RESOURCE PAPER 1: RESILIENCE-BASED DESIGN AND THE NEHRP PROVISIONS

David Bonowitz, S.E., Resilience Subcommittee Chair
Resilience Subcommittee

- David Bonowitz, Bob Pekelnicky, Ibbi Almufti, Nico Luco, Jeff Soulages
- Charge: Part 3 Resource Paper
- Motivated by 2018 NEHRP Reauthorization
- Developments since 2019
  - FEMA, NIST, ICC, EERI, Resilience plans, AB 1329
**Four Key Points**

- Federal policy prioritizes earthquake resilience
- Do this by designing for functional recovery (FR)
- Current code & standard model is promising
- Provisions can support a FR standard
Resilience models

Population and Demographics
Composition, Distribution, Socio-Economic status

Environmental/Ecosystem
Air quality, Soil, Biomass, Biodiversity, etc.

Organized Governmental Services
Legal and security services, Health services, etc.

Physical Safety
Factoring in Quality Factors

The four elements
1. Context e.g. social, geo, regional, etc.
2. Preparedness
3. Response
4. Recovery

Resilience Functions
- Inclusion, Participation, and Governance
- Cultural, Economic, Social
- Physical, Social, Mental, Educational

Critical Reflection and Innovation
- Keeping the core, rethinking, reimagining, rethinking

Community Connectedness
- Partnerships, Communications, and Reflections, Education, and Learning

Essential 1: Make Education and Training a Resilience Capacity
Essential 2: Identify, and Understand Priorities for Training and Projects
Essential 3: Create Awareness and preparedness
Essential 4: Enhance and Protect Ecosystem Services
Essential 5: Build Public Awareness and Capacity

Community Vitality Stability Resilience Safety Economy Reoccupancy Recovery Damage
+
 use / occupancy data
+
 human / organizational qualities

Earthquake Resilience

Resilience Models for Informed Resilience Making
- Physical Modules
- Damage Mitigation
- Infrastructure Damage
- Deposition of Physical Infrastructure

Vitality Stability Resilience Safety Economy Reoccupancy Recovery Damage

Faster recovery
Lower consequences

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Four key points

- Federal policy prioritizes earthquake resilience
  - 2018 Reauthorization: *Community resilience* is a new purpose of NEHRP (42 USC 7702)
    - “The ability of a community to prepare and plan for, absorb, recover from, and more successfully adapt to adverse seismic events.” (42 USC 7703)
  - Reauthorization focuses on community scale
  - Resource Paper recognizes smaller scales too
  - *But what does it mean in terms of:*?
    - Structural performance?
    - Building codes and standards?
Four key points

- Federal policy prioritizes earthquake resilience
- Do this by designing for functional recovery (FR)
  - 2018 Reauthorization:
    - NIST and FEMA charged to convene expert committee to study “options for improving the built environment and critical infrastructure ... in terms of post-earthquake reoccupancy and functional recovery time.” (42 USC 7705b)
  - Resource Paper anticipates FEMA-NIST report
**FEMA-NIST definitions**

- **Functional Recovery (FR) ...**
  
  ... is a post-EQ performance state in which a building ... is maintained, or restored, to ... support the basic intended functions associated with the pre-EQ use or occupancy.

- **A Functional Recovery objective ...**
  
  ... is FR achieved within an acceptable time following a specified earthquake, where the acceptable time might differ for various building uses and occupancies.

- **How does this relate to community resilience?**
Resilience Field

About the physical building
- Structure
- Nonstructure
- Contents

About the group
- Traditional planning context
- Public policy

About more than a building
- Contents \(\rightarrow\) Use, Occupancy
- Function
- Purpose

About one building
- Traditional engineering context
- Traditional code context
Resilience Field

- **Technical**
  - **Design**
    - Provisions
    - ASCE 7
    - IBC
    - ASCE 41
  - **Thinking**
    - NEHRP Reauthorization
    - Rockefeller, etc.

- **Facility**
- **Community**

David Bonowitz, S.E.
FR : Building :: CR : Community

Functional Recovery

Technical

Facility

Community

Community Resilience

David Bonowitz, S.E.
“People who run ball clubs think in terms of buying players. Your goal shouldn’t be to buy players. Your goal should be to buy wins. And in order to buy wins, you need to buy runs.”

(Moneyball, 2011)
“People who regulate development think in terms of designing buildings. Your goal shouldn’t be buildings. Your goal should be community resilience. And in order to get community resilience, you need to design for functional recovery.”

(Moneyball, 2011)
Four key points

- Federal policy prioritizes earthquake resilience
- Do this by designing for functional recovery (FR)
  - Resource Paper also discusses limits of FR relative to larger context of community resilience
  - PUC and others must understand what a code/standard can and cannot achieve
Four key points

- Federal policy prioritizes earthquake resilience
- Do this by designing for functional recovery (FR)
- Current code & standard model is promising
  - 2018 reauthorization:
    - NIST charged with conducting research “to improve community resilience through building codes and standards.” (42 USC 7704b5)
  - Code covers policy – what, why
  - Standard covers technical – how
  - NEHRP PUC not alone thinking about this
Resilience plans

- Resilient San Francisco, 2016
  - Initiative 1.8
    “[Stakeholders should] amend the SFBC ... considering not only basic safety, but also post-disaster usage and occupancy.”

- Resilient Los Angeles, 2018
  - Action 61
    “The City will also work with local, state, and federal partners to develop and adopt a ‘public safety’ standard for new buildings and to advance immediate occupancy building code for new buildings ....”
Resilience plans

- **The Oregon Resilience Plan, 2013**
  
  “[B]eyond the building code ... [L]arge retail buildings, bank buildings ... buildings that support critical healthcare facilities ... will require revisions to the building code and an expanded definition of essential facility.”

- **White House Executive Order, 2016**
  
  “To achieve true resilience against earthquakes ... new and existing buildings may need to exceed those codes and standards ... Agencies are encouraged to consider going beyond the codes and standards set out in this order ....”
California Building Code

- AB 1329 (Nazarian, 2021)

Proposes to:

- Clarify the purpose of the CBC
- Allow locals to make amendments for FR
- Require California to:
  - Develop FR provisions for the 2025 CBC, or
  - Assign all engineered buildings to RC IV
EERI: Developing the FR Concept

- Four issue areas
  - Definitional
  - Policy → code
  - Technical → standard
  - Implementation
FEMA-NIST RECOMMENDATIONS

- Anticipated by Resource Paper
  - Also by AB 1329

- Rec 1: Develop framework for FR
  - FR objectives
  - Design criteria, including hazard
    - Model code provisions (w/ standard)
    - Interim provisions (state, local, straight to code)

- Rec 2: Design new buildings for FR
  - Also good: Voluntary or incentivized work
ICC: Model Code Development

- ICC Seismic Functional Recovery Portal
- 2019 Roundtable and Forum
- “Roadmap” of options
  - Local or state routes
  - Direct to IBC route
  - NEHRP Provisions → ASCE 7-28 → 2030 IBC
Four key points

- Federal policy prioritizes earthquake resilience
- Do this by designing for functional recovery (FR)
- Current code & standard model is promising
- Provisions can support a FR standard
  - Also adaptable into interim provisions
    - FR objectives analogous to safety objectives
    - FR categories analogous to Risk Category or SDC
    - Current design strategies can be adapted and supplemented for FR
FEMA-NIST definitions

- **Functional Recovery (FR)** ...
  
  ... is a post-EQ performance state in which a building ... is maintained, or restored, to ... support the basic intended functions associated with the pre-EQ use or occupancy.

- **A Functional Recovery objective** ...
  
  ... is FR achieved within an acceptable time following a specified earthquake, where the acceptable time might differ for various building uses and occupancies.
PBE ANALOGY

- **Building performance objective: Safety**
  - $\Pr(\text{collapse}) < X\%, \text{ given } 2/3\text{MCE}$

- **Building FR objective**
  - $\Pr(T_{\text{Exp}} > T_{\text{Accept}}) < Y\%, \text{ given } 2/3\text{MCE (or other)}$

- **Community resilience objective**
  - $\Pr(T_{\text{Exp-A}} > T_{\text{Accept-A}}) < Z\%, \text{ given } 2/3\text{MCE (or scenario)}$
  - $\Pr(T_{\text{Exp-B}} > T_{\text{Accept-B}}) < Z\%$
  - $\Pr(T_{\text{Exp-C}} > T_{\text{Accept-C}}) < Z\%$
  - ...

EERI: Developing the FR Concept

- Four issue areas
  - Definitional
  - Policy → code
  - Technical → standard
  - Implementation
- NEHRP Provisions would be largely technical
- Would be a resource for a standard like ASCE 7
The code & standard model

- **Code: Policy questions**
  - What should $T_{\text{Accept}}$ be?
  - Assign each use/occupancy to a class
  - Assign each class to a recovery objective

- **Standard: Technical (engineering) questions**
  - How do I measure or show acceptability?
T_{\text{accept}} \text{ ANALOGOUS TO RC}

■ A policy question
  ■ Should be guided by social science research

■ A normative question
  ■ NIST: Should be subject to community preferences

\begin{align*}
T_{\text{Accept}} &< 6 \text{ mo} \\
T_{\text{Accept}} &< 1 \text{ Mo} \\
T_{\text{Accept}} &< 1 \text{ Wk} \\
T_{\text{Accept}} &< 1 \text{ Dy} \\
T_{\text{Accept}} &< 1 \text{ Hr}
\end{align*}
THE CODE & STANDARD MODEL

■ Code: Policy questions

*What should $T_{\text{Accept}}$ be?*

- Assign each use/occupancy to a class
- Assign each class to a recovery objective

■ Standard: Technical (engineering) questions

*How do I measure or show acceptability?*

- Scope of work
- Acceptable analysis & design procedures
- Acceptability criteria for stress, strain, drift, etc.
- Tools: FEMA P-58, etc.
## Design strategies for FR

<table>
<thead>
<tr>
<th>Design strategy/requirement</th>
<th>Acceptable FR Time</th>
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<tr>
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<td><strong>Structural</strong></td>
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<td><strong>Nonstructural</strong></td>
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<td>Bracing scope increase</td>
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<td>Reliability factors on design forces</td>
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<td>Infrastructure backup</td>
<td>Req’d</td>
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<tr>
<td>Reoccupancy / Recovery planning</td>
<td>Moot</td>
</tr>
</tbody>
</table>
Actual performance varies

- Repair time for different SFRS (FEMA P-58)
  - At $2/3 \times MCE_R$, RC II, varies from 15 – 81 days
  - Some SFRS worse at RC IV than others at RC II
Is FR compatible with “code”?

- Premise of code-based design: Ductile SFRS
  - But ductility = structural damage!
  - And structural damage = high repair time!

- True, but:
  - We accept criteria for RC IV (SDC F)
  - Acceptable time can often be > 0
  - In a scenario, not every building sees the DE
  - Shift in emphasis to FR time has other benefits
  - Opportunity for Low Damage Design
Low-damage design

- Need to link to explicit Functional Recovery time
- Proprietary systems change codes, practice
FOUR KEY POINTS

- Federal policy prioritizes earthquake resilience
- Do this by designing for functional recovery (FR)
- Current code & standard model is promising
- *Provisions* can support a FR standard
FUTURE PUC ISSUES AND RESEARCH NEEDS

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Kelly Cobeen, Wiss Janney Elstner Associates, Inc.
Introduction

• BSSC charge as part of regular updates to the NEHRP Provisions
• Identify and recommend issues to be addressed and research needed to advance the state of the art of earthquake-resistant design
• To serve as basis for future refinements of the provisions
• Issue teams and individuals participating in the 2020 update of the NEHRP Provisions have contributed (contributors are noted in draft document)
• Input has been solicited from BSSC Member Organizations
Content and Organization

• **Future Provisions Issues** – Topics for further development of the NEHRP Provisions. Topics are believed to fall at a level of effort for which a volunteer group assigned to an issue team could make progress.

• **Research Needs** – Topics on which further research is required to advance the state of the art of earthquake-resistant design. Topics are believed to require funded research efforts in order to make progress [not orally presented].
Content and Organization

• Organized by ASCE 7 Chapter
• No prioritization has occurred
• Similar topics have not necessarily been combined; this can occur at a later date, if needed
How is This Used?

• **Future Provisions Issues** – Used to seed work by the next Provisions Update Committee to identify topics to be addressed and issue teams to be established

• **Research Needs** – Published by BSSC and available to researchers and funding organizations to identify and prioritize research needs
Objectives for Today’s Presentation

- Presentation will provide highlights of the identified future issues. Research needs are not orally presented because of time limitations. See published draft for full details.
- Discussion at the end invites attendee input on:
  - Issues and research that are included
  - Recommendations for added issues and research
  - Identification of high priorities for issues and research
  - Other comments
  - Use Q and A box
Overarching Issues
Overarching Future Provisions Issues

• The PUC, BSSC, and FEMA need to think more deeply about how to improve engagement and education so that the code development process targets what the wider community really wants and needs.

What the Community Needs!
Overarching Future Provisions Issues

- The disparity of seismic design results coming from users of ASCE 7 need to be reduced. A nationwide study should be funded for researchers to actively gather feedback on ASCE 7 seismic design provisions from practitioners, code officials, and educators to determine which parts of the provision are most prone to being misinterpreted, misunderstood, misused or where fundamental disagreements with the provisions occur.

Disparity of ASCE 7 Seismic Design Results
Overarching Future Provisions Issues

• Specific performance objectives and associated design criteria for performance beyond current code. When an owner/design team wants to go beyond what is called Basic Performance Objective for New Buildings (BPON) in ASCE 41, they currently have little guidance or standard choices.

Beyond BPON
Overarching Future Provisions Issues

• Develop initial design provisions based on selected functional recovery targets. Once performance targets are identified, design provisions that are thought to achieve the targets can be developed. While developing the design provisions will be a long-term activity, initial work should be undertaken, if at all possible. The 2020 NEHRP Provisions Resource Paper titled Resilience-Based Design and the NEHRP Provisions provides some initial thoughts on how this topic might be pursued.
Overarching Future Provisions Issues

• In all of the discussion on functional recovery, a key component is missing or overlooked: the lifelines/utilities connecting the community together such as power distribution, water distribution, wastewater removal, transportation (e.g. streets/highways/bridges), and communication systems. The longer the functions provided by these systems are down, the greater the misery experienced by the affected population. Therefore, the NEHRP Provisions should be expanded to include these lifeline/utility systems with regard to functional recovery.

Functional Recovery for Utilities and Lifelines
Overarching Future Provisions Issues

- Despite the large number of systems currently defined in the building code, there are still too many limitations on what a responsible structural engineer can do. How can we encourage creativity and maintain safety, but not trigger a full alternative means of compliance and peer review when something a bit different is desired?

Spurring Engineering Creativity
Overarching Research Need

• In order to move forward to establish performance targets and corresponding design requirements for functional recovery, there will need to be both physical testing and numerical modeling, used to judge the viability of targets and the design methods required to achieve them. Numerical studies will be greatly reliant on physical testing and collection of performance data from that testing. Existing testing protocol will need to be revisited and revised with the functional recovery performance objectives in mind.

Overarching Future Provisions Issues

• In order to move forward to establish performance targets and derived design requirements for functional recovery, there will need to be both physical testing and numerical modeling, used to judge the viability of targets and the design methods required to achieve them. Numerical studies will be greatly reliant on physical testing and collection of performance data from that testing. Existing testing protocol will need to be revisited and revised with the functional recovery performance objectives in mind.

Spurring Engineering Creativity
Chapter 1

General
Overarching Future Provisions Issues

- Where $S_1$ is less than or equal to 0.04 and $S_S$ is less than or equal to 0.15, all structures including RC IV structures are permitted to be assigned to SDC A. There are no seismic design requirements for SDC A. Given the critical post-disaster needs of RC IV structures, the minimal seismic design requirements contained in SDC B would at least provide some level of protection. For this reason, the above exemption should not apply to RC IV structures. Also, in Table 11.6-1, for $S_{DS} < 0.167$ and RC IV, SDC A should be changed to B; in Table 11.6-2, for $S_{D1} < 0.067$ and RC IV, SDC A should be changed to B.
Chapter 1 Future Provisions Issues

• The provisions state that Risk Category IV structures provide protection against loss of essential function in the design earthquake. The current provisions are very qualitative, not quantitative. One suggestion is to set a reliability target of a 10% chance of loss of function in the design earthquake.

Quantifying Performance Objective of Essential Facilities
Chapters 11, 20, 21 and 22
Seismic Design Criteria
Site Classification Procedure for Seismic Design
Site-Specific Ground Motion Procedure
Seismic Ground Motion and Long-Period Transition
Chapter 11 Future Provisions Issues

• During the last update cycle, the approach of deriving ground motions for design directly from scientific estimates of seismic hazard was reviewed, in light of constantly evolving seismic hazard models and their inherent uncertainties. Continue discussion is needed of stability in design ground motions and Seismic Design Categories.

Stability in Design Ground Motions and SDCs
Chapter 11 Future Provisions Issues

• During the last update cycle, several proposals were put forward for consolidation of Seismic Design Categories (SDCs). No substantive changes were put forward in the end, however. Continue discussion to identify more broadly supported approaches to SDC consolidation.

Seismic Design Category Consolidation
Chapter 20 Future Provisions Issues

• Currently, unless the 0.5 second period exception applies, sites with potentially liquefiable soils are classified as Site Class F irrespective of the severity of the liquefaction potential. It would appear that the severity of the liquefaction potential could affect the response of the site. Further refine the definition of Site Class F to address this issue.

Further Study Definition of Site Class F
Chapter 21 Future Provisions Issues

• Evaluate alternative means by which deterministic caps can be eliminated in the larger context of establishing appropriate design ground motions that would avoid large spatial variability in risk.

Evaluate Elimination of Deterministic Caps
Chapter 22 Future Provisions Issues

• For the 2020 NEHRP Provisions, multi-period response spectra were calculated by the USGS on evenly-spaced grid points. Preliminary computations were made to increase the resolution of the grids behind the maps in select locations with deep basins, but this was not incorporated in the 2020 NEHRP design maps. More study of the sensitivity of design ground motions to the grid resolution for deep basins as well as for locations near faults is needed to improve estimates of ground motions.

Sensitivity of Design Ground Motions to Grid Resolution
Chapter 12
Seismic Design Requirements
For Building Structures
Chapter 12 Future Provisions Issues

• Design guidance is needed across construction materials for structures specifically designed to rock. These are currently being designed on a case-by-case basis. There should be enough information available from designs to date to set basic design guidance.

• Work is needed to account for rocking in foundation design as a means of limiting force input into a building.

Structures Specifically Designed to Rock
Chapter 12 Future Provisions Issues

• There needs to be Integration of foundation and superstructure design. Right now, one can design a lateral system with the presumption it will yield and dissipate energy in a certain way with no regard for what the foundation will do and whether it will yield first or prevent the intended mechanism from occurring.

Integration of Foundation and Superstructure Design
Chapter 12 Future Provisions Issues

• Results of the ATC 116 Project should be reviewed and incorporated into the *Provisions* as appropriate. ATC-116 objectives are to: Bridge the gap between simulated and observed performance of short period buildings; Improve simulation **techniques** to better match observed performance; Change design provisions to improve performance, if needed.

**The Short-Period Paradox**
Chapter 12 Future Provisions Issues

• With the addition of the rigid wall-flexible diaphragm design method in the 2020 NEHRP Provisions, there are now three methods for derivation of seismic design forces for diaphragms. The potential future removal of the basic method in Section 12.10.1 and 12.10.2 should be considered, because it does not take diaphragm properties into consideration. Additional development of diaphragm design force reduction factors, overstrength factors and deflection amplification factors may be required prior to removal of Section 12.101. and 12.10.2 provisions.

Rational Determination of Diaphragm Design Force
Chapter 12 Future Provisions Issues

• $R_S$-factors for concrete-topped steel deck diaphragms should be brought into the NEHRP Provisions. Include other materials if design parameters are being developed that draw from the IT9-8 resource paper.

The Short-Period Paradox
Chapter 12 Future Provisions Issues

- Design guidance is needed for appropriate calculation, amplification, and combination of diaphragm deflections, paralleling the provisions for vertical systems. This will draw from the IT9-10 Resource Paper. Possible upper and lower bounds on deflections should be considered.

- During the course of the 2020 NEHRP update, the interaction between ductility provided in the vertical elements and that available in the horizontal components of the seismic force-resisting system has been investigated. What are the performance consequences of design choices - ductility in vertical versus horizontal system?

**Diaphragm Deflection Calculations**

\( R \) vs. \( R_s \) Interaction
Chapter 12 Future Provisions Issues

• Evaluate whether it is of benefit to develop a code formula for period for structures with flexible diaphragm to allow design engineers to better estimate force level before applying an $R$ -factor. This is already implemented in the Canadian code.

Flexible Diaphragm Building Period
Chapter 12 Future Provisions Issues

• There are identified needs in high seismic areas to have structures designed for strength rather than ductility. This is the subject of an ASCE 7 SSC proposal for miscellaneous occupancy structures of small footprint. An effort is needed to identify vertical systems for which this is an acceptable approach, and the design approaches for diaphragms and nonstructural components that are needed to address the anticipated increase in seismic demand.

• There are many additional questions about two-stage analytical procedure.
Chapter 12 Future Provisions Issues

• An IT-3 Resource Paper has concluded that the requirements for MRSA can be substantially relaxed from what is currently in ASCE 7-16 Table 12.6-1. However, a more exhaustive evaluation needs to be conducted especially for buildings with significant horizontal irregularity so that the use of ELF can be extended further.

Applicability of MRSA, ELF
Chapter 12 Future Provisions Issues

• In the case of long-span flexible structures, the incorporation of vertical seismic ground motion can add significant demands to the structural elements. There is a need for identifying buildings and setting triggers where vertical analysis (through MRSA or Time History Analysis) needs to be explicitly conducted so that such structures are not under-designed.
Chapter 12 Future Provisions Issues

• Per ASCE 7-16, RC IV buildings are currently designed for an $I_e$ of 1.5 with no requirement for foundations to be designed for overstrength load combinations. 2019 CBC A Chapters overwrite the minimum requirements of ASCE 7-16, requiring foundations for hospitals to be designed for overstrength load combinations. It should be investigated whether it is appropriate for foundations of RC IV buildings to be continued to be designed for non- $\Omega_o$ forces. If $\Omega_o$ forces are indeed necessary, then is their application warranted for all actions or could they be limited to critical force-controlled actions such as shear and relaxed for ductile actions such as flexure?
Chapter 12 Future Provisions Issues

• There is currently no explicit requirements for modeling and analysis of buildings with subterranean levels. There is a need for setting requirements for subterranean elements including proper earth pressures (at rest under no earthquake, active plus seismic increment under earthquake) to be used for their design.

Buildings with Subterranean levels
Chapter 13
Seismic Design Requirements for Nonstructural Components
Chapter 13 Future Provisions Issues

• Develop a more rigorous basis for determining newly added seismic design parameters:
  • CAR – component resonance ductility factor
  • $R_{po}$ – component strength factor
  • $\Omega_{op}$ – anchorage overstrength factor

Rigorous Basis for Design Parameters
Chapter 13 Future Provisions Issues

• Review displacement demands on nonstructural components and provide guidance on how drift-controlled components are to accommodate story drift.

Accommodation of Story Drift
Chapter 13 Future Provisions Issues

• Further develop provisions to address:
  • Potential adverse interactions between nonstructural components and other portions of the structure
  • Determine generic relative displacement between points of attachment of distributed systems such as piping
  • Review requirements related to inadvertent sprinkler activation and wet system pipe rupture

Nonstructural Component Interactions
Chapter 13 Future Provisions Issues

• Review available records of shake table testing of nonstructural components and develop provisions to improve design based on the records.

Data from Shake Table Testing of Nonstructural Components
Chapter 13 Future Provisions Issues

• Develop performance expectations for nonstructural components at several levels of earthquake motion. Use this to assess performance provided by the current provisions and determine if changes are needed to meet the performance expectations.

Performance Expectations for Nonstructural Components
Chapter 14
Material-Specific Seismic Design and Detailing Requirements
Chapter 14 Future Provisions Issues

• Shear friction capacity of reinforcement with yield strength higher than 60 ksi.
• Clarifying what portion of gravity reinforcement can be used as seismic shear reinforcement in concrete diaphragms.

Shear Friction, Diaphragm Reinforcement
Chapter 14 Future Provisions Issues

• The recently developed limit design method (Appendix C of TMS 402) needs to be expanded to apply to perforated shear walls, which are now analyzed and designed using simple approximations.

• For structures with significantly more length of wall than is needed structurally to satisfy seismic design requirements, the preferred solution might be to allow the design of essentially elastic systems. This would offer at least a tradeoff where fewer resources could be put into the walls where it does not improve performance and more into the diaphragms where performance could be improved.

Perforated Shear Walls, Structures with More Shear Wall Length than Required
Chapter 14 Future Provisions Issues

• The performance of wood light-frame shear walls as a function of the uplift deflection permitted at tie-down devices should be evaluated. Criteria should be developed for uplift limitations, as required, to ensure shear wall performance.

• Work is needed to integrate provisions for analysis, design and detailing of hillside structures into ASCE 7 and SDPWS.

Wood Light-Frame Shear Wall Performance and Tie-Downs
Hillside Dwellings
Chapter 14 Future Provisions Issues

• Use of mid-rise wood light-frame construction continues to be prevalent in the U.S. and Canada. For this construction type, the adequacy of formulas for the fundamental period should be re-evaluated and corrected if necessary. Comparison of shear wall load-deflection response by standard calculation to building level load-deflection response is needed.

Mid-Rise Wood Light-Frame Construction
Chapter 15
Seismic Design Requirements for Nonbuilding Structures
Chapter 15 Future Provisions Issues

- Define Table 15.4-2 seismic design parameters for design of pedestal systems typically used for coker structures in refineries.
Chapter 16
Nonlinear Response History Analysis
Chapter 16 Future Provisions Issues

• Refine the calibration of the collapse safety goals implicit in Chapter 16 with more explicit methods

• Review how the collapse safety of a building is affected by the interaction between multiple individual element acceptance criteria

• Study in greater depth the probability of total or partial collapse conditioned on the exceedance of a single component, as currently incorporated in the provisions, and refine as required

NLRHA Collapse Safety Goals and Acceptance Criteria
Chapter 16 Future Provisions Issues

• The uniform hazard shape of the design and maximum considered earthquake spectra is conceptually not the most appropriate shape for the target spectrum used to select and modify acceleration histories. Further study is needed on more appropriate selection and modification criteria and a better justified number of acceleration histories.

Selection and Modification Criteria for Acceleration Histories
Chapter 19

Soil-Structure Interaction for Seismic Design
Chapter 19 Future Provisions Issues

• An ATC project is currently underway exploring reduction of barriers to incorporation of soil-structure interaction into building design. An issue team could review the resulting recommendations and develop proposals for incorporation.

Reduce Barriers to Incorporation of Soil-Structure Interaction
Chapter 19 Future Provisions Issues

• Extend Chapter 19 inertial interaction provisions to deep foundations.

Extend Inertial Interaction Provisions
Chapter 19 Future Provisions Issues

• The ATC-116 project numerical study results suggest that when identical buildings are placed on rigid foundations and on flexible foundations with soil springs, the probability of collapse at MCE$_R$ is the same. This suggests the reduction in ELF seismic design forces currently permitted by Chapter 19 will result in reduced performance. The ELF reduction of seismic design forces needs to be revisited.

Revisit Reduction of ELF Seismic Design Forces
Discussion

• Issues and research that are included?
• Recommendations for added issues and research?
• Identification of high priorities for issues and research?
• Other comments?

• Enter in Q and A box
Jiqiu (JQ) Yuan, Executive Director of MMC and BSSC
Resources: BSSC website

https://www.nibs.org/page/bssc
Outreach & Education: NEHRP Provisions Design Examples and Training Materials

2015 NEHRP Recommended Seismic Provisions: Design Examples
FEMA P-1051/July 2016

September, 2021
Engagement: Recommendations for Improving U.S. Seismic Code Development and Dissemination

1. Identify ways to improve U.S. seismic code development.
2. Identify how to better communicate seismic code updates to practicing engineers and buildings officials.

Look out for a survey in April-May, 2021
**BSSC Mission:** To enhance public safety by providing a national forum that fosters improved seismic planning, design, construction and regulation in the building community.
THANK YOU!

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