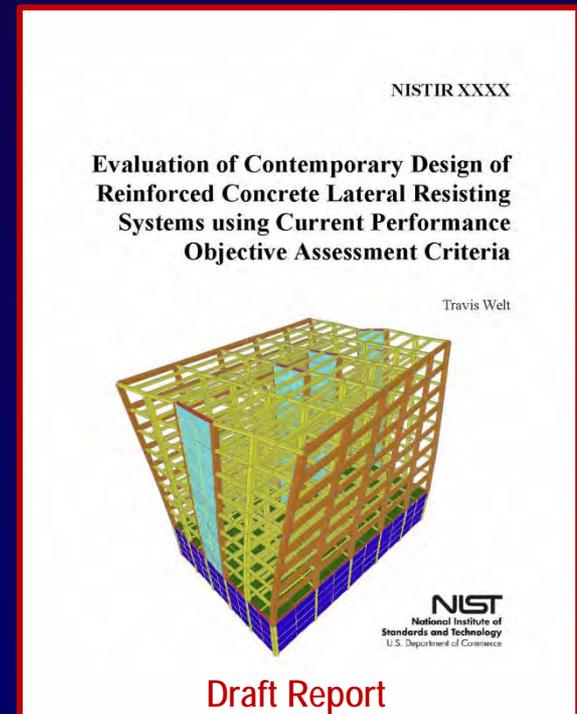
# Performance-Based Seismic Design Development

- **In-House:** *Performance-Based Seismic Engineering Methodologies for Buildings* (2009 startup – to be peer-reviewed)

Identified in NIST GCR 09-917-2 as Current Practice (CP)\* needed research topic CP-1 to support full implementation of Performance Based Seismic Design (PBSD) - *Benchmark current performance-based design methodologies:*

"Results of the ASCE 41 procedures are currently perceived to be conservative, but there has been no systematic effort to critically examine the performance predicted by the procedures, compare them with other evaluation and design methodologies, or thoroughly investigate inconsistencies."

\* Assessed by leading experts as needing immediate attention!



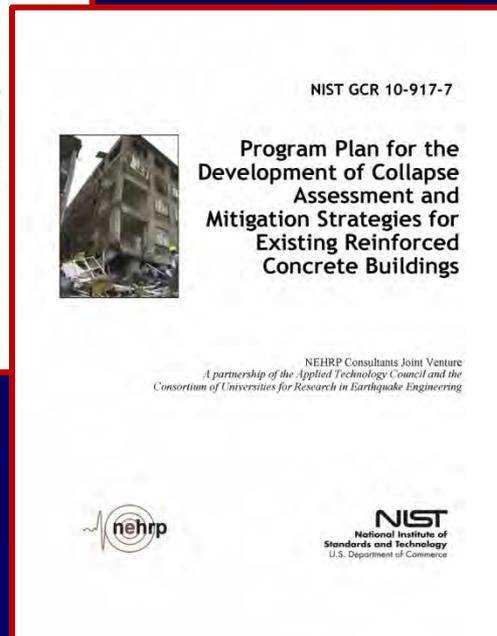
## Roadmap Element **2**

# Performance-Based Seismic Design Development

- **Task Order 5: Integration of Collapse Risk Mitigation Standards and Guidelines for Older Reinforced Concrete Buildings into National Standards, Phase 1**



*NIST GCR 10-917-6  
now available*



- Project is intended to support ongoing NEES Grand Challenge project at PEER with appropriate applied research and tech transfer.
- NIST GCR 10-917-7 now in editorial review.



## Roadmap Element

# Performance-Based Seismic Design Development

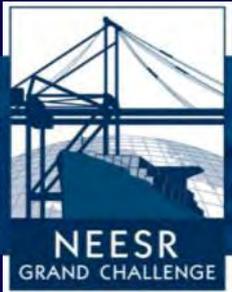
- **Task Order 9: *Selecting and Scaling Earthquake Ground Motions for Performing Time-History Analyses***
  - Identified in NIST GCR 09-917-2 as Current Practice (CP) needed research topic CP-3 to support full implementation of PBSD
  - Slated for completion late 2011
- **Task Order 10: *Procedures for Characterizing and Modeling Soil-Structure Interaction for PBSE***
  - Identified in NIST GCR 09-917-2 as Future Practice (FPA) needed research topic FPA-6 to support full implementation of PBSD
  - Slated for completion late 2011



## Roadmap Element **3**

# National Guidelines and Manuals Development

### Partnership with:



Seismic Risk Management  
for Port Systems

SAFEGUARDING THE INFRASTRUCTURE OF GLOBAL TRADE  
[www.neesgc.gatech.edu](http://www.neesgc.gatech.edu)

- **Task Order 2:** *Development of Seismic Design Guidelines for Port and Harbor Facilities, Phases 1 & 2*

- Concept: Provide knowledge transfer leverage for ongoing NEES Grand Challenge project
- Project team closely tied to ASCE Coasts, Oceans, Ports, and Rivers Institute (COPRI)
- Project has foundered
- Key decision on continuation in mid-2011



*Courtesy National Information Service for Earthquake Engineering,  
University of California, Berkeley*

Images courtesy of Prof Glenn Rix, Georgia Tech



# Roadmap Element

# Evaluated Technology for Practitioners

2008



2010



2009



2010



## Evaluated Technology for Practitioners

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### 2010-2011 Techbrief Production:

- **Task Order 15:** Seismic Design of Reinforced Concrete Shear Walls
- **Task Order 16:** Analysis and Design of Concrete-on-Metal Deck Diaphragms
- *Two additional techbriefs are proposed for 2011-2012 production*

# Program Reception

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- Techbriefs received well by both educators and practitioners
- Techbrief on *Seismic Design of Steel Special Moment Frames* received 2010 Engineering Excellence award from Structural Engineers Association of Northern California
- Other products now beginning to mature



# NIST Grant Activities

- **ARRA Research Grants**
  - *PBSD Methods and Tools for Reinforced Masonry Shear Wall Structures (UCSD)*
  - *Development & Evaluation of PBEE-Compliant Structural Systems (VT)*
  - *Modeling Natural Disaster Risk Management (U DE)*
- **2010 Construction Grant:** Expansion of the Center for Civil Engineering Earthquake Research Facilities at University of Nevada, Reno (UNR)



Figure courtesy of UNR