# NEHRP Consultants Joint Venture

## Program Briefing

NEHRP Advisory Committee Meeting

November 19, 2012

Gaithersburg, Maryland

*Jon A. Heintz*

*Program Manager*

*ATC Director of Projects*

CUREE

ATC

# Agenda

- Program Overview and Accomplishments
  - Reminders: Overarching IDIQ Contract; Program Organizational Structure
  - Program Statistics
  - 2011-2012 Accomplishments
  - Report Dissemination and Use
- Task Order Project Summaries
  - Selected Project Highlights
  - Completed/In Process *(TO 1, 2, 3, 4, …, 23, 24, 25, 26)*
  - Initiated in 2012-2013 *(TO 27, 28, 29, 30, 31, 32, 33, 34)*

# *Program Overview*

# NIST NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM (NEHRP) EARTHQUAKE STRUCTURAL AND ENGINEERING RESEARCH

| | |
|---|---|
| Funding allocation: | $30 million (ceiling) |
| Start date: | September 10, 2007 |
| End date: | September 9, 2012 |

Objectives:

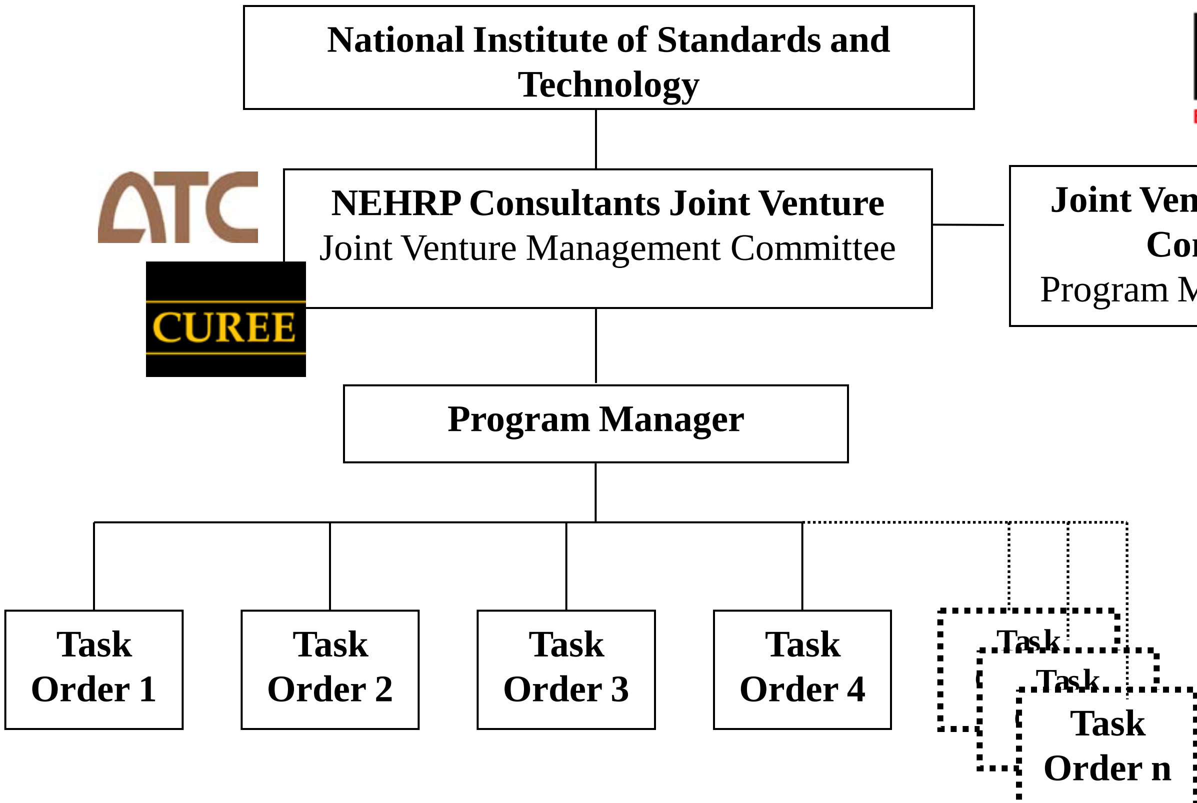
- **Technical support for the seismic and structural engineering practice and National model building code development process**
- **Problem-focused, practitioner-directed research and development on the technical basis for Performance-Based Seismic Design (PBSD)**
- **Problem-focused, practitioner-directed research and development on practical and cost-effective evaluation and reduction of hazards in existing buildings**

# NIST NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM (NEHRP) EARTHQUAKE STRUCTURAL AND ENGINEERING RESEARCH

Objective (cont'd):

- **Problem-focused research and development of technical resources (e.g., guidelines and manuals) to improve seismic, structural, and geotechnical engineering practice**
- **Evaluation and synthesis of available seismic and other extreme hazard mitigation data, to prepare succinct information summary documents ("technical briefs")**
- **Incorporation and integration of seismic and structural tools and methods in electronic data exchange efforts**
- **Expert planning for problem-focused research in each of the above areas**

# Joint Venture Organizational Structure



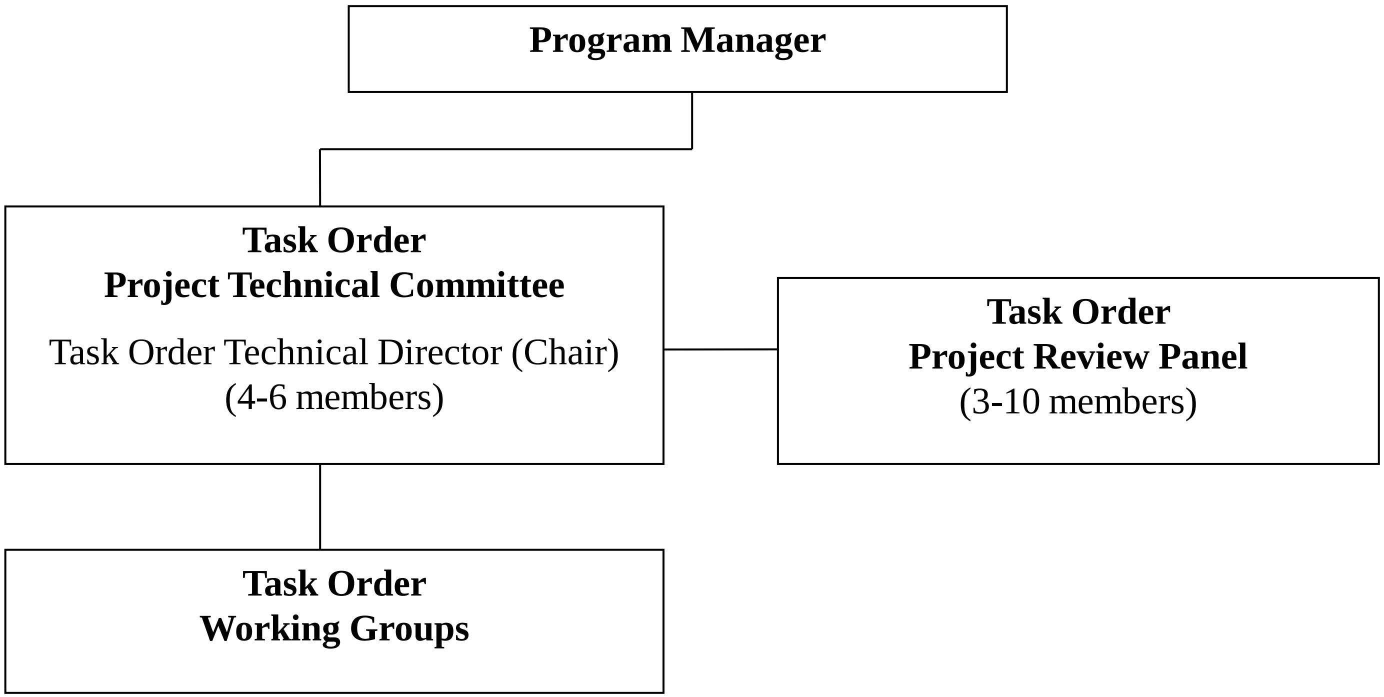
# Joint Venture Management Committee

- Robert Reitherman, CUREE
  *(Chair)*
- Christopher Rojahn, ATC
  *(Chief Financial Officer)*
- Andrew Whittaker, SUNY Buffalo, NY
  *(CUREE representative)*
- James Harris, J.R. Harris & Company, CO
  *(ATC representative)*

# Joint Venture Program Committee

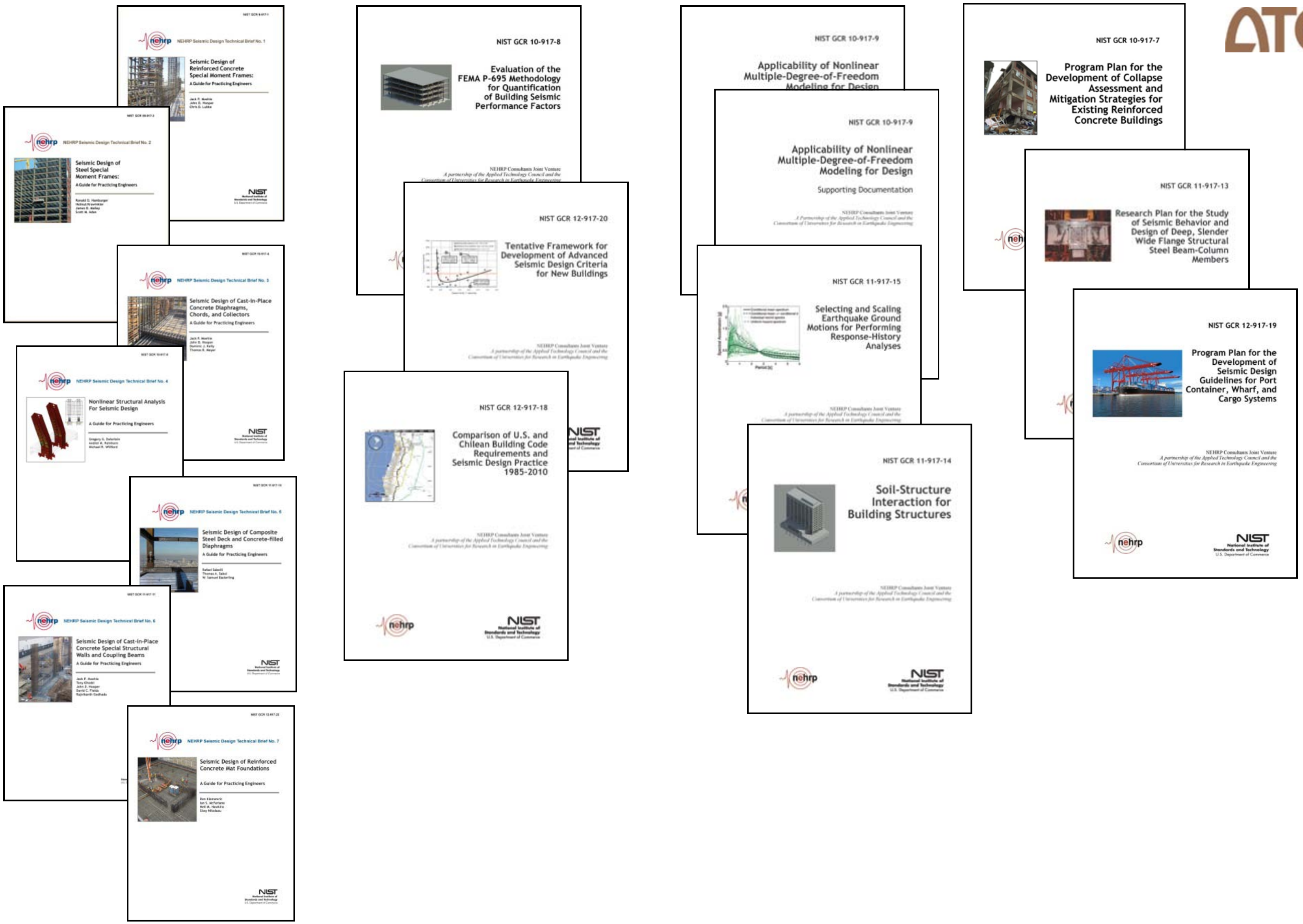
- Jon A. Heintz
  *(Program Manager, Chair)*
- Michael Constantinou, SUNY Buffalo, NY
  *(MCEER representative)*
- C.B. Crouse, URS Corp, Seattle, WA
- James Harris, J.R. Harris & Company, Denver, CO
  *(ATC representative)*
- William Holmes, Rutherford & Chekene, S.F., CA
- Jack Moehle, University of California at Berkeley
  *(PEER representative)*
- Andrew Whittaker, SUNY Buffalo, NY
  *(CUREE representative)*

# Task Order Project Organizational Structure



# Program Status - Overview

- Year 5 of the 5 year IDIQ contract
- 26 Task Order Projects through 2011-12
- $7,706,087 in total awards through 2011-12
- 16 GCR Reports to date (2,700 pages)



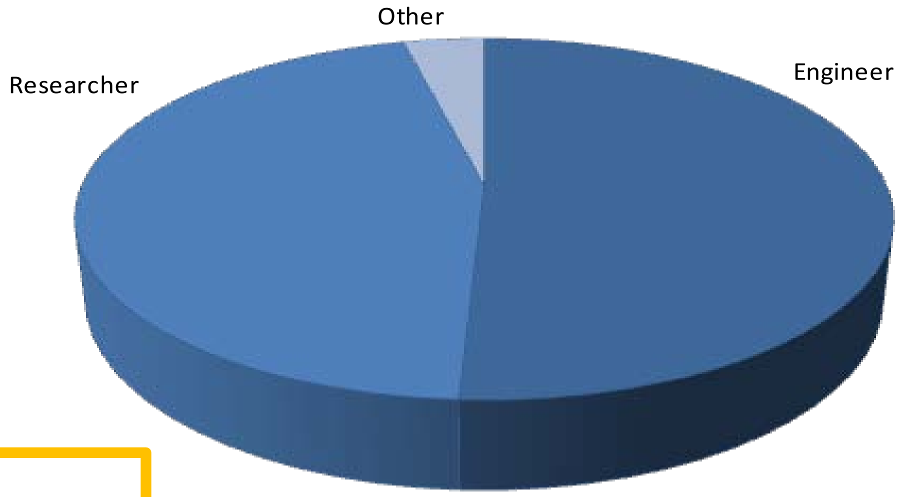

ATC CUREE

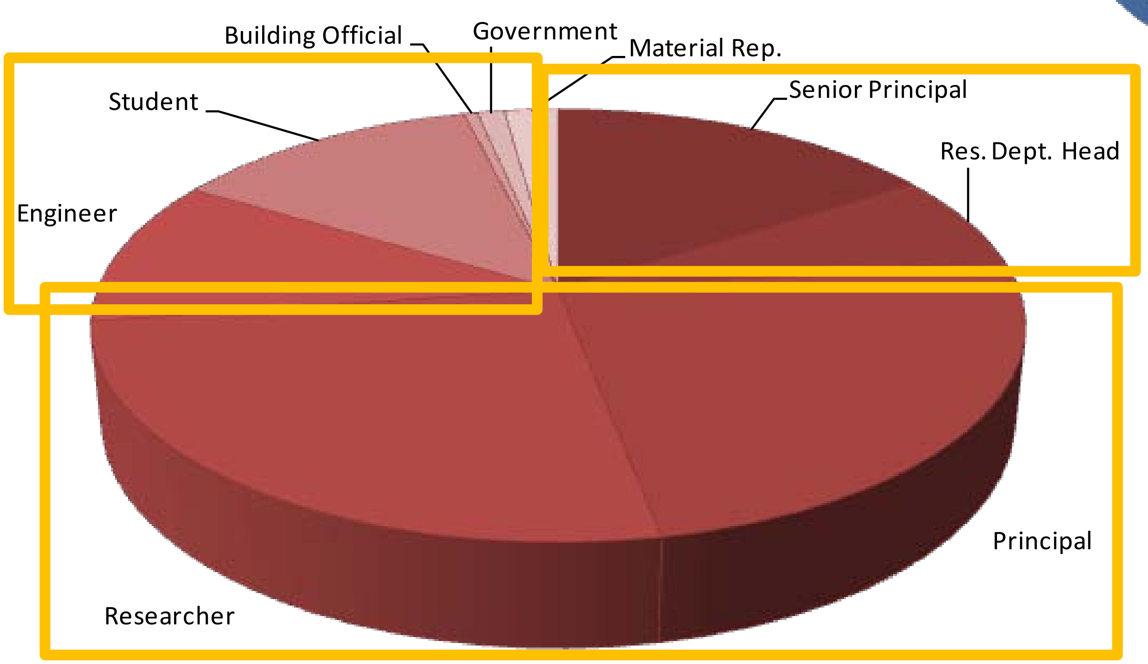
*Disaster-Resilient Structures & Communities, Earthquake Risk Mitigation R&D Program*

*2012 EL STRS Program Review*

# Program Status - Overview

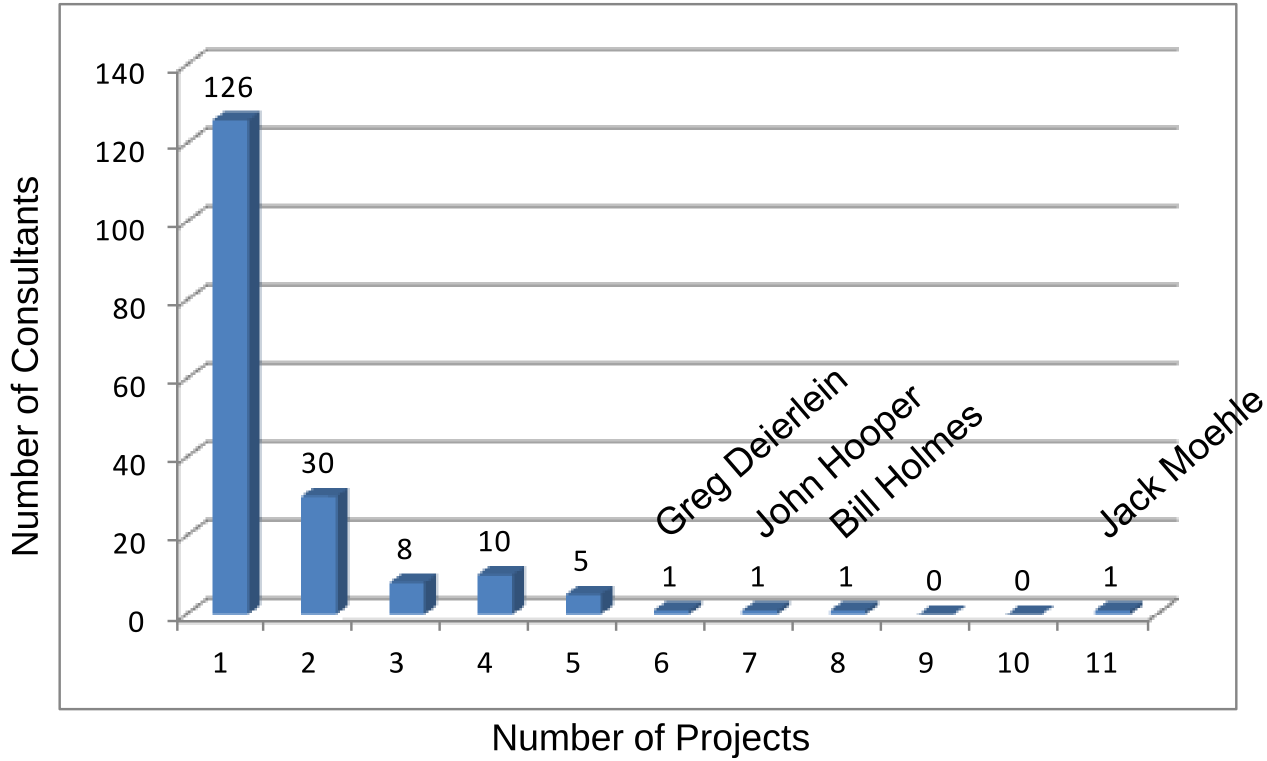
- 307 consultant positions
  - Demographics



# Program Status - Overview

- 307 consultant positions
  - 183 different individuals



*Soundbite*

## Program Status – 2011-2012 Accomplishments – Schedule

- Work on Task Orders scheduled to end was completed (TO 2, 9, 10, 11, 14, 15, 17, 19)
- Work on ongoing Task Orders was on schedule (TO 12, 16, 20, 21)
- Work on new Task Orders was started on time (TO 22, 23, 24, 25, 26)

# Program Status –
# 2011-2012 Accomplishments – Value

- Consultants work below market rates
  - 40% contributed services by rate
    (*source: OMB A-133 Audit, FY 2009, 2010*)
- Consultants work beyond contracted hours
  - Estimated 25% contributed hours
    (*source: anecdotal reports from consultants*)
    (*e.g., TO6 – Krawinkler, 200 contributed on 200 hour contract*)
- Low organizational overhead
  - 25% of total project cost
    (*source: ATC project financials – 30 year average*)

# Program Status – 2011-2012 Accomplishments – Quality

- 16 GCR Reports contributing to:
  - Model code provisions for new buildings
  - Standard provisions for existing buildings
  - Seismic design provisions update committee work
  - National, international, and local engineering conferences
  - NEHRP partner funded projects
  - Engineering practice improvement
  - PhD Theses

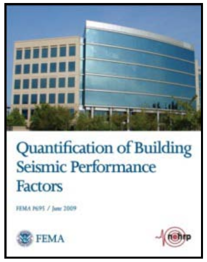
# *Summary Accomplishments*

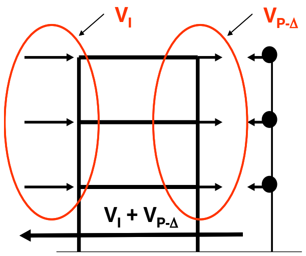
# Program Status – Summary Accomplishments

- Summarized/simplified the design of reinforced concrete special moment frames
- Summarized/simplified the design of steel special moment frames

# Program Status – Summary Accomplishments

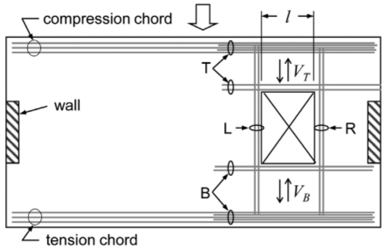
- Tested and validated FEMA's method for quantifying *R*-factors
- Prepared a program plan to solve the non-ductile concrete building hazard in the U.S.
- Studied simplified consideration of nonlinear MDOF effects in structural analysis

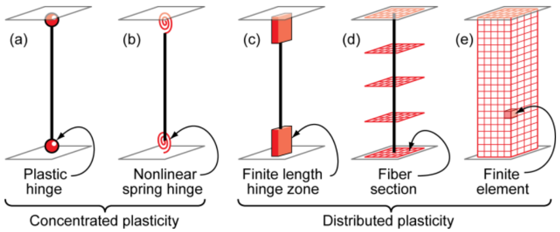


# Program Status –
# Summary Accomplishments

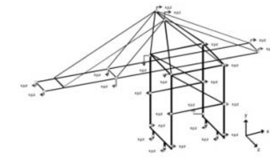
- Summarized/simplified the design of concrete diaphragms
- Summarized/simplified the practice of nonlinear analysis

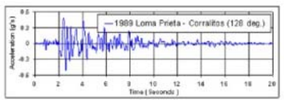


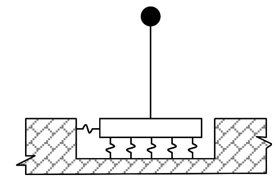



# Program Status –
# Summary Accomplishments

- Completed a program plan to develop port and harbor seismic design guidance
- Solved the ground motion selection and scaling problem
- Improved soil-structure interaction practice
- Developed a framework for advanced seismic design criteria (*R*-factor table and associated design provisions) in the building code
- Summarized/simplified metal deck diaphragm and reinforced concrete shear wall design



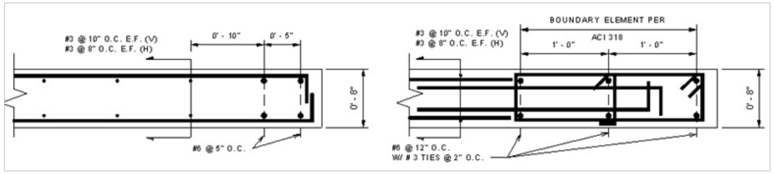


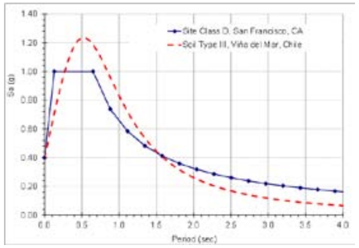


$$V = \frac{I * S_{DS} * W}{R}$$

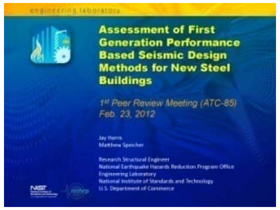
# Program Status – Summary Accomplishments

- Prepared a program plan for testing deep, slender steel beam-column sections
- Summarized/simplified reinforced concrete mat foundation design
- Compared U.S. and Chilean building code provisions and seismic design practices

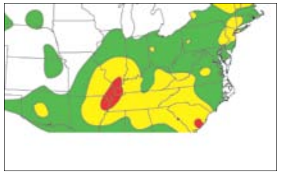


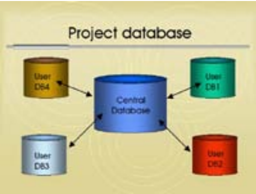
# Program Status – In Process




- Peer reviewing NIST in-house engineering studies



- Performing cost-benefit analyses for seismic design in moderate seismic zones

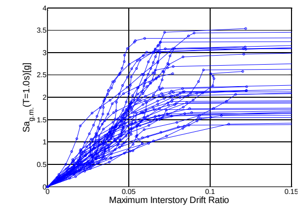


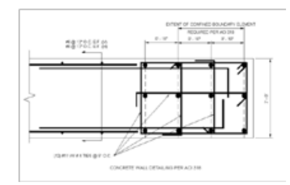

- Developing a Chile EQ data repository as a prototype for the eventual NIST disaster and failure events database

- Evaluating the performance of reinforced concrete buildings in the 2010 Chile EQ

# Program Status – In Process

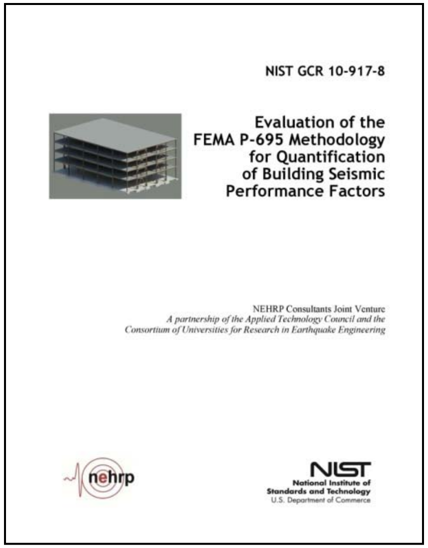
- Identifying collapse indicators for existing reinforced concrete buildings
- Developing a program plan for the future of nonlinear analysis in performance-based engineering
- Investigating the use of high-strength reinforcement in concrete design
- Developing a NIST Roadmap for wind and coastal inundation impact reduction



# *Report Dissemination and Use*

# Report Dissemination and Use


NIST GCR 10-917-8

Evaluation of the
FEMA P-695 Methodology
for Quantification
of Building Seismic
Performance Factors

NEHRP Consultants Joint Venture
*A partnership of the Applied Technology Council and the Consortium of Universities for Research in Earthquake Engineering*

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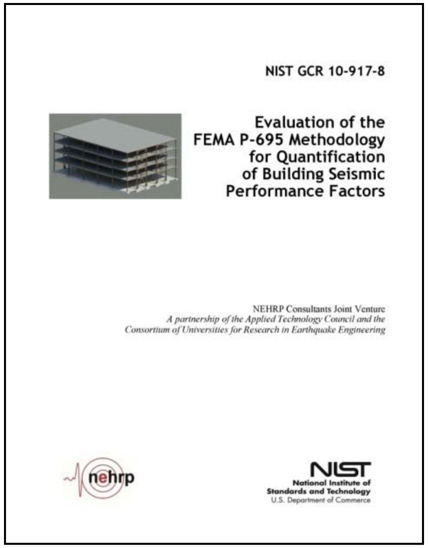
GCR 10-917-8, *Evaluation of the FEMA P-695 Methodology for Quantification of Building Seismic Performance Factors*

- Validated the FEMA P-695 Methodology, and cleared the way for adoption into code development process and ICC Evaluation Service Acceptance Criteria
- Results utilized by the ATC-63 Project Team to refine the FEMA P-695 Methodology
- Results utilized by the BSSC Provisions Update Committee (*NEHRP Recommended Provisions*)
- Results utilized by the ASCE 7 Standards Committee (ASCE/SEI 7 standard)
- Results utilized by the SEAOC Steel Seismology Committee in updating design criteria for Ordinary Steel Moment Frames
- Analytical models and results utilized by the ATC-58 Project Team as part of the FEMA P-58 Methodology beta testing effort.

# Report Dissemination and Use


NIST GCR 10-917-8

Evaluation of the FEMA P-695 Methodology for Quantification of Building Seismic Performance Factors

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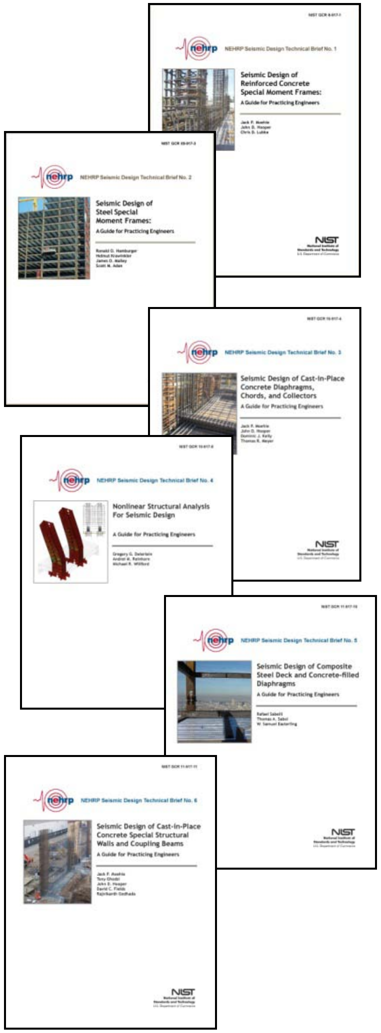
## GCR 10-917-8, *Evaluation of the FEMA P-695 Methodology for Quantification of Building Seismic Performance Factors – (continued)*

- Analytical models and results utilized by the ATC-63-2 and ATC-63-3 Project Teams as part of efforts to benchmark code performance
- Subject of Special Session on Evaluation of Collapse Performance – $9^{th}$US/$10^{th}$CCEE, Toronto, 2010 (Chen, Koutromanos, and Haselton)
- Paper – ASCE Structures Congress, Orlando, 2010 (Zareian, Lignos, and Krawinkler)
- Paper –International Workshop on Protection of the Built Environment Against Earthquakes, Ljubljana, 2010 (Zareian and Krawinkler)
- Paper – ATC U.S.-Japan Workshop paper, Hawaii, 2010 (Haselton and Wallace)
- Results utilized in the development of a post-tensioned reinforced concrete shear wall system at Lehigh University

# Report Dissemination and Use



## NEHRP Seismic Design Technical Briefs

- Technical Brief No. 2 – Winner, Award of Merit, 2010 SEAONC Excellence in Structural Engineering
- Technical Brief No. 2 – Paper, SEAOC Annual Convention, San Diego, 2009 (Adan, Hamburger, Krawinkler, and Malley)
- Technical Brief No. 2 – Article, Structure Magazine, June 2010 (Adan and Hamburger)
- Technical Brief No. 1, 2, 3, and 4 – Subject of 2011 NCSEA Continuing Education Webinar Series (Moehle, Deierlein, and Malley)
- Technical Brief No. 4 – Cited in the FEMA P-58 Methodology for guidance on nonlinear analysis

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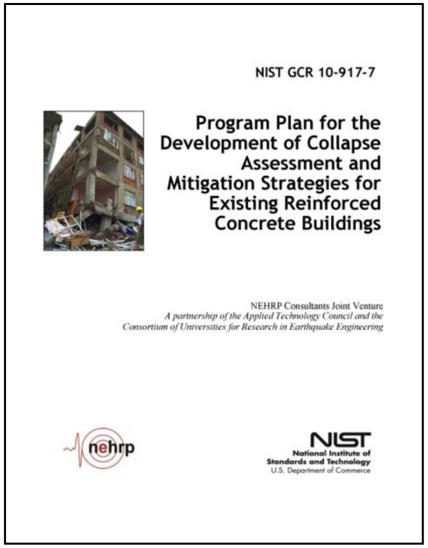
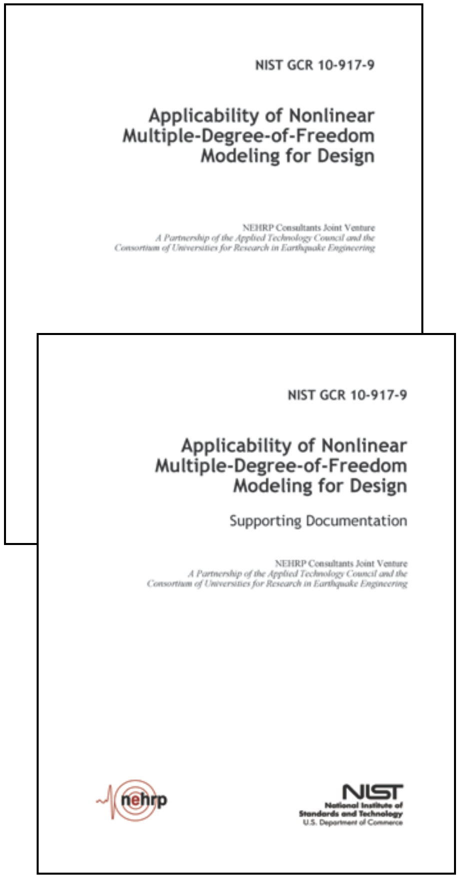
# Report Dissemination and Use




GCR 10-917-7, *Program Plan for the Development of Collapse Assessment and Mitigation Strategies for Existing Reinforced Concrete Buildings*

- Basis for FEMA-funded ATC-78 and ATC-78-1 Projects on Identification and Mitigation of Non-Ductile Concrete Buildings
- Results shared with the EERI Concrete Coalition lobbying for non-ductile concrete building mitigation
- Results shared with ACI Committee 369 on Seismic Repair and Rehabilitation
- Results shared with ASCE Standards Committee on Seismic Evaluation and Rehabilitation (ASCE/SEI 41 standard)
- Paper – 15WCEE, Lisbon, Portugal, 2012 (Elwood, Holmes, Comartin, Heintz, Rojahn, Dragovich, McCabe, Mahoney)

# Report Dissemination and Use


NIST GCR 10-917-9

Applicability of Nonlinear Multiple-Degree-of-Freedom Modeling for Design

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*A Partnership of the Applied Technology Council and the Consortium of Universities for Research in Earthquake Engineering*

NIST GCR 10-917-9

Applicability of Nonlinear Multiple-Degree-of-Freedom Modeling for Design

Supporting Documentation

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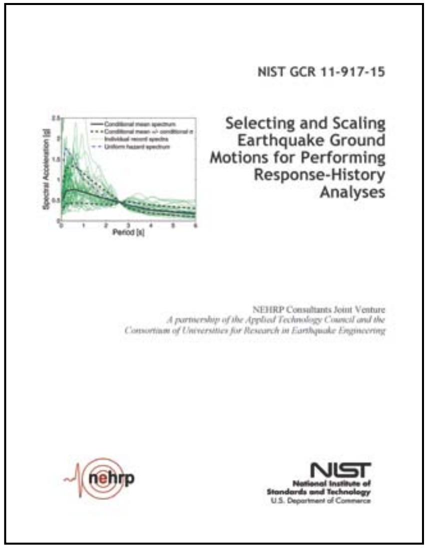
GCR 10-917-9, *Applicability of Nonlinear Multiple-Degree-of-Freedom Modeling for Design*

- Results utilized by ASCE Standards Committee on Seismic Evaluation and Rehabilitation (ASCE/SEI 41 standard)
- Subject of Special Session on Recent Developments in Simplified Nonlinear Static Procedures for Seismic Evaluation and Design – ASCE Structures Congress, Las Vegas, 2011 (Valley, Krawinkler, Lignos, Ashheim, Zareian)
- Paper – COMPDYN 2011, 3rd International Conference on Computational Methods in Structural Dynamics and Earthquake Engineering, Corfu, Greece (Lignos, Putman, Krawinkler)
- Chapter in *Computational Methods in Earthquake Engineering, Vol. 2*, Springer, 2012 (Lignos, Putman, Krawinkler)
- Paper – ASCE Structures Congress, Chicago, 2012 (Sinclair)

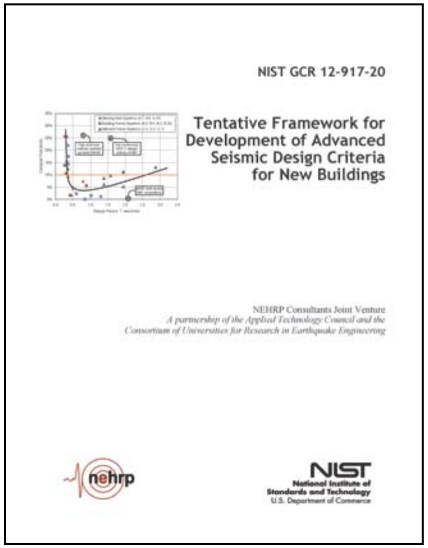
# Report Dissemination and Use




## GCR 11-917-15, *Selecting and Scaling Earthquake Ground Motions for Performing Response-History Analyses*

- Results utilized by the BSSC Issue Team 4 – Response History Analysis (*NEHRP Recommended Provisions*) in developing updates to the ASCE/SEI 7 standard
- Results shared with the SEAONC Ground Motions Subcommittee
- Cited in the FEMA P-58 Methodology for guidance on ground motion selection and scaling
- Paper – Bled4: Performance Based Seismic Engineering, Vision for an Earthquake Resilient Society, Bled, Slovenia, 2011 (Baker, Lin, and Haselton)
- Presented at the Los Angeles Tall Buildings Structural Design Council (LATBSDC) Annual Conference, Los Angeles, 2012 (Heintz)
- Proposed as the basis of an EERI Spectra journal paper (Haselton, et al.)

# Report Dissemination and Use


NIST GCR 12-917-20

Tentative Framework for Development of Advanced Seismic Design Criteria for New Buildings

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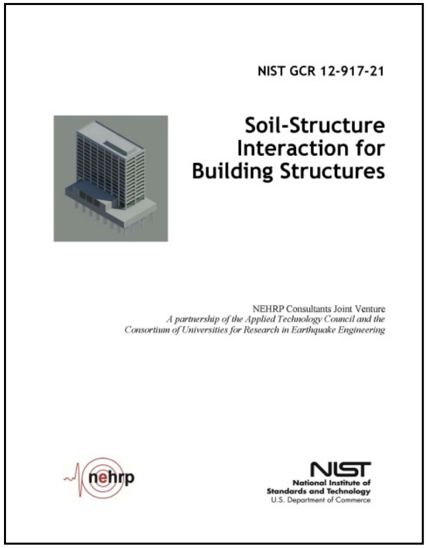
GCR 12-917-20, *Tentative Framework for Development of Advanced Seismic Design Criteria for New Buildings*

- Results utilized by the BSSC Provisions Update Committee (*NEHRP Recommended Provisions*) in developing updates to the ASCE/SEI 7 standard
- Results utilized by BSSC Issue Team 2 and Issue Team 7 – Performance Objectives, in defining risk-based performance measures for the ASCE/SEI 7 standard
- Results utilized in the ATC-63-2 and ATC-63-3 Projects on benchmarking code performance
- Results utilized in the development of cold-formed steel framed shear wall systems for AISI at McGill University, Montreal, Quebec

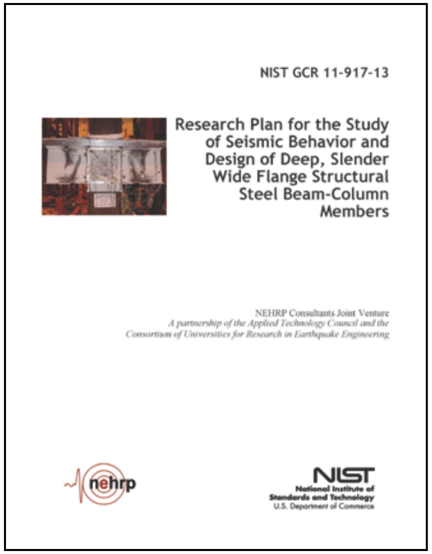
# Report Dissemination and Use




GCR 12-917-21, *Soil-Structure Interaction for Building Structures*

- Results shared with the SEAONC Seismology Committee
- Results utilized by the ASCE Standards Committee on Seismic Evaluation and Rehabilitation (ASCE/SEI 41 standard)
- Presented at the Los Angeles Tall Buildings Structural Design Council (LATBSDC) Annual Conference, Los Angeles, 2012 (Heintz)
- Paper – 9th International Conference on Urban Earthquake Engineering , Tokyo, Japan, 2012 (Givens, Mikami, Kashima, and Stewart)
- Paper – 15WCEE, Lisbon, Portugal, 2012 (Givens, Stewart, Haselton, Mazzoni)

# Report Dissemination and Use


NIST GCR 11-917-13

Research Plan for the Study of Seismic Behavior and Design of Deep, Slender Wide Flange Structural Steel Beam-Column Members

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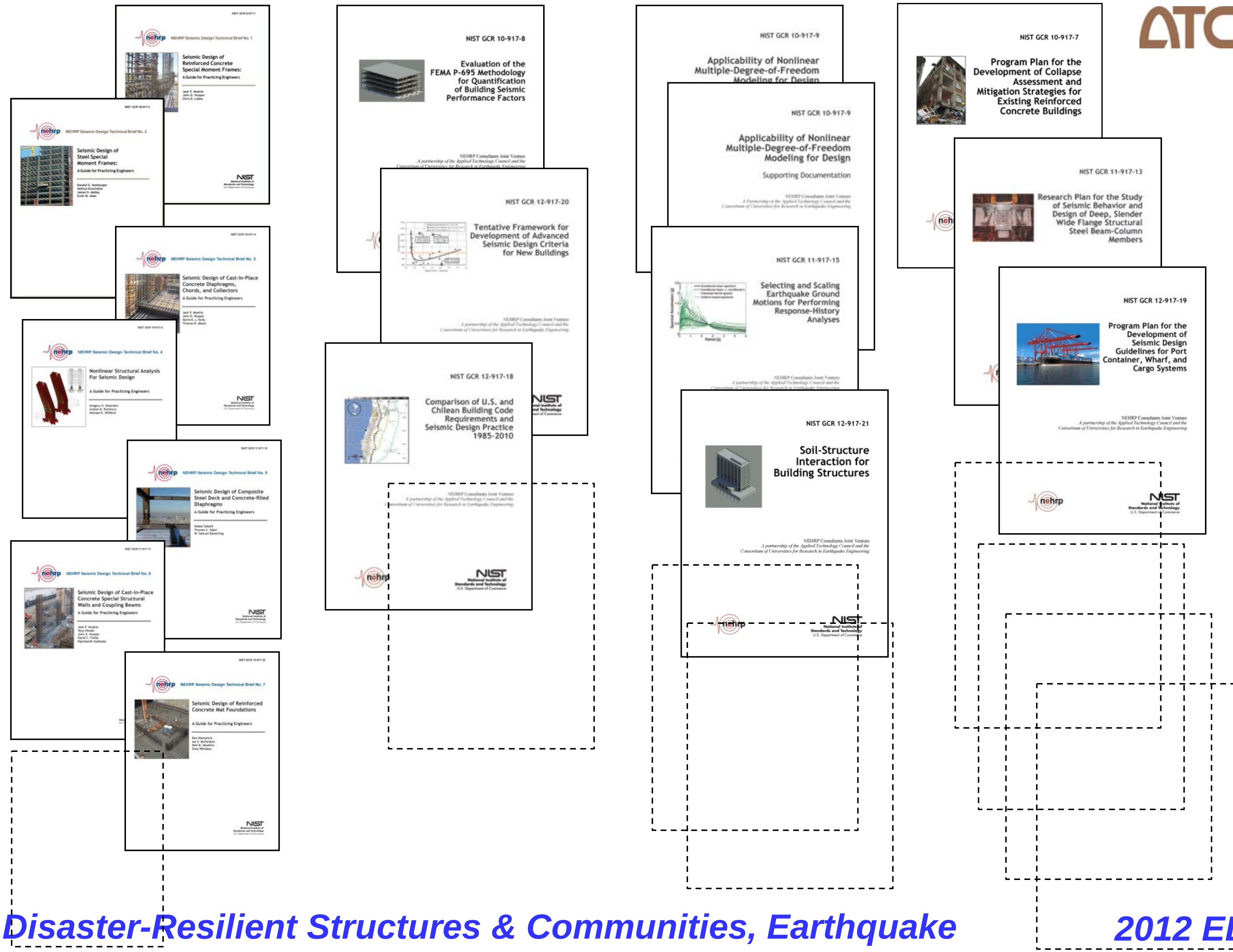
GCR 11-917-13, *Research Plan for the Study of Seismic Behavior and Design of Deep, Slender Wide Flange Structural Steel Beam-Column Members*

- Results utilized in tests of deep, slender beam-column members at McGill University, Montreal, Quebec

# *Task Order Project Summaries*



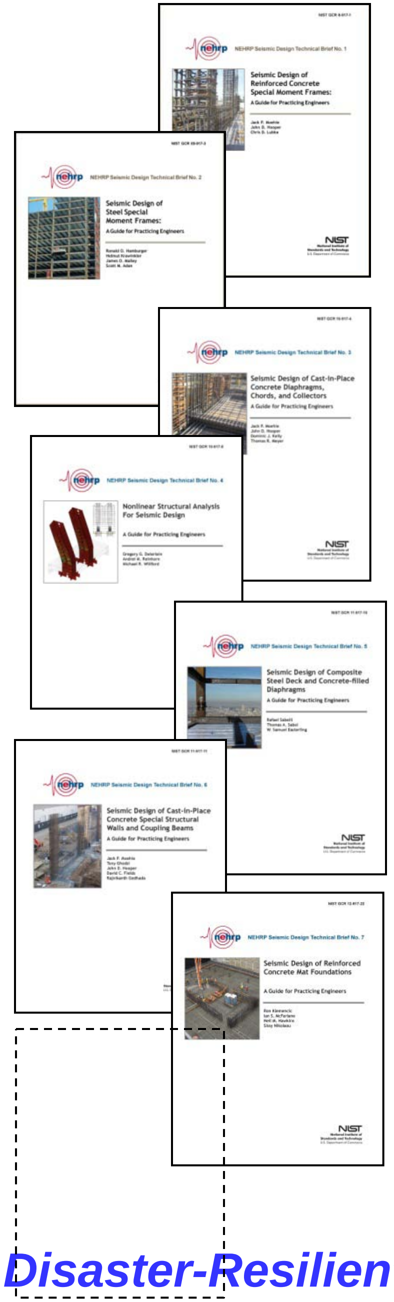

ATC CUREE

**Disaster-Resilient Structures & Communities, Earthquake Risk Mitigation R&D Program**

**2012 EL STRS Program Review**

# *Techbrief Projects*

*(TO 3, 7, 8, 14, 15, 24, 29)*



# Techbrief Projects

## NEHRP Seismic Design Technical Briefs

- Technical Brief No. 1 – Special Reinforced Concrete Moment Frames
- Technical Brief No. 2 – Special Steel Moment Frames
- Technical Brief No. 3 – Cast-in-Place Concrete Diaphragms
- Technical Brief No. 4 – Nonlinear Analysis
- Technical Brief No. 5 – Composite Steel Deck with Concrete Fill
- Technical Brief No. 6 – Special Reinforced Concrete Shear Walls and Coupling Beams
- Technical Brief No. 7 – Reinforced Concrete Mat Foundations
- Technical Brief No. 8 – Special Steel Concentric Braced Frames (Task Order 29)

*Task Order 15*

# Development of Technical Briefs - Topic #6 Special Concrete Shear Wall Design

| | |
|---|---|
| Funding allocation: | $129,144 |
| Start date: | August 23, 2010 |
| End date: | August 22, 2011 |

Objective:
- **Synthesize model code requirements and latest engineering techniques into clear and concise design and construction guidance on special reinforced concrete shear walls**

*Task Order 15*

# Development of Technical Briefs - Topic #6
# Special Concrete Shear Wall Design

Principal Investigator: **Jack Moehle, Univ. of California, Berkeley**

Co-investigators:

Project Technical Committee
**John Hooper, Magnusson Klemencic Assoc., WA**
**Tony Ghodsi, Englekirk & Sabol, Santa Ana, CA**

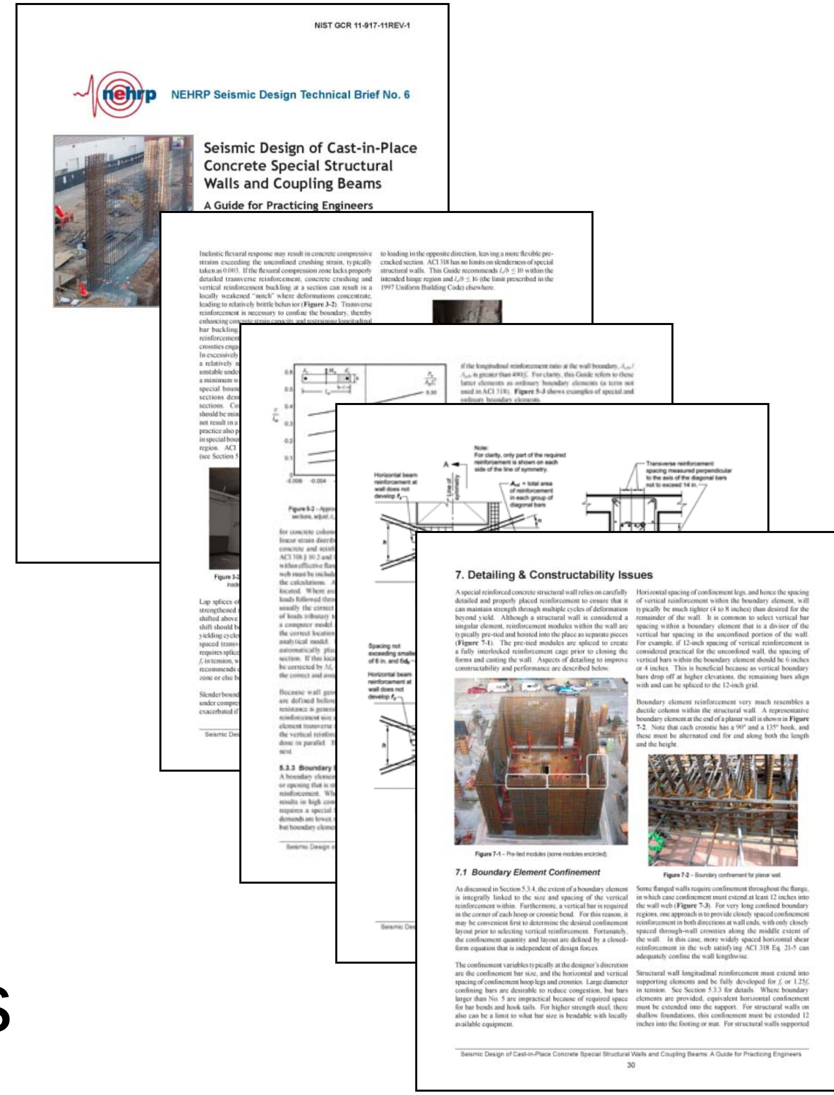
Project Review Panel
**Dawn Lehman, University of Washington, Seattle**
**John Wallace, Univ. of California, Los Angeles**
**Loring A. Wyllie, Jr., Degenkolb Engineers, CA**

## [What are the major outputs and outcomes (accomplished or anticipated) of this project?]

ATC CUREE

***Task Order 15***

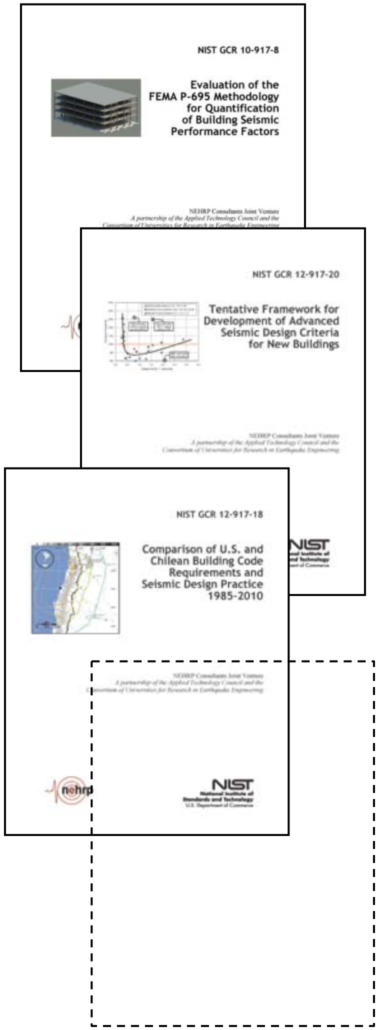
- Techbrief on Special Reinforced Concrete Shear Walls (2011)
  - 41 pages
  - Illustrated/sidebar discussions
- Background
- Design guidance
- Detailing practice
- Constructability issues



# *Code-Related Projects*

*(TO 1, 4, 11, 16, 19)*

# Code-Related Projects




- GCR 10-917-8 *Evaluation of the FEMA P-695 Methodology for Quantification of Building Seismic Performance Factors*
- GCR 12-917-20 *Tentative Framework for Development of Advanced Seismic Design Criteria for New Buildings*
- GCR 12-917-18 *Comparison of U.S. and Chilean Building Code Requirements and Seismic Design Practice, 1985–2010*
- Task Order 16 Project Report on Cost-Benefits of Seismic Design in Regions of Moderate Seismicity

*Task Order 1+4*

# Quantification of Building System Performance and Response Parameters

| | |
|---|---|
| Funding allocation: | $249,896 + $358,522 |
| Start date: | September 19, 2007 |
| End date: | November 5, 2010 |

Objective:

- **Beta Test the FEMA P695 Methodology for Quantification of Building Seismic Performance Factors (FEMA, in production)**
- **Verify reliability and accuracy of the approach**
- **Develop recommended improvements, if needed**
- **Benchmark performance of selected systems: RMSW, RCSW, SCBF, and SMRF**

*Task Order 1+4*

# Quantification of Building System Performance and Response Parameters


Principal Investigator: **Charles Kircher, Kircher & Associates, CA**

Co-investigators: Project Technical Committee
**Greg Deierlein, Stanford University**
**John Hooper, Magnusson Klemencic Assoc., WA**
**Benson Shing, Univ. of California, San Diego**
**John Wallace, Univ. of California, Los Angeles**
**Steve Mahin, Univ. of California, Berkeley**
**Helmut Krawinkler, Stanford University**

*Task Order 1+4*

# Quantification of Building System Performance and Response Parameters

Co-investigators:

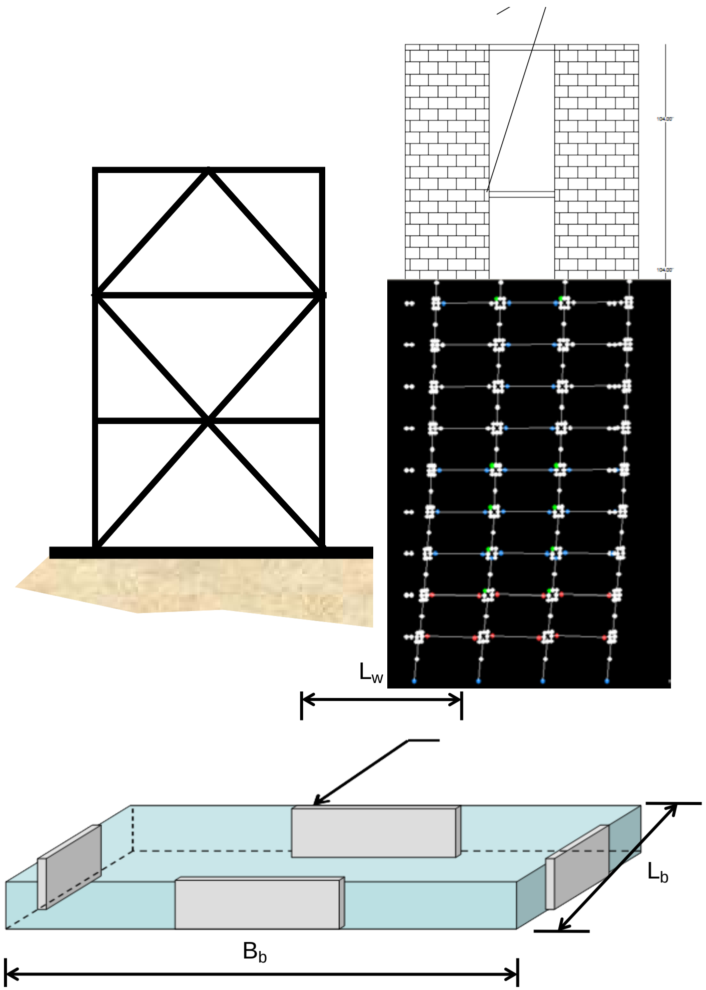
Project Review Panel

**Ron Hamburger, Simpson Gumpertz & Heger, CA**
**James Harris, JR Harris & Company, CO**
**William Holmes, Rutherford & Chekene, CA**
**Rafael Sabelli, Walter P. Moore, CA**
**Maryann Phipps, Estructure, CA**
**Richard Klinger, NCMA representative**
**S.K. Ghosh, PCA representative**
**Bonnie Manley, AISI representative**
**Phillip Line, AF&PA representative**
**Nico Luco, U.S. Geological Survey**
**Kurt Stochlia, ICC Evaluation Service**

# What are the major outputs and outcomes (accomplished or anticipated) of this project?

***Task Order 1+4***

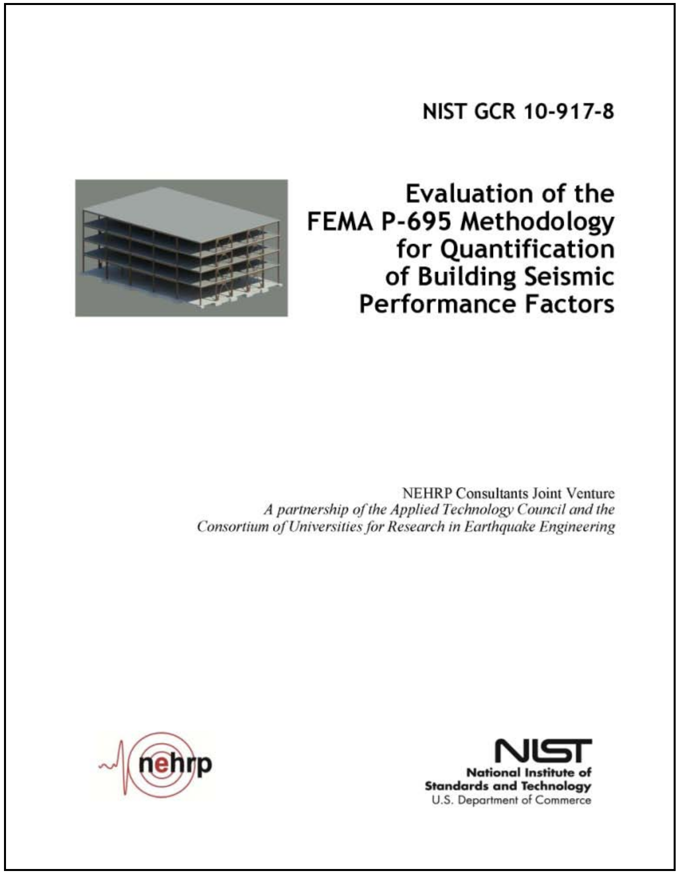
- Developed archetype configurations
- Designed and analyzed archetype buildings
- Checked collapse behavior versus criteria
  - 10% probability of collapse given MCE (on average)
  - 20% probability of collapse given MCE (individual outliers)



## What are the major outputs and outcomes (accomplished or anticipated) of this project?

***Task Order 1+4***

- Report documenting findings on FEMA P-695 and recommendations for code *R* factors
  - Criteria reasonably well-calibrated with inherent safety goals of the code
  - Methodology is reasonable and practical to implement


NIST GCR 10-917-8

Evaluation of the FEMA P-695 Methodology for Quantification of Building Seismic Performance Factors

NEHRP Consultants Joint Venture
*A partnership of the Applied Technology Council and the Consortium of Universities for Research in Earthquake Engineering*

nehrp

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

## What are the major outputs and outcomes (accomplished or anticipated) of this project?

***Task Order 1+4***

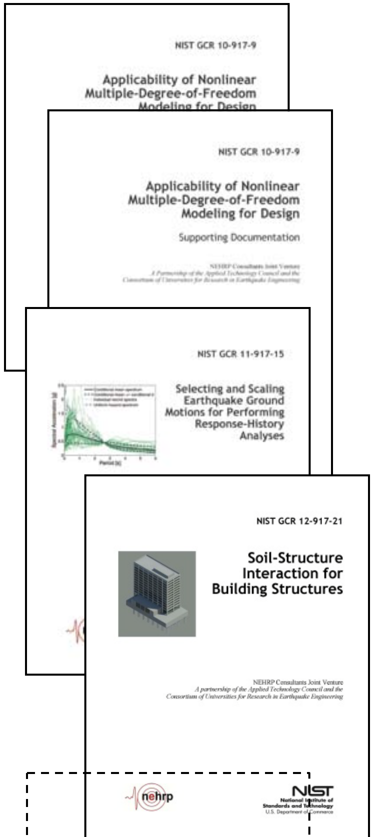
- System Conclusions:
  - Most systems met the acceptance criteria
  - Those that didn't had good reason
    - Ungrouted Masonry Shear Walls
    - Short period systems of some types of construction

**Table 8-1 Number of Archetypes Passing the Acceptance Criterion for Evaluation of Individual Archetypes**

| Seismic Force-Resisting System | | | Primary Analysis Procedure | Short-Period Configurations | | Long-Period Configurations | |
|---|---|---|---|---|---|---|---|
| No. | Type | Detailing | | High Gravity | Low Gravity | High Gravity | Low Gravity |
| 1 | RMSW | Special | ELF | 2 of 5 pass | 3 of 5 pass | All pass | All pass |
| 2 | RMSW | Ordinary | ELF | 1 of 4 pass | 3 of 4 pass | 3 of 6 pass | All pass |
| 3 | RCSW | Special | ELF | 2 of 5 pass | 2 of 5 pass | All pass | All pass |
| 4 | RCSW | Ordinary | ELF | All pass | All pass | All pass | All pass |
| 5 | SCBF | Special | ELF | 3 of 4 pass | | All pass | |
| 6 | BRBF | n/a | ELF | All pass | | All pass | |
| 7a | SMF | Special | ELF | All pass | | All pass | |
| 7b | SMF | Special | RSA | All pass | | All pass | |

# *Engineering-Related Projects*

*(TO 6, 9, 10, 21, 25)*




# Engineering-Related Projects

- GCR 10-917-9 *Applicability of Nonlinear Multiple-Degree-of-Freedom Modeling for Design*
- GCR 11-917-15 *Selecting and Scaling Earthquake Ground Motions for Performing Response-History Analysis*
- GCR 12-917-21 *Soil-Structure Interaction for Building Structures*
- Task Order 21 Project Report on Concrete Building Performance in the 2010 Chile Earthquake
- Task Order 25 Project Report on Use of High-Strength Reinforcement in Seismic Design

*Task Order 10*

# Improved Procedures for Characterizing and Modeling Soil-Structure Interaction for Performance-Based Seismic Engineering

| | |
|---|---|
| Funding allocation: | $502,368 |
| Start date: | September 21, 2009 |
| End date: | September 20, 2012 |

Objective:

- **Develop guidance for implementing soil-structure interaction in response history analyses to more accurately reflect both site geotechnical conditions and foundation impedance**
- **Identify areas of research that are needed to further improve the guidance that is developed**

*Task Order 10*

# Improved Procedures for Characterizing and Modeling Soil-Structure Interaction for Performance-Based Seismic Engineering


Principal Investigator: **Jonathan Stewart, University of California, Los Angeles, CA**

Co-investigators: Project Technical Committee
**Brett Lizundia, Rutherford & Chekene, CA**
**Tara Hutchinson, Univ. of California, San Diego**
**Farzad Naeim, John A. Martin & Associates, CA**
**Farhang Ostadan, Bechtel Corporation, CA**
**C. B. Crouse, URS Corporation, Seattle, WA**

Task Order 10

# Improved Procedures for Characterizing and Modeling Soil-Structure Interaction for Performance-Based Seismic Engineering

Co-investigators:

Project Review Panel

**Norman Abrahamson, PG&E, San Francisco, CA**
**Yousef Hashash, University of Illinois, Urbana**
**Annie Kammerer, NRC, Washington, D.C.**
**Craig Comartin, CDComartin Inc., CA**
**Gyimah Kasali, Rutherford & Chekene, CA**
**Graham Powell, Computers & Structures, Inc., CA**

# [What are the major outputs and outcomes (accomplished or anticipated) of this project?]

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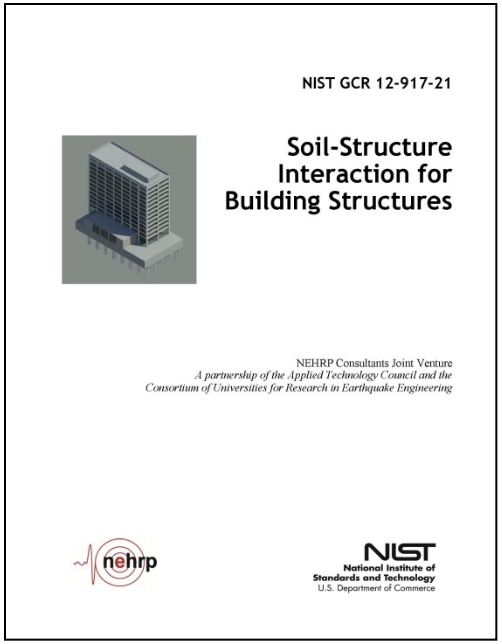
***Task Order 10***

- NIST GCR 12-917-21
  Soil-Structure Interaction for Building Structures (2012)
  - Collected, harmonized past SSI research
  - Provides simple test for when SSI is important
  - Recommends best modeling approaches




| *Degree of Freedom* | *Pais and Kausel (1988)* | *Gazetas (1991); Mylonakis et al. (2006)* |
|---|---|---|
| Translation along z-axis | $\eta_z = \left[1.0 + \left(0.25 + \frac{0.25}{L/B}\right)\left(\frac{D}{B}\right)^{0.8}\right]$ | $\eta_z = \left[1 + \frac{D}{21B}\left(1 + 1.3\frac{B}{L}\right)\right]\left[1 + 0.2\left(\frac{A_w}{4BL}\right)^{2/3}\right]$ |
| Translation along y-axis | $\eta_y = \left[1.0 + \left(0.33 + \frac{1.34}{1 + L/B}\right)\left(\frac{D}{B}\right)^{0.8}\right]$ | $\eta_y = \left(1 + 0.15\sqrt{\frac{D}{B}}\right)\left[1 + 0.52\left(\frac{z_w A_w}{BL^2}\right)^{0.4}\right]$ |
| Translation along x-axis | $\eta_x = \eta_y$ | $\eta_x = \eta_y$ |
| Torsion about z-axis | $\eta_{zz} = \left[1 + \left(1.3 + \frac{1.32}{L/B}\right)\left(\frac{D}{B}\right)^{0.9}\right]$ | $\eta_{zz} = 1 + 1.4\left(1 + \frac{B}{L}\right)\left(\frac{d_w}{B}\right)^{0.9}$ |
| Rocking about y-axis | $\eta_{yy} = \left[1.0 + \frac{D}{B} + \left(\frac{1.6}{0.35 + (L/B)^4}\right)\left(\frac{D}{B}\right)^2\right]$ | $\eta_{yy} = 1 + 0.92\left(\frac{d_w}{B}\right)^{0.6}\left[1.5 + \left(\frac{d_w}{D}\right)^{1.9}\left(\frac{B}{L}\right)^{-0.6}\right]$ |
| Rocking about x-axis | $\eta_{xx} = \left[1.0 + \frac{D}{B} + \left(\frac{1.6}{0.35 + L/B}\right)\left(\frac{D}{B}\right)^2\right]$ | $\eta_{xx} = 1 + 1.26\frac{d_w}{B}\left[1 + \frac{d_w}{B}\left(\frac{d_w}{D}\right)^{-0.2}\sqrt{\frac{B}{L}}\right]$ |

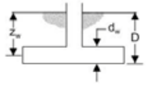
*Notes:*

$d_w$ = height of effective side wall contact (may be less than total foundation height)
$z_w$ = depth to centroid of effective sidewall contact
$A_w$ = Actual sidewall-solid contact area, for constant effective contact height d along perimeter.

For each degree of freedom, calculate $K_{emb} = \eta \cdot K_{sur}$

Coupling Terms: $K_{emb,rx} = \left(\frac{1}{3}\right)\left(\frac{D}{B}\right)K_{emb,x}$

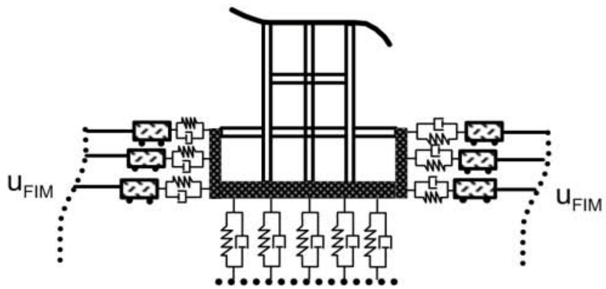
$K_{emb,ry} = \left(\frac{1}{3}\right)\left(\frac{D}{B}\right)K_{emb,y}$



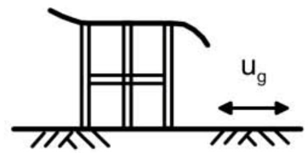
## What are the major outputs and outcomes (accomplished or anticipated) of this project?

***Task Order 10***

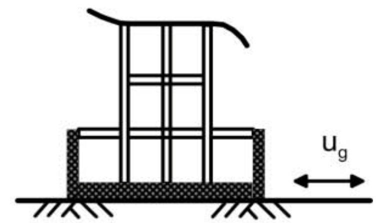
- SSI Modeling Approaches:



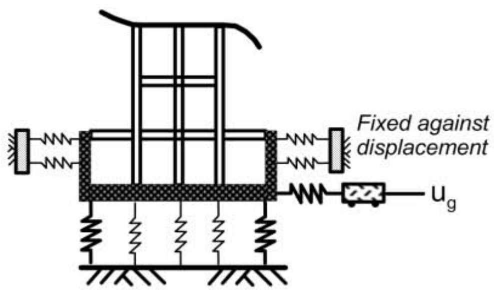

**Baseline Model (MB)**



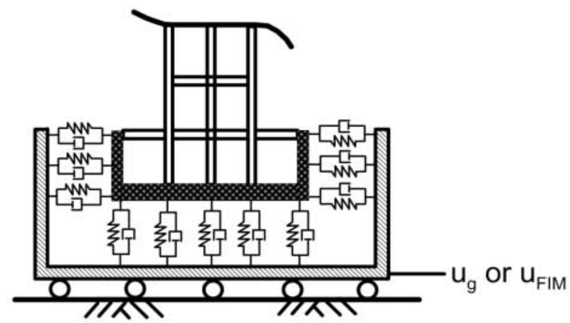

**(1) Fixed at ground surface**




**(2) Subteranean model included, fixed at base**



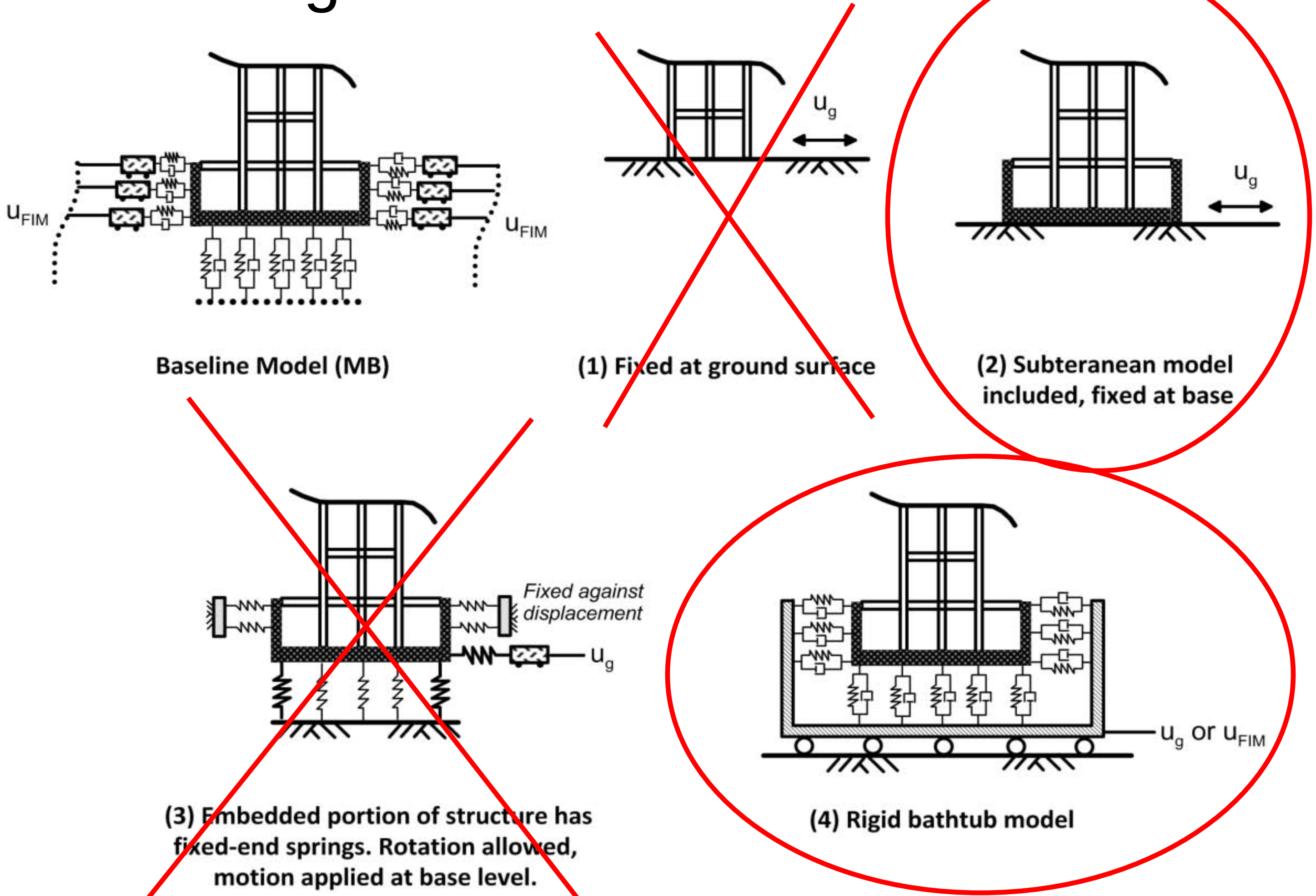

**(3) Embedded portion of structure has fixed-end springs. Rotation allowed, motion applied at base level.**




**(4) Rigid bathtub model**

## What are the major outputs and outcomes (accomplished or anticipated) of this project?

- SSI Modeling Recommendations:



- When is SSI modeling needed?
- Rule of thumb test:

  $h\,/\,(V_sT) > 0.1$, then SSI is significant

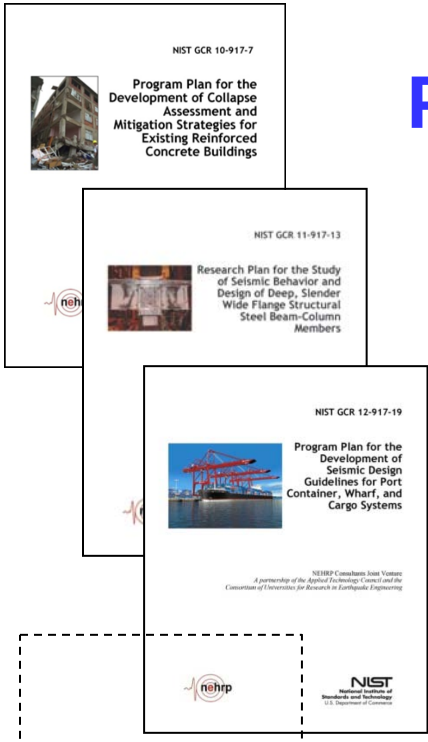
  h = 2/3 of the building height from the lowest basement floor

  $V_s$ = soil shear wave velocity

  T = fixed-base fundamental period
- SSI is more important in shorter, stiffer buildings than in taller, more flexible buildings

# *Planning Projects*

*(TO 6, 9, 10, 21, 25)*




# Planning Projects

- GCR 10-917-7 Program Plan for Assessment and Mitigation of Non-Ductile Concrete Buildings
- GCR 11-917-15 Research Plan for Deep, Slender, Wide-Flange Beam-Columns
- GCR 12-917-19 Program Plan for Port and Harbor Seismic Design Guidelines
- Task Order 23 Program Plan for Nonlinear Analysis Guidance
- Task Order 26 Roadmap for Windstorm and Coastal Inundation Impact Reduction
- Task Order 27 Updated Plan for Coordination of NEHRP Post-Earthquake Investigations
- Task Order 28 Program Plan for Lifelines

*Task Order 5*

# Integration of Collapse Risk Mitigation for Older Reinforced Concrete Buildings into National Standards: Phase I

| | |
|---|---|
| Funding allocation: | $199,846 |
| Start date: | August 10, 2009 |
| End date: | August 9, 2010 |

Objective:

- **Preparation of a program plan for the development of nationally accepted guidelines for assessing and mitigating risks in older concrete buildings**
- **Interface with the NEES Grand Challenge project on mitigation of collapse risk in older concrete buildings**
- **Identify other relevant resources**
- **Recommend scope of eventual guidance document(s)**
- **Estimate budget and duration of developmental effort**

*Task Order 5*

# Integration of Collapse Risk Mitigation for Older Reinforced Concrete Buildings into National Standards: Phase I


Principal Investigator: **Ken Elwood, University of British Columbia, Vancouver**

Co-investigators: Project Technical Committee
**Craig Comartin, CD Comartin, Inc., CA**
**William T. Holmes, Rutherford & Chekene, CA**
**Dominic Kelly, Simpson Gumpertz & Heger, MA**
**Laura Lowes, University of Washington, Seattle**
**Jack Moehle, University of California, Berkeley**

*Task Order 5*

# Integration of Collapse Risk Mitigation for Older Reinforced Concrete Buildings into National Standards: Phase I

Co-investigators:

Project Review Panel

**Nathan Gould, ABS Consulting, St. Louis, MO**
**Afshar Jalalian, Rutherford & Chekene, CA**
**Jim Jirsa, University of Texas, Austin**
**Terry Lundeen, Coughlin Porter Lundeen, WA**
**Mike Mehrain, URS Corporation, CA**
**Julio Ramirez, Purdue University, IN**

## What are the major outputs and outcomes (accomplished or anticipated) of this project?

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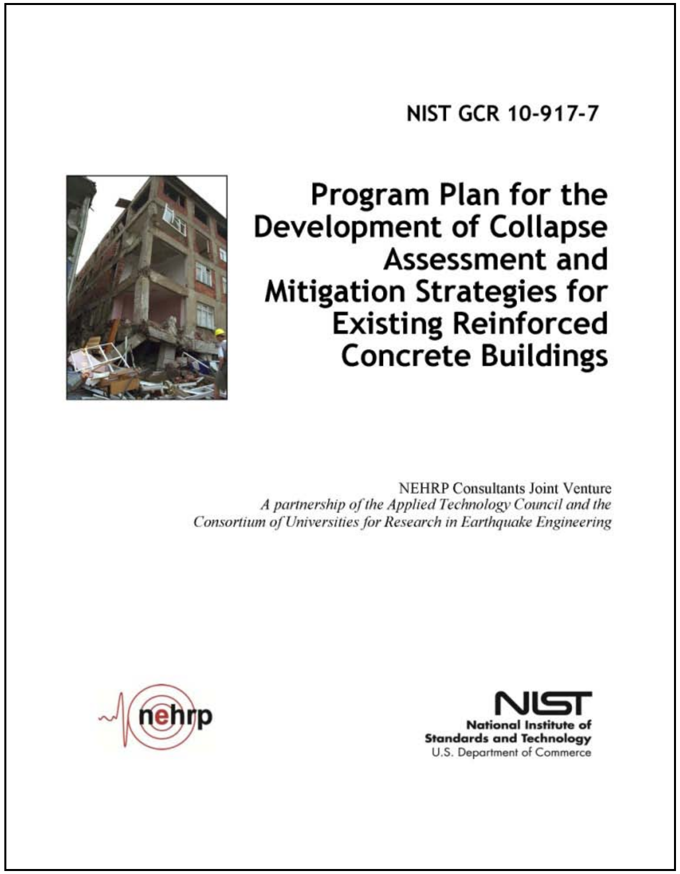
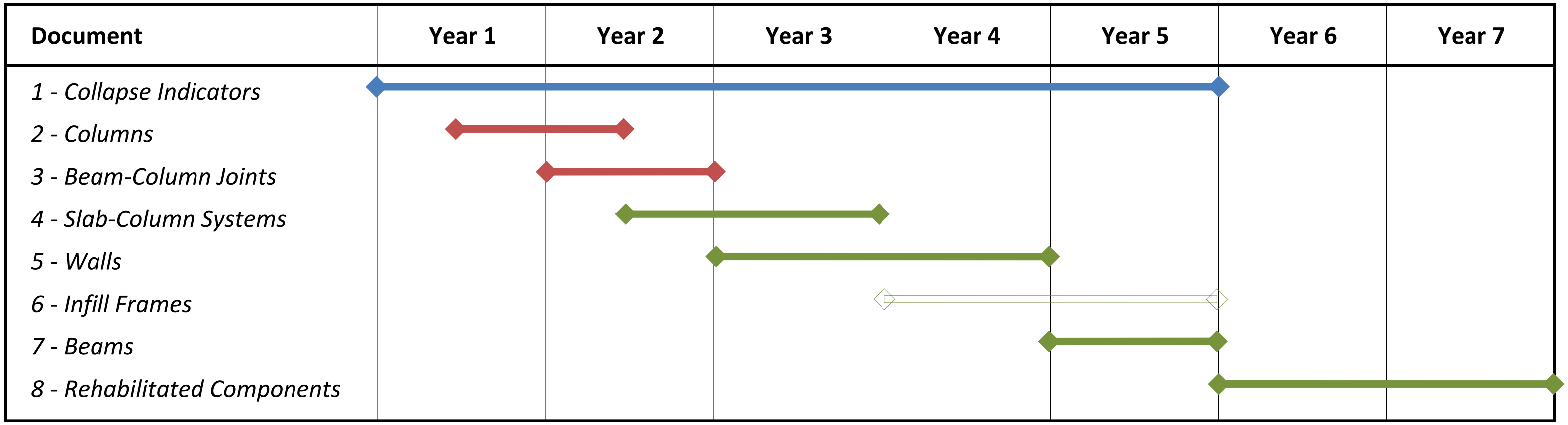
***Task Order 5***

- A Program Plan for the development of nationally applicable seismic design guidelines
- A series of focused-topic volumes addressing:
  - Assessment of Collapse Potential and Mitigation Strategies
  - Acceptance Criteria and Modeling Parameters for columns, beam-column joints, shear walls, etc.



## What are the major outputs and outcomes (accomplished or anticipated) of this project?

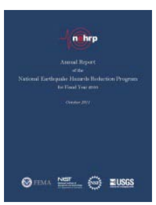
- Program Recommendations:
  - 8 products developed in 5 phases over 7 years
  - Phases range in size from $250K to $2.9 million
  - Total estimated at approximately $5.2 million



# *Miscellaneous Projects*

*(TO 12, 13, 18, 20, 30, 31, 32, 33, 34)*

# Miscellaneous Projects

- Task Orders 12, 18, 30, 34 – Expert Peer Review Services for Internal NIST Research Initiatives (e.g., ASCE 41, Nonlinear Analysis, and Shear Wall Behavior)
- Task Orders 13, 32 – Experimental Testing (e.g. progressive collapse of full-scale concrete specimens; deep, slender, steel beam-column elements)
- Task Order 20 – Chile Earthquake Data Repository
- Task Order 31 – NEHRP Annual Report Support
- Task Order 33 – Update of Wind Speed Maps for ASCE 7-16

# In Conclusion…

*Thank You!*