NIST NEHRP Research

National Earthquake Conference

23 April 2008

Jack Hayes
NEHRP Director
National Institute of Standards and Technology

Presentation Overview

- Statutory requirements
- A framework – ATC “Roadmap”
- Startup activities
- Current projects

Statutory NEHRP R&D Responsibilities

- Perform R&D to improve building codes and standards & practices.
- Work closely with national standards and model building code organizations, in conjunction with FEMA, to promote implementation of research results.
- Promote better building practices among architects and engineers.
- Work closely with national standards organizations to develop seismic safety standards and practices for new and existing lifelines.
- Support development & commercial application of cost-effective and affordable performance-based seismic engineering.
- Work with other program agencies to develop comprehensive plan for earthquake engineering research using existing facilities, upgrade facilities as needed, and integrate new testing approaches.

Budgets and Program Philosophy

President's ***American Competitiveness Initiative*** supports renewed NIST earthquake research program:

- FY 2007 budget started process (+$800K from FY 2006).
- FY 2008 budget continues startup funding level (same as FY 2007).
- FY 2009 budget *request* strengthens commitment (+$4.75M from FY 2008).

NIST will follow the "**ATC Roadmap**" approach with a program that combines in-house and extramural research efforts.

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.

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

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

Implementing the ATC "Roadmap"

- Began process in FY 2007.
- Develop 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 research centers (MAE Center, MCEER, PEER Center) also tied to partnership.
- Build new in-house research staff in FY 2008 and FY 2009 – collaborative with, but not overlapping, existing NIST structures staff.
- Use NEES sites for any experimental work that is undertaken.

Implementing the “ATC Roadmap”

Combined in-house and extramural program to have primary 6 focus areas:

- Technical support for building code development.
- Performance-based seismic design development.
- National design guidelines development.
- Evaluated technology dissemination.
- Enhanced design productivity and interoperability development.
- Development of improved evaluation and strengthening for existing buildings.

Pending resource availability, two additional cross-cutting NEHRP cooperative efforts:

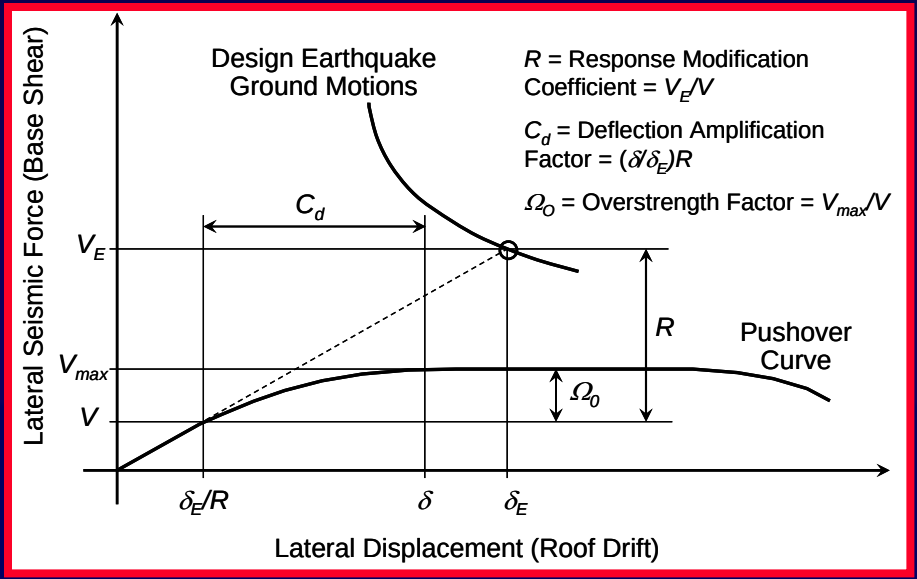
- Development and maintenance of Post-earthquake Information Management system.
- Analysis and application of ANSS instrumented buildings data (from earthquakes)

First Steps

- FY 2007 and 2008 saw startup of extramural program – discussed in following slides.
- Final form of FY 2008 program hinges on initial staff recruitment.
- Initiated one key FY 2007 in-house project through BFRL Office of Applied Economics:
  - Development of comprehensive database of available research products from NSF-supported projects.
  - Database needed to support development of “bridge” between NSF basic research and practitioner application via codes, standards, and guidelines.

Extramural Project: Quantification of Building System Performance and Response Parameters

FEMA Project ATC-63: Establish and document a recommended methodology for reliably quantifying building system performance and response parameters for use in seismic design.



Seismic performance factors (R, Ω_o, C_d) as now defined by *NEHRP Recommended Provisions* for use in model building codes.

Figures provided from draft ATC-63 report.

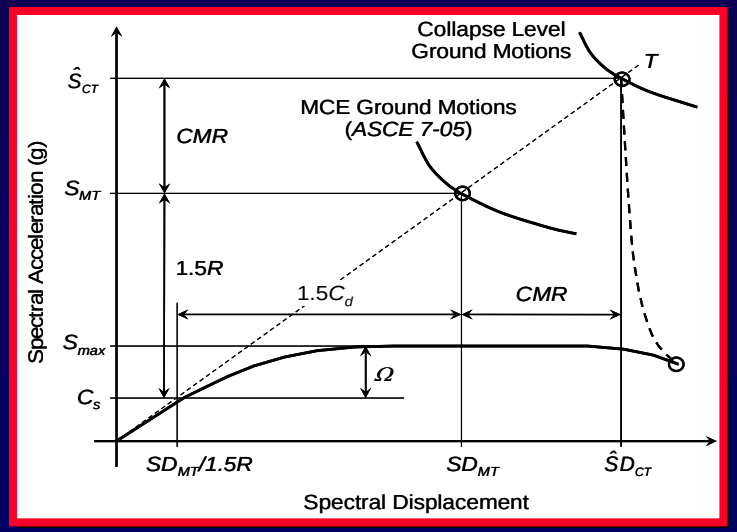
Today …

- *R* factors are used to estimate strength demands on structural systems that are designed using linear methods but are expected to respond satisfactorily in the nonlinear range.
- *R* factors were originally introduced in 1978 in ATC 3-06 and generally used in model building codes since then.
- *R* factors are largely based on judgment, with number of systems considered having expanded from a relatively small number with well-known response capabilities to over 80 systems, many of which have not been tested in the lab or in earthquakes.

Addresses Roadmap Element 1: Technical support for seismic practice and code development.

Extramural Project: Quantification of Building System Performance and Response Parameters

ATC-63 goal: Develop recommended methodology for determining building system performance and response parameters that will result in *equivalent safety against collapse in earthquakes for buildings across different seismic force-resisting systems*.



Redefined derivation of seismic performance factors based on ATC-63 methodology.

- Targets "life safety" in new buildings.
  - Higher performance levels not considered.
  - Assumes deformation compatibility & detailing requirements of ASCE 7-05 are satisfied.
- Requires acceptably low probability of collapse when structure is subjected to Maximum Considered Earthquake (MCE) ground motions.
- Combines:
  - Ground motions.
  - Analysis methods (nonlinear).
  - Test data requirements.
  - Design information requirements.
  - Peer review requirements.

Extramural Project: Quantification of Building System Performance and Response Parameters

ATC-63 methodology:

- Uses nonlinear models of seismic force-resisting “archetype” structures that capture the essence and variability of the performance characteristics of the systems of interest.
- Requires nonlinear analyses of a sufficient number of archetype models, with realistic design parameter variations, to represent broadly the systems of interest.
- Robustness of design requirements, test data availability, and analysis model detail are all considered in developing seismic response factors.
- Key recommendation in draft ATC-63 report: “Beta test” the methodology to verify for the construction materials industries and to codes and standards organizations that the procedure will reliably and accurately quantify building seismic performance. [Objective for this project!]

Extramural Project: Quantification of Building System Performance and Response Parameters

Beta Testing of ATC-63 Methodology

Seismic Force-Resisting System

- **Special reinforced concrete shear walls**
- **Special reinforced masonry shear walls**
- **Special steel concentric braced frames**
- **Ordinary reinforced concrete shear walls**
- **Ordinary masonry shear walls**
- **Ordinary steel moment frames**

Systems selected with practitioner input to augment other "beta tests" in ATC-63, examine multiple construction materials, and "bound" seismicity applicabilities.

- Project Director: Charles Kircher, Kircher & Associates
- Technical Lead - Concrete shear walls: John Wallace, UCLA
- Technical Lead - Masonry walls: Benson Shing, UCSD
- Technical Lead - Steel braced frames: Steve Mahin, UC Berkeley
- Technical Lead – Steel moment frames: Helmut Krawinkler, Stanford University

Extramural Project: Quantification of Building System Performance and Response Parameters

Project Status

- Beta testing teams being formed.
- Project to have substantial Technical Committee and Peer Review Panel.

  Ensures ties to ATC-63, materials industries, code/standard organizations, practitioners, researchers.

- Beta testing to occur during summer of 2008.
- Beta test reports due in December 2008/January 2009.
- Reports to assess viability and limitations of proposed ATC-63 methodology – while "new" seismic performance factors will be developed for example systems, they will not automatically be recommended for model building code use.

Extramural Project: Development of Seismic Design Guidelines for Port and Harbor Facilities, Phase I

Partnership with:

NEESR GRAND CHALLENGE

Seismic Risk Management for Port Systems

SAFEGUARDING THE INFRASTRUCTURE OF GLOBAL TRADE

www.neesgc.gatech.edu

The economic impact of the two-week labor disruption at West Coast ports in October 2002 is estimated at $1 billion to $2 billion per day.

Source: Sheffi (2005), "The Resilient Enterprise"

The Port of Kobe, Japan, once the 6th largest container port in the world, has fallen to 35th as a result of extensive damage caused by the 1995 Kobe earthquake.

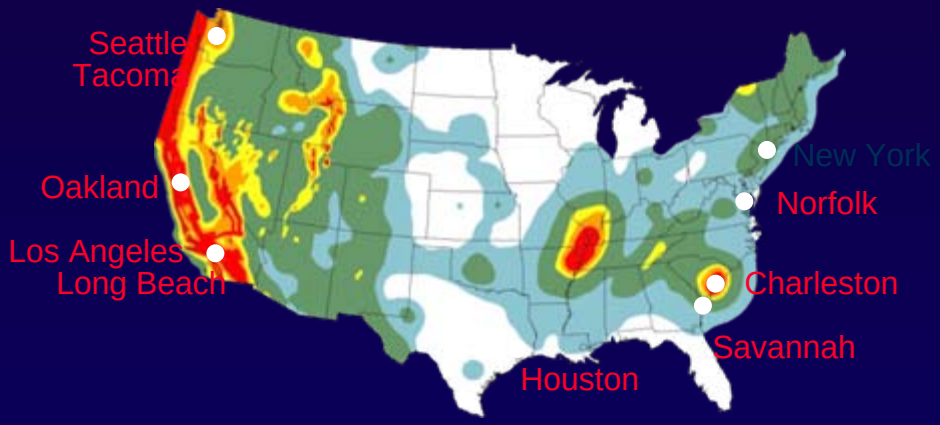
Source: AAPA World Port Rankings

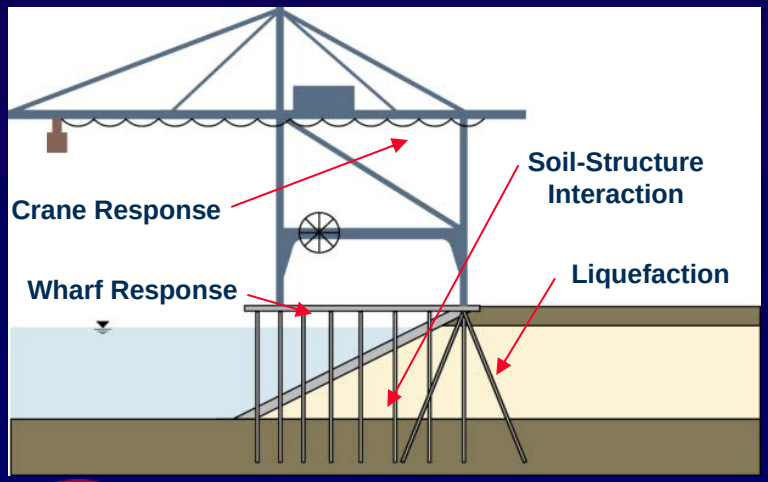
Addresses Roadmap Element 3: Problem-focused research and technical resources development to improve seismic engineering practice.

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

NEESR Project Information Courtesy of Professor Glenn Rix, Georgia Tech

Extramural Project: Development of Seismic Design Guidelines for Port and Harbor Facilities, Phase I





The Problem

- No widely accepted seismic codes
- Focus is on individual container wharves
- Vaguely defined performance requirements
- Based on arbitrary ground motion probabilities rather than loss probabilities
- No explicit consideration of business interruption losses
- Mixture of public and private organizations

NEESR Project Information Courtesy of Professor Glenn Rix, Georgia Tech

Extramural Project: Development of Seismic Design Guidelines for Port and Harbor Facilities, Phase I

NEESR Project Objectives

Help port stakeholders gain a better understanding of:

- Their facilities' vulnerability to natural hazards.
- Potential economic losses due to hazard-induced damage.
- Benefits of investing in more stringent design and/or retrofit methods.

➢ Primary focus on crane response/design, wharf response/design, pile response/design, and geotechnical conditions (liquefaction, etc.).

Extramural Project: Development of Seismic Design Guidelines for Port and Harbor Facilities, Ph I

Project Objective

- Bridge gap between NEESR basic research results and practitioners, by:
  - Partnering with NEESR team to provide mechanism for effective knowledge transfer.
  - Assessing needs for added knowledge beyond NEESR products.
  - Developing effective knowledge transfer vehicles in consultation with practitioners.
- Project Status:
  - September 2007 award of Phase 1 (initial scoping) task to ATC-CUREE.
  - Team now being formed.
  - Pace governed by NEESR project pace.
  - Phase II work plan anticipated June/July 2008.

Extramural Project: Development of TechBriefs on Structural Design Issues

TechBriefs: "Topical, tightly written, and well-illustrated discussions of practical problems faced by many engineering design and construction practitioners." (ATC-57)

- First topic: Practical design of special reinforced concrete moment frames IAW ACI 318 Ch 21.
- Technical Team:
  - Professor Jack Moehle, University of California, Berkeley
  - John Hooper, Magnusson Klemencic Associates
- Anticipated topic completion: June/July 2008.

Addresses Roadmap Element 4: Evaluated technology made available to practicing professionals in the design and construction communities.

Photos courtesy of Professor Jack Moehle, UC Berkeley