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

David Bonowitz, S.E., Resilience Subcommittee Chair

nehrp FEMA

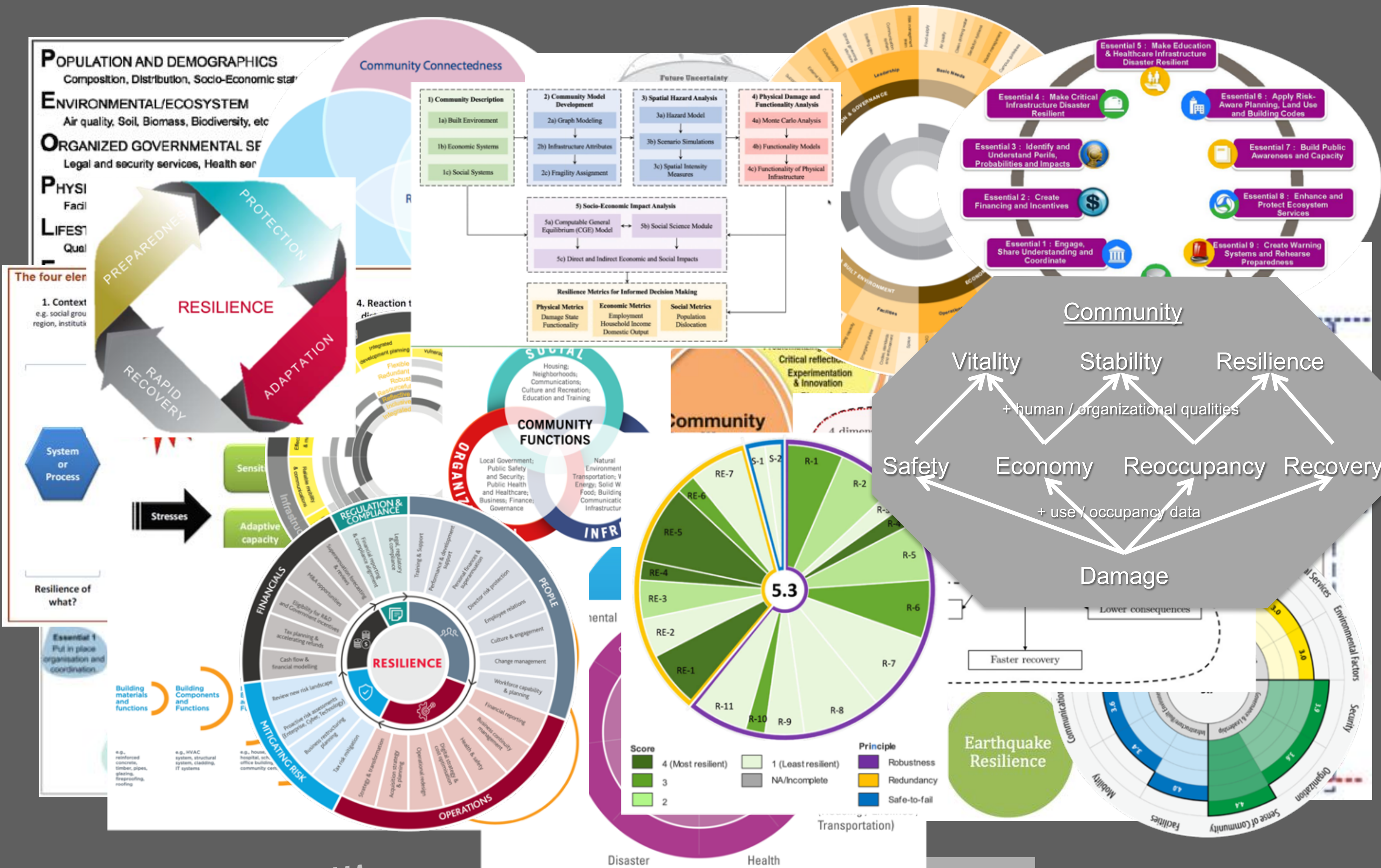
Resilience subcommittee

- 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 <u>resilience</u>
- Do this by designing for functional recovery (FR)
- Current code & standard model is promising
- *Provisions* can support a FR standard

Resilience models



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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)
  - Precedents: ASCE 41, FEMA P-58, NIST (2018), SEAONC BRC, AB 393 (2019), EERI (2019)
  - 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

Technical

Facility

Community

About one building

- Traditional engineering context
- Traditional code context

About the group

- Traditional planning context
- Public policy

About more than a building

- Contents → Use, Occupancy
- Function
- Purpose

Holistic

Meister Consultants Group, 2017

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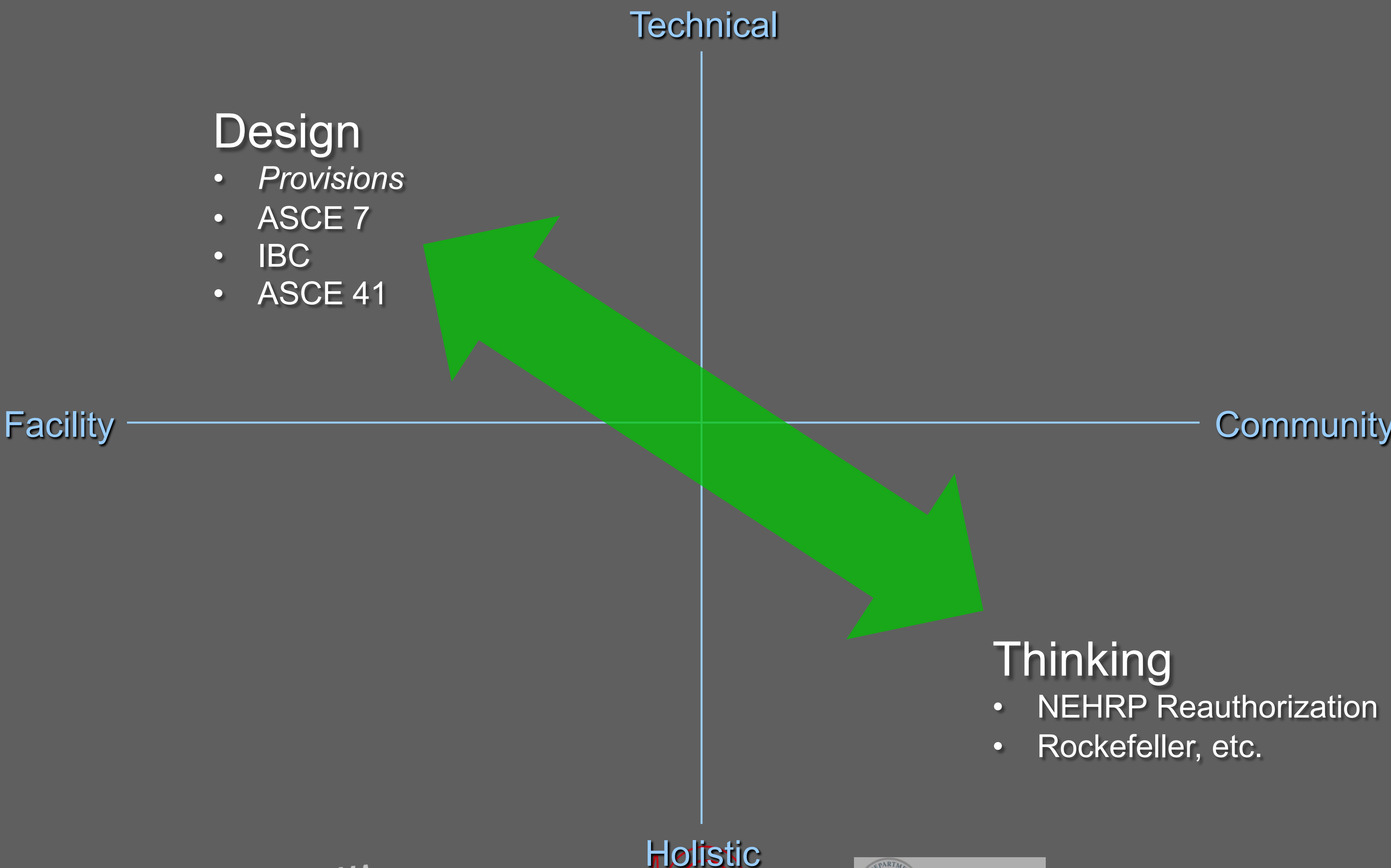
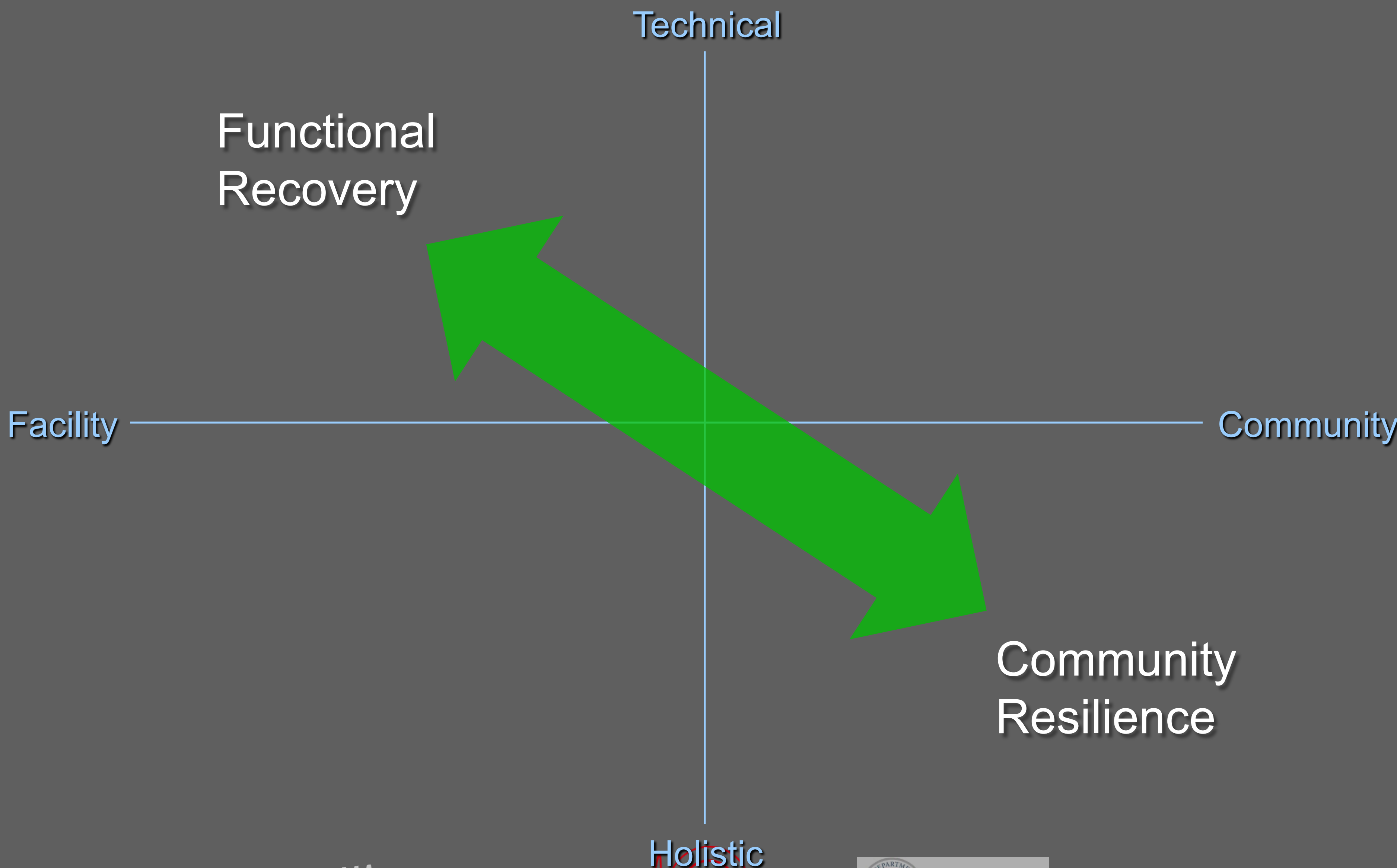
Resilience field



FR : Building :: CR : Community



What is the goal?

"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)

What is the goal?

"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

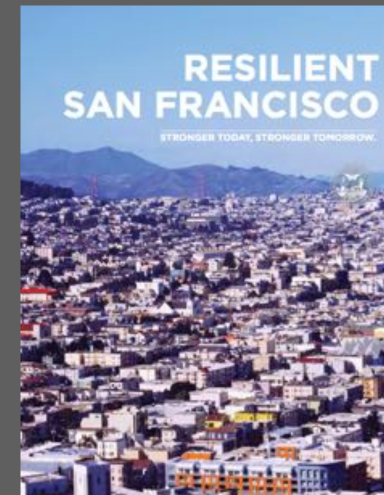
Four key points

- 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."



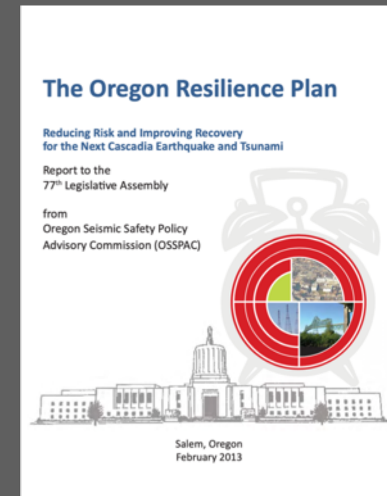
- *Resilient Los Angeles*, 2018
  - Action 61

    "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."



The Oregon Resilience Plan

Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami

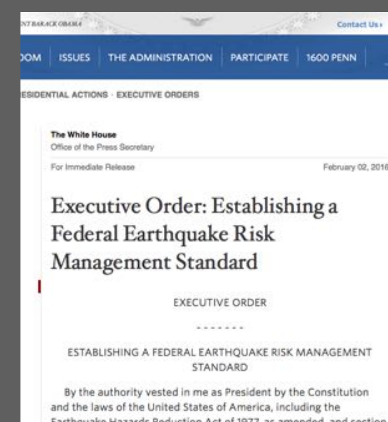
Report to the 77th Legislative Assembly

from Oregon Seismic Safety Policy Advisory Commission (OSSPAC)

Salem, Oregon
February 2013

- 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 …."



The White House
Office of the Press Secretary

For Immediate Release | February 02, 2016

Executive Order: Establishing a Federal Earthquake Risk Management Standard

EXECUTIVE ORDER

ESTABLISHING A FEDERAL EARTHQUAKE RISK MANAGEMENT STANDARD

By the authority vested in me as President by the Constitution and the laws of the United States of America, including the Earthquake Hazards Reduction Act of 1977, as amended, and section

Building Seismic Safety Council nehrp FEMA

California Building Code

- AB 1329 (Nazarian, 2021)
  - AB 393 (2019), AB 1997 (2020)
- 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

CALIFORNIA LEGISLATURE—2021–22 REGULAR SESSION

ASSEMBLY BILL **No. 1329**

Introduced by Assembly Member Nazarian

February 19, 2021

An act to amend Sections 18941 and 18941.5 of, and to add Section 18941.11 to, the Health and Safety Code, relating to building standards.

LEGISLATIVE COUNSEL'S DIGEST

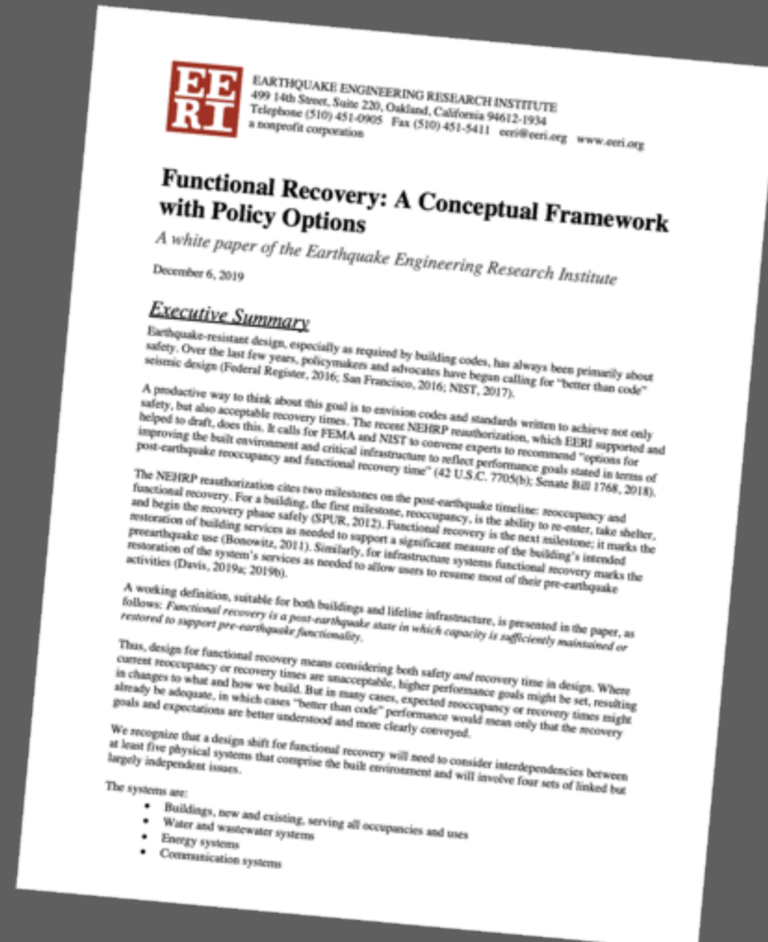
AB 1329, as introduced, Nazarian. Building codes: earthquakes: functional recovery standard.

Existing law, the California Building Standards Law, provides for the adoption of building standards by state agencies by requiring all state agencies that adopt or propose adoption of any building standard to submit the building standard to the California Building Standards Commission for approval and adoption.

This bill, in addition to making specified findings and declarations, would require the Building Standards Commission to develop, adopt, and publish building standards that would require new construction of buildings, except for buildings regulated by the Office of Statewide Health Planning and Development or the Division of the State Architect, to be designed and built to a functional recovery standard, as defined, for earthquake loads. The bill would specify that if a functional recovery standard is not completed in time for inclusion in the building code with an effective date of January 1, 2026, engineered buildings, as defined, will be assigned to Risk Category IV, as defined in the building code. The bill would require the commission to actively consult with interested parties, as specified, in proposing and adopting functional recovery standards.

EERI: Developing the FR concept

- Four issue areas
  - Definitional
  - Policy → *code*
  - Technical → *standard*
  - Implementation



EARTHQUAKE ENGINEERING RESEARCH INSTITUTE
499 14th Street, Suite 220, Oakland, California 94612-1934
Telephone (510) 451-0905 Fax (510) 451-5411 eeri@eeri.org www.eeri.org
a nonprofit corporation

Functional Recovery: A Conceptual Framework with Policy Options

A white paper of the Earthquake Engineering Research Institute

December 6, 2019

Executive Summary

Earthquake-resistant design, especially as required by building codes, has always been primarily about safety. Over the last few years, policymakers and advocates have begun calling for "better than code" seismic design (Federal Register, 2016; San Francisco, 2016; NIST, 2017).

A productive way to think about this goal is to envision codes and standards written to achieve not only safety, but also acceptable recovery times. The recent NEHRP reauthorization, which EERI supported and helped to draft, does this. It calls for FEMA and NIST to convene experts to recommend "options for improving the built environment and critical infrastructure to reflect performance goals stated in terms of post-earthquake reoccupancy and functional recovery time" (42 U.S.C. 7705(b); Senate Bill 1768, 2018).

The NEHRP reauthorization cites two milestones on the post-earthquake timeline: reoccupancy and functional recovery. For a building, the first milestone, reoccupancy, is the ability to re-enter, take shelter, and begin the recovery phase safely (SPUR, 2012). Functional recovery is the next milestone; it marks the restoration of building services as needed to support a significant measure of the building's intended preearthquake use (Bonowitz, 2011). Similarly, for infrastructure systems functional recovery marks the restoration of the system's services as needed to allow users to resume most of their pre-earthquake activities (Davis, 2019a; 2019b).

A working definition, suitable for both buildings and lifeline infrastructure, is presented in the paper, as follows: *Functional recovery is a post-earthquake state in which capacity is sufficiently maintained or restored to support pre-earthquake functionality.*

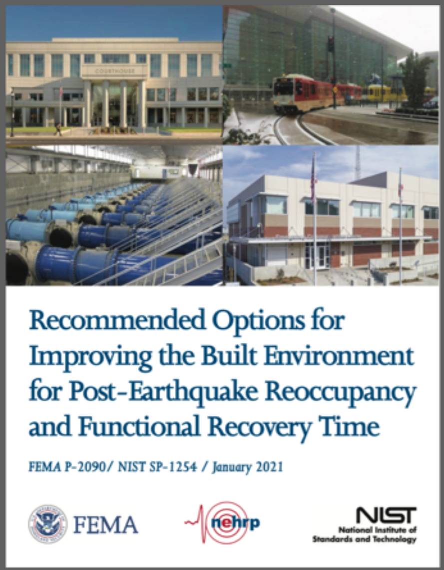
Thus, design for functional recovery means considering both safety *and* recovery time in design. Where current reoccupancy or recovery times are unacceptable, higher performance goals might be set, resulting in changes to what and how we build. But in many cases, expected reoccupancy or recovery times might already be adequate, in which cases "better than code" performance would mean only that the recovery goals and expectations are better understood and more clearly conveyed.

We recognize that a design shift for functional recovery will need to consider interdependencies between at least five physical systems that comprise the built environment and will involve four sets of linked but largely independent issues.

The systems are:

- Buildings, new and existing, serving all occupancies and uses
- Water and wastewater systems
- Energy systems
- Communication systems

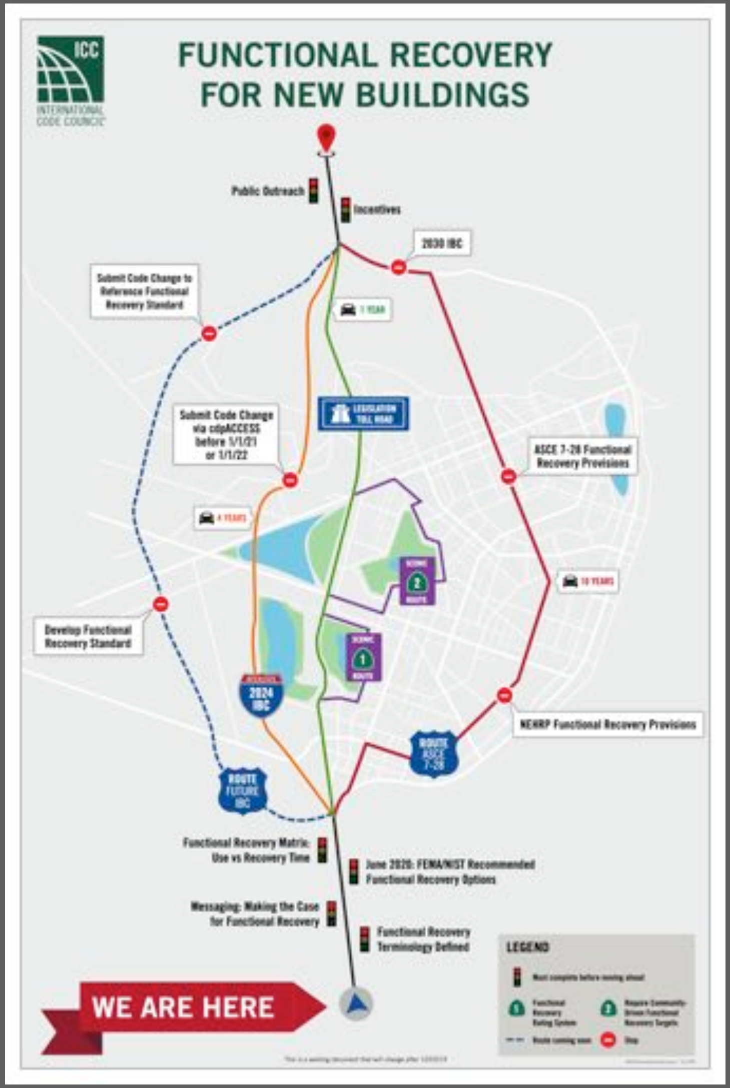
FEMA-NIST recommendations



- 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 ...

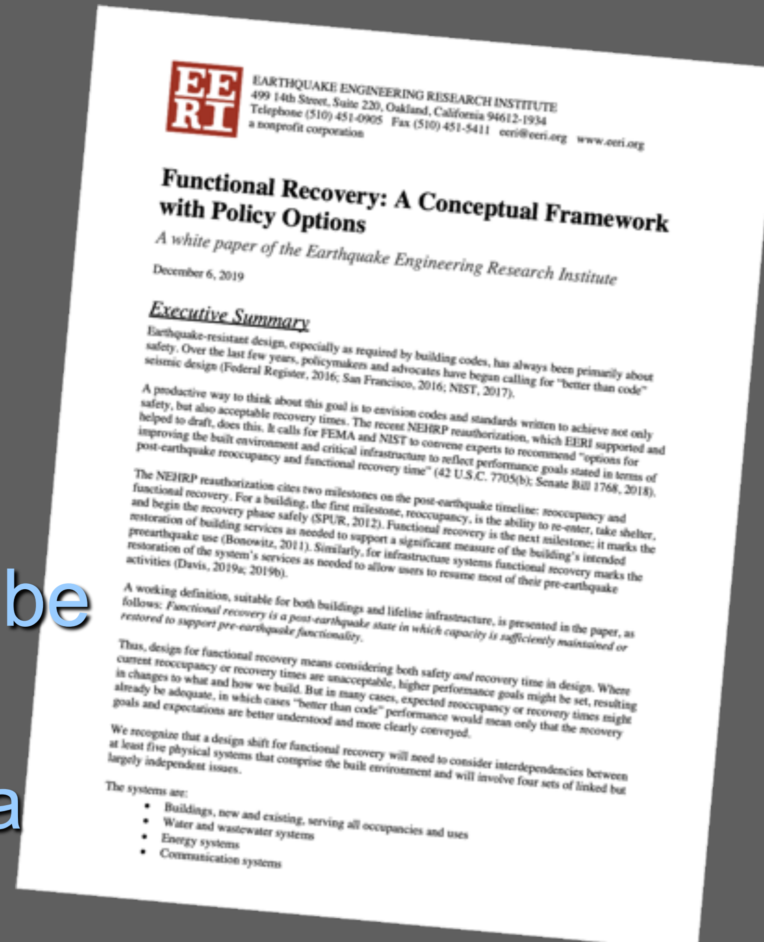
  ... is FR achieved within an acceptable time following a specified earthquake, where the acceptable time might differ for various building uses and occupancies.

PBE analogy

- Building performance objective: Safety
  - P(collapse) < X%, given 2/3*MCE
- Building FR objective
  - $P(T_{Exp} > T_{Accept}) < Y\%$, given 2/3*MCE (or other)
- *Community resilience* objective
  - $P(T_{Exp\text{-}A} > T_{Accept\text{-}A}) < Z\%$, given 2/3*MCE (or scenario)
  - $P(T_{Exp\text{-}B} > T_{Accept\text{-}B}) < Z\%$ " " "
  - $P(T_{Exp\text{-}C} > T_{Accept\text{-}C}) < Z\%$ " " "
  - ...

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



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The systems are:

- Buildings, new and existing, serving all occupancies and uses
- Water and wastewater systems
- Energy systems
- Communication systems

The code & standard model

- Code: Policy questions

  What should T_{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_{Accept} analogous to RC

- A policy question
  - Should be guided by social science research
- A normative question
  - NIST: Should be subject to community preferences

TABLE 1604.5
RISK CATEGORY OF BUILDINGS AND OTHER STRUCTURES

RISK CATEGORY	NATURE OF OCCUPANCY
T_{Accept} < 6 mo	Buildings and other structures that represent a low hazard to human life in the event of failure, including but not limited to: • Agricultural facilities. • Certain temporary facilities. • Minor storage facilities.
T_{Accept} < 1 Mo	Buildings and other structures except those listed in Risk Categories I, III and IV.
T_{Accept} < 1 Wk	Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to: • Buildings and other structures whose primary occupancy is public assembly with an occupant load greater than 300. • Buildings and other structures containing Group E occupancies with an occupant load greater than 250. • Buildings and other structures containing educational occupancies for students above the 12th grade with an occupant load greater than 500. • Group I-2 occupancies with an occupant load of 50 or more resident care recipients but not having surgery or emergency treatment facilities. • Group I-3 occupancies. • Any other occupancy with an occupant load greater than 5,000.ᵃ • Power-generating stations, water treatment facilities for potable water, wastewater treatment facilities and other public utility facilities not included in Risk Category IV. • Buildings and other structures not included in Risk Category IV containing quantities of toxic or explosive materials that: Exceed maximum allowable quantities per control area as given in Table 307.1(1) or 307.1(2) or per outdoor control area in accordance with the *International Fire Code*; and Are sufficient to pose a threat to the public if released.ᵇ
T_{Accept} < 1 Dy T_{Accept} < 1 Hr	Buildings and other structures designated as essential facilities, including but not limited to: • Group I-2 occupancies having surgery or emergency treatment facilities. • Fire, rescue, ambulance and police stations and emergency vehicle garages. • Designated earthquake, hurricane or other emergency shelters. • Designated emergency preparedness, communications and operations centers and other facilities required for emergency response. • Power-generating stations and other public utility facilities required as emergency backup facilities for Risk Category IV structures. • Buildings and other structures containing quantities of highly toxic materials that: Exceed maximum allowable quantities per control area as given in Table 307.1(2) or per outdoor control area in accordance with the *International Fire Code*; and Are sufficient to pose a threat to the public if released.ᵇ • Aviation control towers, air traffic control centers and emergency aircraft hangars. • Buildings and other structures having critical national defense functions. • Water storage facilities and pump structures required to maintain water pressure for fire suppression.

The code & standard model

- Code: Policy questions

  What should T_{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

	Acceptable FR Time			
Design strategy/requirement	**1 Hr**	**1 Dy**	**1 Wk**	**1 Mo**
Structural				
Lateral system limits	Req'd	Req'd	Req'd	
Tighter drift limits	Req'd	Req'd	Req'd	
...				
Nonstructural				
Bracing scope increase	Req'd	Req'd	Req'd	
Reliability factors on design forces	Req'd	Req'd		
...				
Function-critical contents bracing	Req'd	By case		
Infrastructure backup	Req'd	By case		
Reoccupancy / Recovery planning	Moot	Req'd		

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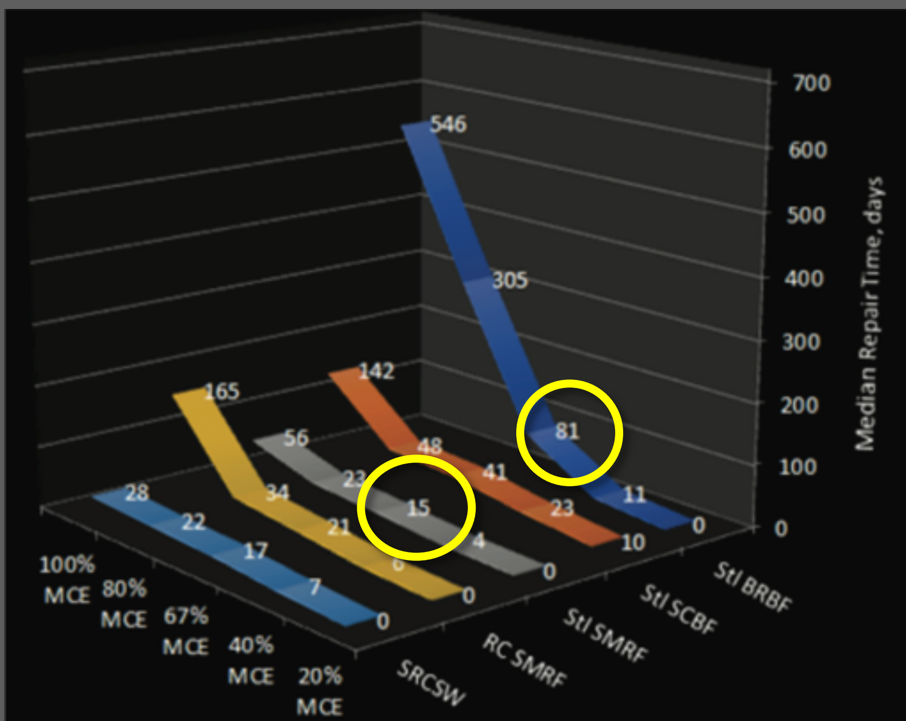
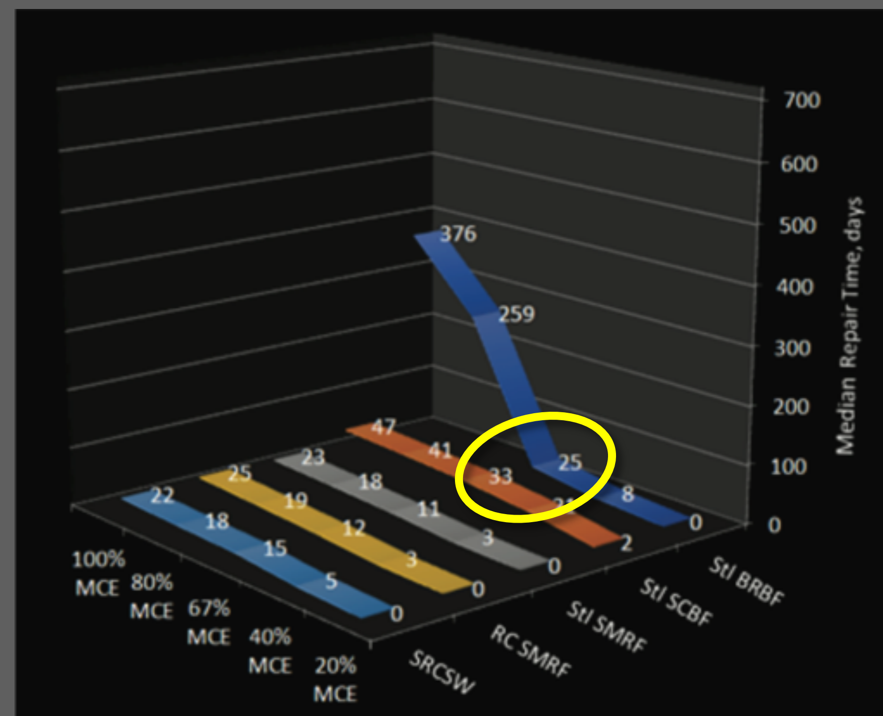
Actual performance varies

- Repair time for different SFRS (FEMA P-58)
  - At 2/3*MCE_R, RC II, varies from 15 – 81 days
  - Some SFRS worse at RC IV than others at RC II



Risk Category II, Office



Risk Category IV, Office

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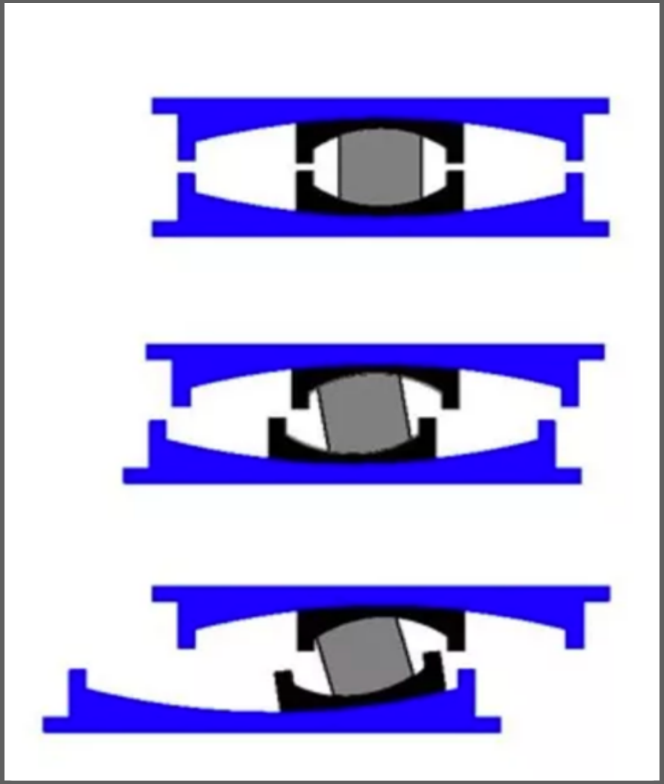
Is FR compatible with "code"?

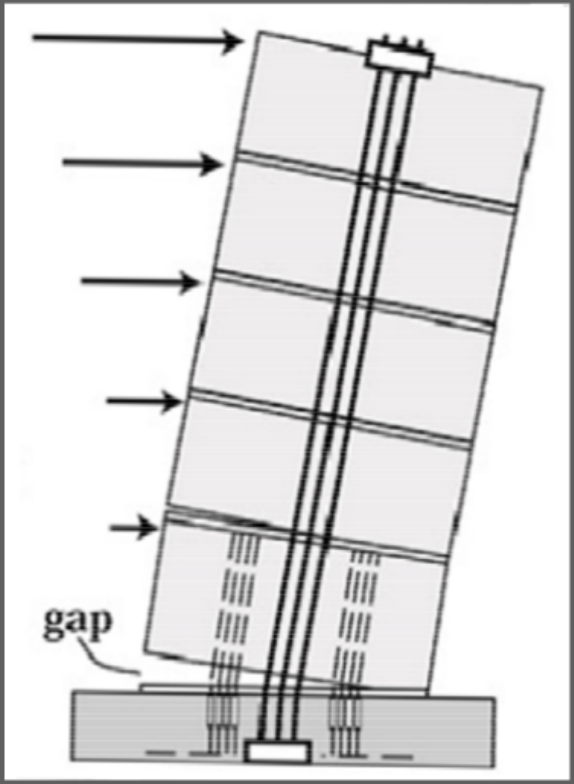
- Premise of code-based design: Ductile SFRS
    - *But ductility = structural damage!*
    - *And structural damage = high repair time!*
- True, but:
    - We accept criteria for RC IV (SDC F)
    - Acceptable time can often be > 0
    - In a scenario, not every building sees the DE
    - Shift in emphasis 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



Earthquake Protection Systems



Rahman & Restrepo (Nazari, 2016)

Hogg, 2013

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

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FUTURE PUC ISSUES AND RESEARCH NEEDS

S. K. Ghosh, S.K. Ghosh Associates LLC
Kelly Cobeen, Wiss Janney Elstner Associates, Inc.

nehrp FEMA

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.

Functional Recovery

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.

Research to Support Development of Functional Recovery Provisions

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

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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.

Spurring Protection of Essential Facilities

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

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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.

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.

Structures Designed for Strength rather than Ductility

2-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.

Vertical Seismic Ground Motion

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- Ω_o forces. If Ω_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
  - Ω_{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

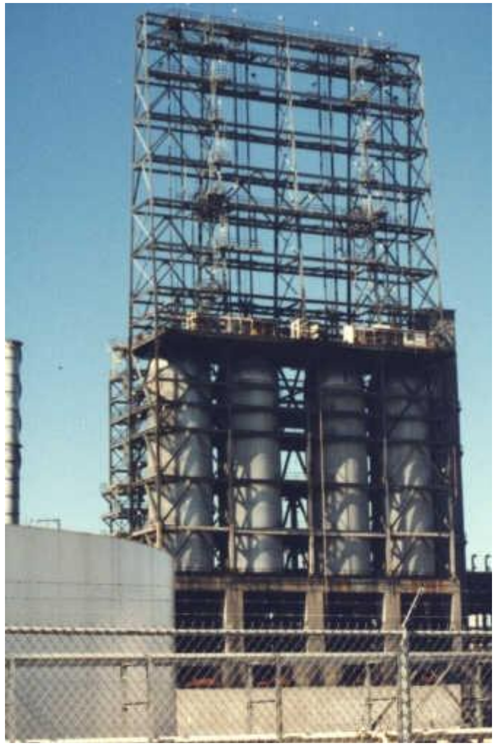
Chapter 15

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.

Seismic Design Parameters for Pedestal Systems



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 it 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

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BSSC LOOKOUT

Jiqiu (JQ) Yuan, Executive Director of MMC and BSSC

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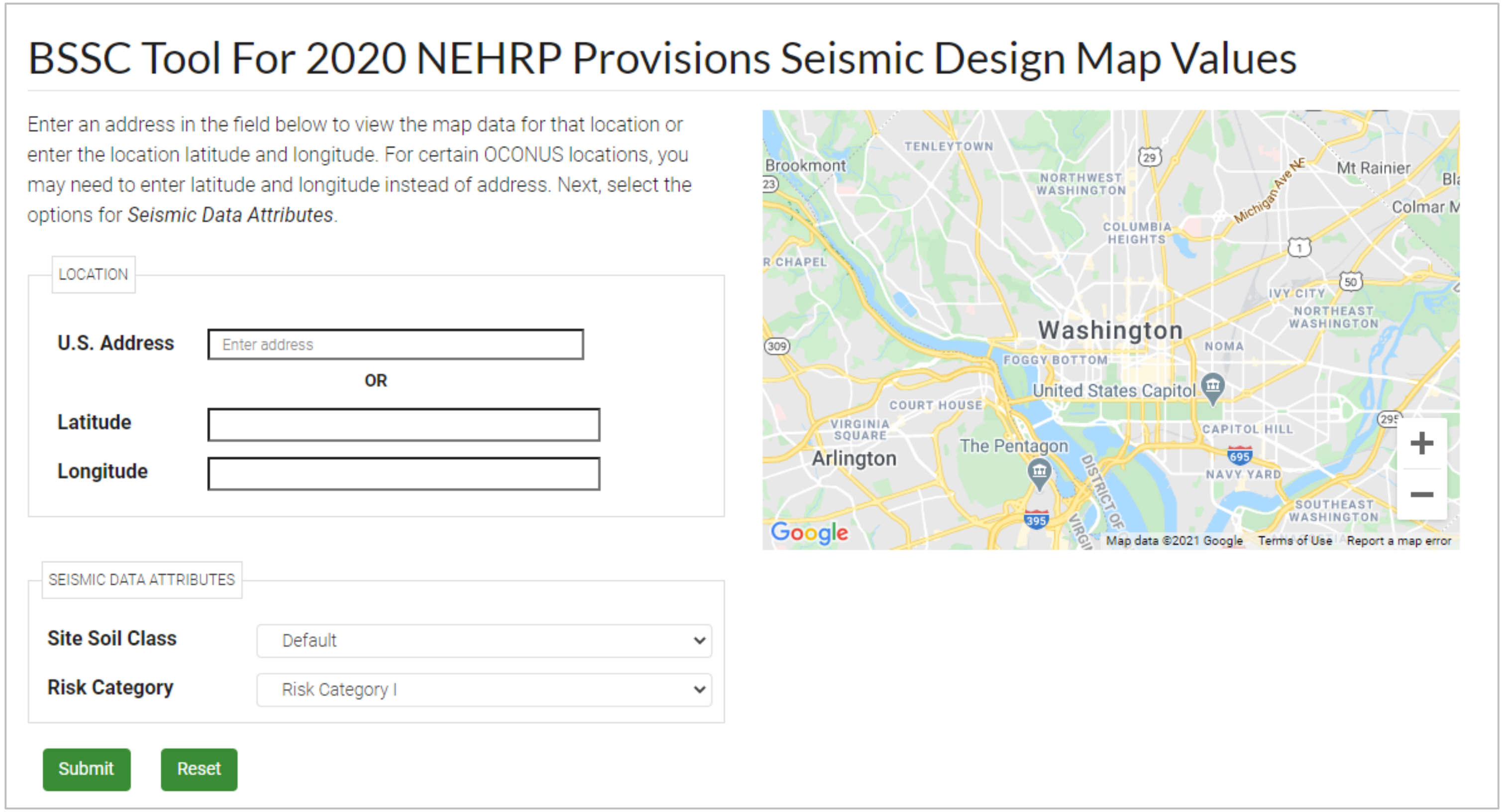
Resources: BSSC website

https://www.nibs.org/page/bssc



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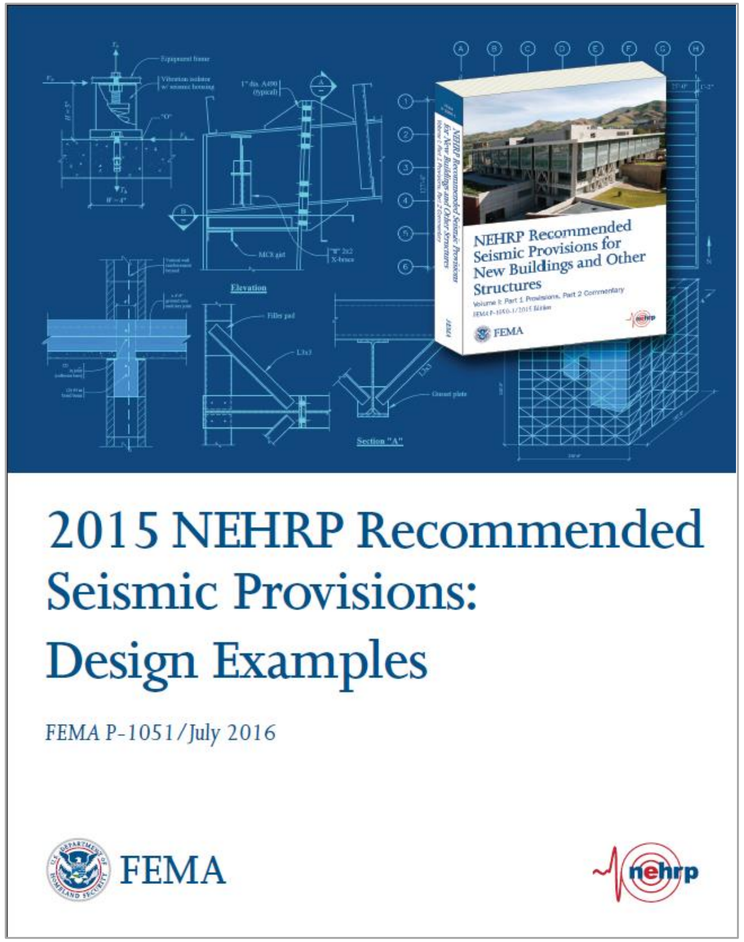
Outreach & Education: NEHRP Provisions Design Examples and Training Materials



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

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BSSC Mission: To enhance public safety by providing a national forum that fosters improved seismic planning, design, construction and regulation in the building community.

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THANK YOU!

Jiqiu (JQ) Yuan, jyuan@nibs.org

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