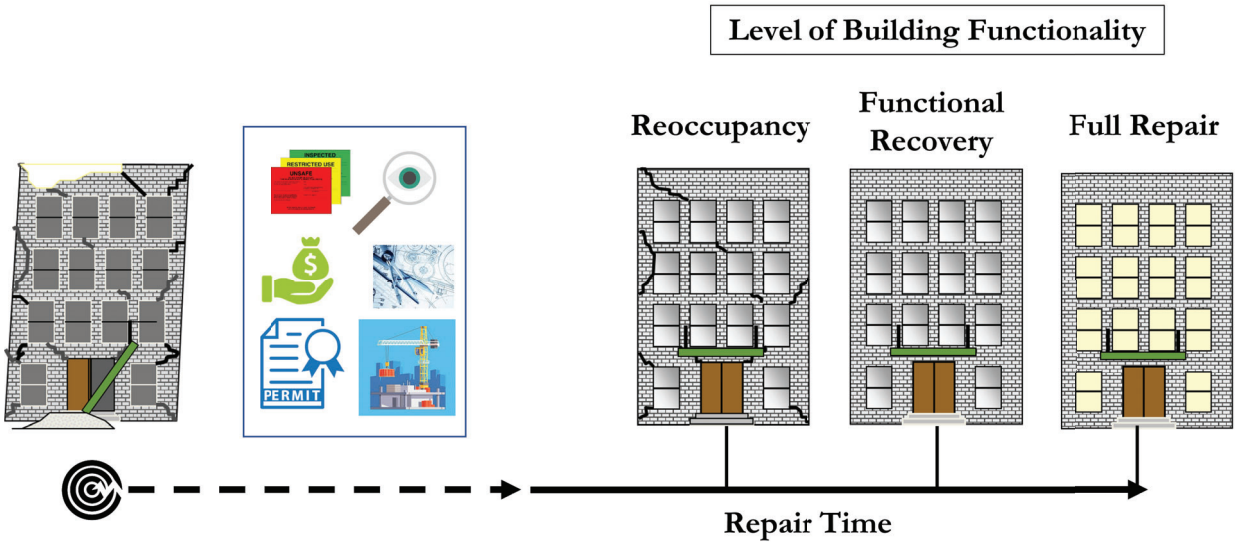
ATC 58-7

Proceedings of
FEMA-sponsored workshop on functional recovery



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Applied Technology Council

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Cover image: Repair time, with impeding factors, for achieving post-earthquake recovery milestones identified as reoccupancy, functional recovery, and full repair.

ATC-58-7

Proceedings of FEMA-Sponsored Workshop on Functional Recovery

August 17-18, 2022
Burlingame, California

by

APPLIED TECHNOLOGY COUNCIL
201 Redwood Shores Parkway, Suite 240
Redwood City, California 94065
www.ATCouncil.org

Funded by

FEDERAL EMERGENCY MANAGEMENT AGENCY
Michael Mahoney, Project Officer
Robert D. Hanson, Technical Monitor
Washington, D.C.

2022

Preface

In 2021, the Federal Emergency Management Agency (FEMA), in cooperation with the National Institute of Standards and Technology (NIST), completed the FEMA-NIST Special Publication, FEMA P-2090/NIST SP-1254, *Recommended Options for Improving the Built Environment for Post-Earthquake Reoccupancy and Functional Recovery Time* (FEMA-NIST, 2021), which provided options in the form of recommendations, tasks, and alternatives for improving the built environment in terms of reoccupancy and functional recovery time. Even before the publication of the FEMA P-2090/NIST SP-1254 report, there has been growing interest, momentum, and activity related to researching, predicting, and codifying reoccupancy and functional recovery times for buildings and lifeline infrastructure systems. This has included ongoing work by FEMA, NIST, and others.

In September 2021, FEMA awarded the Applied Technology Council (ATC) a task order (70FA6021F00000048) under its "Seismic Technical Guidance Development and Support" contract (HSFE60-17-D-0002), which included a task to plan and conduct a workshop that would serve to coordinate the various efforts related to functional recovery that are being undertaken at the local and national levels. The *FEMA-Sponsored Workshop on Functional Recovery* is the result of this work.

The purpose of this workshop was to advance the conversation around reoccupancy and functional recovery concepts using information from recent FEMA, NIST and other projects, and to identify and discuss ongoing activities and areas for potential future collaboration. Attendees consisted of stakeholders involved in implementation of policy, research, and technical development activities centered around resilience and functional recovery, including engineers, non-engineering design professionals, researchers, owners/facility managers, building officials, code developers, and state and federal government entities.

ATC is indebted to the leadership of the Workshop Planning Committee, including Ryan Kersting, Jonathan Buckalew, and Susan Dowty, who planned and conducted workshop activities, and to the support provided by the ATC-138-4 Project Technical Committee, including Ron Hamburger (Project Technical Director), Greg Deierlein, Curt Haselton, John Hooper,

Abbie Liel, and David Mar, and Working Group Members Jack Baker, Dustin Cook, and Jared DeBock, who participated in the development and presentation of technical information presented at the workshop.

ATC gratefully acknowledges the ATC-138-4 Project Review Panel that attended the workshop, including Peter Morris, Jonathan Siu, and Steve Winkel, and the entire group of invited workshop participants for their contributions to workshop plenary and breakout discussions, especially Siamak Sattar, Nico Luco, Katherine (Jo) Johnson, Carlos Molina Hutt, Jakub Valigura, and Brian Meacham, who agreed to present their individual projects and perspectives in plenary sessions. The names and affiliations of all who attended the workshop are provided in Appendix A.

ATC also gratefully acknowledges funding provided by the Federal Emergency Management Agency, guidance and support provided by Michael Mahoney (FEMA Project Officer) and Robert Hanson (FEMA Technical Monitor), workshop logistical support provided by Bernadette Hadnagy (ATC), and report production services provided by Ginevra Rojahn (ATC).

Jon A. Heintz
ATC Executive Director

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Chapter 1
Introduction

In 2021, the Federal Emergency Management Agency (FEMA), in cooperation with the National Institute of Standards and Technology (NIST), completed the FEMA-NIST Special Publication, FEMA P-2090/NIST SP-1254, *Recommended Options for Improving the Built Environment for Post-Earthquake Reoccupancy and Functional Recovery Time* (FEMA-NIST, 2021), which provided options in the form of recommendations, tasks, and alternatives for improving the built environment in terms of reoccupancy and functional recovery time.

Even before the publication of the FEMA P-2090/NIST SP-1254 report, there has been growing interest, momentum, and activity related to researching, predicting, and codifying reoccupancy and functional recovery times for buildings and lifeline infrastructure systems. This has included ongoing work by FEMA, NIST, and others.

To coordinate the various efforts related to functional recovery being undertaken at the local and national levels, and to advance the functional recovery conversation using information from recent projects, FEMA contracted with the Applied Technology Council (ATC) to plan and conduct the *FEMA-Sponsored Workshop on Functional Recovery*. This report describes the workshop program and presents the findings and conclusions from workshop discussions.

1.1 Resilience, Reoccupancy, and Functional Recovery

Community resilience is defined as the ability to prepare for and adapt to changing conditions and to withstand and recover rapidly from disruptions (The White House, 2013). The overarching purpose of community resilience is to maintain the long-term viability of a community following an earthquake or other natural hazard event. Goals of improved community resilience, however, are challenging to achieve and difficult to enforce. To support resilience goals at the community level, there is a need to establish a link between the design, construction, and retrofit of individual buildings and lifeline infrastructure systems, and community resilience as measured by time to recovery of function. The concepts of reoccupancy and functional recovery have been introduced to serve as this link.

In contrast with community resilience, functional recovery refers to the performance of a distinct piece of the built environment, such as an individual building or lifeline infrastructure system (NIBS, 2019). Reoccupancy and functional recovery are performance milestones that are beyond basic safety, but are somewhat less than full functionality, as shown in Figure 1-1.

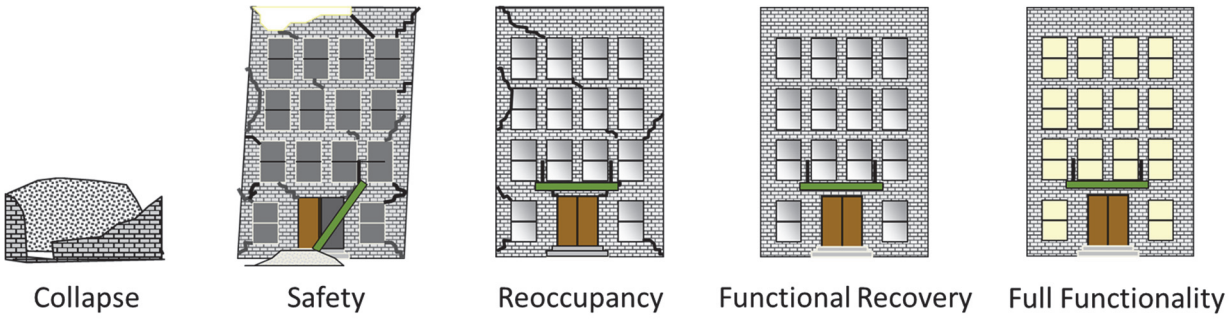

Figure 1-1 Range of building performance and relative placement of safety-based and recovery-based goals (FEMA-NIST, 2021).

Reoccupancy is defined as a post-earthquake performance state in which a building is maintained, or restored, to allow safe re-entry for the purposes of providing shelter or protecting building contents (FEMA-NIST, 2021).

Functional recovery is defined as a post-earthquake performance state in which a building or lifeline infrastructure system is maintained, or restored, to safely and adequately support the basic intended functions associated with the pre-earthquake use or occupancy of a building, or the pre-earthquake service level of a lifeline infrastructure system (FEMA-NIST, 2021). A key concept for functional recovery is that *basic intended functions* are something less than full pre-earthquake functionality, but more than what would be considered the minimum sufficient for reoccupancy of buildings or temporary provision of lifeline services.

Using concepts from performance-based seismic design, designing for reoccupancy or functional recovery would require a performance objective that defines the desired performance, within an acceptable time frame, with a specified reliability, following a specified earthquake. Acceptable time frames might vary for different building uses or occupancies or lifeline infrastructure services.

Although the concepts have been defined, additional research, study, and discussion is needed to clarify how much function constitutes basic function, what is necessary for reoccupancy of a building, what earthquake hazard levels or risk targets should be used, and what recovery times at what

reliability levels would be considered acceptable for different building occupancies or lifeline infrastructure systems. Discussion to advance functional recovery concepts is one of the key motivations for this workshop.

1.2 Recent Research, Practice, and Policy Milestones

Decades of research, practice, and attempts at implementation of policy have resulted in a recent surge of interest and activity centered around functional recovery concepts. Important research, practice, and policy milestones contributing to the functional recovery context are shown in Figure 1-2.

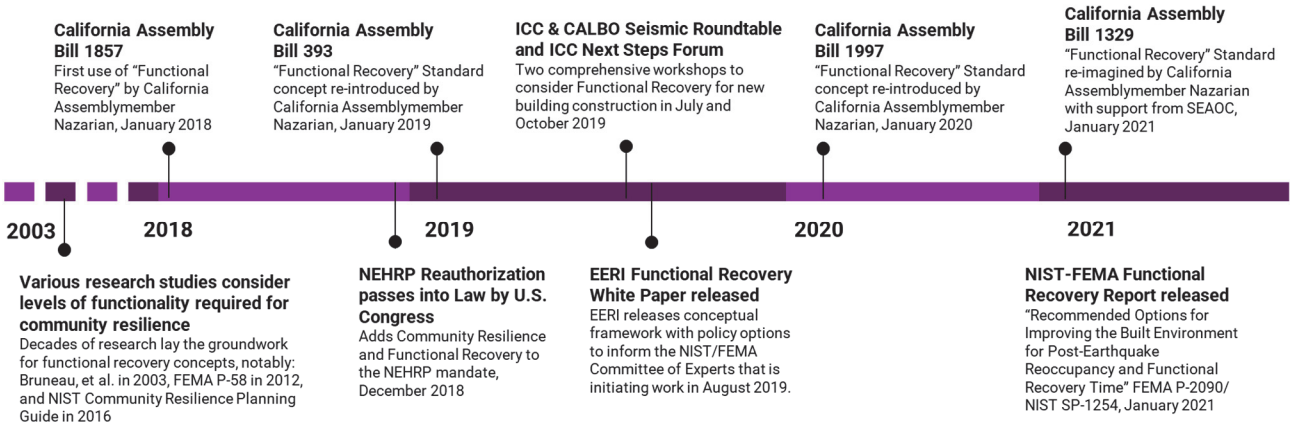

Figure 1-2 Recent research, practice, and policy milestones (courtesy of R. Kersting).

In 2003, Bruneau et al. is credited with defining the concept of community resilience in terms of time to recovery of function.

In 2012, ATC completed the first phase of a multi-phase program for FEMA to develop next-generation concepts for performance-based seismic design, resulting in the publication of the FEMA P-58 series of reports, *Seismic Performance Assessment of Buildings, Methodology and Implementation* (FEMA, 2012). The FEMA P-58 methodology probabilistically characterizes performance in terms of losses including casualties, repair costs, and repair time. The FEMA P-58 loss algorithms form the basis of a computational engine that can be used to estimate time for recovery of function for individual buildings.

In 2016, NIST published the *Community Resilience Planning Guide for Buildings and Infrastructure Systems* (NIST, 2016), defining communities as an assembly of political, social, human, and cultural needs, and outlining a process for resilience planning intended to result in a built environment that supports the government, industry, business, education, social, cultural, and health services necessary for everyday life.

In 2018, Congress reauthorized the National Earthquake Hazard Reduction Program (NEHRP), and added community resilience and functional recovery concepts into the NEHRP mandate. NIST and FEMA were charged with assembling a committee of experts to develop a report to Congress on options for improving the built environment in terms of reoccupancy and functional recovery time.

In 2019, the International Code Council (ICC) and California Building Officials (CALBO) hosted a "Roundtable Discussion" to chart a path toward achieving a national approach for functional recovery design for new construction, followed by a "Next Steps Forum" hosted by ICC at their 2019 Annual Conference (ICC, 2019a; 2019b).

Also in 2019, the Earthquake Engineering Research Institute (EERI) published a white paper, *Functional Recovery: A Conceptual Framework with Policy Options* (EERI, 2019), defining functional recovery and its relation to community resilience, and outlining four issue areas as a framework for thinking about functional recovery concepts: definitional, policy, technical, and implementation.

In the period between 2018 and 2021, the California State Assembly considered a series of bills introducing the concept of functional recovery and the development of functional recovery design provisions for adoption into the California Building Code. Although these bills were ultimately not approved, the effort has resulted in growing support among the legislature, industry stakeholders, and the public.

In 2021, NIST and FEMA completed their charge under the NEHRP reauthorization to convene a committee of experts and develop a report to Congress with the publication of the FEMA-NIST Special Publication, FEMA P-2090/NIST SP-1254.

1.3 FEMA-NIST Special Publication

The FEMA-NIST Special Publication, FEMA P-2090/NIST SP-1254, establishes definitions for reoccupancy and functional recovery, and explains their relation to community resilience. It makes the case for why recovery-based concepts are needed to protect U.S. communities and taxpayers against future loss of life and property, and negative impacts to the economy, on the scale of those experienced in Hurricane Katrina or predicted in earthquake scenario studies. Finally, it provides a set of options in the form of recommendations, tasks, and alternatives for improving the built environment in terms of reoccupancy and functional recovery time.

The seven recommendations are listed below, and the relationship among the recommendations is depicted in Figure 1-3:

1. Develop a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives.
2. Design New Buildings to Meet Recovery-Based Objectives.
3. Retrofit Existing Buildings to Meet Recovery-Based Objectives.
4. Design, Upgrade, and Maintain Lifeline Infrastructure Systems to Meet Recovery-Based Objectives.
5. Develop and Implement Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives.
6. Provide Education and Outreach to Enhance Awareness and Understanding of Earthquake Risk and Recovery-Based Objectives.
7. Facilitate Access to Financial Resources Needed to Achieve Recovery-Based Objectives.

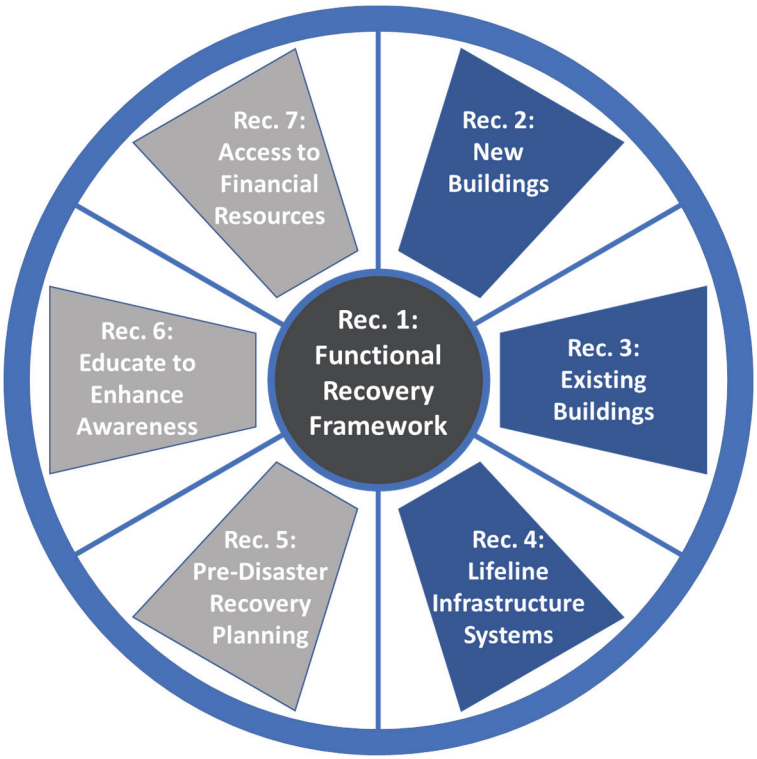

Figure 1-3 Interactions among the seven FEMA-NIST recommendations (FEMA-NIST, 2021).

Recommendations, tasks, and alternatives identified in FEMA-NIST Special Publication were not explicitly assigned to Congress, FEMA, NIST, or any specific federal, state, or local agency or private entity. It was envisioned

that the NEHRP agencies would, ideally, leverage their past success in similar activities to lead, support, and coordinate with all appropriate public and private partners in the development of technical information, policies, and programs supporting the implementation of the recommendations. Identification of ongoing activities, and coordination among those activities, is one of the key motivations for this workshop.

1.4 The ATC-138 Functional Recovery Methodology

The FEMA P-58 methodology was developed under the ATC-58 series of projects. It was initially published in 2012 and updated in a subsequent phase of work completed in 2018 (FEMA, 2018).

In the FEMA P-58 methodology, seismic performance is characterized on a probabilistic basis in terms of the potential for incurring damage and losses in the form of repair costs, repair time, casualties, unsafe placarding, and environmental impacts. The general methodology and procedures can be applied to seismic performance assessments of new or existing buildings of any type, regardless of age, construction, or occupancy. Implementation of the methodology requires basic data on the vulnerability of structural and nonstructural components to damage (fragility), and information on the impacts resulting from that damage (consequence), which can be used to: (1) assess the probable performance of a building; (2) design new buildings to be capable of providing desired performance; or (3) design seismic upgrades for existing buildings to improve their performance.

As part of its ongoing commitment to performance-based seismic design, FEMA funded the ATC-138 series of projects to support, enhance, and facilitate the use of the FEMA P-58 methodology in engineering practice. Using the results from a recent NIST-funded grant to researchers at the University of Colorado Boulder and Texas A&M University, the ATC-138 project expanded the FEMA P-58 methodology to update red-tag algorithms, enhance repair time computations, and consider functional consequences of damage in the development of a functional recovery methodology.

The preliminary methodology is described in the ATC-138-3 report, *Seismic Performance Assessment of Buildings, Volume 8 – Methodology for Assessment of Functional Recovery Time* (ATC, 2021), which will eventually be published as Volume 8 in the FEMA P-58 series of reports. A beta version of the methodology has been used to generate information on the potential functional performance of code-conforming building archetypes, as measured by the methodology. Use of data from the ATC-138 functional

recovery methodology to inform discussions of functional recovery concepts is one of the key motivations for this workshop.

1.5 FEMA-Sponsored Workshop on Functional Recovery

This *FEMA-Sponsored Workshop on Functional Recovery* was planned and conducted in response to the growing interest in functional recovery concepts and accelerated activity centered around functional recovery research and development that has occurred since the publication of the FEMA P-2090/NIST SP-1254 special report.

The purpose of this workshop was to bring together researchers, design professionals, engineering associations, codes and standards development organizations, building officials, and government agencies actively involved in research, development, and implementation of functional recovery concepts, policies, and technologies. Discussions were intended to address the following key objectives: (1) advance the conversation around functional recovery concepts informed by data from the ATC-138 Project; and (2) identify ongoing activities in and areas for potential future collaboration among public and private entity partners at the federal, state, and local levels.

The workshop provided a forum for interaction among different stakeholder groups to develop a common understanding of the current state of knowledge and context, and to provide a launching point for further discussion on conceptual and technological challenges associated with functional recovery concepts. Discussions included questions such as: (1) what is necessary to achieve reoccupancy and functional recovery performance states in buildings; (2) what are reasonable and acceptable recovery times; (3) what hazard level or risk target should functional recovery be measured at; and (4) who is active in this area, what is being done, and where do we go from here? Prior to the workshop, participants were asked to submit information about ongoing activities, which was used to seed workshop discussions.

Information gathered during this workshop is intended to inspire collaboration and inform future functional recovery efforts by FEMA, other federal, state, and local agencies, research institutions, engineering associations, codes and standards development organizations, and other research and development partner organizations.

Chapter 2
Workshop Program

A two-day *FEMA-Sponsored Workshop on Functional Recovery* was held in Burlingame, California on August 17-18, 2022. This chapter summarizes the workshop program and describes the structure of the plenary presentations and breakout discussions.

2.1 Workshop Overview and Agenda

The workshop format included plenary sessions followed by focused breakout discussions. The workshop was broadly organized into three sessions: (1) keys to measuring functional recovery; (2) hazard levels and target recovery times; and (3) future actions: where do we go from here? The workshop agenda is shown in Figure 2-1.

The workshop was attended by 57 participants. Attendees included engineers, non-engineering design professionals, researchers, owners/facility managers, building officials, code developers, and state and federal government entities. A list of workshop participants, and their affiliations, is provided in Appendix A.

The overall context for the workshop was set in an introductory presentation (by R. Kersting) providing an overview of current and planned efforts to advance functional recovery concepts, including important research, practice, and policy milestones in recent history. This included a summary of the seven recommendations in the FEMA P-2090/NIST SP-1254 special report, with a focus on Recommendation 1: Develop a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives, and Recommendation 2: Design New Buildings to Meet Recovery-Based Objectives, which are closely related to the planned workshop discussions. It also included an overview of the upcoming 2026 cycle of the NEHRP Provisions Update Committee (PUC), which includes a special Task Committee (TC) on functional recovery that will attempt to: define key terms and concepts; identify recovery categories with appropriate ranges and precision; identify target functional recovery times for various occupancies; develop prescriptive design provisions to meet recovery objectives; and select appropriate hazard levels or risk targets for measuring functional recovery performance. This introductory presentation, and all subsequent plenary presentations, are provided in Appendix B for future reference.

FEMA-Sponsored Workshop on
Functional Recovery

August 17-18, 2022
Embassy Suites SFO Waterfront
Burlingame, California

DAY 1: 8:30AM – 5:00PM

Time	*Subject*	*Lead*
8:30 am	**Welcome – Day 1** • Introductory Remarks • Agenda Review, Workshop Objectives, and Format	 Mike Mahoney Jon Heintz
8:40 am	**Introductory Presentation / Setting the Stage** Overview of relevant recent, current, and planned efforts to advance Functional Recovery development	Ryan Kersting
9:20 am	**Session #1: Keys to Measuring Functional Recovery** ***Presentations*** • Development of an ATC-138 Functional Recovery Methodology, Challenges and Assumptions • SEAOC Resilience Committee – Defining Building Uses for Functional Recovery	 Jon Heintz Jonathan Buckalew
10:10 am	**BREAK**	
10:20 am	**Session #1: Keys to Measuring Functional Recovery** ***Small Group Break-out Discussions*** • Topic 1A (70 min): What is necessary to achieve reoccupancy and functional recovery in a building? What level of function is necessary? What amount of temporary repair is acceptable? What relaxation of habitability standards would be required?	
11:30 am	**Session #1: Keys to Measuring Functional Recovery** ***Report out***	
12:00 pm	**LUNCH**	
1:15 pm	**Session #2: Hazard Level(s) and Target Recovery Times** ***Presentations*** • Building Reoccupancy and Recovery Times as Measured by the ATC-138 Functional Recovery Methodology • NIST Study on Recovery Categories and Recovery Times • Risk-Targeted Ground Motions and Hazard Level and Shaking Intensity of Recent and Scenario Earthquakes • Risk Considerations for Selection of a Hazard Level for Functional Recovery Assessment	 Curt Haselton Siamak Sattar Nico Luco Jack Baker
2:45 pm	**BREAK**	

Figure 2-1 Agenda – FEMA-Sponsored Workshop on Functional Recovery.

2:55 pm	**Session #2: Hazard Level(s) and Target Recovery Times** ***Small Group Break-out Discussions*** • Topic 2A (35 min): What hazard level(s) should be used for FR performance objective(s)? (What is appropriate amount of consideration for FR at various hazard levels?) • Topic 2B (30 min): What should be the Target FR times or priorities for various occupancies (and for different hazard levels)? • Topic 2C (30 min): How should impeding factors be addressed in recovery time calculations and in communicating results?	
4:30 pm	**Session #2: Hazard Level(s) and Target Recovery Times** ***Report out***	
5:00 pm	**Adjourn – Day 1**	

DAY 2: 8:30AM – 12:30PM

Time	*Subject*	*Lead*
8:30 am	**Welcome – Day 2** • Agenda Review	Jon Heintz
8:35 am	**Session #3: Future Actions: Where do we go from here?** ***Presentations – Other Ongoing Work*** • Overview of Other Ongoing Work from Pre-Workshop Questionnaires • NIST Study on Prescriptive Design Procedures • NIST Study on Benefit-Cost Analysis • NIST Study on Lifelines / ATC-152 Project • FEMA Study on Lifelines / ATC-150 Project • An Analytical Framework for Downtime and Recovery • Functional Recovery Time for Code-Compliant Bldgs. • Reimagining the ICC Performance Code	Susan Dowty Dustin Cook Juan Fung Katherine Johnson Mike Mahoney Carlos Molina Hutt Jakub Valigura Brian Meacham
10:15 am	**BREAK**	

10:25 am	**Session #3: Future Actions: Where do we go from here?**
	Small Group Break-out Discussions
	• Topic 3A (65 min): Develop list / table of items discussed within group identifying:
	  • Areas of current / ongoing work: How does what was discussed/presented today affect what you are currently working on? How does what you are currently working on fit-in to next steps?
	  • Other areas in need of research or progress: What do you need from other stakeholder groups?
	  • Timeframes, deliverables, and opportunities for advancing functional recovery concepts?	

11:30 am	**Session #3: Future Actions: Where do we go from here?** ***Report out / Panel discussion*** *Panelists from each stakeholder group will report-out from the break-out discussions and participate in open Q&A*	
12:15 pm	**Overall Closing / Wrap-up / Next Steps**	
12:30 pm	**Adjourn – Day 2**	

Figure 2-1 Agenda – FEMA-Sponsored Workshop on Functional Recovery (continued).

2.2 Session 1: Keys to Measuring Functional Recovery

The purpose of Session 1 was to explore key concepts for measuring functional recovery, including challenges related to defining basic function and requirements for reoccupancy. Plenary presentations for Session 1 included:

- An overview of the development of the ATC-138 functional recovery methodology (by J. Heintz), which explained how the FEMA P-58 methodology was adapted to assess function, showed how criteria for basic function and requirements for reoccupancy have been embedded in the computational algorithms, and highlighted challenges associated with linking damage to function.
- A method of evaluating building uses for functional recovery (by J. Buckalew), which illustrated a logical approach for itemizing and assessing the importance of key systems deemed necessary for function and reoccupancy of a building, and subsequently defining basic intended function, as presented in a paper by Buckalew and Lang (2020).

Attendees were divided into three multi-disciplinary breakout groups, each addressing a different occupancy:

- Group 1-A: Critical Healthcare (RC IV)
- Group 1-B: Commercial Office (RC II)
- Group 1-C: Single and Multi-Family Residential (RC II)

For the assigned occupancy, each group was instructed to answer the following questions:

- What is necessary for basic function?
- What is necessary for occupancy?
- What is the basic function for a given use or occupancy?

To drill down in additional detail, each group was also asked to evaluate what level of functionality for each system was necessary (or acceptable), what temporary workarounds were possible, and how long temporary workarounds might be acceptable?

2.3 Session 2: Hazard Levels and Target Recovery Times

The purpose of Session 2 was to explore key concepts related to hazard levels (or risk targets) for measuring functional recovery, consideration of impeding factors in recovery time calculations, and selection of target

recovery times for different occupancies. Plenary presentations for Session 2 included:

- A summary of building reoccupancy and recovery times for selected code-forming buildings, as measured by the ATC-138 functional recovery methodology (by J. DeBock for C. Haselton), illustrating the overall magnitude and variability of the reported recovery time (in days) for earthquakes with return periods ranging from 22 years to 2475 years.
- A description of the development of recovery categories and target recovery times (by S. Sattar), based on a conceptual framework presented in the FEMA P-2090/NIST SP-1254 special report, explored in a series of stakeholder workshops in 2020, and revisited in a mini-workshop at the 12th National Conference on Earthquake Engineering in 2022.
- An explanation of how ground motions are specified in a performance-based design context (by N. Luco), including pros and cons associated with the use of scenario/deterministic, uniform-hazard, or risk-targeted ground motions.
- An overview of considerations for selection of risk targets for functional recovery assessment (by J. Baker), including approaches for choosing performance goals, units of measure, and target hazard levels.

Attendees were divided into the same three multi-disciplinary breakout groups (Groups 2-A, 2-B, and 2-C), each addressing the following questions:

- What hazard level(s) should be used for functional recovery performance objectives?
- How should impeding factors be addressed in recovery time calculations and in communicating results?
- What should be the target functional recovery times or priorities for various categories of buildings?
- At what scale should risk be considered for functional recovery performance objectives (individual building level, community level, or regional level)?

For discussion and illustration purposes, examples of previously published target recovery times and recovery frameworks were shared with the groups. Figure 2-2 summarizes recovery time information available in published literature; Figure 2-3 shows a conceptual recovery category framework presented in the FEMA P-2090/NIST SP-1254 special report; Figure 2-4 shows one possible proposed framework for recovery categories and target

recovery times; and Figure 2-5 presents a performance matrix showing the possible variation in recovery times versus hazard level.

Table 1. Previous literature on target recovery times for buildings and infrastructure systems.

	Document	Performance Objective	Hazard Level	Recovery Goal
Design Guides	FEMA P-2082 [3]	Building Function	Design Earthquake	Less than a 10% probability of loss of essential function, where essential function is defined by a building owner or facility operator.
	PEER TBI [8]	Building Serviceability	Service-level Earthquake	Peak drifts should be less than 0.5%. Limited damage to structural components. No significant residual deformation.
	FEMA P-2055 [4]	Building Habitability	Unspecified Event	Weather protection for shelter within 7 days. Utilities operational within 30 days. Fire sprinklers and sufficient egress within 90 days. HVAC operational within 90 days.
Community Resilience Plans	SPUR [5,6]	Community Recovery	Mw 7.2 San Andreas Earthquake	Critical facilities operational immediately. Public shelters operations safe and usable in 24 hours. 90% of lifelines recovered in 72 hours, 95% in 30 days, 100% in 3 years. 95% of residence provided shelter in 24 hours, 100% in 4 months. 90% Businesses open within 30 days, 95% in 4 months, 100% in 3 years. Medical offices and schools open in 30 days.
	Oregon Resilience Plan [9]	Community Recovery	Mw 9.0 Cascadia Subduction Earthquake	Emergency facilities operational immediately. Emergency shelters and residential housing recovered in 72 hours. Business recovery/continuity in 2-4 weeks. Schools recovered in 30-60 days.
	Resilient LA [10]	Self-Sufficiency	Major Earthquake	Prepare people to be self-sufficient for at least 7-14 days after a major shock.
	Resilient SF [11]	Community Shelter	Mw 7.2 San Andreas Earthquake	Keep 95% of residents in San Francisco (references SPUR).
	NIST CRPG [7]	Community Recovery	Design Event	Community-specific recovery goals for building clusters and infrastructure systems providing critical community function.

Figure 2-2 Summary of target recovery time information available in the literature (Sattar et al., 2022).

Table B-1 Conceptual Functional Recovery Categories for a Design Hazard Level

Functional Recovery Category	Target Functional Recovery Time	Recovery Phase and Associated Functions and Services (1)	Examples of Buildings and Lifeline Infrastructure Systems
Functional Recovery Category A (FRC-A)	Hours (or Less)	Near-Term (Nearly Immediate) and Emergency Response – rescue, safety, security, and event stabilization	Emergency and first-responder facilities (e.g., hospitals, fire and police stations), designated shelters, emergency operations centers, and lifeline infrastructure systems supporting emergency response (e.g., power, communication, critical transportation)
Functional Recovery Category B (FRC-B)	Days to Weeks	Short-Term – shelter, governance, daily necessities, and care for vulnerable populations	Single- and multi-family residential, local government, schools, outpatient medical facilities, nursing homes, critical retail (e.g., food distribution, pharmacy, home improvement), and lifeline infrastructure systems supporting short-term activities
Functional Recovery Category C (FRC-C)	Weeks to Months	Intermediate-Term – restoration of neighborhood activities and economic vitality	Critical business enterprises, possibly exceeding a certain size threshold, and lifeline infrastructure system services supporting intermediate-term activities
Functional Recovery Category D (FRC-D)	Months to Years	Long-Term – cultural, quality of life, and leisure activities	Buildings not assigned to other categories, possibly including less critical business enterprises, less-critical retail, entertainment, leisure, and cultural facilities, and lifeline infrastructure system services supporting long-term activities

Figure 2-3 A conceptual recovery category framework (FEMA-NIST, 2021).

Table 2. Proposed Functional Recovery Categories and Target Recovery Times

Recovery Category	Recovery Phase	Community Functions or Services	Target Recovery Time	Example Buildings and Infrastructure Enabling Function or Service
A	Immediate	• Public Health and Safety • Telecommunications and Cyber Infrastructure • Healthcare (acute) • Shelter	0-24 hours	Cell Phone Towers; Emergency Operations Center; Fire Stations; Hospitals; Lifelines; Police Stations; Designated Shelters
B	Near Term	• Key Transportation Services • Banking and Finance • Energy and Electricity • Food and Water Resources • Healthcare (outpatient) • Housing	1-6 days	Critical Retail (Grocery Stores, Home Improvement); Nursing Homes; Outpatient Medical; Pharmacies; Residential Water; Transportation Nodes (roads, bridges, ports, runways)
C	Short Term	• Education • Governance • Housing • Local Economy (jobs) • Social Support • Cultural Identity (religious)	1-4 weeks	Courthouses; Daycares; Government Buildings; Lifeline Infrastructure that supports Short Term Functions; Major Regional Employers; Schools and Rec Centers; Single- and Multi-family Residential
D	Long Term	• Cultural Identity (landmark) • Entertainment • Recreation	1 month+	Buildings not assigned to other categories; Historic Buildings; Landmarks; Museums; Night Clubs; Religious Centers; Stadiums; Restaurants; Other Commercial Buildings (small business, retail, etc.); Theaters; Country Clubs

Figure 2-4 A proposed framework for recovery categories and target recovery times (Sattar et al., 2022).

Table B-2 Possible Functional Recovery Times for Different Earthquake Hazard Levels

Functional Recovery Category	Earthquake Hazard Level (Frequency of Occurrence)		
	Frequent (return period of 50-100 years)	Design (return period of 300-700 years)	Maximum Considered (return period of 1,000-3,000 years)
Functional Recovery Category A (FRC-A)	Hours (or less)	Hours (or less)	Days to Weeks
Functional Recovery Category B (FRC-B)	Hours to Days	Days to Weeks	Weeks to Months
Functional Recovery Category C (FRC-C)	Days to Weeks	Weeks to Months	Months to Years
Functional Recovery Category D (FRC-D)	Weeks to Months	Months to Years	Years

Figure 2-5 Matrix of possible variation in recovery times versus hazard level (FEMA-NIST, 2021).

2.4 Session 3: Future Actions: Where Do We Go From Here?

The purpose of Session 3 was to identify future actions and where public and private organizations can go from here in moving functional recovery concepts forward. As part of workshop preparations, participants were asked to submit, in advance, information about ongoing research, design practice, committee, code development, or federal/state/local government program activities related to functional recovery. Information about ongoing activities submitted by workshop participants is provided in Appendix C for future reference. Plenary presentations for Session 3 included:

- A summary of ongoing activities submitted by workshop participants (by S. Dowty).
- A description of an ongoing NIST project using artificial intelligence to develop prescriptive functional recovery design procedures for reinforced concrete moment frame systems (by D. Cook).
- A description of an ongoing NIST project investigating economic considerations for recovery-based design using benefit-cost analysis principles (by D. Cook for J. Fung).
- A description of the ongoing NIST-funded ATC-152 project developing a framework for expected recovery times for lifeline infrastructure system components and assets after earthquake events (by K. Johnson).
- A description of the ongoing FEMA-funded ATC-150 project developing a framework for identifying target lifeline infrastructure system recovery times needed by users (by M. Mahoney).
- A description of an alternative framework for assessing earthquake-induced downtime, and evaluation of the impact of design interventions, using resilience-based metrics such as robustness and rapidity (by C. Molina Hutt).
- An overview of the Structural Engineers Association of Northern California (SEAONC) Resilience Committee plans to evaluate the functional recovery times of code compliant buildings (by J. Valigura).
- An overview of ICC plans for reimagining the ICC Performance Code and opportunities for incorporation of functional recovery performance concepts (by B. Meacham).

Attendees were divided into four stakeholder-specific groups:

- Group 3-A: Federal Government Entities
- Group 3-B: Researchers and Lifelines Professionals

- Group 3-C: Design Professionals
- Group 3-D: Building Officials and State and Local Government Entities

Each group was instructed to answer the following questions:

- How does what was discussed/presented today affect what you are currently working on?
- From the perspective of your stakeholder group, what is the "next step" for functional recovery development, and how does your current work support that development?
- What do you need from your own stakeholder group, and from other stakeholder groups, to advance functional recovery?
- What are actionable items that your stakeholder group can accomplish to advance functional recovery?

Chapter 3
Workshop Findings and Conclusions

This chapter summarizes information provided by breakout groups in each session, followed by a summary of overarching findings and conclusions drawn from the collective information provided by all groups in each session.

3.1 Breakout Session 1: Keys to Measuring Functional Recovery

Breakout Session 1 consisted of three multi-disciplinary groups, each addressing a different occupancy: Group 1-A: Critical Healthcare (RC IV); Group 1-B: Commercial Office (RC II); and Group 1-C: Single and Multi-Family Residential (RC II). The process for answering questions was a graphical exercise. In identifying what is needed for basic function and occupancy, each group was asked to rate the relative importance of key building systems in a PowerPoint template used to record their responses. Results and comments from each group are provided in the sections that follow.

3.1.1 Group 1-A: Critical Healthcare (RC IV)

Group 1-A completed all exercises. Figure 3-1 shows critical healthcare requirements for function, and Figure 3-2 shows critical healthcare requirements for occupancy. Notes and comments from the group included the following:

- The initial default position for critical healthcare occupancies was that all systems were 100% necessary for occupancy and function, and all systems needed to be fully functional.
- Upon reflection, this was considered unrealistic, and it was suggested that 100% functionality for all systems should be considered an aspirational goal.
- It was decided that temporary workarounds (e.g., emergency power, and 72-hour backup supplies) could be used to relax functional and occupancy requirements for selected systems, as depicted in the figures.

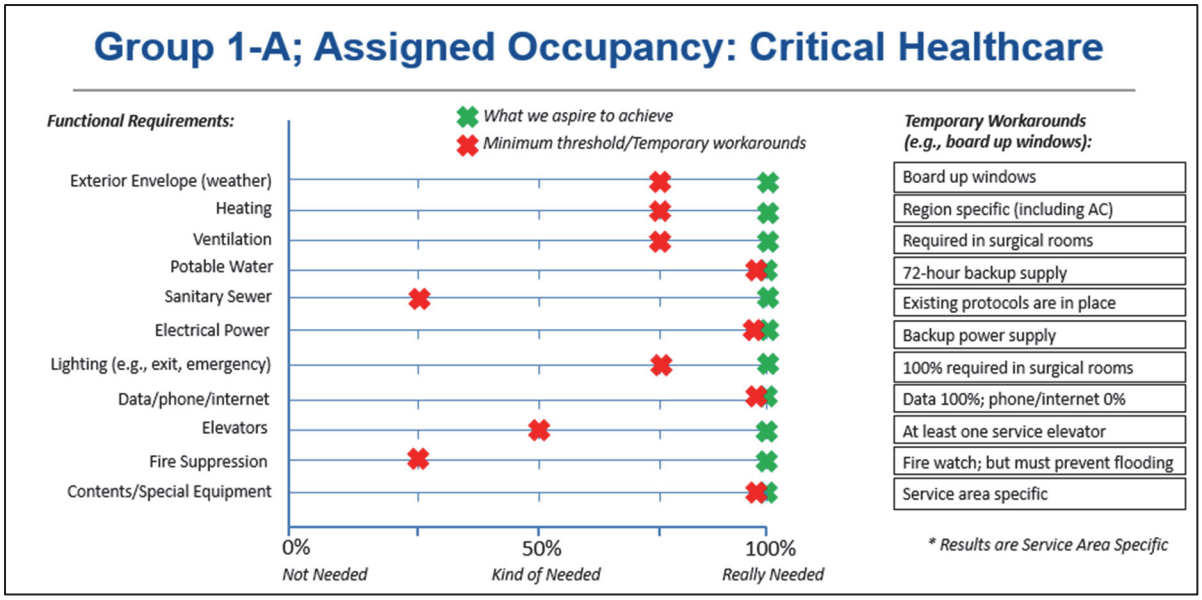

Figure 3-1 Group 1-A: Critical Healthcare requirements for function.

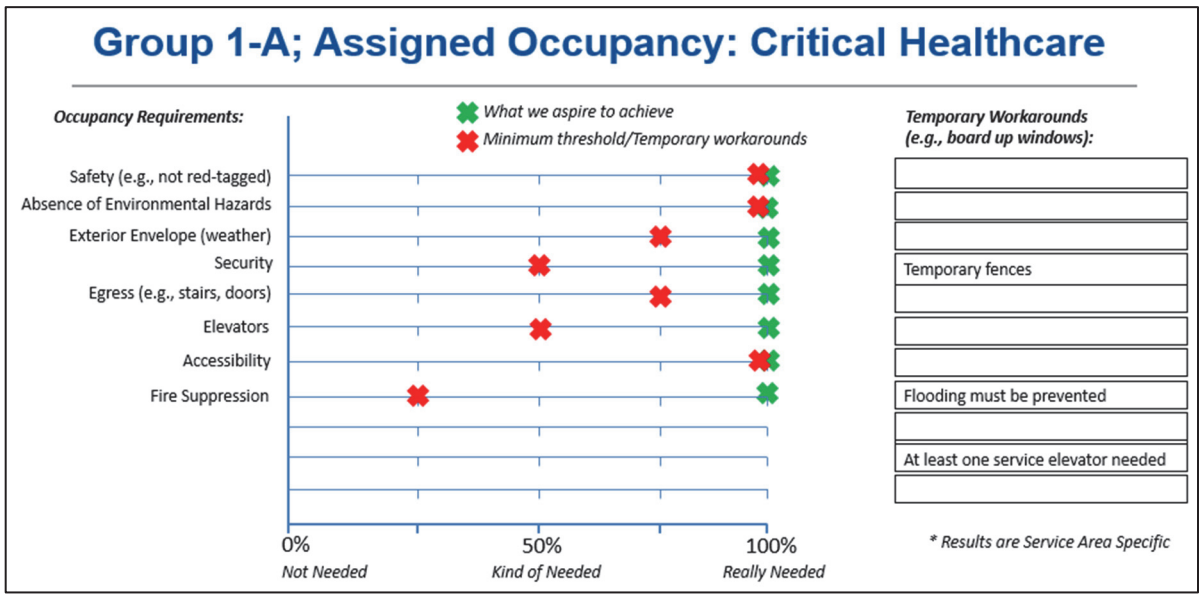

Figure 3-2 Group 1-A: Critical Healthcare requirements for occupancy.

- Answers were specific to different hospital service areas, and certain service areas (e.g., surgical rooms) had higher requirements for functionality.
- The need for heating (and air conditioning) was noted to be region specific.
- Most hospitals are already required to maintain alternative sanitary sewer protocols for unanticipated disruption to normal service, which could be leveraged as a temporary workaround for post-earthquake disruption of

the system, reducing the importance of a fully functioning sanitary sewer system.

- While data was considered 100% necessary, phone and internet were considered separately and deemed 0% necessary.
- Minimum requirements for elevators included one functioning elevator capable of patient transport for both functionality and occupancy.
- Adequate fire watch was considered an acceptable substitute for a functioning fire suppression system, although flooding must be prevented.

Based on the information developed in this exercise, Group 1-A suggested that the basic intended function of a critical healthcare occupancy is to *provide emergency treatment and critical life support after a major earthquake*.

3.1.2 Group 1-B: Commercial Office (RC II)

Group 1-B only had time to discuss functional requirements for commercial offices, and did not address occupancy requirements. Figure 3-3 shows commercial office requirements for function. Notes and comments from the group included the following:

- An initial suggested position for commercial office occupancies was that recent work-from-home lifestyles have shown that a functioning office space may not be completely necessary (at least for some businesses), so if any system was not fully functional, occupants would simply choose to work remotely.
- Further, because people can choose to work at remote locations with limited functionality (e.g., at the beach), it was suggested that many office functions may not really be necessary.
- In contrast, it was suggested that some offices can serve essential business operations and would need to remain functional. If a function could not be replicated somewhere else (e.g., at home), then it should be considered 100% necessary.
- Owners/landlords feel a responsibility to provide basic necessities (e.g., intact exterior envelope; functioning mechanical, electrical, and plumbing systems), and are concerned about the liability associated with allowing work in an environment with damage. From this perspective, most systems would be considered 100% necessary.

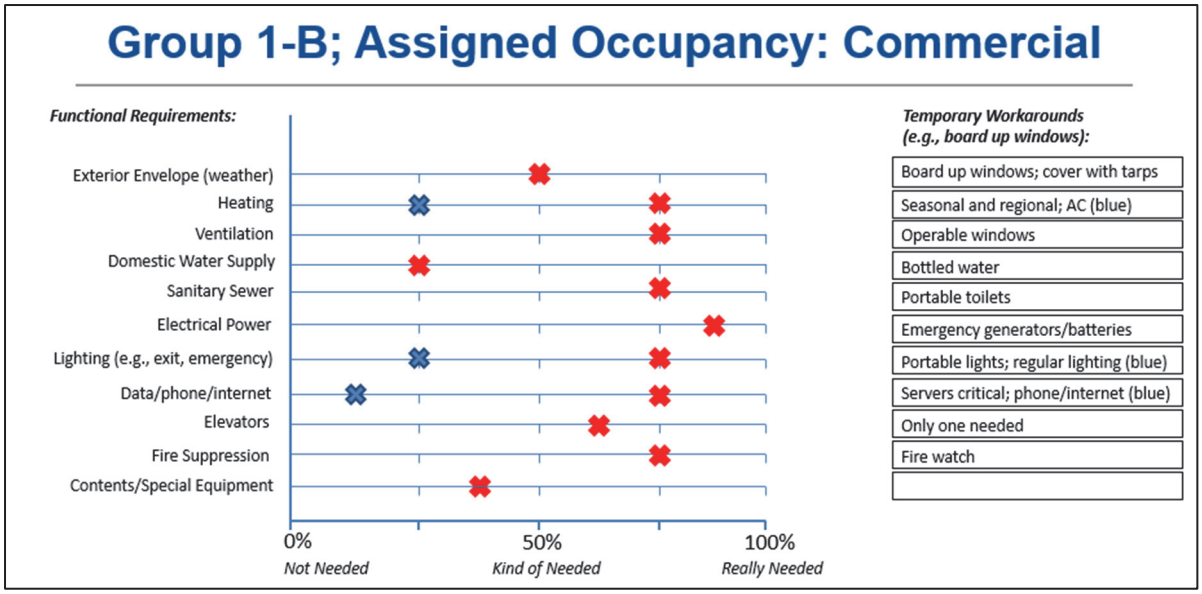

Figure 3-3 Group 1-B: Commercial Office requirements for function.

- In discussing the necessity of each system, it was suggested that temporary workarounds are possible in most cases, and the use of temporary workarounds factored into the relaxation of functional requirements depicted in the figures. "Good enough" was considered an important concept, and it was suggested that limited functionality could also mean capacity for less than full occupancy.
- It was noted that exterior envelope considerations are not just about weather or comfort. In the case of multi-story (i.e., high rise) buildings, there are also safety considerations (e.g., fall protection and fire separation).
- The need for heating (and air conditioning) was noted to be region specific, and air conditioning was considered less important than heating.
- A distinction was made between emergency lighting (75% necessary) and regular lighting (25% necessary), and portable lighting was suggested as a feasible workaround for both.
- Data, phone, and internet systems were considered separately. Data servers were considered important (75% necessary), while phone and internet were considered less important and could be more easily accommodated by temporary workarounds (e.g., use of personal cell phones or outside wifi connections).
- Minimum requirements for elevators included one functioning elevator.
- Fire watch was considered an acceptable substitute for lowering the functional requirement for fire suppression systems.

Group 1-B was not able to come up with a consensus statement defining basic function for commercial office occupancies, but suggested, in general, that basic intended function is *about 80-90% as effective as would normally be the case in the occupancy under consideration*.

3.1.3 Group 1-C: Single and Multi-Family Residential (RC II)

Group 1-C chose to discuss occupancy requirements for residential occupancies, and did not have time to address functional requirements. Figure 3-4 shows multi-family residential requirements for occupancy. Notes and comments from the group included the following:

- The group noted considerable difficulty in quantifying necessary requirements for occupancy without considering other important aspects, such as time frame (i.e., time that occupants would be expected to live without a system or service). A time frame of about one month was chosen for consideration.
- It was noted that answers would be different for single-family versus multi-family residences, and would depend on building height. Multi-family residences, 4-5 stories in height, were chosen for consideration.

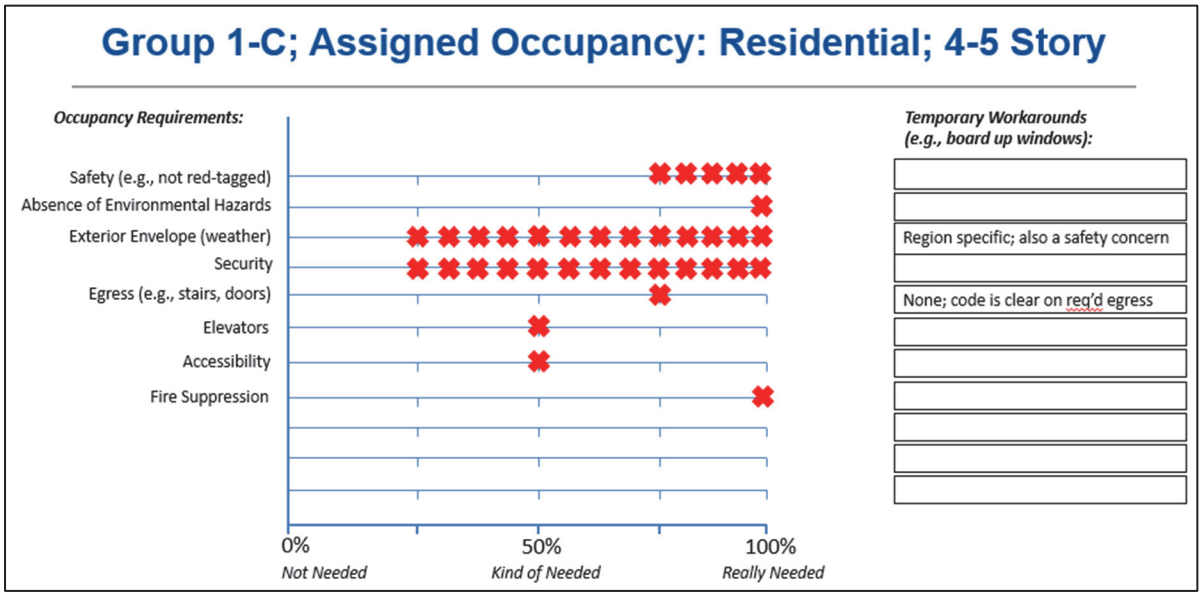

Figure 3-4 Group 1-B: Multi-Family Residential requirements for occupancy.

- In some cases, the group had difficulty agreeing on a single value of importance for certain occupancy requirements, so the range of responses from the group is depicted in the figure (i.e., from 75%-100%, or 25%-100%)

- Weather considerations associated with the exterior envelope were noted as a regional-specific concern. It was further noted that the exterior envelope also includes safety concerns (e.g., fall protection and fire separation).
- It was suggested that the code is clear on egress, and that there is little flexibility in compromising egress requirements related to occupancy.
- The group anecdotally referred to housing studies in Berkeley, California that suggested the need for at least one operational elevator at all times in residential occupancies.
- Regarding accessibility considerations, it was noted that anyone in a given population can become non-ambulatory for a period of time (e.g., sports injury). It was suggested that occupancy of a building should not be restricted solely because a single occupant may be temporarily unable to access upper stories.
- In contrast with the other groups, fire suppression was identified as 100% necessary, even though the existence of temporary workarounds (e.g., fire watch) were discussed.

Group 1-C was not able to come up with a consensus statement defining basic function for multi-family residential occupancies.

3.1.4 Key Themes and Overarching Observations from Session 1

Overarching observations and key themes expressed across multiple breakout groups included the following:

- Prior conversations on necessities for functional recovery, such as the NIST-FEMA Workshops (NIST, 2021) held as part of the development of the FEMA P-2090/NIST SP-1254 special report, have tended to identify almost all systems and services to be important and necessary within a short time frame (i.e., hours or days) following an earthquake event. Similar to these prior conversations, groups tended to identify most functional and occupancy requirements as closer to 100% necessary (with few exceptions). This was the case, even when participants were fully aware of the likely potential for damage in an earthquake, and were presented with information showing the potential for long recovery times (i.e., months) for code-conforming buildings with limited damage.
- With a limited number of exceptions, it proved difficult for groups to decide that it was acceptable for a system to be damaged to the point that functionality was significantly impaired.

- Most groups noted that temporary workarounds are possible for many important functional and occupancy requirements. The existence of an "easy workaround" factored into discussions of reduced level of importance (or necessity), but also complicated the ability to determine an absolute level of importance (or necessity).
- Most groups noted that the need for heating (and air conditioning) was region specific, and that air conditioning was less important than heating.
- Most groups noted that weather considerations associated with the exterior envelope were region specific, and that the exterior envelope included safety concerns (e.g., fall protection and fire separation).
- While access to data (e.g., servers) was considered very important, most groups considered phone and internet separately, and deemed these services to be less important.
- Most groups agreed that adequate fire watch was considered an acceptable substitute for a functioning fire suppression system, although flooding must be prevented.
- All groups suggested that minimum requirements for elevators consisted of one functioning elevator for both functionality and occupancy.

3.2 Breakout Session 2: Hazard Levels and Target Recovery Times

Breakout Session 2 consisted of the same three multi-disciplinary groups (Groups 2-A, 2-B, and 2-C), each addressing the same series of questions in four topical areas. The questions were generally poll-based, intending to capture votes for various options but also capture discussion based on the results of the polls. Every group did not answer every question within each topical area, so responses across all groups are reported for each topical area in the sections that follow.

3.2.1 Topic 1: What Hazard Level(s) Should be used for Functional Recovery Performance Objectives?

Question 1A: If only one hazard level were to be considered for functional recovery performance, which should it be?

Answer choices:

a) Small / Frequent (assume approximate mean return period of 25-100 years)
b) Medium / "Design" level (assume approximate mean return period of 300-700 years)

c) Large / MCE (assume approximate mean return period of 1000-2500 years)
d) A specific scenario event for a given community

In response to the question and answer choices as written, the clear majority of responses supported functional recovery performance being considered only at a singular medium, or "design level," hazard level (assumed approximate mean return period of 300-700 years).

Generalized comments supporting this answer included:

- The "design level" approach is familiar to and understood by those currently involved in the design of buildings, in building code development and enforcement, and in related research and development.
- The "design level" approach would be consistent with, and support the desire for, achieving improved recovery time relative to what is expected from the current life-safety design basis.

Generalized reservations expressed regarding this answer included:

- A "design level" basis for functional recovery may not provide adequate information for community planners, emergency response managers, and other related professionals who often consider MCE or certain scenario events as the basis for pre-disaster planning and post-disaster response.
- Owners and users of buildings and members of the public generally do not understand, and have difficulty relating to, "design level" performance objectives for buildings used for code-based design and enforcement.

Given the plenary presentations by N. Luco and J. Baker that preceded this breakout session, each group also spontaneously discussed a modified question that included an additional answer choice of taking a "risk-targeted" approach to the hazard consideration for functional recovery performance. For the purposes of this conversation, a "risk-targeted" approach was understood to mean that seismic hazard would be selected such that it would provide a desired probability of not exceeding a certain functional recovery time (for example, a certain number of days) when considering the probability of various earthquakes that may occur over the lifespan of a building (for example, 50 years). Most participants were in favor of a "risk-targeted" approach compared to the selection of a singular hazard intensity, and the following generalized comments were provided in support but also with some reservation:

- A "risk-targeted" approach for functional recovery would be consistent with the current approach for code-based building design that applies a specified low risk of collapse due to the effects of earthquakes over a 50-year time frame.
- A "risk-targeted" approach may be a better basis for other professionals to inform pre-disaster planning and to evaluate overall community resilience. Similarly, a "risk-targeted" approach may be a better way to communicate performance to building owners, building users/occupants, and the general public.
- A singular "design level" hazard could be selected as an approach for development of first-generation functional recovery objectives to improve recovery performance of code-conforming buildings, if a "risk-targeted" approach involves additional research and development that cannot be completed within near-term code-development deadlines.

Question 1B: Should multiple hazard level(s) be considered for functional recovery performance?

Answer choices:

a) No; only one hazard level is appropriate
b) Yes, but only for certain buildings
c) Yes, for all buildings

In response to the question and answer choices as written, the responses were generally spread across the three choices, suggesting a slight preference for consideration of multiple hazard levels, at least for some buildings. The distribution of responses likely reflects the "risk-targeted" approach considered for Question 1A, as discussed in more detail below.

The resulting discussion can be summarized with the following observations:

- Responses in support of multiple hazard levels being considered for at least some buildings tended to focus on a desire for targeting acceptable recovery times under different hazard levels for essential service facilities (e.g., Risk Category IV) and other services critical to community recovery, suggesting that adequate recovery times for such services are needed for small, medium, and large earthquakes (even if the targeted times might vary based on hazard level).
- It was generally noted by many participants that a "risk-targeted" approach inherently would address the question by considering all earthquake events, the probability of those events occurring, and the expected recovery time across all earthquake intensities. Even if

recovery times vary based on earthquake intensity, a "risk-targeted" approach would be able to provide a probability of achieving a desired post-earthquake recovery over the life of a building considering the probability of various earthquakes that may occur in that time frame.

Question 1C: If multiple hazard levels were to be considered for functional recovery performance, which one(s) should be explicitly or directly considered and which one(s) should be implicitly or indirectly considered?

Answer choices:

a) Small / Frequent
b) Medium / "Design" level
c) Large / MCE
d) A specific scenario event for a given community

In response to the question and answer choices as written, the clear majority of responses generally supported the concept of using a singular "design level" hazard for explicit code-based functional recovery design provisions and performance objectives. Some responses (although not a clear majority) expressed support for the explicit "design level" to also implicitly meet specific recovery goals at other hazard levels, particularly for a smaller, more-frequent earthquake.

Although a "risk-targeted" approach also considers multiple hazard levels, a distinction was noted between this question and the "risk-targeted" approach being considered in the context of this workshop. This question was generally interpreted to be asking if specific recovery performance objectives should be established at multiple hazard levels and if performance should be explicitly assessed at those hazard levels in the design process, or whether the desired performance at multiple hazard levels could be implicitly achieved through the selection of an appropriate hazard level used in a single explicit design check. In other words, this question was essentially asking whether multiple specific performance objectives envisioned in Figure 2-5 (Table B-2 from the FEMA P-2090/NIST SP-1254 special report) should be established and explicitly checked. The responses were generally interpreted as a majority being in support of establishing and explicitly checking a singular performance objective. A minority also expressed a preference that the explicit performance objective should also provide an implied performance at other hazards, even if not explicitly checked.

The resulting discussion can be summarized with the following additional observations:

- Those in support of performance objectives at multiple hazard levels suggested a desire or preference that the performance objective for explicit code-based design should be selected to implicitly provide adequate recovery for most buildings under smaller earthquakes, and adequate recovery for essential service or recovery-critical buildings under larger earthquakes.
- Although a "risk-targeted" approach would provide a probability of achieving a desired post-earthquake recovery over the life of a building considering the probability of all earthquakes that may occur, the concept of whether adequate recovery time is provided for a specific hazard level under a "risk-targeted" approach may warrant additional consideration and investigation.
- Beyond what might be specified in code provisions, some building owners or some jurisdictions may be interested in explicitly knowing expected performance at alternative hazard levels or regional-specific earthquake scenarios.

3.2.2 Topic 2: How Should Impeding Factors be Addressed in Recovery Time Calculations and in Communicating Results?

Question 2A: Should impeding factors be considered when calculating and reporting functional recovery time and/or when setting functional recovery performance objectives?

Answer choices:

a) Overall
b) By Individual Impeding Factor: post-earthquake inspection; engineering, including hiring, mobilization, design, and permitting; contractor, including hiring, mobilization, and material procurement; financing, including cash on hand and procuring other financing; and long lead time items

For the purposes of discussion, impeding factors were defined as all predecessor activities that need to occur prior to initiation of repair work. In introducing this question, it was discussed that impeding factors are generally outside the control of building designers, and that designers may not be able to accurately or confidently quantify the effects of impeding factors when assessing recovery performance. In response to the question and answer choices as written, the results were mixed, with a slight majority supporting that impeding factors need to be considered, although the discussion included many concerns about how they should be considered, and by whom.

The plenary presentation showing the recovery performance of buildings as measured by the ATC-138 functional recovery methodology (by J. DeBock for C. Haselton) demonstrated that impeding factors overall had a large impact on calculated recovery times, but there was a lack of sensitivity to any one specific impeding factor. Based on this information, all groups chose to avoid consideration of individual specific impeding factors, and instead focused on whether impeding factors should be considered overall.

The resulting discussion can be summarized with the following additional observations:

- The interest in considering impeding factors seemed to be based on a desire to acknowledge that recovery time is indeed a function of both repair time and impeding factors. Similarly, there was a desire to be as transparent as possible in communicating results for anticipated recovery times that will likely better align with actual post-earthquake recovery experiences.
- Many concerns were expressed about the ability to reliably predict the effects of impeding factors, as well as the recognition that most aspects of impeding factors are beyond the control of designers, may be unknown at the time of design, or may change over the life of a building.
- The ability to report repair time separately from impeding factors was considered important because repair time is more easily calculated, tends to have less uncertainty, and is more directly controlled in the design process.
- The difference between considering impeding factors as part of the design process versus considering impeding factors as part of communicating realistic results was discussed.
- Reservations were expressed over the development and implementation of code provisions that require a designer to quantify the effects of impeding factors, unless default values are established for consistent use.
- There was general recognition that once a certain threshold of damage was reached, impeding factors on the order of months would be triggered, and it would not be possible to achieve recovery times on the order of hours, days, or weeks. Therefore, target recovery times will likely need to recognize the impact of impeding factors, with realistic objectives based on the design criteria selected, and the potential likelihood of damage triggering impeding factors (or not).

Question 2B (open-ended): How should the effect of impeding factors (regardless of whether considered or not) be quantified when communicating

functional recovery performance objectives (target times) and/or when reporting results of functional recovery time calculations?

Due to time limitations, no group was able to fully address this question. Instead, most groups noted a common theme:

- It was considered important to develop a clear and consistent way for considering and implementing impeding factors as part of the recovery time calculation methodology. Furthermore, it was considered important to develop a clear and consistent way of communicating recovery time results, which identifies whether impeding factors have been considered and how they contribute to the total expected recovery time. This could be a combination of clear expectations, instructions, and acceptable defaults contained in code provisions, related commentary, best practice guidelines, permitting requirements, and even public-facing education and outreach.

3.2.3 Topic 3: What Should be the Target Functional Recovery Times or Priorities for Various Categories of Buildings?

Question 3A: What level of detail should be used to describe the recovery time associated with different recovery categories?

Answer choices:

a) "Precise" time ranges (e.g., 5-30 days, 1-3 months, 3-12 months, or > 12 months)
b) "Order of magnitude" time ranges (e.g., hours, days, weeks, months, or years)
c) "Generic time" descriptions (e.g., short, medium, or long)
d) "Generic priority" descriptions (e.g., high, medium, or low)

Not all groups were able to answer this question. Using the results from those who did, a slight majority (55%) favored use of "order of magnitude" time ranges, while most of the remaining minority (29%) favored use of "precise" time ranges, and a smaller minority (16%) favored use of "generic time" descriptions.

The related discussion can be summarized with the following observations:

- If "order of magnitude" time ranges are used, it will still be necessary to identify the threshold at which the transition occurs between categories (i.e., after how many "weeks" does the "months" category get assigned?).
- It was noted that if a "risk-targeted" approach is selected, then it might be more meaningful to use probability of meeting or exceeding a certain

recovery time (or range of times). For example, a "risk-targeted" approach would specify the desired probability of not exceeding a certain functional recovery time (e.g., number of days) considering all earthquakes that may occur over the lifespan of a building (e.g., 50 years).

Question 3B: Functional recovery times are probabilistic in nature and can be communicated in different formats. Given the current state of analytical tools and how much they have been tested or validated, what level of detail or confidence should engineers use to express those results?

Answer choices:

a) 50th percentile recovery time for all buildings
b) 50th percentile recovery time for most, but 90th percentile for some
c) 90th percentile recovery time for all buildings

Not all groups were able to answer this question. Using the results from those who did, a slight majority (53%) favored use of 90^{th} percentile for all buildings, while the remaining minority was almost equally split (25% and 22% respectively) between using 50^{th} percentile for most but 90^{th} percentile for some, and 50^{th} percentile for all buildings.

Question 3C: What is the unit of time and rough order of magnitude you would assign to the two categories with the quickest recovery times?

Answer choices for first category (quickest recovery category):

a) Hours (< 72)
b) Days (< 14)
c) Weeks (< 4)
d) Months (< 2)
e) Longer

Answer choices for second category (next quickest recovery category):

a) Days (< 14)
b) Weeks (< 4)
c) Months (< 2)
d) Months (< 6)
e) Longer

Not all groups were able to answer this question. Using the results from those who did, a clear majority favored use of "hours" as the unit of time for the first recovery category (quickest recovery) and a slight majority favored use of "days" as the unit for the second recovery category (although there was less agreement about the threshold number of days to use).

The limited extent of discussion can be summarized with the following observations:

- The category with the quickest recovery time should be benchmarked toward recovery time on the order of hours, even if this might be an aspirational goal, or might require design improvements to achieve that goal. One response advocated for an even better category that could provide effectively zero recovery time.
- It was noted that short recovery times on the order of hours, days, and weeks will require designs that prevent damage triggering impeding factors. It was further noted that the choice of confidence level discussed in Question 3B will affect the ability to achieve shorter recovery times (as shorter recovery times with a higher level of confidence will be more difficult to achieve).
- It was acknowledged that further investigation and discussion is needed regarding the selection, precision, confidence level, and differentiation of target recovery times to be assigned to functional recovery categories.

3.2.4 Topic 4: At What Scale Should Risk be Considered for Functional Recovery Performance Objectives?

Question 4A: At what scale should risk be considered for functional recovery performance objectives?

Answer choices:

a) Individual: Where design parameters are selected such that the performance and risk is considered by the probability of a given building meeting (or not meeting) its target functional recovery time over a given length of time (or specified hazard level).
b) Community: Where design parameters are selected such that the performance and risk is considered by the probability of a given community meeting (or not meeting) its community resilience goals over a given length of time (or specified hazard level).
c) Regional: Where design parameters are selected such that the performance and risk is considered by the probability of a larger region meeting (or not meeting) its regional resilience goals over a given length of time (or specified hazard level).

Due to time limitations, not all groups were able to answer this question nor have a full discussion. Using the results from those who did, there was a slight majority favoring the individual compared to a community scale, with no support for a regional consideration. These results recognize that design happens at an individual building level, and there would be difficulty

developing design criteria that reflects risk at a community scale when different communities have a different compilation of (and therefore different dependencies on) individual buildings. It was considered important to be able to develop minimum design criteria for individual buildings that could be modified (exceeded) by local communities, if needed.

3.3 Breakout Session 3: Future Actions: Where Do We Go From Here?

Breakout Session 3 consisted of four stakeholder-specific groups: Group 3-A: Federal Government Entities; Group 3-B: Researchers and Lifelines Professionals; Group 3-C: Design Professionals; and Group 3-D: Building Officials and State and Local Government Entities, each addressing the same series of questions. Each group independently chose how much time to dedicate and how much detail to offer in response to each question. Responses have been sorted and presented in three basic categories: (1) needs; (2) immediate next steps; and (3) longer-term actions.

3.3.1 Group 3-A: Federal Government Entities

Federal government entities, including the NEHRP agencies (FEMA, NIST, NSF, and USGS) are the primary leaders, supporters, and funders in the development of technical information, policies, and programs that support implementation of functional recovery.

Needs:

- Additional resources are needed. Current funding levels only allow for small, incremental progress without the commitment of future resources. Other stakeholder groups (e.g., state and local government entities, research organizations, and engineering associations) must be the advocates for additional commitment and funding.
- Improved interagency coordination and collaboration, and engagement at the appropriate level within each agency.
- Broader education and advocacy for functional recovery throughout the agencies.
- USGS needs to be involved in discussions on functional recovery intent and implementation to have the full understanding necessary for hazard development.
- NSF needs to be engaged at the appropriate level to make sure functional recovery is on the list of desirable projects so that research can support development of new technologies and methodologies.

- Improved progress on lifeline infrastructure systems.

Immediate Next Steps:

- Explore interagency coordination and collaboration, including: (1) quarterly interagency working group meetings; (2) annual meetings to present progress on functional recovery to agency managers; (3) the ongoing NIST Disaster Resilience Symposium (with NSF); and (4) coordination of funding priorities to identify gaps, needs, and redundancies.
- Pursue functional recovery for new construction (e.g., new buildings), as the "low-hanging fruit" and ideal next step, including:
    - Development of a performance objective consisting of a defined performance state and earthquake hazard (risk-targeted or uniform hazard) as soon as possible.
    - Research and development support for the NEHRP Provisions Update Committee, Functional Recovery Task Committee in the current Provisions update cycle.

Longer-Term Actions:

- Ongoing FEMA support for performance-based design for functional recovery (e.g., ATC-138 Project), including near-term refinement and publication of the completed functional recovery methodology and longer-term monitoring, facilitation, and enhancement of technologies.
- Ongoing FEMA support for the NEHRP Provisions Update Committee, Functional Recovery Task Committee over the 3-5 year duration of the current Provisions update cycle.
- Ongoing USGS support to the NEHRP Provisions Update Committee, Functional Recovery Task Committee to develop appropriate earthquake hazard (possibly including main-shock and after-shock effects) and consideration of other earthquake-induced geologic hazards (liquefaction, surface displacement, etc.) for functional recovery objectives.
- Ongoing NIST support for their Prescriptive Design Project
- Ongoing NIST support for their Benefit-Cost Analysis Project, including extension of functional recovery BCA to the community/regional scale.
- Ongoing NIST support for their Community Resilience Group to establish a link between community resilience (recovery aspect) to functional recovery of individual buildings, including future research on

how recovery of buildings affects recovery at the community/regional scale.

- Work with the Administration to explore possible options for development of functional recovery guidelines for federally owned or leased buildings to lead by example (per the FEMA P-2090/NIST SP-1254 special report)
- Develop and implement a plan for functional recovery of lifeline infrastructure systems, including leveraging current work on the FEMA-funded ATC-150 Project and NIST-funded ATC-152 Project developing frameworks for decision-making, extension to consider transportation, future research on prescriptive versus performance-based approaches, and identification of opportunities for collaboration.
- Develop and implement a plan for functional recovery of existing buildings, which is expected to be more challenging, and may need broader stakeholder support.
- Leverage and promote the adaptation of earthquake-related research, concepts, and solutions for applicability to other hazards.

3.3.2 Group 3-B: Researchers and Lifelines Professionals

Researchers are called upon to develop the fundamental information and technologies necessary for advancement of functional recovery concepts. Lifelines professionals are expected to implement functional recovery priorities within the lifeline infrastructure system context.

Needs:

- Funding for functional recovery fundamental research, and time to conduct research studies.
- More multidisciplinary research activities, including social scientists (equity and disadvantaged populations) and economists (detailed economic analyses of scenario modeling).
- Additional data and information on key aspects of functional recovery, including: benefit-cost models; impeding factors; demand-surge; reoccupancy decisions (so that building officials can make consistent decisions); and updated information on community tolerance for living without services for a period of time.
- Transparency and consistency of assumptions related to data and criteria embedded in different methods for estimating functional recovery.

Immediate Next Steps:

- Forge ahead and start defining functional recovery to answer the question "what do users need and when do they need it?" recognizing that there might be differences for lifelines versus buildings, and for different types of uses or occupancies.
- Mapping exercise to explain what FEMA P-58 damage states impact function, including a collaborative workshop to provide input, development of protocols for how to judge functional impacts, and a taxonomy for organizing and presenting the information.

Longer-Term Actions:

- Data mine past recovery research with a new functional recovery perspective to obtain information on impeding factors, demand-surge, reoccupancy decisions, and updated information on community tolerance.
- Promote open-source tools for estimation of functional recovery and get them into hands of users.
- Collect new functional recovery specific data from structures, both before and after events, and consider the use of social media for collecting information on the experiences of "real" people.
- Develop integrated building-community models to calibrate target performance criteria.
- Create infrastructure (clearinghouse) for sharing functional recovery research and information.
- Support modern-day "librarians" to help navigate repositories (e.g., DesignSafe and SimCenter) because it is difficult to find specific information.

3.3.3 Group 3-C: Design Professionals

Design professionals are involved in code and technology development activities, and are expected to implement functional recovery concepts within the building and non-building structure context. They also serve as a key interface with public stakeholders in the form of owners, developers, and users of the built environment.

Needs:

- Research information on how to achieve functional recovery.

- An understanding of what we are achieving now in terms of expected recovery-based performance using current safety-based design provisions.
- Tools for every-day engineers to apply functional recovery (in common and familiar terms and processes), including simple design improvements that yield meaningful results, and possible tweaks to what we are already doing to improve performance without increasing costs.
- Education for engineers on how to implement functional recovery in practice.
- Education on functional recovery concepts for owners, architects, and contractors, to promote understanding and create allies across the entire project team.
- Invention of better ways to build structural and nonstructural components in buildings to limit potential damage (e.g., drywall partitions, elevators).

Immediate Next Steps:

- Collaborate internally among practitioners through sharing at conferences, committee discussions, word of mouth, and peer-to-peer.
- Benchmark and understand the functional performance of code-conforming buildings.
- Engage in the codes and standards development process (from the PUC, to ASCE 7 and the IBC) to bring minimum functional recovery concepts into building code provisions, appendices, or commentary, as appropriate.

Longer-Term Actions:

- Develop guidelines and best practices.
- Utilize lessons learned from introduction of sustainable design concepts (e.g., LEED).
- Develop advocacy information to facilitate buy-in from owners and developers, including:
    - Justification for why recovery-based performance is desirable and economical (benefit-cost data), and why it would be important to prospective tenants and other users.
    - Quantification of impacts on probable maximum loss (PML) assessments and insurance premiums.

- Specification of uniform, national, and codified criteria and procedures so that everyone is on an "equal playing field."

3.3.4 Group 3-D: Building Officials and State and Local Government Entities

The concept of functional recovery has broad implications to state agencies and local jurisdictions that are actively promoting risk reduction or resilience plans. Those involved in such efforts have been asking how proactive policies affect state and local government agencies and the workload on building departments.

Needs:

- Education for state and local officials and emergency managers on what functional recovery is and how it could work in their jurisdictions, and resources to help answer the questions that will arise.
- Information on costs and benefits, including costs for implementation of functional recovery (who pays), and potential benefits (who receives the benefit), and consequences associated with not doing anything.
- Outreach and communication to broaden stakeholder support, including: (1) information on earthquake risks, vulnerabilities, and expected losses for banking and lending institutions to engage those that can provide the money to do something; and (2) outreach to construction trades and associations that might oppose changes affecting construction costs and affordability, to promote benefits and minimize potential opposition.

Immediate Next Steps:

- Plan to take advantage of opportunities for public policy advocacy in the immediate aftermath of an earthquake (or other natural hazard event) when state and local officials and politicians might be more ready and willing to act. Includes draft legislative actions or pre-prepared programs for mitigating risk before the next disaster.

Longer-Term Actions:

- Incorporate functional recovery provisions for new and existing buildings into building code provisions, appendices, or commentary, as appropriate. Use knobs and levers available to change design requirements (e.g., strength, drift, detailing, bracing) to improve seismic performance.

- Incorporate building and lifeline performance objectives into the ICC Performance Code, and train building departments on implementation of performance-based approaches to design.
- Assess the functional performance provided by the current building code. Communicate the expected performance to the general public, and correct misperceptions on what the building code provides.
- Examine how research and development products are translated into the building code, and look for ways to reduce the time it takes to translate research into practice.
- Develop and promote advocacy materials on why functional recovery is needed, considering what it might mean to each state, and how it relates to all hazards (including wildfire).

3.3.5 Key Themes and Overarching Observations from Session 3

The perspectives of each stakeholder group are unique to their area of emphasis and operation, but certain needs and activities were observed to come up more than once, or cut across multiple groups:

- All groups expressed a need for more information, suggesting a strong coordinated need for additional leadership and funding at the federal level, the conduct of fundamental research, and technical and code development work to support implementation by design and lifelines professionals in buildings and lifeline infrastructure systems.
- Most groups expressed a need for benefit cost procedures and advocacy information, which was considered necessary for making a strong case for implementation to owners, developers, code writers, building officials, politicians, and state and local government entities seeking to create risk mitigation or resilience programs.
- Most groups expressed a need for education on functional recovery concepts and implementation at a multitude of levels (e.g., among federal agencies, state and local government entities, emergency managers, engineering practitioners, other design professionals, and owners, developers, and contractors).
- All groups expressed a desire for uniform, consistent, and codified procedures for recovery-based design (i.e., code provisions), and more than one group expressed a need to benchmark and better understand the functional recovery performance that current code provisions are providing.

3.4 Use of Workshop Findings and Conclusions

Information gathered during this *FEMA-Sponsored Workshop on Functional Recovery* is intended to inspire collaboration and inform future functional recovery efforts by FEMA and other research and development partners, including: other federal, state, and local agencies; research institutions; engineering associations; and codes and standards development organizations.

It is envisioned that detailed discussions of functional recovery concepts in Breakout Sessions 1 and 2 will be used to inform ongoing and future technical development efforts, including, but not limited to, the ATC-138 Project, and the NEHRP Provisions Update Committee Functional Recovery Task Committee. It is further envisioned that information from plenary presentations (Appendix B), and information on ongoing activities from workshop participants (Appendix C) will be used to coordinate among public and private partners at all levels in future functional recovery developmental efforts.

Each group plays a role, and we must all work together in advancing the state of knowledge and practice on improving post-earthquake functional recovery.

Appendix A
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Appendix B
Plenary Presentations

B.1 Introductory Presentations

B.2 Session 1 Presentations

B.3 Session 2 Presentations

B.3 Session 3 Presentations

ATC-137 and ATC-138 Projects

FEMA-Sponsored Workshop on Functional Recovery

August 17-18, 2022

Introduction & Overview

Ryan A. Kersting, S.E., *Buehler*
PUC Functional Recovery Committee Chair

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Welcome and Thank you!

2

Introduction & Overview

Workshop Goals

- Convene individuals & organizations actively involved in developing and advancing functional recovery
- Connect past, current, and future work, with FEMA P-2090 / NIST SP-1254 report, ATC-138 methodology, BSSC/PUC cycle, and other efforts
- Coordinate and collaborate as much as possible
- Converge on common terms, objectives, platforms, & timelines
- Contribute to future action

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Introduction & Overview

~~Workshop~~ YOUR Goals

- Why are you here?
- What does functional recovery mean to you, your practice/research, our collective profession/industry?
- What does functional recovery mean to our communities?
- How can you contribute?

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Introduction & Overview

Workshop Topics

- Session #1: Keys to Measuring Functional Recovery
- Session #2: Hazard Level(s) and Target Recovery Times
- Session #3: Future Actions: Where do we go from here?

Each session has introductory plenary presentations, small group break-out discussions, and reports back

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Introduction & Overview

Functional Recovery

Definition from FEMA-NIST Special Publication:

- *Functional recovery* is a post-earthquake performance state in which a building or lifeline infrastructure system is maintained, or restored, to safely and adequately support the basic intended functions associated with the pre-earthquake use or occupancy of a building, or the pre-earthquake service level of a lifeline infrastructure system.

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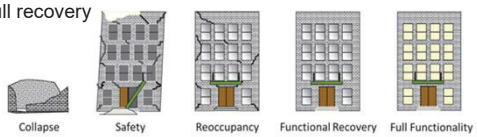
Introduction & Overview

Functional Recovery

Definition from FEMA-NIST Special Publication:

- Functional recovery is one of three recovery milestones beyond basic safety, which include reoccupancy, functional recovery, and full recovery



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Introduction & Overview

Functional Recovery

Definition from FEMA-NIST Special Publication:

- A *functional recovery objective* is functional recovery achieved within an acceptable time following a specified earthquake, where the acceptable time might differ for various building uses and occupancies, or lifeline services.

Functional recovery does not mean "Immediate Recovery" performance for all uses, occupancies, or services.

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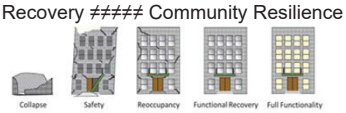
Introduction & Overview

Functional Recovery

- Functional Recovery ~~#####~~ Immediate Occupancy
- Functional Recovery ~~#####~~ Immediate Recovery
- Functional Recovery ~~#####~~ Full Recovery
- Functional Recovery ~~#####~~ ASCE 7 "Functionality"
- Functional Recovery ~~#####~~ Community Resilience



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Introduction & Overview

Why shifting from Life Safety?

- Current codes and standards do not explicitly protect against economic losses nor target performance for return of function
  - 20-40% of modern code-conforming buildings projected to be unfit for occupancy following major earthquake
  - 15-20% economically unrepairable
  - Older buildings perform even worse
- To protect individuals and communities against such losses, a change in codes, standards, construction practices, and societal values is needed (FEMA P-2090 / NIST SP-1254, 2021)

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Introduction & Overview

Why shifting from Life Safety?

- Public wants and expects resilient communities
- Focus on community resilience at all levels of government
- Natural hazard events cost U.S. $100B / year on average
- 2018 NEHRP Reauthorization added focus on community resilience and post-earthquake functional recovery

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Introduction & Overview

Functional Recovery and Community Resilience

- Need a link between community resilience and the design, construction, and retrofit of individual buildings and lifeline infrastructure systems, as measured by time to recovery of function (Bruneau, et al., 2003)
- Functional recovery performance objectives serve as this link

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Introduction & Overview

Functional Recovery and Community Resilience

Functional Recovery : Buildings & Lifelines ::
Community Resilience : Communities

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Introduction & Overview

design, construction, retrofit of **individual buildings**
and lifeline infrastructure systems
for **Functional Recovery**

Resilient Community

has the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse seismic events. [S.1768]

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Functional Recovery - How did we get here?

Many years of effort: research, practice, & policy

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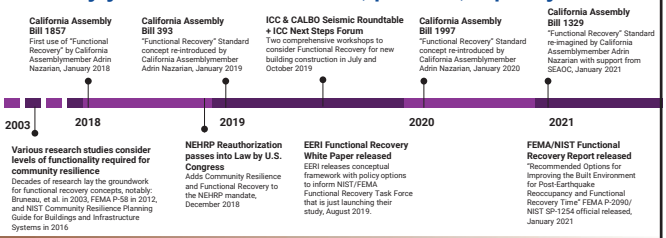
Functional Recovery - How did we get here?

Many years of effort: research, practice, & policy



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Functional Recovery - How did we get here?

Research lays groundwork for Functional Recovery

- Multiple decades (2003+) of notable contributions:
  - Bruneau, et al. in 2003
  - FEMA P-58 in 2012 (and beyond) developed performance-based design tools to measure performance as safety, repair time, and repair cost
  - NIST Community Resilience Planning Guide for Buildings and Infrastructure Systems in 2016

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Functional Recovery - How did we get here?

Structural Engineers Association of California (SEAOC)

- Legislative Efforts advance technical concepts and policy options
  - California Assembly Bill 1857 (2018)
    - First use of "Functional Recovery" term
  - California Assembly Bill 393 (2019)
  - California Assembly Bill 1997 (2020)
  - California Assembly Bill 1329 (2021)

Advocating for "Functional Recovery Standard" to be developed and adopted into California Building Code

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Functional Recovery - How did we get here?

Earthquake Engineering Research Institute (EERI)

- Support of 2018 NEHRP Reauthorization
- Support of various California legislative activities with SEAOC
- 2019 White Paper - "Functional Recovery: A Conceptual Framework with Policy Options" identified four Issue Areas
  - Definitional – What needs to be functional?
  - Policy – What is an acceptable time?
  - Technical – What strategies/criteria will achieve functional recovery?
  - Implementation – How will current practices need to change?

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Functional Recovery - How did we get here?

International Code Council (ICC)

- 2019 ICC-CALBO Seismic Roundtable
- 2019 ICC Next Steps Forum
- "A National Approach to Seismic Functional Recovery for New Construction"
- "Roadmap" for code development for functional recovery for new buildings
- Seismic Functional Recovery Portal
  https://www.iccsafe.org/advocacy/seismic-functional-recovery/

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Functional Recovery - How did we get here?

Additional Functional Recovery Work Current/Ongoing

- FEMA / ATC 138 FR Project
- NIST FR projects
- EQ FR Roundtable
- ICC RC IV Code Change Proposals
- ICC Performance Code re-write
- And more…

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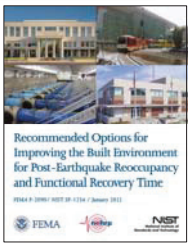
Functional Recovery - How did we get here?

FEMA-NIST Functional Recovery Report

- FEMA P-2090 / NIST SP-1254
- Committee Formed 6/2019
- Stakeholder Workshops 2/2020
- Review Panel Complete 3/2020
- Committee Complete 5/2020
- Published 1/2021



https://www.fema.gov/sites/default/files/documents/fema_p-2090_nist_sp-1254_functional-recovery_01-01-2021.pdf

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FEMA P-2090 / NIST SP-1254

Recommendations

#1: Develop a Framework for Post-Earthquake Recovery-based Objectives
#2: Design New Buildings to Meet Recovery-Based Objectives
#3: Retrofit Existing Buildings to Meet Recovery-Based Objectives
#4: Design, Upgrade, and Maintain Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
#5: Develop and Implement Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
#6: Provide Education and Outreach to Enhance Awareness and Understanding of Earthquake Risk and Recovery-Based Objectives
#7: Facilitate Access to Financial Resources Needed to Achieve Recovery

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FEMA P-2090 / NIST SP-1254

Relevant Recommendations for this Workshop

#1: Develop a Framework for Post-Earthquake Functional Recovery
#2: Design New Buildings to Meet Recovery-Based Objectives
#3: Retrofit Existing Buildings to Meet Recovery-Based Objectives
#4: Design, Upgrade, and Maintain Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
#5: Develop and Implement Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
#6: Provide Education and Outreach to Enhance Awareness and Understanding of Earthquake Risk and Recovery-Based Objectives
#7: Facilitate Access to Financial Resources Needed to Achieve Recovery

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FEMA P-2090 / NIST SP-1254

Relevant Recommendations for this Workshop

#1: Develop a Framework for Post-Earthquake Functional Recovery

#2: Design New Buildings to Meet Recovery-Based Objectives

#3: Retrofit Existing Buildings to Meet Recovery-Based Objectives

#4: Design, Upgrade, and Maintain Lifeline Infrastructure Systems to Meet Recovery-Based Objectives

#5: Develop and Implement Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives

#6: Provide Education and Outreach to Enhance Awareness and Understanding of Earthquake Risk and Recovery-Based Objectives

#7: Facilitate Access to Financial Resources Needed to Achieve Recovery

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FEMA P-2090 / NIST SP-1254

#1: Develop a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives

Tasks:

- Develop a policy for recovery-based objectives
  - Target recovery times for key functions / services
  - May vary for new and existing buildings / systems
- Develop design criteria for recovery-based objectives
  - Separate but parallel for buildings and lifelines
- Determine appropriate hazard level(s)

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FEMA P-2090 / NIST SP-1254

#1: Develop a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives

- What recovery time is needed for what functions and services to meet community resilience goals?
  - Target recovery time is related to when those functions and services are needed in the overall community recovery spectrum

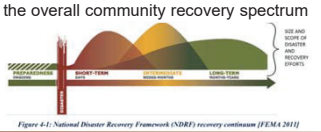

Figure 4-1: National Disaster Recovery Framework (NDRF) recovery continuum [FEMA 2011]

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FEMA P-2090 / NIST SP-1254

#1: Develop a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives

- What recovery time is needed for what functions and services to meet community resilience goals?
  - Not all functions and services need quick recovery, but what are essential or critical to recovery for today's communities?

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FEMA P-2090 / NIST SP-1254

#1: Develop a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives

- What design criteria will achieve desired recovery times?
  - Start with simple approach as comprehensive solutions are developed
  - Use of risk category criteria as interim approach
  - Ultimately envision prescriptive design parameters deemed to meet desired recovery times
    - Recovery-based importance factor, system coefficients and factors (Table 12.2-1), drift limits, structural and nonstructural detailing requirements, utilities, etc.
  - Transition to use of Functional Recovery Categories

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FEMA P-2090 / NIST SP-1254

#1: Develop a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives

Table B-1 Conceptual Functional Recovery Categories for a Design Hazard Level

Functional Recovery Category	Target Functional Recovery Time	Recovery Phase and Associated Functions and Services [1]	Examples of Buildings and Lifeline Infrastructure Systems
Functional Recovery Category A (FRC-A)	Hours (or Less)	Near-Term (Nearly Immediate) and Emergency Response – rescue, safety, security, and event stabilization	Emergency and first-responder facilities (e.g., hospitals, fire and police stations), designated shelters, emergency operations centers, and lifeline infrastructure systems supporting emergency response (e.g., power, communication, critical transportation)
Functional Recovery Category B (FRC-B)	Days to Weeks	Short-Term – shelter, governance, daily necessities, and care for vulnerable populations	Single- and multi-family residential, local government, schools, outpatient medical facilities, nursing homes, critical retail (e.g., food distribution, pharmacy, home improvement), and lifeline infrastructure systems supporting short-term activities
Functional Recovery Category C (FRC-C)	Weeks to Months	Intermediate-Term – restoration of neighborhood activities and economic vitality	Critical business enterprises, possibly exceeding a certain size threshold, and lifeline infrastructure system services supporting intermediate-term activities
Functional Recovery Category D (FRC-D)	Months to Years	Long-Term – cultural, quality of life, and leisure activities	Buildings not assigned to other categories, possibly including less critical business enterprises, less-critical retail, entertainment, leisure, and cultural facilities, and lifeline infrastructure system services supporting long-term activities

Note 1: Recovery phases refer to the FEMA National Disaster Recovery Framework, Second Edition (FEMA, 2016)

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FEMA P-2090 / NIST SP-1254

#1: Develop a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives

- What hazard level(s) should be used for recovery-based objectives?
  - Risk-based?
  - Scenario-based?
  - National, regional, local or individual perspective?

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FEMA P-2090 / NIST SP-1254

#1: Develop a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives

- What recovery times should be targeted for different hazard levels (return periods)?

Table B-2 Possible Functional Recovery Times for Different Earthquake Hazard Levels

Functional Recovery Category	Earthquake Hazard Level (Frequency of Occurrence)		
	Frequent (return period of 50-100 years)	Design (return period of 300-700 years)	Maximum Considered (return period of 1,000-3,000 years)
Functional Recovery Category A (FRC-A)	Hours (or less)	Hours (or less)	Days to Weeks
Functional Recovery Category B (FRC-B)	Hours to Days	Days to Weeks	Weeks to Months
Functional Recovery Category C (FRC-C)	Days to Weeks	Weeks to Months	Months to Years
Functional Recovery Category D (FRC-D)	Weeks to Months	Months to Years	Years

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FEMA P-2090 / NIST SP-1254

#2: Design New Buildings to Meet Recovery-Based Objectives

Alternatives

- Mandate the design of new buildings to meet recovery-based objectives using future national model codes
- Mandate the design of new buildings to meet recovery-based objectives using interim provisions
  - Use of Risk Category IV to achieve quicker recovery for a broader class of buildings
- Encourage the voluntary design of new buildings to meet recovery-based objectives
  - Federal and/or SLTT programs can lead by example and/or provide incentives

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FEMA P-2090 / NIST SP-1254

Coordinated action across all recommendations

Figure 7-1 Interactions among the recommendations.

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FR – Where do we go from here?

BSSC/PUC efforts for 2026 NEHRP Seismic Provisions

- Provisions Update Committee formed 5/22
- Includes specific Functional Recovery Task Committee with five FR topic subcommittees

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2026 NEHRP PUC

Functional Recovery Topic Subcommittees

- TS1: Key Terms and Concepts
- TS2: Functional recovery categories with appropriate ranges and/or precision of recovery time
- TS3: Target functional recovery times for various occupancies/services
- TS4: Prescriptive provisions to meet functional recovery objectives
- TS5: Hazard level(s) applicable for functional recovery objective(s)

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2026 NEHRP PUC

TS1: Key Terms and Concepts

- Leverage FEMA-NIST SP, 2020 NEHRP Resource Paper, ATC-138 project, and other publications or current work
  - What is "Functional Recovery?" What is "Reoccupancy?"
  - What is (or what is needed for) "basic intended function" for various occupancies/services? ("Basic intended function" implies something less than full function)
  - What damage is allowed (relates to achieving Functional Recovery)?
  - What temporary fixes are allowed (relates to achieving Functional Recovery)?
  - What are the post-disaster occupancy/habitability requirements (given a "less than perfect" building) and how does these affect functional recovery requirements?
  - How does availability of utility services (accessed or provided beyond the building footprint) affect functional recovery?

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2026 NEHRP PUC

TS2: Functional recovery categories with appropriate ranges and/or precision of recovery time

- Leverage FEMA-NIST SP, 2020 NEHRP Resource Paper, NIST CRPG, SPUR and other publications or current work
  - How many categories?
  - What is recovery time (or range of time) associated with each?
  - How precise should the time (or range of time) be?
  - Establish targets and precision that represent what engineering can provide or what communities need?

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2026 NEHRP PUC

TS3: Target functional recovery times for various occupancies/services

- Leverage FEMA-NIST SP, Current NIST projects, NIST CRPG, SPUR and other publications or current work
  - What time is needed for what occupancies and services?
  - Establish common minimums that can be modified by local/state priorities
  - Does it have to meet target or just be improved?

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2026 NEHRP PUC

TS4: Prescriptive provisions to meet functional recovery objectives

- Leverage FEMA-NIST SP, ATC-138 project, Current NIST projects, 2020 NEHRP Resource Paper, and other publications or current work to define/address key concepts
  - Study what current design provisions provide in terms of recovery time and test new criteria to meet FR objectives
  - Consider real building designs (reasonable levels of overstrength, redundancy, etc.)
  - Consider use of Risk Category criteria to provide improved functional recovery
  - Can/should also look at recommendations for QA/QC and adaptive solutions
  - What about need for back-up lifeline systems?
  - Pilot study that takes a design from cradle to grave (critical to test the methodology)

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2026 NEHRP PUC

TS5: Hazard level(s) applicable for functional recovery objective(s)

- Leverage FEMA-NIST SP, Current NIST projects, USGS expertise, and other publications or current work to define/address key concepts
  - Similar to current design approach that uses a "design level" as a portion of MCE, that is deemed to provide adequate performance at the MCE as well as some smaller, more frequent events? Or, should specific scenarios for specific communities be considered instead?
  - How does cost-benefit analysis affect hazard level(s) for considering functional recovery?

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2026 NEHRP PUC

Functional Recovery Task Committee

Likely deliverables:

- Part 1/2 – Provisions & Commentary
  - New/Proposed Stand-alone Chapter or Appendix for NEHRP Provisions / ASCE 7 that addresses "Design for Functional Recovery"
- Part 3 – Resources
  - Potential revisions to IBC language and/or new Appendix for IBC to address "Design for Functional Recovery"

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2026 NEHRP PUC

Functional Recovery Task Committee

- Part 1/2 – Provisions & Commentary
  - New/Proposed Stand-alone Chapter or Appendix for NEHRP Provisions / ASCE 7 that addresses "Design for Functional Recovery"
    - Includes key terms/definitions, possibly as additions/revisions to ASCE 7
    - Includes a functional recovery category table (detail TBD)
    - Addresses design criteria, possibly as revisions to / replacement of otherwise applicable sections of ASCE 7
    - Addresses potential QA/QC criteria, possibly as revisions to / replacement of otherwise applicable sections of ASCE 7 or IBC
    - Address potential coordination with other provisions, possibly as revisions to ASCE 7 Chapter 1 and/or IBC

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2026 NEHRP PUC

Functional Recovery Task Committee

- Part 3 – Resources
  - Potential revisions to IBC language and/or new Appendix for IBC to address "Design for Functional Recovery"
    - Potential new Functional Recovery Categories and/or revisions to Risk Categories, presented in "alternative" provisions (but written in mandatory code language) and/or possibly as "code change proposal" language
    - Potential revisions to IBC Table 1604.5 "Risk Category of Buildings and Other Structures" and/or addition of New Functional Recovery Category Table
    - Potential revisions to other sections of IBC Chapter 16 and Chapter 17
    - Potential stand-alone appendix that mimics the Part 1/2 concepts

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FR – Where do we go from here?

Today's Workshop

- Session #1: Keys to Measuring Functional Recovery
- Session #2: Hazard Level(s) and Target Recovery Times
- Session #3: Future Actions: Where do we go from here?

- Today's conversations are aligned with the FEMA-NIST report recommendations and will set the stage for future action, including the upcoming BSSC/PUC cycle

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Thank you!

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ATC-138 Project

Development of an ATC-138 Functional Recovery Methodology: Challenges and Assumptions

FEMA-Sponsored Workshop on Functional Recovery
August 17-18, 2022

Jon A. Heintz
Applied Technology Council

1

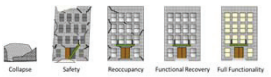
Outline

- Set up for Breakout Session #1 – Keys to Measuring Functional Recovery
  - What is necessary for building function, and what building functional assessment looks like
  - Introduce some key concepts
  - Describe the context, overview, and development of the ATC-138 methodology
  - Identify challenges around defining and measuring functional recovery

2

Key Concepts

- Functional Recovery
  - Recovery to "basic function"
  - More than reoccupancy, but less than full functionality
- Risk-based performance assessment (FEMA P-58)
- Community Resilience versus Functional Recovery
  - Complicated by the interdependency of buildings and lifelines



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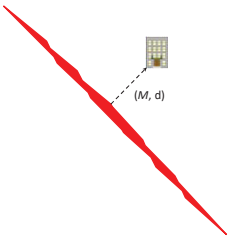
Individual Building



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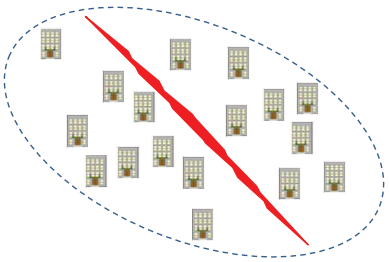
Population of Buildings



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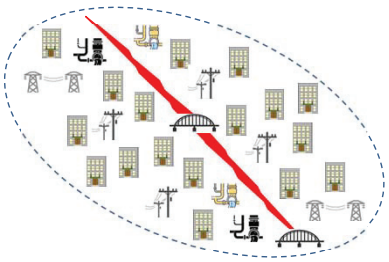
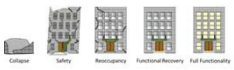
Community



6

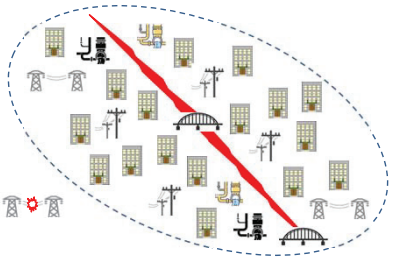
Building and Lifeline Performance

Performance Continuum:



- Damage and Functionality of Buildings

- Functionality of Lifeline Systems
- Ability to Provide Services

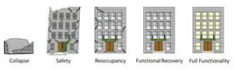


ATC FEMA-Sponsored Workshop on Functional Recovery

7

Component versus Community Performance

Performance Continuum:



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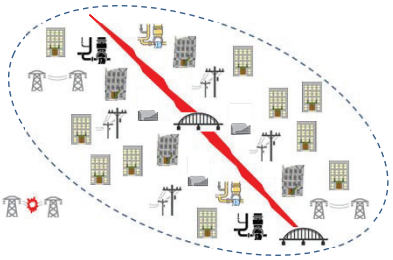

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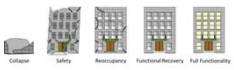
Component versus Community Performance

Performance Continuum:



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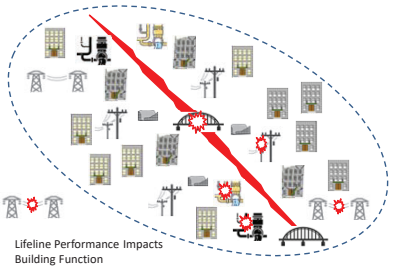

Lifeline Performance Impacts Building Function

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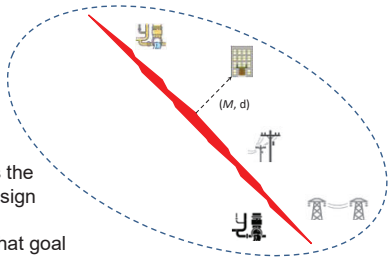
Design of an Individual Building

- Resilience versus Functional Recovery
  - Community Resilience is the goal
  - Functional Recovery is the performance-based design objective that will help communities achieve that goal



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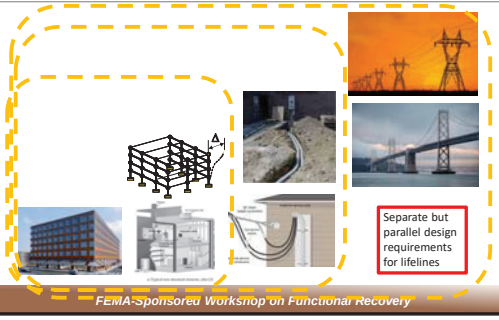
10

Boundaries of consideration



ATC FEMA-Sponsored Workshop on Functional Recovery

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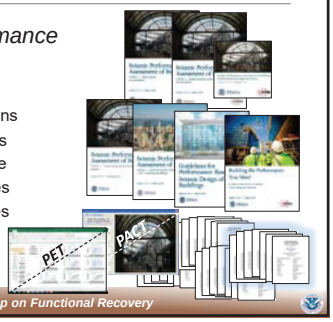
FEMA P-58 (ATC-58 Project)

- FEMA P-58 *Seismic Performance Assessment of Buildings,* (2012, updated in 2018)
  - Volume 1, 2, and 3, Second Editions
  - Volume 4 – Environmental Impacts
  - Volume 5 – Expected Performance
  - Volume 6 – Engineering Guidelines
  - Volume 7 – Stakeholder Guidelines
  - Calc. Tools/Background Docs.

Based on the PEER PBEE Framework, 2004 and 2009



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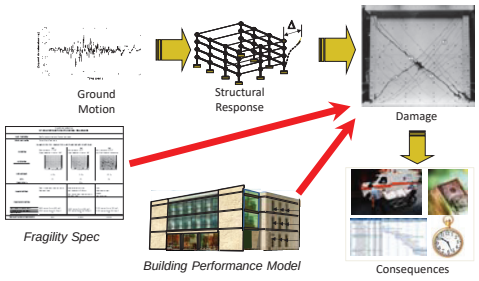
FEMA P-58 Assessment Process



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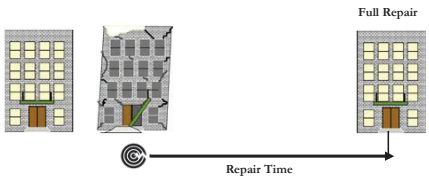
What FEMA P-58 provides



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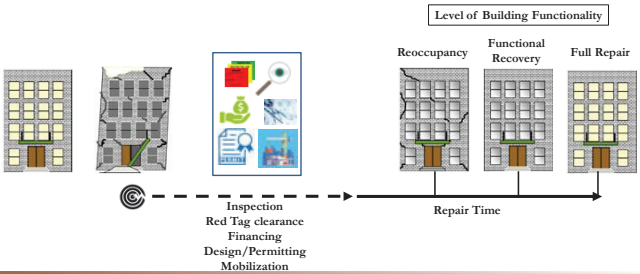
What is needed



15

Key Questions

- What is basic function?
- How long can we live without it?
- At what hazard level?

- What damage impairs function?
- For how long?
- Can we tune designs to achieve desired recovery times?

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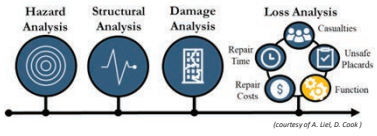
Extension of FEMA P-58 (ATC-138 Project)



- Assessment of Function requires:
  - Update of Unsafe Placard (Red-Tag) logic
  - Update of Repair Time scheduling
  - Assessment of Impeding Times
  - Fault tree logic for functional impacts of damage

Based on the research of A. Liel and D. Cook under a NIST funded grant, 2019

17

Unit of Analysis: Tenant Unit

- Real buildings may consist of more than one occupancy type
- Building Performance models must be adjusted to match the level of detailed needed for assessment
- Fragility Specifications must include damage and consequences related to function

(courtesy of A. Liel, D. Cook)

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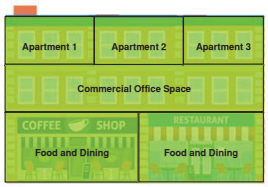
Unit of Analysis: Tenant Unit



FEMA P-58 PG's:
- Components at each level in each direction

FEMA P-58-FR PG's:
- Components at each level in each direction, in each tenant unit

(courtesy of A. Liel, D. Cook)

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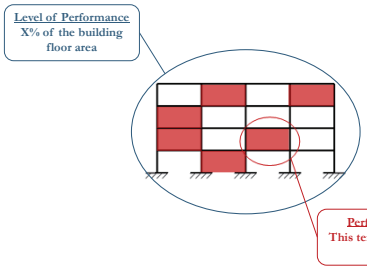
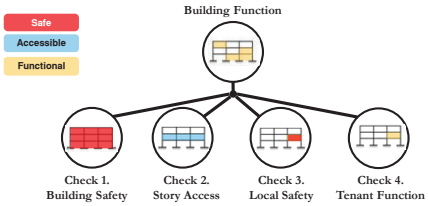
Measure of Performance



(courtesy of A. Liel, D. Cook)

20

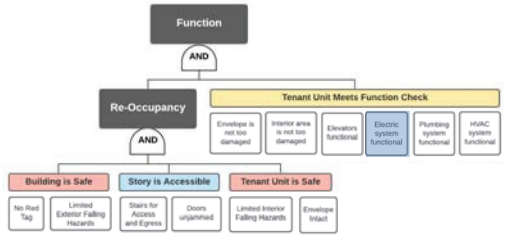
Assessment of Function



(courtesy of A. Liel, D. Cook)

21

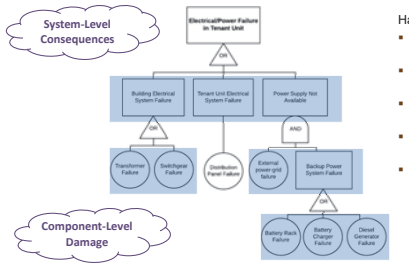
Basic Fault Tree Logic



(courtesy of A. Liel, D. Cook)

22

Mapping Damage to Function - Electrical



Hard Questions:
- What damage impairs function of a system?
- How much damage results in a red-tag?
- How much damage is locally safe/unsafe?
- What access is needed for reoccupancy?
- What systems are needed for basic function?

(courtesy of A. Liel, D. Cook)

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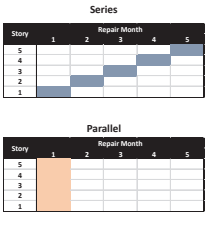
Repairs and Repair Scheduling

- FEMA P-58 Repair Times
  - Series (lower bound)
  - Parallel (upper bound)
- More sophisticated scheduling is needed
  - Consideration of impeding factors
  - Prioritization of repair schedule



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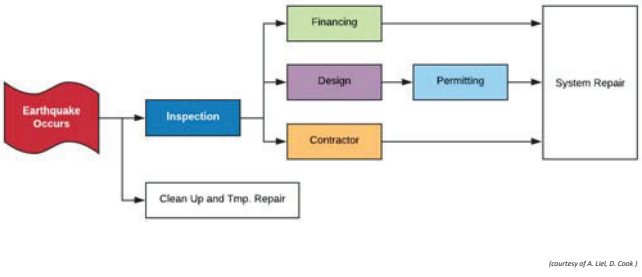
Impeding Factors and Repair Scheduling

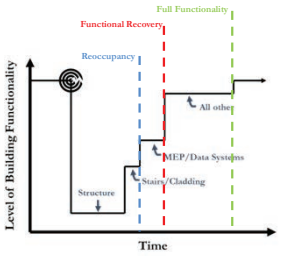


(courtesy of A. Liel, D. Cook)

25

Repair Sequencing

1. Temporary and/or structural repairs necessary for safety
2. Access repairs (stairs, doors, elevators) necessary for occupancy
3. Other repairs necessary for occupancy (fire protection, HVAC, lighting, exterior envelope containment)
4. Other repairs necessary for function (data, tenant special equipment)
5. Nice to have repairs (patch and paint)



26

Summary and Conclusions

- The ATC-138 Project has developed a working (beta) version of a methodology that:
  - Quantifies time to recovery of function
  - Maps component damage to building function through a series of fault trees
  - Identifies reoccupancy, functional recovery, and full functionality as separate repair states
  - Summarizes specific component damage states affecting building function (to aid resilient design)

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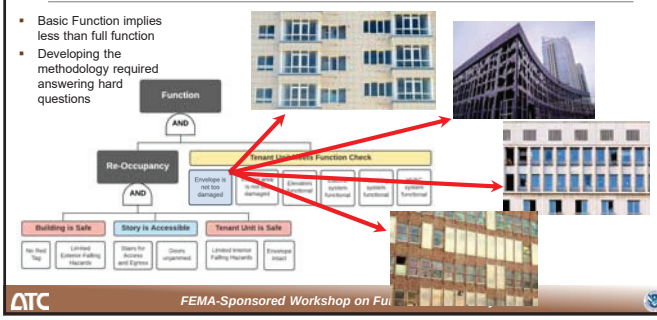
Summary and Conclusions

- It is envisioned that this methodology can be used to:
  - Design buildings to meet functional performance objectives
  - Provide cost-benefit data for decision makers to inform development of functional recovery policy
  - Quantify risk-based prescriptive requirements for functional recovery design in future editions of the building code

28

Back to Breakout Session #1

- Basic Function implies less than full function
- Developing the methodology required answering hard questions



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Back to Breakout Session #1

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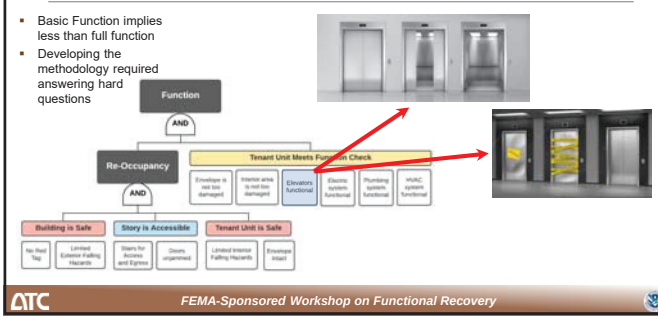

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Back to Breakout Session #1

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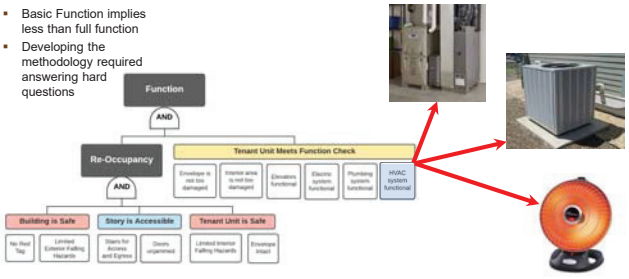

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Thank you!

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Defining Building Uses for a Future Functional Recovery Standard

Burlingame, California
August 17-18, 2022

Jonathan Buckalew,
Nabih Youssef & Associates
(Based on 2020 SEAOC Convention Paper with Anna Lang)

1

Outline

- What is a building's basic intended function?
- What systems are needed for functionality?

2

Basic Intended Function

3

Basic Intended Function

Government services	City hall, post office, embassy, courthouses, police stations, fire stations, libraries, jails/prisons
Health care	Hospital, outpatient care center (doctor's office, dentist, physical therapist, optometrist, etc.), outpatient procedure centers, pharmacies, nursing home, mental health facilities, veterinary, animal shelter
Education	Classroom, day care, cafeteria, labs, assembly building,
Residential	Short term residential (hotels, motels, etc.), multi-family residential (apartment, condos, dormitories), single-family homes, mobile homes, homeless shelter
Cultural and Entertainment	Religious centers, community centers, movie theater, museum, casinos, media production (radio station, music recording, television, etc.), music and performing arts venues, convention center, sporting venues, landmarks, theme parks
Commercial	Retail businesses, service-based businesses, office buildings, grocery store, parking structures, restaurants, warehouse/distribution centers, food processing (wholesale stuff like winery, brewery, etc.), and manufacturing

4

Basic Intended Function

Simple format for definition:
"The basic intended function of _____ is to _____."

The basic intended function of a hospital is to take care of, perform operations on, and help people that are sick or injured.

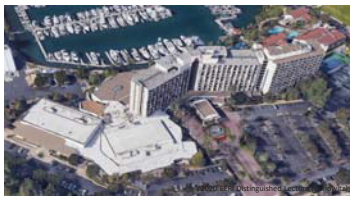
The basic intended function of a restaurant is to prepare and sell food and drinks to customers

Full list of definitions provided in paper

5

Basic Intended Function

- Multiple purposes
- Amenities are not basic intended functions



6

What is needed to function?

Example:

The basic intended function of a single-family home is to provide a habitable space for a family unit.

What is required to function?

How does this change in the post-disaster context?

Need to identify attributes to qualify the status of a building

7

What is needed to function?

Building needs to be safe enough for reoccupancy

- ATC 20 Green Tag

Building needs to be habitable. (FEMA P-2055, ATC-137)

- Environmental hazards
- Building systems/services
- Other issues

8

What is needed to function?

Environmental hazards need to be addressed (FEMA P-2055, ATC-137)

- Carbon monoxide
- Chemical release
- Soot and fumes
- Blackwater, sewage, or mold
- Asbestos, lead-based paint
- Parasites, wild animals, biting/stinging insects
- Debris and refuse

FEMA P-2055 (Figure 4-2)

9

What is needed to function?

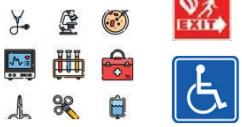
Building Systems/Services

- Sanitation*
- Lighting*
- Electricity*
- Ventilation*
- Heating and cooling*
- Potable water*
- Smoke/CO alarms*
- Fire suppression*
- Phone and internet

*From P-2055

Other issues

- Habitable space*
- Means of egress/escape*
- Security*
- Equipment
- Contents



10

What is needed to function?

Reoccupancy successful (green tag) and environmental hazards have been addressed

Now what systems and **in what capacity** are required for functional recovery?

Building Systems/Services	Other Issues
Sanitation Lighting Ventilation Heating and cooling Electricity Potable water Smoke and carbon monoxide alarms Fire suppression (sprinklers) Phone and Internet	Habitable space Means of egress/escape Accessibility Security Equipment Contents

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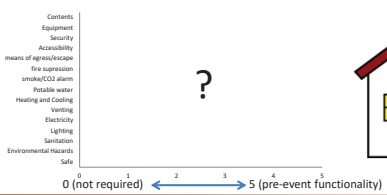
What is needed to function?

Example: single family home

The basic intended function of a single-family home is to provide a habitable space for a family unit.



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What is needed to function?

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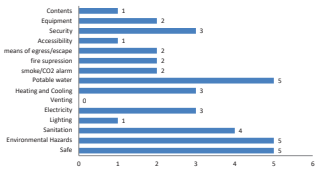


13

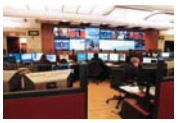
What is needed to function?

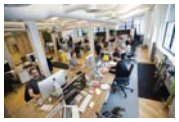
Does that mean we need a bar chart for each type of building?

Many buildings have different basic intended functions, but require the same systems to perform that function

- Emergency Response Center
- Accounting Office

→Lump buildings with similar system requirements into groups





14

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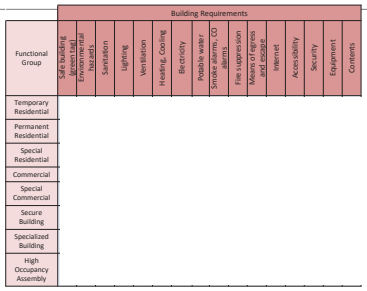
Create "functional groups"

Buildings have different basic intended functions but have similar system requirements:

- Temporary Residential
- Permanent Residential
- Special Residential
- Commercial
- Special Commercial
- Secure Buildings
- Specialized Buildings
- High Occupancy Assembly

15

What is needed to function?



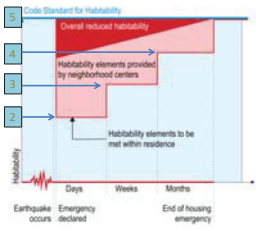
16

What is needed to function?

Temporary standards may be needed to allow functional recovery

- Are temporary workarounds allowed? If so, how long?
- Can building be functional if system are not at pre-event capacity?

See FEMA P-2055 for additional information on temporary standards



Shelter-in-place (SPUR)

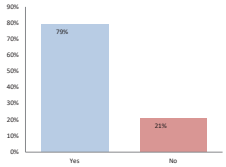
17

What is needed to function?

FEMA P-2055 webinar survey

Scenario 1 – domestic sewer and water service to an apartment are lost due to damaged infrastructure, but the building is otherwise fine

Q1. If the owner or the city provides portable toilets, water supplies, and community showers, can the building stay open?



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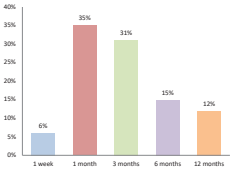
What is needed to function?

FEMA P-2055 webinar survey

Scenario 1 – domestic sewer and water service to an apartment are lost due to damaged infrastructure, but the building is otherwise fine

Q2. If this is acceptable initially, how long can this continue until a return to permanent standards is required?



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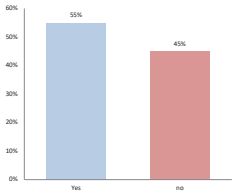
What is needed to function?

FEMA P-2055 webinar survey

Scenario 2 – An earthquake damages the fire sprinklers in a hotel, so they don't work, but structurally the building is not compromised, and power is on, so no one needs to use candles to see.

Q1. Should the building official close the hotel?



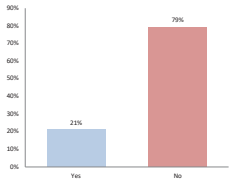
20

What is needed to function?

FEMA P-2055 webinar survey

Scenario 2 – An earthquake damages the fire sprinklers in a hotel, so they don't work, but structurally the building is not compromised, and power is on, so no one needs to use candles to see.

Q2. Should the hotel management be able to make the decision?



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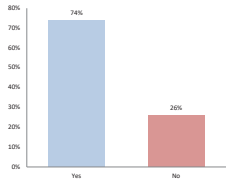
What is needed to function?

FEMA P-2055 webinar survey

Scenario 2 – An earthquake damages the fire sprinklers in a hotel, so they don't work, but structurally the building is not compromised, and power is on, so no one needs to use candles to see.

Q3. Can the hotel remain open if the hotel informs guests of the situation, sets up a fire watch by staff, and has extinguishers in place?



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Conclusion

- Basic Intended Function
  - Simple definition
  - Separate from amenities
- There is a discrete set of system requirements for a building to perform its basic intended function

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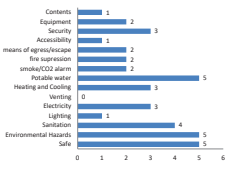
Conclusion

Qualitative values for building systems → Qualitative Definitions → help inform code provisions?
→ Temporary Standards



Qualitative Table

sanitation (toilets and showers)

- 0 – showers and toilets not required
- 1 – toilets required, showers not required, service can be provided externally
- 2 – toilets and showers required, acceptable to have outside of building
- 3 – toilets and showers required inside building (25% capacity)
- 4 – toilets and showers required inside building (50% capacity)
- 5 – toilets and showers required inside building (100% capacity)

Qualitative Definitions

Sanitation (toilets and showers)

- 0, 1 – Code provisions ##.###
- 2, 3 – Code Provisions ##.###
- 4 – Code Provisions ##.###
- 5 – Code Provision ##.###

Code Provisions

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ATC-138 Functional Recovery Project

Building Reoccupancy and Recovery Times as Measured by the ATC-138 Functional Recovery Methodology

Work by: Ed Almeter, Laxman Dahal, D. Jared DeBock, Curt Haselton, Abbie Liel (and Dustin Cook via NIST collaboration)

Presented by: D. Jared DeBock, PhD, PE

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Functional Recovery Workshop | August 17-18, 2022

1

Purpose of this Presentation

Purpose of Talk: Provide seed information for the Session #2 breakout discussions.

Session #2: Hazard Level(s) and Target Recovery Times

Small Group Break-out Discussions:

- Topic 2A (35 min): What hazard level(s) should be used for FR performance objective(s)? (What is appropriate amount of consideration for FR at various hazard levels?)
- Topic 2B (30 min): What should be the target FR times or priorities for various occupancies (and for different hazard levels)?
- Topic 2C (30 min): How should impeding factors be addressed in recovery time calculations and in communicating results?

2

Overview

Focus of Talk: Show estimated functional recovery times (and reoccupancy times) for new buildings. Times based on FEMA P-58 with recent ATC-138 Functional Recovery Methodology extension.

Overview of Topics:

- Building/site text matrix (592 buildings shown here)
- Functional recovery time results for modern buildings
  - ✓ Individual building examples
  - ✓ Results for all buildings (average and variability)
  - ✓ "Common offenders" (which building systems/components are damaged)
- Sensitivity assessments:
  - ✓ Methodology components (e.g. if we include impeding times)
  - ✓ Design aspects (e.g. RC II vs. RC IV)
- Summary/discussion

3

Building Test Matrix: Building Types

Structural System	Age	Occupancy	Risk Category	Stories
Wood Light Frame	New	Residential	II	1, 2
Wood Light Frame	New	Residential	II, IV	5
Wood Light Frame	New	Office	II, IV	5
Precast Concrete Tilt-Up	New	Warehouse	II, IV	1
Precast Concrete Tilt-Up	Pre-NR	Warehouse	II, IV	1
Steel Perimeter Moment Frame	New	Office, Healthcare	II, IV	3, 5, 12, 20
Steel Perimeter Moment Frame	Pre-NR	Office	II, IV	5, 12
Steel BRBF, no back-up frame	New	Office	II, IV	5, 12
Steel BRBF, with back-up frame	New	Office	II, IV	5, 12
Steel Concentric Braced Frame	New	Office	II, IV	5, 12
Reinforced Concrete Moment Frame	New	Office, Residential	II, IV	5, 12
Reinforced Concrete Moment Frame	Pre-1971	Office	II	5, 12
RC Shear Wall (coupled in one direction)	New	Office, Healthcare	II, IV	3, 5, 12, 20
RC Shear Wall (coupled in one direction)	New	Residential	II, IV	5
RC Cantilever Shear Wall	Pre-1971	Office	--	5, 12

4

Building Test Matrix: Site Locations

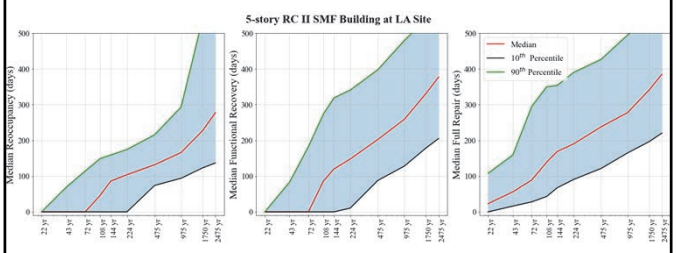
City	State	Site Class	S_s [g]	S_1 [g]	SDC	Lat	Long	FEMA 570 Site ID	Return Period @ DE (years)	Return Period @MCE (years)
Los Angeles	California	D	2.40	0.84	E	34.05	-118.25	1	581	1356
Riverside	California	D	1.50	0.60	D	33.95	-117.40	6	330	839
San Francisco	California	C	1.50	0.64	D	37.75	-122.40	16	415	986
San Diego	California	D	1.25	0.48	D	32.70	-117.15	9	--	
Oakland	California	D	1.86	0.75	D	37.80	-122.25	12	--	
Sacramento	California	D	0.67	0.29	D	38.60	-121.50	15	--	
San Jose	California	D	1.50	0.60	D	37.35	-121.90	18	--	
Seattle	Washington	C	1.37	0.53	D	47.60	-122.30	22	--	
Portland	Oregon	D	0.98	0.42	D	45.50	-122.65	25	--	
Salt Lake City	Utah	D	1.54	0.56	D	40.75	-111.90	26	--	
St. Louis	Missouri	C	0.44	0.17	C	38.60	-90.20	30	--	
Memphis	Tennessee	D	1.01	0.35	D	35.15	-90.05	31	--	
New York	New York	C	0.28	0.07	B	40.75	-74.00	34	--	
Anchorage	Alaska	D	1.50	0.68	D	61.22	-149.90	--	--	
Hilo	Hawaii	C	1.50	0.60	D	19.71	-155.09	--	--	
Average									**442**	**1060**

592 building cases run. Baseline plots are for new RC II buildings at three high seismic sites (LA, Riverside, SF), and variations are noted.

5

Results for Individual Buildings: New Steel Moment Frame

Take Away: Low times at SLE (just for median), several months at DE, a year at MCE.



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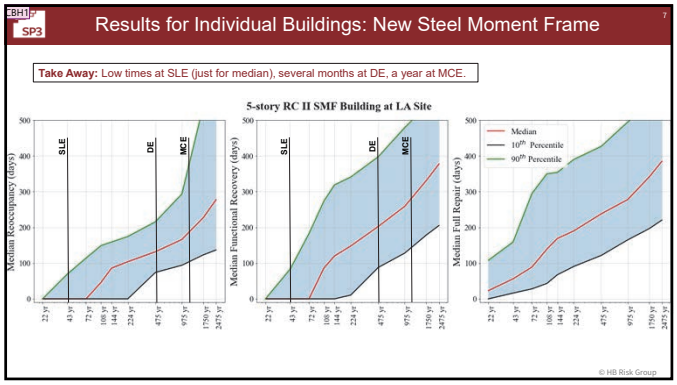
SP3
Results for Individual Buildings: New Steel Moment Frame
7
Take Away: Low times at SLE (just for median), several months at DE, a year at MCE.
5-story RC II SMF Building at LA Site
Median Reoccupancy (days)
Median Functional Recovery (days)
Median Full Repair (days)
SLE
DE
MCE
Median
10th Percentile
90th Percentile
© HB Risk Group

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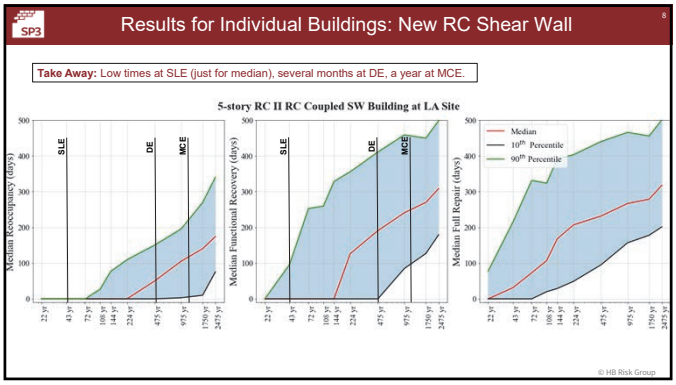
SP3
Results for Individual Buildings: New RC Shear Wall
8
Take Away: Low times at SLE (just for median), several months at DE, a year at MCE.
5-story RC II RC Coupled SW Building at LA Site
Median Reoccupancy (days)
Median Functional Recovery (days)
Median Full Repair (days)
SLE
DE
MCE
Median
10th Percentile
90th Percentile
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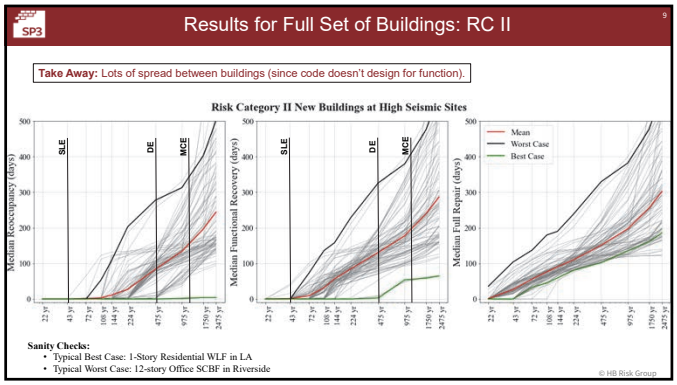
SP3
Results for Full Set of Buildings: RC II
9
Take Away: Lots of spread between buildings (since code doesn't design for function).
Risk Category II New Buildings at High Seismic Sites
Median Reoccupancy (days)
Median Functional Recovery (days)
Median Full Repair (days)
SLE
DE
MCE
Mean
Worst Case
Best Case
Sanity Checks:
• Typical Best Case: 1-Story Residential WLF in LA
• Typical Worst Case: 12-story Office SCBF in Riverside
© HB Risk Group

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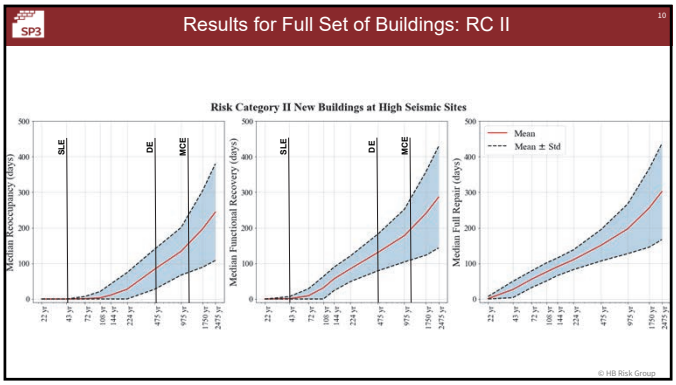
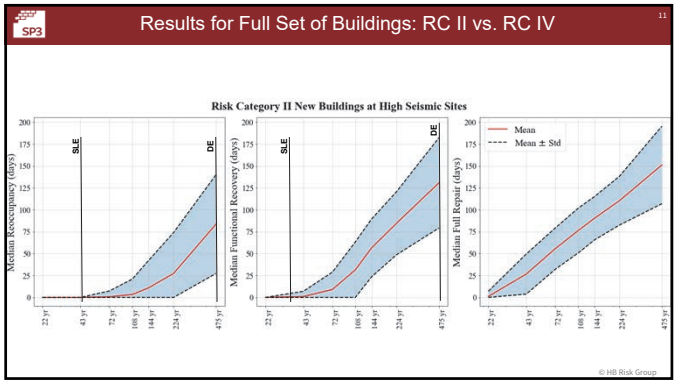

SP3
Results for Full Set of Buildings: RC II
10
Risk Category II New Buildings at High Seismic Sites
Median Reoccupancy (days)
Median Functional Recovery (days)
Median Full Repair (days)
SLE
DE
MCE
Mean
Mean ± Std
© HB Risk Group

10


SP3
Results for Full Set of Buildings: RC II vs. RC IV
11
Risk Category II New Buildings at High Seismic Sites
Median Reoccupancy (days)
Median Functional Recovery (days)
Median Full Repair (days)
SLE
DE
Mean
Mean ± Std
© HB Risk Group

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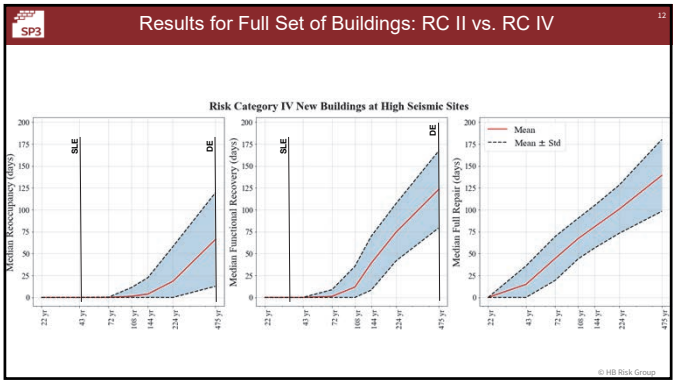
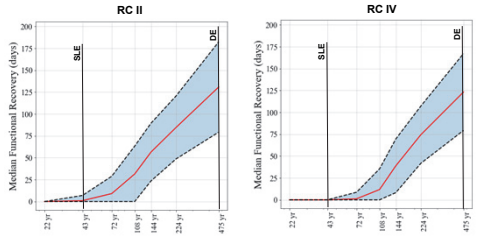

SP3
Results for Full Set of Buildings: RC II vs. RC IV
12
Risk Category IV New Buildings at High Seismic Sites
Median Reoccupancy (days)
Median Functional Recovery (days)
Median Full Repair (days)
SLE
DE
Mean
Mean ± Std
© HB Risk Group

12

Results for Full Set of Buildings: RC II vs. RC IV

13

Take Away: Risk Category IV delays the onset of damage around SLE, but results similar at DE (and MCE) levels.

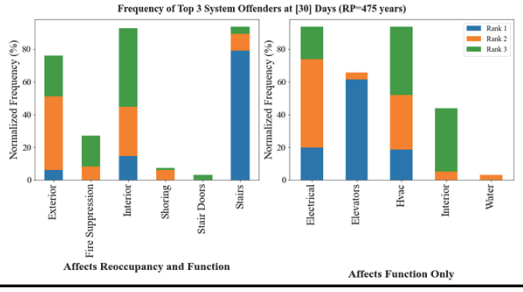


13

Most Frequent System/Component "Offenders"

14

Take Away: FEMA P-58/ATC-138 identifies system causing issues, so they can be designed resiliently.



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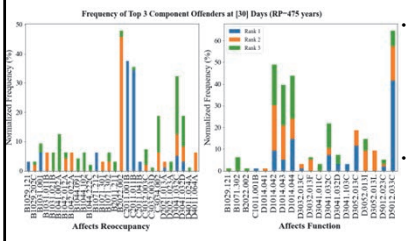
Most Frequent System/Component "Offenders"

15

Take Away: FEMA P-58/ATC-138 also identifies the specific components causing issues, so they can be designed resiliently.

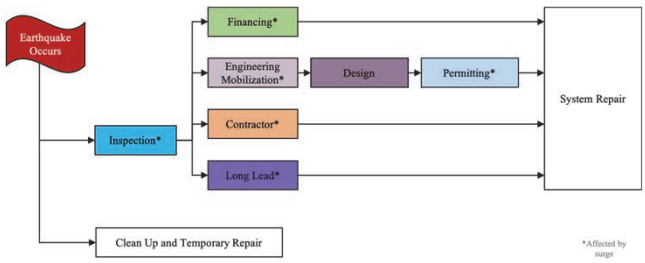


- Reoccupancy offenders (ordered, mostly falling hazards):
  - Stairs when no seismic joint (C2011.xx)
  - Curtain/exterior walls (B2022/B1071)
  - HVAC components (C3041)
  - Pendant lighting (C3034.002)
  - Suspended ceilings (C3032.003c)
- Functional Recovery (ordered):
  - Electrical distribution panel (D5012)
  - Elevators (D1014)
  - HVAC components – ducting, drops, VAV boxes (D3041)
  - Air handling units (D3052)
  - Cooling tower (D3031)
  - Exterior walls (B1071)

15

Sensitivity to Methodology Components

16

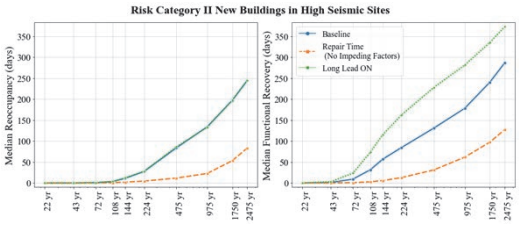


16

Sensitivity to Method Components: Impeding and Long-Lead

17

Take Away: Impeding factors and long-lead items increase recovery times substantially.

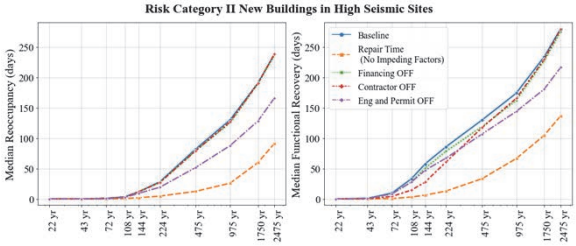


17

Sensitivity to Method Components: Specific Impeding Times

18

Take Away: Impeding factors are mostly in parallel, so you get most of the effect even if you turn some off.



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Sensitivity to Method Components: Cash-on-Hand Before Loan

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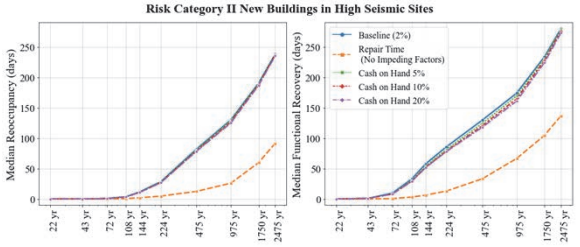
Take Away: Financing details generally don't control (permitting/design/contracting does).



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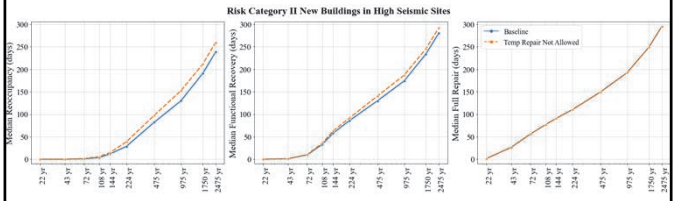
Sensitivity to Method Components: Temp. Repair Allowance

20

Take Away: Allowing temporary repairs reduces recovery times some. Important caveat is that the impact depends heavily on what is allowed to be temporarily repaired to regain basic function; if we are more permissible with what can be resolved with temp repair, then recovery times would be much lower between at SLE and even some DE levels.



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Trends for Building Design

21

How do some occupancy and design items affect results?

- RC II vs. IV
- New vs. Old buildings
- Occupancy (residential vs. commercial office)

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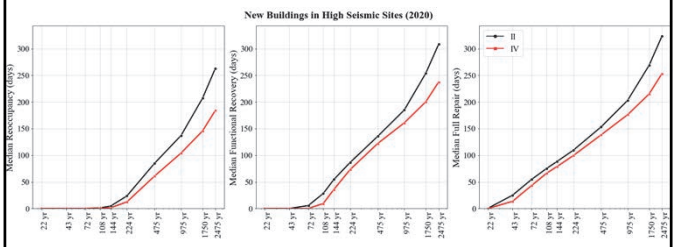
Trends for Building Design: Risk Category II versus IV

22

Take Away: RC IV delays onset of FR issues (near 72yr to 108yr), but then results are similar for DE and MCE.



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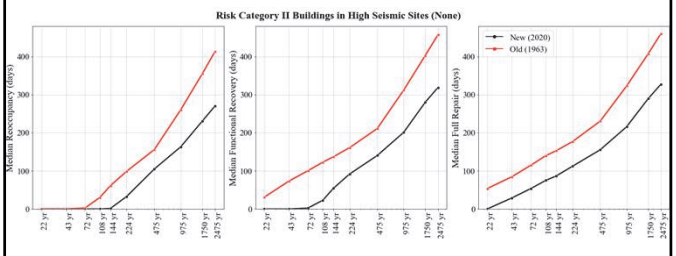
Trends for Building Design: Old vs. New Buildings

23

Take Away: New buildings are better (but we didn't need to tell you that).



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Trends for Building Design: Occupancy

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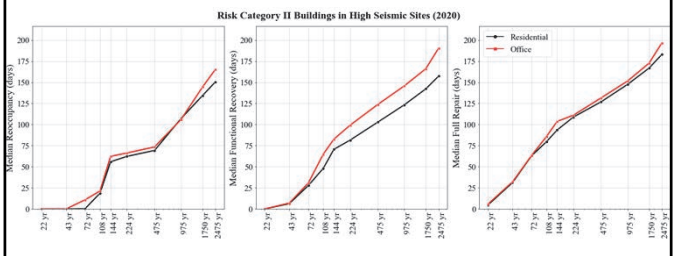
Take Away: Similar results, with residential slightly better because more damage is allowed.



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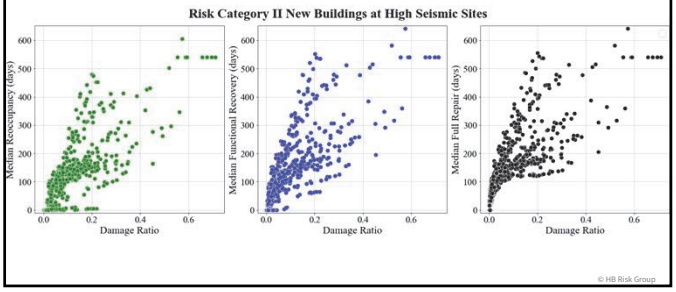
Recovery Times vs. Damage Ratio



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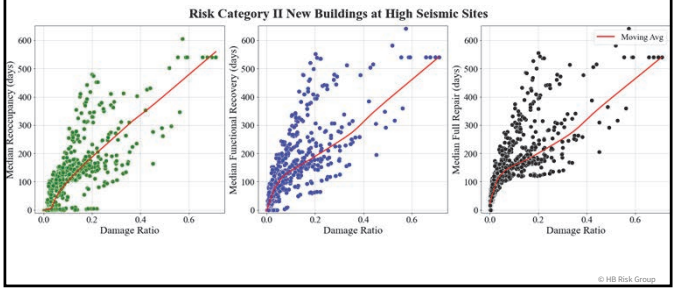
Recovery Times vs. Damage Ratio



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Results for a Real Project (Mar Structural Design)

Take Away: New practitioner design (RC wall lab building) was also taken through this process (full RHA). Results are comparable to what we have shown for main 592 building study. FEMA P-58/ATC-138 is enabling resilient design for this project by identifying which specific components need more resilient design.

27

Summary

- ATC-138 has extended the FEMA P-58 analysis method to now modeling/estimate functional recovery time (and reoccupancy times).
- Results for code-compliant buildings vary widely building-to-building and site-to-site (because the code doesn't try to design for function). Typical average values for high-seismic CA sites are:
  - ✓ SLE: Current code design delivers near-immediate occupancy/function for most systems
  - ✓ DE: Several months of recovery time (so need more resilient design to have quick recovery at DE)
  - ✓ MCE: Long recovery (but probably not the focus of FR design)
- Impeding factors have important influence in the estimated recovery times (so please discuss how to handle them in Breakout #2c!).
- Risk Category IV delays onset of damage and function issues (near SLE), but doesn't help much once we get to DE and MCE levels.
- Results are similar for a current practitioner design (and this methodology is already being used to inform resilient design as we speak).
- Looking toward the future, FEMA P-58/ATC-138 studies like this can be use to both inform FR acceptance criteria, and also to calibrate what prescriptive design requirements would meet FR goals.

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Recovery Categories and Target Recovery Times for Development of a Functional Recovery Framework

Siamak Sattar, Katherine Johnson, Dustin Cook

FEMA-ATC Workshop on Functional Recovery
August 17, 2022, Burlingame, CA

1

Motivation:

Recommendation 1:

Develop a Functional Recovery Framework

New design paradigm: designed to meet specific **recovery time goals** at a specified hazard level
- Design Criteria
- Policy for ***recovery-based objectives***
- Appropriate hazard level

Recovery Category (RC)	Target Recovery Time
RC-4	Hours
RC-3	Days
RC-2	Weeks
RC-1	Months

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Outline

- Background
- Stakeholder Workshops- Winter 2020
- Preliminary framework for Recovery Categories and Timeframes
- 12NCEE Special Session- Summer 2022
- Thoughts and next steps?

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Establishing Recovery Goals: Previous Efforts

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Community-Level Goals

- Specific performance goals for community services within a region to prevent permanent out-migration of population or other community well-being metrics
- Examples: SPUR, Oregon Resilience Plan, Resilient LA, Resilient SF, CRPG

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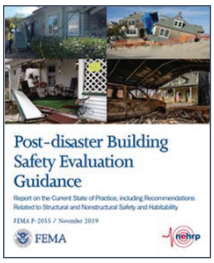
Building-Level Goals

- Specific performance goals targeting temporary use and habitable space of an individual building to prevent permanent dislocation of building tenants
- Example: FEMA P-2055



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Example Recovery Goals

Document	Target	Hazard	Service	Example Recovery Goal
FEMA P-2055	Building-level habitability	Unspecified Event	Utilities	Operational within 30 days
			HVAC	Operational within 90 days
			Egress	Conforming in 90 days
SPUR	Community-level recovery	Mw 7.2 San Andreas Earthquake	Residences	95% provide shelter in 24 hours, 100% in 4 months
			Businesses	90% open in 30 days, 95% in 4 months, 100% in 3 years
			Schools	Open in 30 days
			Lifelines	90% recovered in 72 hours, 95% in 4 months, 100% in 3 years

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Example Recovery Goals

Document	Target	Hazard	Service	Example Recovery Goal
FEMA P-2055	Building-level habitability	Unspecified Event	Utilities	Operational within 30 days
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			Schools	Open in 30 days
			Lifelines	90% recovered in 72 hours, 95% in 4 months, 100% in 3 years

What's needed for functional recovery?

- Asset-level functional recovery goals

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Stakeholder Workshops supporting development of the NIST-FEMA Functional Recovery Report

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National Input on Functional Recovery

- Workshops Jan-Feb 2020
- 5 locations:
  - St. Louis, MO
  - Salt Lake City, UT
  - Seattle, WA
  - San Francisco, CA
  - Los Angeles, CA

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Workshop Participation

- About70 attendees
- Representation from private sectors, academia, local, state, and federal governments, and non-profit organizations
- Range of areas of expertise across engineering, social science, policy, and planning communities

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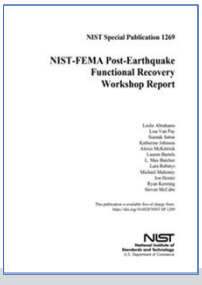
Workshop Objectives

- Explore *acceptable recovery times* for various components of the built environment
- Investigate potential criteria for assessing and/or evaluating the proposed options for improving functional recovery


NIST Special Publication 1269

NIST-FEMA Post-Earthquake Functional Recovery Workshop Report

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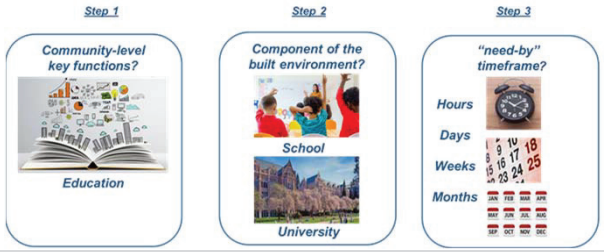
Defining Acceptable Recovery Times



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Stakeholder Workshop Takeaways

Timeframes: Designate recovery time frames based on needed functions (rather than only components); participants described the recovery time categories fairly consistently

Future work: Participants wanted additional research across broader audiences to define acceptable recovery times

Draft Conceptual Basis for Framework

Recovery Time	Function
Hours	life safety, emergency response, and basic services
Days	
Weeks	supporting a return to community normality
Months	improving quality of life

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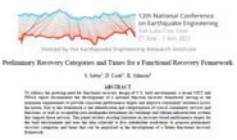
Proposed Recovery Categories and Recovery Times: 12NCEE Paper



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Recovery Category	Recovery Phase	Community Functions or Services	Target Recovery Time	Example Buildings and Infrastructure Enabling Function or Service
A	Immediate	Public Health and Safety; Telecommunications and Cyber; Infrastructure; Healthcare (acute); Shelter	0-24 hours	Cell Phone Towers; Emergency Operations Center; Fire Stations; Hospitals; Lifelines; Police Stations; Designated Shelters
B	Near Term	Key Transportation Services; Housing; Banking and Finance; Resources; Energy and Electricity; Food and Water; Healthcare (outpatient)	1-6 days	Critical Retail (Grocery Stores, Home Improvement); Nursing Homes; Outpatient Medical; Pharmacies; Residential Water; Transportation Nodes (roads, bridges, ports, runways)
C	Short Term	Education; Governance; Housing; Cultural Identity (religious); Local Economy (jobs); Social Support;	1-4 weeks	Courthouses; Daycares; Government Buildings; Lifeline Infrastructure that supports Short Term Functions; Major Regional Employers; Schools and Rec Centers; Single- and Multi-family Residential
D	Long Term	Cultural Identity (landmark); Entertainment; Recreation	1 month+	Buildings not assigned to other categories; Historic Buildings; Landmarks; Museums; Night Clubs; Religious Centers; Stadiums; Restaurants; Other Commercial Buildings (small business, retail, etc.); Theaters; Country Clubs

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Results from 12NCEE Special Session Salt Lake City, UT June 2022

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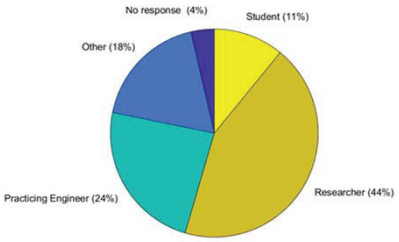
Question 1: What is your current position?



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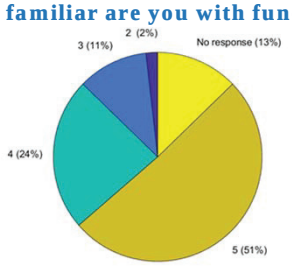
Question 2: On a scale of 1 (unfamiliar) to 5 (very familiar), how familiar are you with functional recovery concepts?



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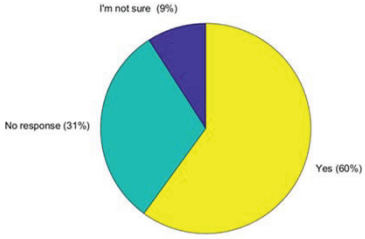
Question 3: Should target recovery timeframes be defined in terms of hours, days, weeks, etc....?



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Question 3a: If not, what alternative timeframes would you suggest?

- Year or more *(3 responses)*
- Uncertainty of timeframe
- Practical design differences between very short recovery times
- % service/function restored

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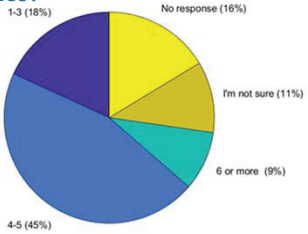
Question 4: What is your preference for the number of recovery categories needed to represent variations in recovery priorities?



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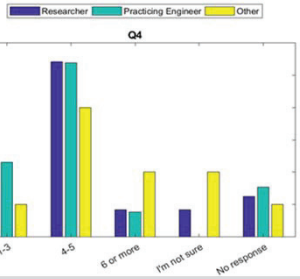
Question 4: What is your preference for the number of recovery categories needed to represent variations in recovery priorities?



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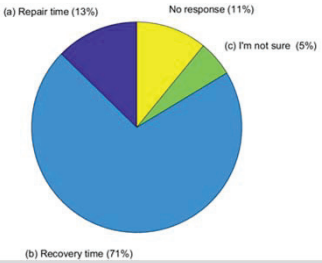
Question 5: Should target recovery times (a) only include the time to repair the damage (i.e., repair time) or (b) also include delays impeding the repairs (i.e, recovery time)?



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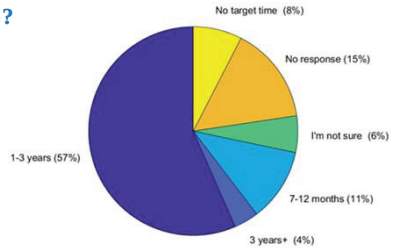
Question 5b: If recovery time was targeted, what should be the target recovery time be for recovery category D (long term)?



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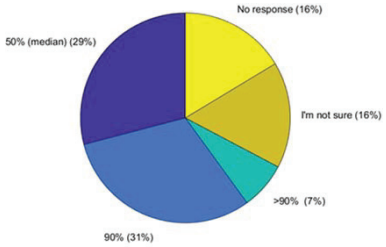
Question 6: Whether considering recovery or repair time, what confidence level should be targeted?



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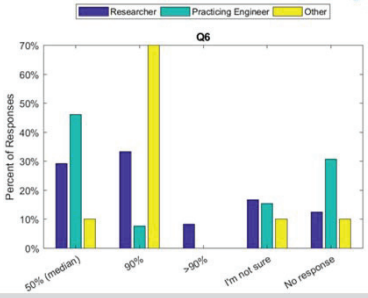

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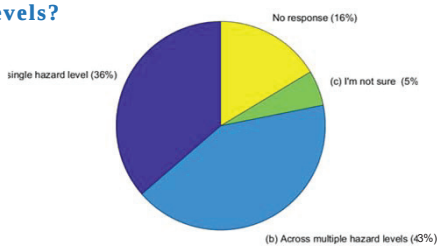
Question 7: Should target recovery times be established for a (a) single hazard level or (b) across multiple hazard levels?



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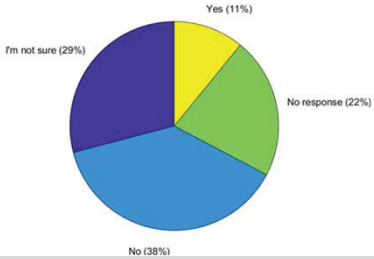
Question 8: Should the table be based on something other than community functions and services?



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Question 9: What critical information is missing from the table?

- Inclusion of vulnerable and underinsured populations
- Alignment with current occupancy code classifications (2)
- Address mixed occupancies
- Incorporate lifelines dependencies in classifications
- Quantification of uncertainty; probability of exceedance (2)
- Eliminate times, focus only on recovery prioritization in initial phase

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Key Takeaways from Mini Workshop

- Key questions to answer (or key decisions to be made)
  - Whether to include the target recovery times and if so how? (hours, days, … or PoE of X number of hours, days, …)
  - Aspirational or realistic recovery time?
  - Confidence level that we should target in our design
  - Single or multiple hazard levels
  - Do we want to incorporate utilities/infrastructure in the table? how?

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Next Steps on Improving/Finalizing the Dataset

- More comprehensive and consistent dataset regarding target/acceptable recovery times for services and functions
- Approach for data collection:
  - Data collected from a public survey
  - SMEs propose RCs and RTs
  - Mixed approach

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Thanks!

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"Risk-Targeted Ground Motions and Hazard Level and Shaking Intensity of Recent and Scenario Earthquakes"

FEMA-Sponsored Workshop on Functional Recovery: Hazard Level(s) and Target Recovery Times

Nicolas Luco, PhD
Research Civil Engineer

USGS science for a changing world

Geologic Hazards Science Center
Golden, Colorado

1

Motivation

Small Group Break-out Discussion Topic 2A:

What hazard level(s) should be used for FR performance objective(s)? (What is appropriate amount of consideration for FR at various hazard levels?)

Related question:

What **type of performance/risk objectives, from which ground motion levels can be back-calculated,** should be used for FR?

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Candidate Performance/Risk Objectives

A. Functional recovery (with high probability) in, e.g., a magnitude 7.2 San Andreas earthquake
→ *Scenario/deterministic* ground motions

B. Functional recovery (with high probability) under, e.g., 500-year ground motion
→ *Uniform-hazard* ground motions

C. Functional recovery with, e.g., 95% probability over the lifetime of a building (50 years)
→ *Risk-targeted* ground motions

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Scenario/Deterministic Ground Motions

Pros:

- Intuitive

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Figure citation: Trailer Addict, 2015. San Andreas Movie Poster.

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Scenario/Deterministic Ground Motions

FUNCTIONAL FORM OF THE MODEL

EQUATIONS FOR THE MEDIAN GROUND MOTION

Basic Form

Pros:

- Intuitive
- Relatively simple to calculate

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Figure citation: Abrahamson, Silva, & Kamai, 2015. Summary of the ASK14 Ground Motion Relation for Active Crustal Regions. *Earthquake Spectra*, 30(3), 1025-1055.

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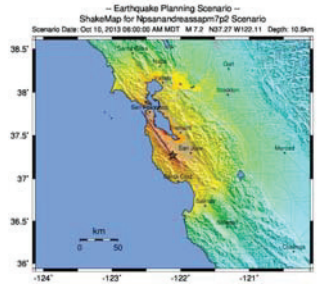
Scenario/Deterministic Ground Motions



Pros:

- Intuitive
- Relatively simple to calculate

Cons:

- Only reflect one of many potential earthquakes (faults, magnitudes, locations)
- Typically neglect the probability of the earthquake

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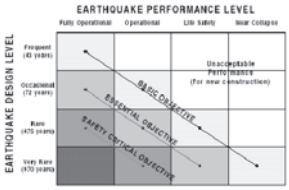
Uniform-Hazard Ground Motions



Pros:

- Traditional

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Figure citation: Applied Technology Council (ATC), 1996. Seismic Evaluation and Retrofit of Concrete Buildings. *ATC-40.*

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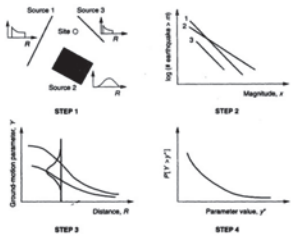
Uniform-Hazard Ground Motions



Pros:

- Traditional
- Reflect many potential earthquakes and their probabilities

Cons:

- Complex computation (PSHA)

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Figure citation: Kramer, 1996. Geotechnical Earthquake Engineering. *Prentice Hall.*

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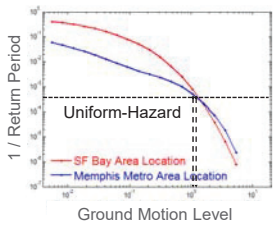
Uniform-Hazard Ground Motions



Pros:

- Traditional
- Reflect many potential earthquakes and their probabilities

Cons:

- Complex computation (PSHA)
- Just one chosen return period
- Non-uniform lifetime risk of unacceptable performance

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Disclaimer: This information is preliminary and is subject to revision. It is being provided to meet the need for timely best science. The information is provided on the condition that neither the U.S. Geological Survey nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the information.

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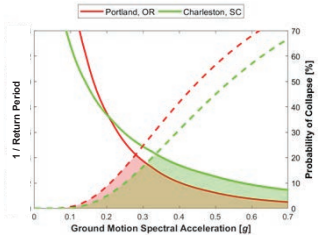
Risk-Targeted Ground Motions



Pros:

- Resultant risk is explicit
- Reflect all influential uniform-hazard return periods
- Explicitly reflect "fragility"

Cons:

- Require a fragility
- Added complexity

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Explicit vs. Implicit Risk

"Often the courts become the final judge of whether a proposed course of action for mitigating a hazard is acceptable. The body of law that has been developed in the area of flood plain regulation is a useful guide to judicial reactions to hazard mitigation. ***The lesson is to match severity of the regulation to the severity of the risk.*** *The courts follow the principle of the reasonable person who strives to achieve this balance, and uses data to support findings of the appropriate balance."*

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11 *Figure citation:* Applied Technology Council (ATC), 1978. Tentative Provisions for the Development of Seismic Regulations for Buildings. *ATC 3-06.*

11

Examples of Risk-Targeted Ground Motions

- Considered for collapse prevention of buildings as early as 1978 in *(ATC 3-06)*
- Adopted for nuclear facilities in 2005 *(ASCE 43-05)*
- Adopted for buildings in 2010 (*ASCE 7-10*)
- Analogous snow loads adopted in 2016 (*ASCE 7-16)*
- Adopted for bridges in *2023 AASHTO Specifications*

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Risk-Targeted Ground Motions for FR

Table 2. Proposed Functional Recovery Categories and Target Recovery Times

Recovery Category	Recovery Phase	Community Functions or Services	Target Recovery Time	Example Buildings and Infrastructure Enabling Function or Service
A	Immediate	• Public Health and Safety • Telecommunications and Cyber Infrastructure • Healthcare (acute) • Shelter	0-24 hours (≤ 1 day)	Cell Phone Towers; Emergency Operations Center; Fire Stations; Hospitals; Lifelines; Police Stations; Designated Shelters
B	Near Term	• Key Transportation Services • Banking and Finance • Energy and Electricity • Food and Water Resources • Healthcare (outpatient) • Housing	1-6 days (≤ 1 week)	Critical Retail (Grocery Stores, Home Improvement); Nursing Homes; Outpatient Medical; Pharmacies; Residential Water; Transportation Nodes (roads, bridges, ports, runways)
C	Short Term	• Education • Governance • Housing • Local Economy (jobs) • Social Support • Cultural Identity (religious)	1-4 weeks (≤ 1 month)	Courthouses; Daycares; Government Buildings; Lifeline Infrastructure that supports Short Term Functions; Major Regional Employers; Schools and Rec Centers; Single- and Multi-family Residential
D	Long Term	• Cultural Identity (landmark) • Entertainment • Recreation	1 month+ (≤ 1 year?)	Buildings not assigned to other categories; Historic Buildings; Landmarks; Museums; Night Clubs; Religious Centers; Stadiums; Restaurants, Other Commercial Buildings (small business, retail, etc.); Theaters; Country Clubs

+ **Target risk**, i.e., target life-time probability of achieving recovery time, e.g., 95% over 50 years
+ **Fragility**, i.e., conditional probability of achieving recovery time under chosen ground motion level(s)

→ **Risk-Targeted Ground Motions**

USGS science for a changing world

Table citation: Saltar, Cook, & Johnson, 2022. Preliminary Recovery Categories and Times for a Functional Recovery Framework. *Proceedings of the 12th National Conference on Earthquake Engineering*, Salt Lake City, Utah.

13

13

Community-Level Risk Info (not Objective)

PROBABILITY OF NOT HAVING ANY FAILURES DURING A 50-YEAR PERIOD

	Type of Failure: Life-Threatening Damage	Type of Failure: Structural Collapse
Single building	99%	99-99.9%
100 buildings - 1 city	90%	95%
100 buildings - 5 cities	65%	85%

USGS science for a changing world

14 *Figure citation:* Applied Technology Council (ATC), 1978. Tentative Provisions for the Development of Seismic Regulations for Buildings. *ATC 3-06.*

14

Community-Level Scenario Info (not Objective)

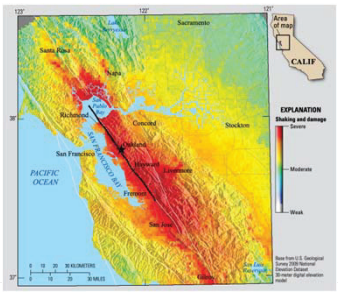

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Figure caption: Detweiler and Wein, editors, 2017. The HayWired earthquake scenario—Earthquake hazards. *U.S. Geological Survey Scientific Investigations Report 2017–5013–A–H*, 126 p.

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15

Summary

- Choosing a hazard level can start with choosing a performance/risk objective.
- Candidate performance/risk objectives result in (A) scenario/deterministic, (B) uniform-hazard, or (C) risk-targeted ground motions.
- Risk-targeted ground motions have been adopted for collapse prevention of buildings (*ASCE 7*) and bridges, under earthquake and snow loads.
- Even if not as objectives, community-level risk and scenarios can inform building-level risk objectives.

USGS science for a changing world

16

16

Risk Considerations for Selection of Targets for Functional Recovery Assessment

Jack W. Baker

FEMA-Sponsored Workshop on Functional Recovery

Stanford | ENGINEERING

1

Topics

1. Approaches for choosing performance goals
2. Unit of measure for target performance criteria
3. Choosing a target hazard level for analysis

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2

Question 1

What general approaches are used to choose tolerable performance criteria?

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3

Big picture: bases for tolerable performance criteria

There are four bases for developing risk regulations and criteria

1. risk-cost–benefit measures
2. past performance or revealed preferences
3. societal preferences or expressed preferences
4. natural standards, e.g. as in some environmental risk criteria

Vrijling et al. (2004) A framework for risk criteria for critical infrastructures: fundamentals and case studies in the Netherlands.

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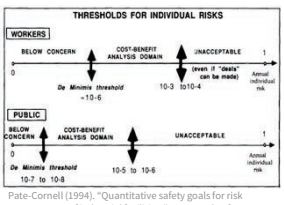
Bases for performance criteria

1. risk-cost–benefit measures
2. past performance or revealed preferences
3. societal preferences or expressed preferences
4. natural standards, e.g. as in some environmental risk criteria



Pate-Cornell (1994). "Quantitative safety goals for risk management of industrial facilities." *Structural Safety*.

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Bases for performance criteria

1. risk-cost–benefit measures
2. past performance or revealed preferences
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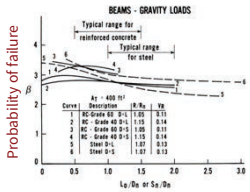
4. natural standards, e.g. as in some environmental risk criteria



Reliability of components per Allowable Stress Design criteria

Galambos et al. (1982). "Probability Based Load Criteria - Assessment of Current Design Practice."

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6

Bases for performance criteria

7

1. risk-cost–benefit measures
2. past performance or revealed preferences
3. societal preferences or expressed preferences
4. natural standards, e.g. as in some environmental risk criteria

See also Tanner, Chang, and Elwood (2020). "Incorporating societal expectations into seismic performance objectives in building codes." *Earthquake Spectra.*

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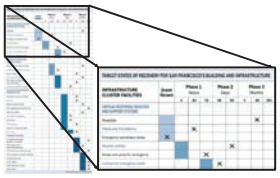
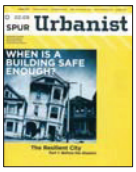
Bases for performance criteria

8

1. risk-cost–benefit measures
2. past performance or revealed preferences
3. societal preferences or expressed preferences
4. natural standards, e.g. as in some environmental risk criteria





SPUR (2009)

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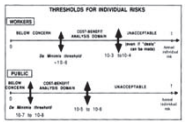
8

How might these bases apply for functional recovery?

9

1. Cost-benefit is informative
2. Past building codes have not quantified resilience, and so provide little calibration
3. Revealed and expressed preferences are generally at a community level, not for individual buildings
4. (Natural standards are not relevant)



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Question 2

10

What unit of measure could we use to specify target performance criteria?

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10

Unit of measure for target performance criteria

11

- A person?
- A building?
- A community?
- The nation?

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11

Per-community metrics don't lead to unique per-building strategies

12

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Per-community metrics don't lead to unique per-building strategies

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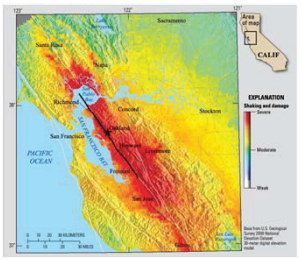
Per-community metrics don't lead to unique per-building strategies



Haywired scenario

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Per-nation analysis should likely be normalized to a per-person risk metric

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15

16

Question 3

What hazard level should we choose for analysis?

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16

17

Choosing a target hazard level

An analysis procedure can be considered a predictive tool:

the designer, having followed the procedure, will expect the resulting structure to be sufficiently functional during its lifetime

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17

18

Choosing a target hazard level

An analysis procedure can be considered a predictive tool:

the designer, having followed the procedure, will expect the resulting structure to be sufficiently functional during its lifetime

Procedure:		Performance:
LRFD equation check with design loads	→	Low probability of component failure
ASCE 7 DBE seismic member forces and drifts are acceptable	→	Low lifetime probability of building collapse

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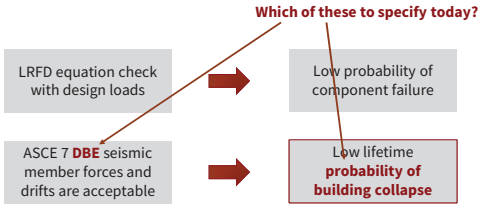
Choosing a target hazard level

An analysis procedure can be considered a predictive tool:

the designer, having followed the procedure, will expect the resulting structure to be sufficiently functional during its lifetime



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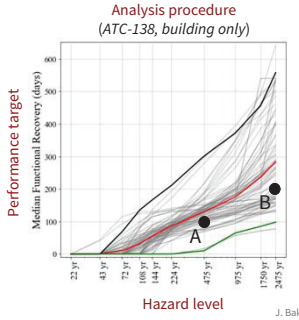
Choosing a target hazard level

We have three coupled choices to make for an analysis procedure:

1. The checking procedure
2. The hazard level
3. The performance target at that hazard level

Good choices will produce informative performance predictions



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Considerations for your discussion

We can consider multiple resources when setting performance goals

1. Cost-benefit analysis
2. Past performance
3. Expressed preferences

Our hazard level targets need to be compatible with other decisions:

1. Unit of measure for performance (e.g., building vs community)
2. Analysis check conditions
   - Analysis procedure
   - Hazard level
   - Performance target

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Session #3: Where do we go from here?

Overview of Ongoing Work from
Pre-Workshop Questionnaires

Susan Dowty

Inspire Collaboration and Inform Future Efforts

1

Sent Email on July 22, 2022

2

How Many Were Received?

51 Questionnaires were received from 35 individuals

Stakeholder Group	
Federal Government Agencies	7
Researchers & Lifelines	12
Practitioners	22
State & Local Gvt Codes & Stds Organizations	10

3

How Do Projects Relate to FEMA/NIST Report Recommendations?

Figure 7-1 Interactions among the recommendations.

4

How Do Projects Relate to FEMA/NIST Report Recommendations?

	Recommendation	#
1	Functional Recovery Framework	33
2 & 3	Designing New & Existing Buildings to Meet Recovery-Based Objectives	31
4	Designing New and Existing Lifeline Infrastructure	14
5	Pre-Disaster Recovery Planning	20
6	Education and Outreach	14
7	Financial Resources	7

5

Breaking Down the Projects

- **ATC Projects: 5**
- **NIST Projects: 4**
- **Code & Standard Development Projects: 9**
- **Other Projects: 23**

6

ATC Projects

- **ATC 138:** Support of Performance-Based Seismic Design of Buildings
- **ATC 140:** Update of Seismic Evaluation and Retrofit of Existing Buildings Guidance
- **ATC 150:** Improving the Nation's Lifelines Infrastructure to Achieve Seismic Resilience (FEMA)
- **ATC 152:** Developing a Framework for Design of Lifeline Infrastructure Systems for Functional Recovery (NIST)
- **ATC 155:** Development of an Updated Plan to Coordinate NEHRP Post-Earthquake Investigations, Phase II

7

NIST Projects

- NIST Study on Recovery Categories and Recovery Times
- NIST Reports and Journal Papers
  - Prescriptive requirements for FR
  - Improve nonstructural performance data for recovery-based PBEE
  - Target building level performance objectives based on regional performance

8

Codes & Stds Development Projects

- 2023 Update of the USGS National Seismic Hazard Model
- BSSC/PUC Functional Recovery Task Committee
- ASCE 7-28 Seismic Subcommittee
- Reimagining the ICCPC
- 2024 IBC development (S74-22 through S78-22)
- FEMA Seismic Code Support Committee (SCSC, ATC 136)
- Ongoing BSSC and code and standards work
- ASCE 41: Seismic Evaluation and Retrofit of Existing Buildings
- NEHRP Resource Paper: Resilience Based Design

9

Other Projects

- Structural Extreme Events Reconnaissance (StEER) Network Project
- PEER Transportation Research Program
- Bridge Rapid Assessment Center for Extreme Events (BRACE2) Project
- Concrete Wall Typology Study with Rocking and Conventional Walls
- Downtime and model recovery of buildings.

10

Other Projects (cont.)

- Investing in Housing Capacity for Crisis Preparedness
- Center for Risk-Based Community Resilience Planning
- Automated Structure Alert Program (ASAP)
- Educate design professionals and advance FR legislation
- Identify reach opportunities beyond the SE community to advance FR and CR Concepts
- Automated building inventory collection for disaster mitigation and civil projects

11

Other Projects (cont.)

- Accelerated Building Reoccupancy Program
- WAsafe Building Safety Evaluators
- Community Resilience Group Leader and Program Manager
- Statewide Community Outreach and Education
- Utah Credentialing of ATC Evaluators
- Ongoing CA Seismic Safety Commission Work
- FR Times of Code Compliant Buildings

12

Other Projects (cont.)

- Hazard and Climate Risk Acknowledgment Form
- ASTM Resilience Property Assessment Guide
- Resilience-based Inventories Project (SEAONC Special Project)
- Earthquake Functional Recovery Roundtable
- Risk Communication Strategies for Community Preparedness
- Seismic/Resilience Support for a large water infrastructure project in Portland, OR

13

Opportunities for Collaboration?

YES!

Inspire Collaboration and Inform Future Efforts

14

Other Information included with Questionnaires

- Contact information
- Description
- Timeline
- Deliverable and Intended Audience
- Opportunities for Collaboration with Others
- How to Learn More

15

Today's Presentations

- NIST Prescriptive Design Procedures (Dustin Cook)
- NIST Study on Benefit-Cost Analysis (Juan Fung)
- NIST Study on Lifelines, ATC-152 (Katherine Johnson)
- FEMA Study on Lifelines, ATC-150 (Mike Mahoney)
- Downtime & Recovery Framework (Carlos Molina Hutt)
- FR Times of Code-Compliant Buildings (Jakub Valigura)
- ICCPC and Functional Recovery (Brian Meacham)

16

Be Thinking About

- How does it relate to what you're currently working on?
- What is your "next step" for functional recovery development?
- What are some challenges you're facing?
- What do you need from this group to overcome those challenges?

Inspire Collaboration and Inform Future Efforts

17

Thank you!

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Prescriptive Design for Functional Recovery

Dustin Cook, PhD, PE
Siamak Sattar, PhD
Earthquake Engineering Group
National Institute of Standards and Technology

August 18, 2022

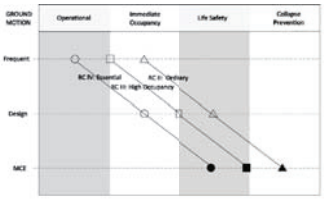
1

Functional Recovery

"Functional recovery is a post-earthquake performance state in which a building or lifeline infrastructure system is maintained, or restored, to safely and adequately support the ***basic intended functions*** associated with the pre-earthquake use or occupancy of a building…"

2

The Goal: Develop *prescriptive design requirements* targeting a functional recovery performance objective



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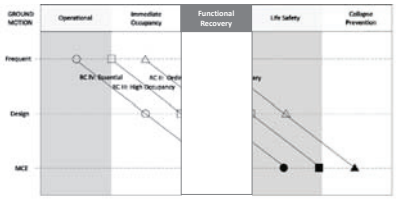
The Goal: Develop *prescriptive design requirements* targeting a functional recovery performance objective



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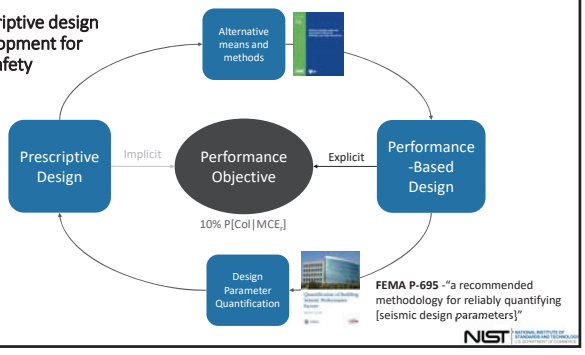
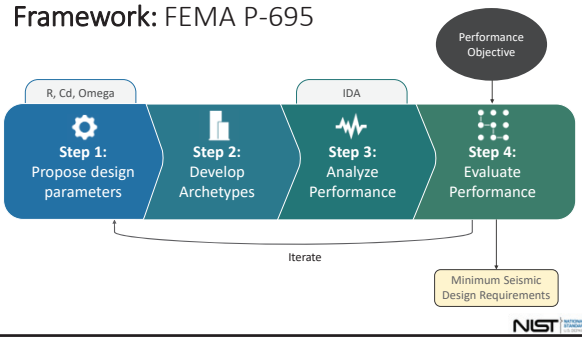
Prescriptive design development for Life Safety



FEMA P-695 -"a recommended methodology for reliably quantifying [seismic design *parameters*]"

5

Framework: FEMA P-695



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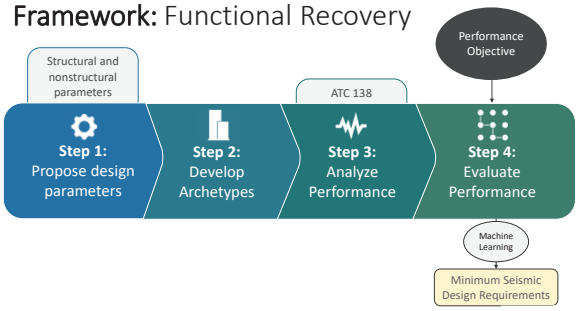
Framework: Functional Recovery



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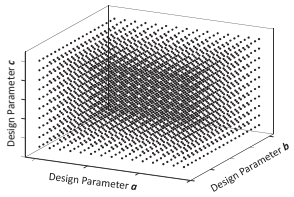
Step 1: Identify Design Parameters

- Design parameters for functional recovery should…
  a) be within the design engineer's control using standard prescriptive design processes
  b) have an impact on performance target (functional recovery)
  c) cover both structural and nonstructural components
- Examples
  - Strength of lateral system (Ie)
  - Lateral system or component deformation limits
  - Chapter 13 nonstructural factors (Ip)
  - Structural or nonstructural system redundancy (Ip)

8

Step 2: Develop Archetypes

- Archetypes for functional recovery should:
  - "… capture the essence and variability of the performance characteristics of the system of interest" (FEMA P-695)
  - be designed to meet minimum life safety standards
  - represent performance features beyond collapse performance
  - represent a *range of possible values* for selected design parameters (instead of single *proposed* value)



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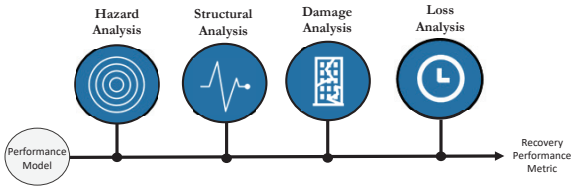
Step 3: Simulate Performance

Simulate functional recovery time for each archetype



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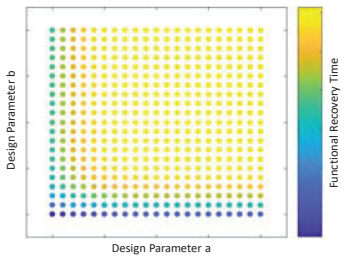
Step 4: Evaluate Performance

Classify performance of each archetype against performance objective



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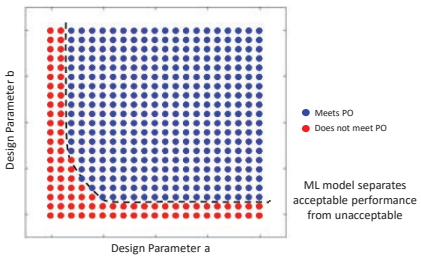
Step 4: Evaluate Performance

Classify performance of each archetype against performance objective



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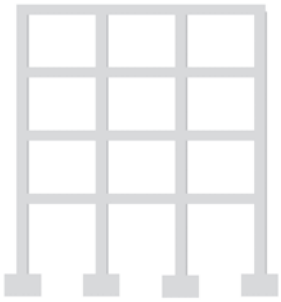
Example Application

13

Case Study: Design Space

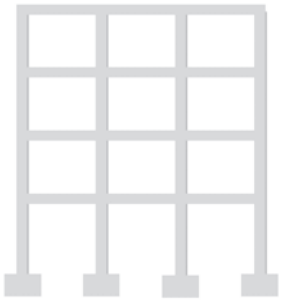
- 4-story RC SMF
- Designed according to ASCE 7-16
- Forces distributed using ELF
- S_{DS} = 1g, S_{D1} = 0.6g
- SDC: D
- Site Class: C
- Office Occupancy



14

Case Study: Design Parameters

- **Nonstructural:**
  - I_p and I_p/R_p per nonstructural system
- **Structural:**
  - I_e



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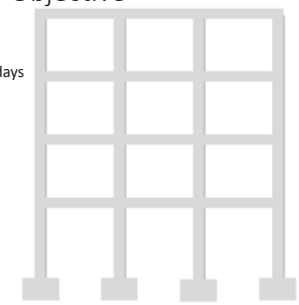
Case Study: Performance Objective

- **Recovery Time:**
  - Median functional recovery time < 60 days
  - Includes impeding factors
- **Hazard Level:**
  - 475-year return period



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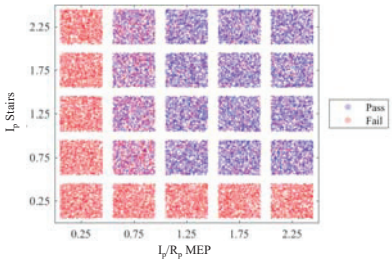
Visualizing the Results



17

Training a model: Logistic regression

ML model $Logit(Y) = 1.3 * \log(I_e) + 3.7 * \log(Ip_{ext}) + 3.6 * \log(Ip_{stair}) + 4 * \log(Ip_{mep}) - 1$

...

$2 \leq I_e * Ip_{ext}{}^3 * Ip_{stair}{}^3 * Ip_{mep}{}^3$

Governing Code Equation

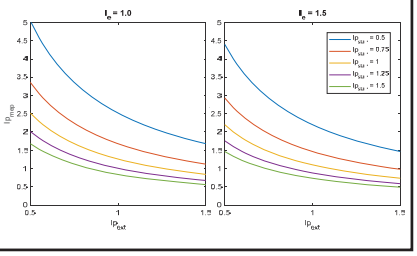
18

Training a model: Logistic regression

ML model $Logit(Y) = 1.3 * \log(I_e) + 3.7 * \log(Ip_{ext}) + 3.6 * \log(Ip_{stair}) + 4 * \log(Ip_{mep}) - 1$

Governing Code Equation

$$2 \leq I_e * {Ip_{ext}}^3 * {Ip_{stair}}^3 * {Ip_{mep}}^3$$



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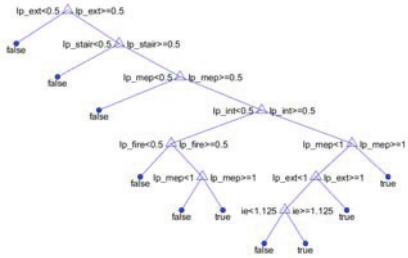
Training a model: Decision tree



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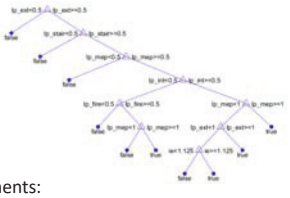
Training a model: Decision tree



Minimum Requirements:

Ip/Rp for exteriors, MEP, stairs, interior > 0.5 **and** Ip/Rp for MEP or Exteriors > 1

– or –

Ip/Rp for exteriors, MEP, stairs, interior > 0.5 **and** Ie > 1.125

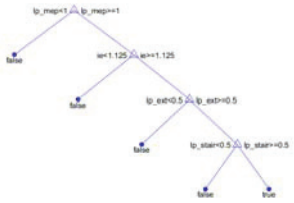
21

Alternative Performance Objectives

- What if I wanted to target: ***84th percentile < 6 months*** at 475-year ground motion?
  - I_e > 1.125

    -- and --
  - I_p/R_p for MEP > 1

    -- and --
  - I_p/R_p for exteriors and stairs > 0.5



22

In Summary

The proposed framework represents a robust approach for ***reliably quantifying seismic design parameters*** specifically targeting functional recovery performance objectives

- Leverages previously established methods
- Proposes more direct and statistically robust approach by utilizing machine learning methods to determine minimally acceptable design requirements
- Applicable to various performance objective decision points

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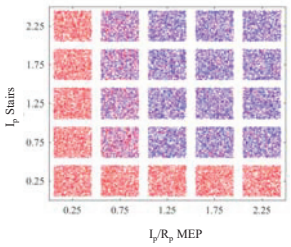
Next steps

1. Test, finalize, and publish the framework
2. Develop performance objectives for functional recovery for future standards
3. Apply framework to large archetype sets across multiple systems



24

Older/Other

25

Alternative Approaches for Determining Min Design Requirements

- Optimization and surrogate modeling (Omar Issa)
  - Add optimization "law" to further refine recommendations
  - Use surrogate model to give building specific requirements instead of code-based requirements (hosted on web-based cite)
- Repairability thresholds, cite Elwood and Opabola
  - Work around large uncertainties in nonstructural performance and repair time by just targeting component based "repairability" limit states
  - Can use the same ML methods create recommendations for various systems
- Relative difference / cliff point targets
  - Instead of targeting specific recovery times, target the point where the design improvements make the most difference.

26

Questions for Workshop Attendees

- How do we identify test design parameters / seismic performance factors? What additional design parameters would you suggest investigating?
- What design or configuration features should we consider when developing an archetype space?

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Presentation Takeaways

- Understand why a framework is needed to make decisions about prescriptive based design requirements (ie contributions)
- The proposed framework is a natural stepping-stone considering the precedence of FEMA P-695 and PBEE-Recovery
- Realize the machine learning techniques used in this study are not magic, won't take their jobs, and are a straight-forward way to develop robust min requirements
- Know what is part of the framework, and what are the framework inputs that need engineering decision (decision points)

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Step 3: Simulate *Nonstructural* Performa

Is this too detailed? Maybe... Just mention in previous

- Design parameter: $\mathbf{I_p}$ or $\mathbf{I_p/R_p}$
- For each component:
  1. calculate the $\mathbf{F_p}$ and $\mathbf{D_{pI}}$ values from chapter 13
  2. Define the capacity of the fragility as the minimum design requirement (without uncertainty)
  3. Simulate damage and consequences (functional recovery assessment)
- The performance model represents the functional recovery performance, given the minimum prescribed requirements

$$F_p = \frac{0.4 a_p S_{DS} W_p}{\left(\frac{R_p}{I_p}\right)} \left(1 + 2\frac{z}{h}\right) \quad (13.3\text{-}1) \qquad D_{pI} = D_p I_e I_p \quad (13.3\text{-}6)$$

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Economic Considerations for Recovery-Based Design

FEMA-ATC Workshop on Functional Recovery

Juan F. Fung
Dustin Cook
Yating Zhang
Katherine Johnson
Siamak Sattar

National Institute of Standards and Technology

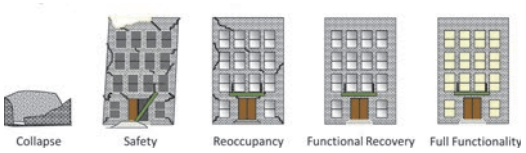
August 18, 2022

1

Introduction and motivation

2

Introduction and motivation

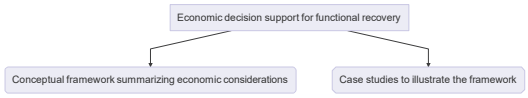


What do we need to advance functional recovery?

- Design guidelines (engineering for recovery time)
- Performance evaluation (modeling recovery time)
- Economic evaluation (value of improved recovery time)
  - Key to adoption and implementation

3

This project: Economic evaluation



Feasible economic analysis for plausible recovery-based design

4

Economic framework

5

Goal: Tailor economic evaluation for functional recovery

Conceptual framework to guide economic evaluation[1]

- Assist implementation by providing a thorough checklist of benefits, costs, and relevant stakeholders
- Suggest existing methods for quantification or areas where research is needed
- Applies to any **new or existing** building

[1]NIST SP 1277 (2022). A Framework to Evaluate the Cost-Effectiveness of Recovery-Based Design. https://doi.org/10.6028/NIST.SP.1277

6

Framework: Estimating benefits

Category	Loss	Examples
Direct	Damage	Building damage
	Casualties	Injuries/fatalities
Indirect	Economic losses	Business interruption Indirect property* Supply chain disruption*
	Social losses	Displacement Underserved communities** Government assistance**
	Physical losses	Debris Energy consumption Emissions*

Note: * = research need with precedent in related literature; ** = research need without precedent

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7

Framework: Estimating costs

Table 5.3. Potential adoption/implementation costs, who bears cost, and how to estimate cost.

Cost	Who bears	Estimation methods
New construction	Developer	• Construction cost data (e.g., RSMeans, Craftsman) • Historical data • Statistical models
Retrofit (hard and soft)	Owner (title holder)	• Construction cost data (e.g., RSMeans, Craftsman) • Historical data • Statistical models
Maintenance	Owner	• Life-cycle cost data (e.g., RSMeans) • Historical data (e.g., ASHRAE Service Life and Maintenance Cost database) • Statistical models
Code implementation	State and local governments	Historical data (e.g., code book purchase, education and training expenses, technical support, financial incentives)
Plan evaluation	Owner	Covered by permit fees
Site inspection	Owner	Covered by permit fees
Construction permit application	Owner	% of construction or improvement costs
Financing	Owner	(Interest rate) × Principal
Additional cost to preserve historical or cultural characteristics	Government	Historical data (e.g., cost estimates, dedicated funds, financial incentives)

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8

Framework: Benefit-cost analysis (BCA)

- Why BCA?
  - Comprehensive
  - Interpretable
  - LCC or CEA may be appropriate when cost is primary concern
- What is new/different?
  - Benefits tied to (time to) recovery of function

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9

Framework: Benefit-cost analysis (BCA)

Decision criteria

- BCR:

$$\frac{PV(B_i)}{PV(C_i)} > 1$$

- NPV:

$$PV(B_i) - PV(C_i) > 0$$

10/ 23

10

Case study

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11

Goal: Illustrate economic analysis

Not meant to convey recommendations on acceptable design.

- Focus on new buildings
- Show steps, inputs, considerations for conducting economic evaluation
- Highlight gaps
- Benefits included:
  - Repair costs
  - Business income
  - Rental income
  - Displacement (relocation costs)

12/ 23

12

Case study: Analysis parameters

Parameter	Values
δ	3%
T	50
0	Baseline design: - Commercial office building - Site: SDC D (Sds = 1.0g and Sd1 = 0.6g) - Soil: Site Class C - Designed per ASCE 7-16 (B-4)[2]

[2]Cook, D. and Sattar, S. (2022). The Effect of Increased Strength and Stiffness Requirements on the Functional Recovery Performance of Reinforced Concrete Special Moment Frames. 12th National Conference on Earthquake Engineering, Salt Lake City, UT.

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Case study: Analysis parameters

Parameter	Values
$i = s$	(RCMF) Ie = 1.5, Drift = 1% (BRBF) Add backup frame
$i = ns$	Includes bracing upgrades, stiffening and anchoring improvements, falling hazard mitigation, and use of seismically rated components

s = structural improvements, ns = nonstructural improvements

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Case study: RCMF

Table 3: 8-story RCMF: Benefit-cost ratio (BCR), net present value (NPV), and cost increase, for T=50, delta=0.03.

Model	BCR	NPV	Cost increase
s	0.002	-$690,538	4.17%
ns	3.568	$350,575	0.82%
s+ns	0.710	-$240,498	4.99%

Note: s = structural improvements only; ns = nonstructural improvements only; s+ns = structural + nonstructural improvements

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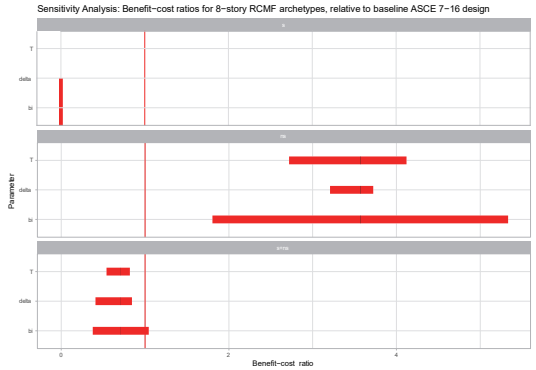
15

Case study: RCMF



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Case study: BRBF

Table 4: 4-story BRBF: Benefit-cost ratio (BCR), net present value (NPV), and cost increase, for T=50, delta=0.03.

Model	BCR	NPV	Cost increase
s	0.671	-$33,773	1.49%
ns	4.510	$302,609	1.25%
s+ns	2.429	$270,047	2.74%

Note: s = structural improvements only (backup frame), ns = nonstructural improvements only, s+ns = structural + nonstructural improvements

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17

Case study: BRBF

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18

Case study: Distributed BCA Example

Table 5: Distributed benefit-cost analysis: 4-story RCMF with nonstructural improvements only (ns), assuming cost is shared evenly by owner (title holder) and tenant, for T=50, delta=0.03. Based on NIBS (2019).

Stakeholder	Weights	Distributed Cost	Distributed BCR	Distributed NPV
Developer	0.004	$0.00		$1,009.15
Title holder	0.316	$65,714.50	1.21	$14,008.13
Lender	0.014	$0.00		$3,532.02
Tenant	0.466	$65,714.50	1.79	$51,851.15
Community	0.200	$0.00		$50,457.36

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Conclusion

20

Case study takeaways

- Benefits from nonstructural improvements may be significant compared to their costs
- Biggest beneficiaries do not necessarily bear cost
- Opportunities to quantify additional (e.g., community-level) benefits of improved recovery time => results represent plausible lower bound

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Case study limitations

- Single building (e.g., no variation in site seismicity or other design parameters)
- Results illustrate FR-BCA and are not intended to make or inform design recommendations
- Cost estimates plausible, within data constraints. Not intended to reflect actual construction costs
- Assumption: Cost *deltas* are reasonable
- Did not consider potential increases in implementation costs (e.g., QAQC)

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Future directions

- Future directions
  - Extending the case studies to consider SMF and RC shear wall systems (in progress)
  - Estimating environmental benefits from improved recovery times (in progress)
  - From framework to standard

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DEVELOPING LIFELINES FUNCTIONAL RECOVERY

NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY U.S. DEPARTMENT OF COMMERCE

Presenter: Katherine Johnson
Co-Authors: Craig Davis, Applied Technology Council, Siamak Sattar

FEMA-Sponsored Workshop on Functional Recovery
August 18, 2022

1

OUR MOTIVATION

- NIST is a bureau of the U.S. Department of Commerce, which currently has 5 key strategy areas:
  - Drive U.S. Innovation and Global Competitiveness
  - Foster Inclusive Capitalism and Equitable Economic Growth
  - Address the Climate Crisis Through Mitigation, Adaptation, and Resilience Efforts
  - Expand Opportunity and Discovery Through Data
  - Provide 21st Century Service with 21st Century Capabilities
- NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life.
- Our efforts within NIST's Engineering Laboratory fall under the *Earthquake Risk Reduction in Buildings and Infrastructure Program*
- NIST is also a core partner in, and lead agency for, the National Earthquake Hazards Reduction Program (NEHRP)

2

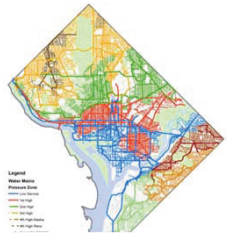
BACKGROUND LITERATURE

- (2014) NIST GCR 14-917-33: *Earthquake-Resilient Lifelines: NEHRP Research, Development and Implementation Roadmap*
- (2016) NIST GCR 16-917-39: *Critical Assessment of Lifeline System Performance: Understanding Societal Needs in Disaster Recovery*
- (2018) NIST SP 1224: *Research Needs to Support Immediate Occupancy Building Performance Objective Following Natural Hazard Events*
- (2021) NIST SP-1254/ FEMA P-2090: *Recommended Options for Improving the Built Environment for Post-Earthquake Reoccupancy and Functional Recovery Time*
- (2021) NIST SP-1269: *NIST-FEMA Post-Earthquake Functional Recovery Workshop Report*

3

RELATED NIST ACTIVITIES INVOLVING INFRASTRUCTURE

- NIST Community Resilience Group
- NIST CoE on Community Resilience
- Contract on Transportation Recovery Decision-making Tool
- Transportation Functional Recovery Roundtable
- Other infrastructure-focused research projects



Washington, D.C. water main network, for interest

4

PROJECT SCOPE

- [ATC 152] Title: ***"Developing a Framework for Design of Lifeline Infrastructure Systems for Functional Recovery"***
- Organization: Project Director- Craig Davis; Technical Committee, Review Panel (tbd)
- Support identification of target recovery timeframes for the functional recovery of three lifelines systems: water, wastewater, and electric power
- Key recommendation from NIST SP 1254: *"Recommended Options for Improving the Built Environment for Post-Earthquake Reoccupancy and Functional Recovery Time"* to establish nationally applicable set of recommendations for producing functional recovery of lifelines

5

WHAT ARE WE TARGETING ON THE RECOVERY CURVE?

- There are a number of service categories which together constitute a lifeline service; each recovers at a different rate and most are not independent of one another
- Before full functionality (full system restoration) can be achieved, there is usually some level of operability whereby basic functions/services of the lifeline are operational; this is the same concept as functional recovery but the specific attributes needed for each system may differ

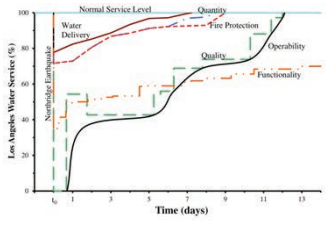


Figure 3. Los Angeles water system service restorations following the 1994 Northridge earthquake. Operability is not a service; it is a milestone delineating collective restoration of water delivery, quality, quantity, and fire protection services.

From Davis, Earthquake Spectra 2014

6

BUILDING ON CURRENT METHODOLOGIES

- The project is building upon the idea of performance based seismic design to identify a suitable process for lifelines infrastructure
- The technical committee has stressed the need not only for asset design procedures, but also delineation of organizational activities necessary to support performance achievement and is developing a framework which incorporates these parallel tracks

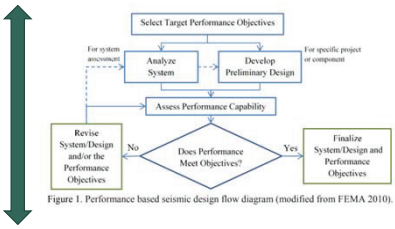


Figure 1. Performance based seismic design flow diagram (modified from FEMA 2010).

From Davis, 2019

7

FOR WHOM?

Table 1a. Defining asset/component criticality levels (written in general for all lifelines. For each lifeline descriptions can be given in greater detailed, see water example in Figure 1b)

Criticality Category	Description
I	Components that present very low hazard to human life in the event of failure. Not needed for post-earthquake system performance, response, or recovery.
II	Normal and ordinary components. They provide services for typical residential, commercial, and industrial use within the system and include all components not identified in Criticality Categories I, III, and IV.
III	Components providing services that represent a substantial hazard or mass disruption to human life in the event of failure. Failure of these components may result in significant social or economic impacts. **Critical B Customers.**
IV	Components needed to provide services to essential facilities for post-earthquake response, public health, and safety. These components are intended to remain functional during and following an earthquake. **Critical A Customers**

- This *draft* concept for criticality categories specifies the level of impact that failure or damage to the asset poses to users, and specifies two customer types (A & B) who could benefit from enhanced design, "Critical C Customers" would be all others served by components under criticality category I and II

Adapted from Davis 2019

8

PROJECT OUTCOMES

- Literature review
- NIST publication which:
  - Defines the acceptable state of functionality needed to define a lifeline infrastructure system as functionally recovered
  - Establishes common understandings for: operability, function, functionality, basic intended functions, and relationship with basic service categories
  - Identifies recovery categories and recovery times (focus on asset/component recovery, with consideration for supporting organizational actions)
  - Documents a transparent process for defining functional recovery categories/assignments with regard to customer types

Outcomes from this project are intended to be of use to a wide variety of individuals, not only researchers and academics, but also practitioners, planners, emergency managers, and lifelines professionals!

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FEMA

nehrp

A Framework to Establish National Lifeline Infrastructure System Recovery Goals for Seismic Resilience

ATC-150 Project Series

Mike Mahoney, FEMA

1

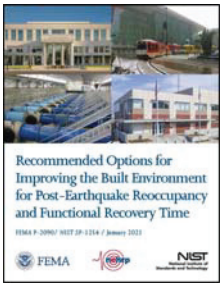
FEMA P-2090/NIST SP-1254

Recommendation 1:

Develop a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives

Recommendation 4:

Design, Upgrade, and Maintain Lifeline Infrastructure Systems to Meet Recovery-Based Objectives



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NIST Earthquake Lifelines Roadmap Program Element 1:

Establish national lifeline systems performance and restoration goals

- Topic No. 1: Develop an overarching framework for national lifeline performance and restoration goals.
- Topic No. 2: Assess current societal expectations of acceptable lifeline performance levels and restoration times informed by the phases of response and recovery.

3

ATC-150 Project Series

- Timeline: 2020-2022
- Team:
  - Project Technical Committee
    - Craig Davis (Project Technical Director)
    - Rachel Davidson (University of Delaware)
    - Ron Eguchi (Imagecat)
    - James Kendra (University of Delaware)
  - Experts:
    - Lucy Arendt
    - Workshop Participants (system experts)
    - Review Panel

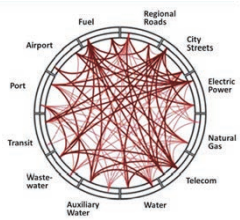
FEMA Team:
Mike Mahoney
Laurie Johnson (SME)

ATC Project Manager:
Ayse Hortacsu

4

Framework Attributes

- Applies to physical infrastructure and the spectrum of organizations that own and operate them
- Consistently applicable to different systems (16!)
- Allows adaptations
- Documents a transparent process
- Scalable for different system sizes
- Applies to spatially distributed networks
- Adaptable to different hazards and intensities



Interdependencies!

5

Recovery Objectives for Lifelines

- Identify what is needed and when
  - Target maximum losses and recovery times for restoring basic service categories for different user groups consistently across all lifeline infrastructure systems as a function of hazard intensities
- Identify how to get what is needed and when
  - For each system, basic intended functions needed to achieve the service restoration goals
- Requires multidisciplinary input and knowledge of social function needs, leading to policy decisions
- Incorporates adaptations by the systems and customers

6

Objective

- Define target post-earthquake recovery goals for a lifeline system
  - for a selected lifeline system
  - for each basic service category (type of service the lifeline system provides)
  - for each user category (group of user types)
  - for each specified earthquake intensity level.

Defines What We Need & When We Need It

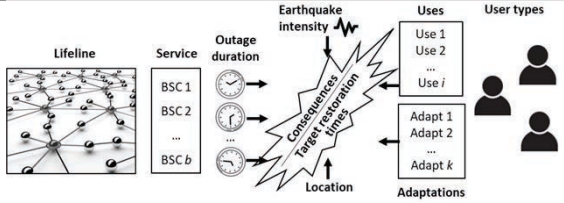
7

Expected Output

EQ INTENSITY LEVEL	TARGET WATER SYSTEM PERFORMANCE OBJECTIVES	PHILOSOPHY
I	Limited damage to water system, no casualties, few to no water service losses. All customer services operational within about 3 days.	Small event, Limited damage, no significant adaptations needed
II	All customer services operational within about 20 days, except water quantity; rationing may extend up to 30 days.	Large event causing significant damage requiring adaptations
III	Life safety and property protection. All customer services operational within about 30 days, except water quantity; rationing may extend up to 60 days.	Very large event causing serious damage requiring extended use of adaptations
IV	Life safety and property protection. All customer services operational within about 60 days, except water quantity; rationing may be extended to 90 days or more.	Rare and very extreme, but plausible, event. System response is to contain losses in support of community recovery. Resilience planning for the plausible but unknown.

8

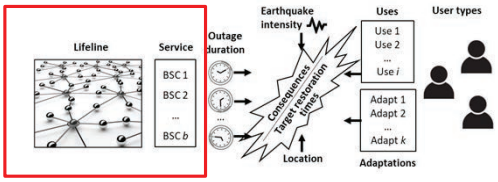
Philosophy



Target restoration times depend on the consequences at the societal level

9

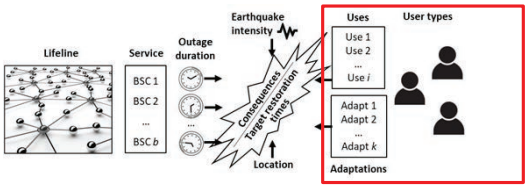
Services Provided



Each lifeline may offer multiple basic services, some may be interrupted while others are not, and not all basic services are required to support all customer uses

10

Uses and Users



- Knowledge, experience, and resources to cope with outages through user adaptations
- Level of consequences depends on number and types of users and their uses
- Societal impact is based on aggregate of impacts

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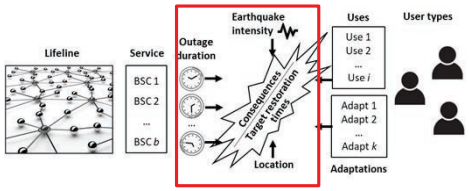
Context of Event



- Based on Earthquake intensity and geographic extent
- Target Recovery Time is time available for system recovery
- Determines feasible adaptations and expected social and government support to mitigate and help recovery from outages

12

Framework's Seven Steps

DEFINITIONS

- System: purpose and basic services
- User: uses, needs, adaptations
- Target: societal impact level for given hazard level

INDIVIDUAL ASSESSMENT

Assess consequences of service interruption for each user type-use-outage duration with and without adaptations

AGGREGATION

- Aggregate target restoration times for each BSC and user category
- Relate to hazard level including earthquake context
- Define societal level target restoration times

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Example Application to a Water System

Water Services — Kinds of Uses

User Type	Critical Customer Cat. (A, B, C)	d= 0 up to 1 day: Drinking/cooking	Bathing/washing	Toilet flushing	Outdoors (lawn, garden, pool)	Medical care	Production of product(s)	Work/business/livelihood	HVAC	Equipment Cooling	Fire Suppression	d= 1 up to 3 days: Drinking/cooking	Bathing/washing	Toilet flushing	Outdoors (lawn, garden, pool)	Medical care	Production of product(s)	Work/business/livelihood	HVAC	Equipment Cooling	Fire Suppression
Healthcare facilities (critical)	A	H	M	M	n/a	H	n/a	M	M	H	L	H	H	M	H	n/a	H	n/a	M	H	L	H
Emergency Operations Facilities (inc. gov. needed for Em. Resp.)	A	M	M	M	n/a	L	n/a	M	M	L	H	H	H	H	n/a	L	n/a	M	M	L	H
Emergency Evacuation Center (designated locations)	A	M	M	H	n/a	M	n/a	n/a	H	L	H	H	H	H	n/a	M	n/a	n/a	H	L	H
First Responders (Police/Fire Stations)	A	M	M	M	n/a	L	n/a	M	M	L	H	H	H	H	n/a	M	n/a	M	M	L	H
Jail & Mass detention facilities (incl. animal - shelter, zoo, ...)	A	M	M	M	n/a	M	n/a	L	H	L	H	H	H	H	n/a	M	n/a	M	H	L	H
Elem. to Univ. Schools (not designated as evac. cntr.; excl. dorms)	B	L	L	M	L	n/a	n/a	M	M	L	H	H	M	H	L	n/a	n/a	M	M	L	H
Schools (not designated as evac. cntr.; incl. dorms)	A	M	M	M	L	n/a	n/a	M	M	L	H	H	H	H	L	n/a	n/a	M	M	L	H
Commercial	B/C	L	L	L	n/a	n/a	n/a	M	L	L	M	L	L	M	n/a	n/a	n/a	M	M	L	M

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Consequences – with Adaptations

Water Services — Kinds of Uses

User Type	Critical Customer Cat. (A, B, C)	d= 0 up to 1 day: Drinking/cooking	Bathing/washing	Toilet flushing	Outdoors (lawn, garden, pool)	Medical care	Production of product(s)	Work/business/livelihood	HVAC	Equipment Cooling	Fire Suppression	d= 1 up to 3 days: Drinking/cooking	Bathing/washing	Toilet flushing	Outdoors (lawn, garden, pool)	Medical care	Production of product(s)	Work/business/livelihood	HVAC	Equipment Cooling	Fire Suppression
Healthcare facilities (critical)	A	M				M			M		M	H		H		H			H		H
Emergency Operations Facilities (inc. gov. needed for Em. Resp.)	A										M	M	M	M							M
Emergency Evacuation Center (designated locations)	A	M	M	M					M		M	H	H	H					H		H
First Responders (Police/Fire Stations)	A										M	M	M	M							M
Jail & Mass detention facilities (incl. animal - shelter, zoo, ...)	A								M		M	H	H	H					H		H
Elem. to Univ. Schools (not designated as evac. cntr.; excl. dorms)	B										M	M		M							H
Schools (not designated as evac. cntr.; incl. dorms)	A										M	H	H	H							H
Commercial	B/C																				

Delivery
Quality
Quantity
Fire Protection

15

User Adaptations

- Literature review and user interviews conducted to better understand how a possible water outage impacts organizations and how they would adapt
  - Literature exists for similar work with residential customers

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Recovery Times

Different sets of target recovery times will achieve different levels of societal performance:

- Target recovery time assuming NO adaptations
- Target recovery time assuming WITH adaptations
- Target recovery time assuming adaptations used for an extended duration
- Target recovery time beyond with societal impacts may not be recoverable (Maximum)

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Service Category	Service Description	No Adaptations	With Adaptations	With Extended Adaptations	Maximum Manageable
Delivery	Restore to all customers	3 days	7 days	14 days	30 days
Quality	Restore to all customers	3 days	15 days	30 days	60 days
	Restore to all Critical A customers	<1 day	3 days		
	Restore to all Critical B customers	2 days	7 days		
Quantity	Restore to pre-event normal demand (rationing removed)	7 days	30 days	60 days	>90 days
Fire Protection	Restore to all hydrants and customers having fire service at main service connections	<1 day	20 days	30 days	60 days

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Potential Uses of Framework

- Improved understanding of likely user consequences of different types and durations of service outages
- Improved understanding of the role of user adaptations to service interruptions

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Future of ATC-150 Project

- FEMA FY 2022 appropriations cut by $400,000 by the Senate with no explanation provided.
- That means the ATC-150 project will end with the publication of this report.

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THE UNIVERSITY OF BRITISH COLUMBIA

Other frameworks to assess earthquake-induced downtime and evaluate the impact of design interventions on functional recovery

ATC & FEMA Workshop on Functional Recovery
August 18, 2022

Carlos Molina Hutt, PhD, PE
Assistant Professor of Structural and Earthquake Engineering
www.esrlab.org

1

1

OBJECTIVE & OUTLINE

Objective:

Share relevant ongoing work & identify opportunities for collaboration

Outline:

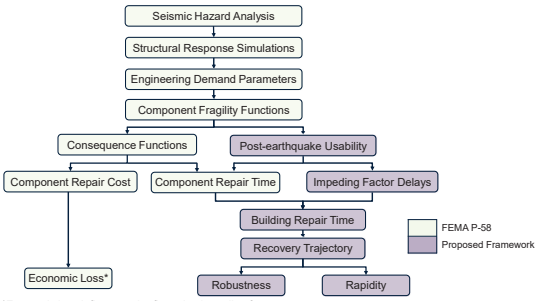
1. Analytical framework to assess downtime and model building recovery
2. Prescriptive design strategies to minimize earthquake-induced downtime

Objective & Outline → Downtime Assessment Framework → Prescriptive Design Strategies

2

2

1. DOWNTIME ASSESSMENT FRAMEWORK



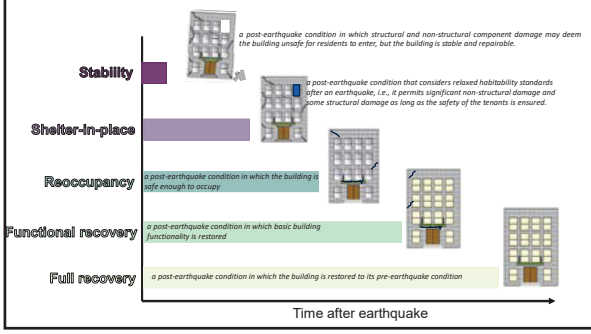
*Economic loss influences the financing impeding factor

Objective & Outline → Downtime Assessment Framework → Prescriptive Design Strategies

3

3

1. DOWNTIME ASSESSMENT FRAMEWORK



Objective & Outline → Downtime Assessment Framework → Prescriptive Design Strategies

4

4

1. DOWNTIME ASSESSMENT FRAMEWORK

Existing performance measures

1. Life-safety:
   - P(collapse) < 10% given site-specific MCE_R

Proposed (additional) performance measures

2. Robustness (usability of building immediately after the earthquake):
   - P(not achieving shelter in place) < 10% given FLE
3. Rapidity (speed of recovery):
   - P(downtime to functional recovery > 4 months) < 10% given FLE

**For Risk Category II Buildings*

***FLE = functional-level earthquake (~475 yr ground motion intensity)*

Objective & Outline → Downtime Assessment Framework → Prescriptive Design Strategies

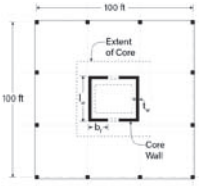
5

5

2. DESIGN STRATEGIES TO MINIMIZE DOWNTIME

Residential RC shear wall buildings:

- Reference (REF) or Baseline Designs
- 8-, 12-, 16-, 20- & 24-stories
- Designed to ASCE 7-16
- Downtown Seattle, WA
- Modal Response Spectrum Analysis
- Seismic Response Modification Factor, R = 6
- Importance Factor, I = 1.0
- Site Properties: V_{s30} = 500 m/s



Compute Wall Forces using Modal Analysis → Size Core to Satisfy Drift Target → Check Shear Stress → Design Wall Reinforcement for Flexure → Detail Reinforcement according to ACI 318-14 (Chapter 18)

Source: Marafi et al. (2020)

Objective & Outline → Downtime Assessment Framework → Prescriptive Design Strategies

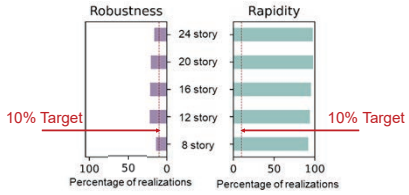
6

6

2. DESIGN STRATEGIES TO MINIMIZE DOWNTIME

Baseline Design Results:

- Robustness and rapidity performance for the 8- to 24-story REF archetypes
- Baseline designs (REF archetypes) that meet minimum code requirements
- Functional Level Earthquake (FLE) or 475 year hazard level



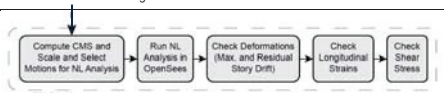
FLE assessment results for the 8- to 24-story REF archetypes

7

2. DESIGN STRATEGIES TO MINIMIZE DOWNTIME

Structural & Other Design Interventions:

Design Strategy	Description	*SC: with enhanced slab-column connections
REF + SC	Reference archetype designed per ASCE 7-16 (2% drift limit)	
S25% + SC	REF archetype redesigned with 25% increase in design lateral loads	
S50% + SC	REF archetype redesigned with 50% increase in design lateral loads	
DL1.5% + SC	REF archetype redesigned to meet 1.5% drift limit	
DL1.25% + SC	REF archetype redesigned to meet 1.25% drift limit	
S25%+DL1.5% + SC	REF archetype redesigned with 25% increase in design lateral loads and 1.5% drift limit	
PBD + SC	Performance-Based Design	



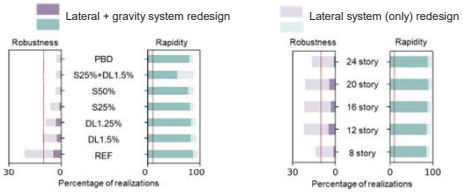
Source: Kourehpaz et al. (2020)

8

2. DESIGN STRATEGIES TO MINIMIZE DOWNTIME

Structural Design Interventions:

- Robustness and rapidity performance
- Design strategies (w/ and w/out enhanced slab-column connections)
- Functional Level Earthquake (FLE) or 475 year hazard level



16-story archetypes

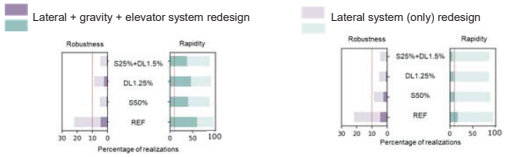
8- to 24-story REF

9

2. DESIGN STRATEGIES TO MINIMIZE DOWNTIME

Structural & Non-structural Design Interventions:

- Robustness and rapidity performance for the **16-story archetypes**
- 4 struct. schemes + enhanced slab-column connections + enhanced elevator
- Baseline (left) vs reduced (right) impeding factors
- Functional Level Earthquake (FLE) or 475 year hazard level



16 story archetype
Baseline impeding factors

16 story archetype
Reduced impeding factors

10

CONCLUSIONS

- I showcased **an analytical framework to assess earthquake-induced downtime and model recovery of buildings**, which evaluates the **immediate post-earthquake usability** of the building and models the individual **building-level recovery trajectory** to a range of recovery states.
- It permits evaluating probabilistic seismic performance measures for individual buildings in terms of resilience-based metrics, such as **robustness** and **rapidity.**
- For the case study buildings assessed under a functional level earthquake, **structural interventions** alone are sufficient to ensure a low probability of not achieving **shelter-in-place** (robustness performance measure), but need to be coupled with **nonstructural enhancements and mitigation measures** that minimize impeding factor delays to ensure a low probability of not achieving **functional recovery** within 4 months (rapidity performance measure).

11

12

RELEVANT PUBLICATIONS

- Molina Hutt, C., Vahanvaty, T. and Kourehpaz, P. (2022). "An analytical framework to assess earthquake induced downtime and model recovery of buildings." *Earthquake Spectra,* 38(2) 1283–1320. https://doi.org/10.1177/87552930211060856
- TREADS or Tool for Recovery Estimation And Downtime Simulation: https://github.com/carlosmolinahutt/treads
- Molina Hutt, C., Hulsey, A. M., Kakoty, P., Deierlein, G. G., Eksir Monfared, A., Yen, W. Y. and Hooper, J. D. (2022). "Towards functional recovery performance in the seismic design of modern tall buildings." *Earthquake Spectra,* 38(1) 283–309. https://doi.org/10.1177/87552930211033620

13

13

ARUP

Functional Recovery Times of Code Compliant Buildings

SEAONC Resilience Committee
Jakub Valigura

FEMA Sponsored Workshop on Functional Recovery
August 17-18, 2022

1

ARUP

SEAONC Resilience Committee

- General Committee
- Wildfire Task Group
- Functional Recovery Group
  - 10 members (all practicing)
  - 3 project managers
  - 5 project engineers
  - 2 risk analysts

2

ARUP

Motivation

- What is our baseline?

3

ARUP

Motivation

- What is our baseline?
  - Addressed by researchers based on archetypes

4

ARUP

Motivation

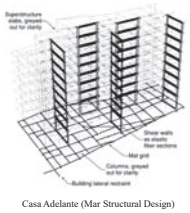
- We design buildings that may not look like archetypes.

5

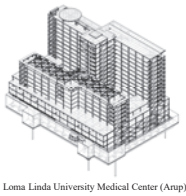
ARUP

Motivation

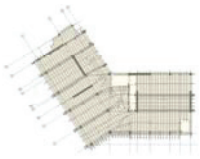
- We design buildings that may not look like archetypes.



Casa Adelante (Mar Structural Design)



Loma Linda University Medical Center (Arup)



Haas School of Business (Tipping)

6

ARUP

Motivation

- Several methods currently out there:
  - ATC 138
  - REDi
  - Carlos Molina-Hutt
  - PEER (Vesna Terzic)
  - …

7

ARUP

Motivation

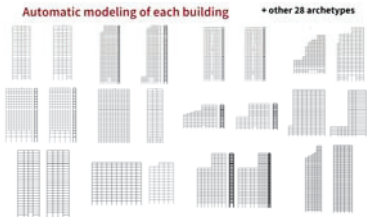
- Several methods currently out there:
  - ATC 138
  - REDi
  - Carlos Molina-Hutt
  - PEER (Vesna Terzic)
  - …
- What is the epistemic uncertainty?

8

ARUP

Ideas

- If we were not constraint by free time of volunteers:



Courtesy of Francisco Galvis

9

ARUP

Ideas

- Blind Prediction Competition
  - Except we would not really know the correct answer.

10

ARUP

- Questions
- Comments
- Suggestions
- Getting involved

jakub.valigura@arup.com

11

Reimagining the ICCPC and Functional Recovery

Brian Meacham, Meacham Associates
ATC FEMA-Sponsored Workshop on Functional Recovery
17-18 August 2022, Embassy Suites SFO Waterfront, Burlingame, CA

1

Reimagining the ICCPC Research Effort

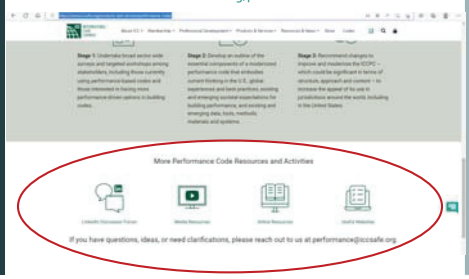
www.iccsafe.org/performance

Reimagining the ICC Performance Code

2

Reimagining the ICCPC Research Effort

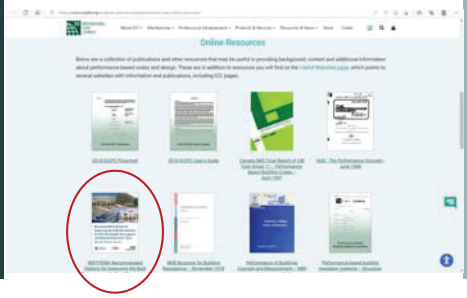
www.iccsafe.org/performance



3

Reimagining the ICCPC Research Effort

https://www.iccsafe.org/products-and-services/performance-code-online-resources/



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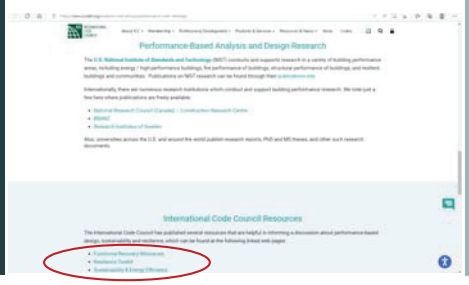
Reimagining the ICCPC Research Effort

https://www.iccsafe.org/products-and-services/performance-code-websites/



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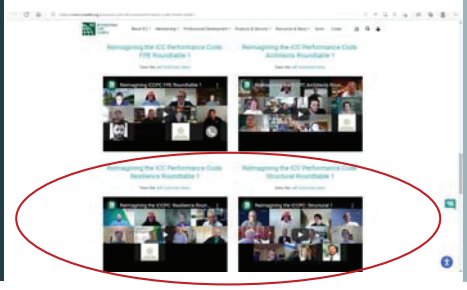
Reimagining the ICCPC Research Effort

https://www.iccsafe.org/products-and-services/performance-code-media-center/



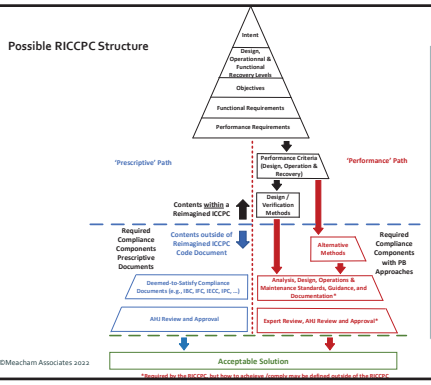
6

Reimagining the ICCPC Research Effort

- Benchmarking survey in summer 2021, stakeholder group roundtable discussions in fall 2021, workshop in late winter 2022.
- Participants support mechanisms to facilitate performance-based design and verification.
- Participants support concepts embodied in ICCPC.
- Participants support moving forward, but not 100% consensus on how. Majority support for standalone document like the current ICCPC.
- Quantification & verification critical. Expert (peer) review needed. Flexibility & appropriateness key.

7

Possible Reimagined ICCPC Structure



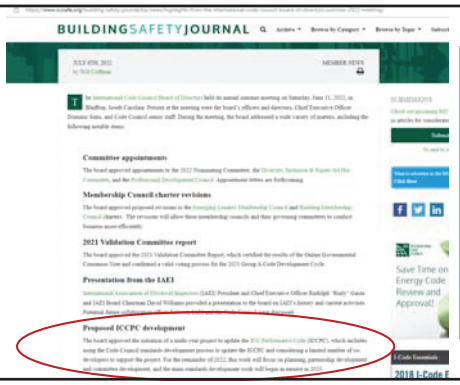
8

Key New Considerations

- In addition to 'performance group' concept (which will be changed to 'risk groups' for building design
  - Explore the concept of outcome-based performance objectives, requirements and measures as part of new sustainability focus (i.e., in-use performance)
  - Introduce functional recovery performance objectives, requirements and measures as part of new community resilience focus (including coupled event magnitude and time to functional recovery level(s) for different events)
- Will require collaboration with key groups / experts that have the knowledge, like this group today

9

Outcome of Research Effort



10

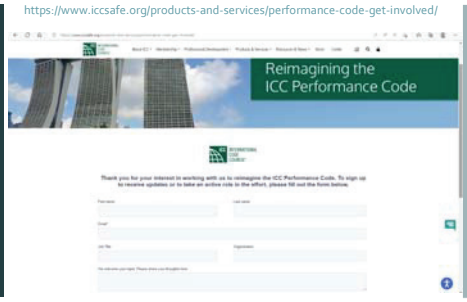
Steps Forward

- I am starting some work for ICC to expand on input gained in research effort to provide additional resources for document development (fall 2022)
- ICC will be reaching out to entities to collaborate with on the development, starting the process to form committees, seeking committee members, etc.
- The new ICCPC will remain a code, but will follow the ICC standards development process
- Standards development to begin in 2023

11

Steps Forward

https://www.iccsafe.org/products-and-services/performance-code-get-involved/



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Appendix C

Ongoing Activities

C.1 Ongoing Activities Reported by Workshop Participants

FEMA-Sponsored Workshop on Functional Recovery

Pre-Workshop Questionnaire

Objective: The purpose of this questionnaire is to collect information on research, design practice, committee, code development, or federal/state/local government program activities related to functional recovery. Please complete one questionnaire for each activity you wish to report. Information will be used to inform workshop discussions and may be shared with workshop participants.

Contact:

Name: David Bonowitz	Email: dbonowitz@att.net
Affiliations: (*list organizations you are involved with*) EQFR Roundtable, FEMA-ATC SCSC, NEHRP PUC, SEAONC/SEAOC Resilience Coms, EERI coms, ASCE 41 com	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Code development, Public policy development, Structural engineering consulting

Activity:

Title:	Earthquake Functional Recovery Roundtable
Brief Description: (*e.g., what problem is being solved*)	Problem: Different groups -- from researchers to practitioners to government agencies -- are working on FR but might not be aware of each others' work or aware of the process by which their work can contribute to future FR policy (especially as represented by the IBC). Solution: A loose affiliation of about 30 researchers, practitioners, and organization reps sharing information about their work and, where feasible, collaborating on new products to move that work forward in a coordinated way. Started by me, Curt Haselton, and Ryan Kersting, with (non-financial) assistance from ATC through Jon Heintz.
Timeline: (*e.g., start and end dates*)	The group met in Jan 2022 and has had a little correspondence since. There is no timeline for follow-up work.
Deliverable and Intended Audience:	Based on a post-meeting survey, the group is interested in developing two products, if individuals' schedules allow: A glossary of terms, and a common testbed for trial applications of various FR assessment and prediction tools.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	EQFR's intent is to coordinate multiple streams of activity related to the development of FR. Therefore, it covers all of the topics below, but it is mostly focused on buildings, not infrastructure.

Yes	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
Yes	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
Yes	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
Yes	*Providing Education and Outreach to Enhance Awareness and Understanding*
Maybe	*Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives*

Opportunities for Collaboration with others?	Yes, if the group remains active.
How to Learn More: (*e.g., website, report, or contact information*):	Contact me.

FEMA-Sponsored Workshop on Functional Recovery

Pre-Workshop Questionnaire

Objective: The purpose of this questionnaire is to collect information on research, design practice, committee, code development, or federal/state/local government program activities related to functional recovery. Please complete one questionnaire for each activity you wish to report. Information will be used to inform workshop discussions and may be shared with workshop participants.

Contact:

Name: David Bonowitz	Email: dbonowitz@att.net
Affiliations: (*list organizations you are involved with*) EQFR Roundtable, FEMA-ATC SCSC, NEHRP PUC, SEAONC/SEAOC Resilience Coms, EERI coms, ASCE 41 com	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Code development, Public policy development, Structural engineering consulting

Activity:

Title:	2024 IBC development (on my own and with FEMA-ATC SCSC)
Brief Description: (*e.g., what problem is being solved*)	Problem: IBC does not properly address expected and needed FR time for certain occupancies. Solution: Assign 5 additional occupancies to Risk Category IV, which is the code's tool for prioritizing FR: Non-emergency medical, Assisted living facilities, Detention facilities, Public utilities for water and power, Food processing facilities
Timeline: (*e.g., start and end dates*)	Current. Will be resolved at ICC hearings in Sept 2022. But if successful, effort might be made to get states to adopt similar provisions before 2024 code is adopted.
Deliverable and Intended Audience:	If successful, 2024 IBC. Audience: All model code users, starting when the 2024 edition is adopted, which varies by state with 2025 or 2026 the likely earliest dates.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

	Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives
Yes	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	Yes, if successful at ICC hearings, collaboration would involve advocacy for early adoption by states.
How to Learn More: (*e.g., website, report, or contact information*):	Contact me. For copies of the code changes and public comments, see ICCsafe.org. The five proposals are S74-22 through S78-22.

FEMA-Sponsored Workshop on Functional Recovery

Pre-Workshop Questionnaire

Objective: The purpose of this questionnaire is to collect information on research, design practice, committee, code development, or federal/state/local government program activities related to functional recovery. Please complete one questionnaire for each activity you wish to report. Information will be used to inform workshop discussions and may be shared with workshop participants.

Contact:

Name: David Bonowitz	Email: dbonowitz@att.net
Affiliations: (*list organizations you are involved with*) EQFR Roundtable, FEMA-ATC SCSC, NEHRP PUC, SEAONC/SEAOC Resilience Coms, EERI coms, ASCE 41 com	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Code development, Public policy development, Structural engineering consulting

Activity:

Title:	Resilience-based Building Inventories
Brief Description: (*e.g., what problem is being solved*)	Problem: Inventory is the first stage in developing earthquake risk-reduction programs (such as "soft story" or URM retrofit programs), but traditional inventories focus only on structure type, not on use or occupancy, and do not consider the broader building stock context. Therefore, they are inadequate to a planning process like the NIST Community Resilience Planning Guide. Solution: Develop key concepts and recommended procedures for conducting resilience-based inventories for small or mid-size communities.
Timeline: (*e.g., start and end dates*)	In progress as a SEAONC Special Project. Report due by end of 2022.
Deliverable and Intended Audience:	Primary audience (though they don't know it) should be CalOES, FEMA. and other agencies with the ability to fund local jurisdictions through mitigation grants. Ideally, they would require or recommend a resilience-based inventory as part of the funded programs and would use this report as a guide. (cont. in next box)
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	Cont from above: Secondary (but more likely) audience: Cities and their engineer consultants who might do this work without funding.

Yes	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
Yes	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
Yes	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
Yes	*Providing Education and Outreach to Enhance Awareness and Understanding*
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	No, as the project is well underway.
How to Learn More: (*e.g., website, report, or contact information*):	Contact me.

FEMA-Sponsored Workshop on Functional Recovery

Pre-Workshop Questionnaire

Objective: The purpose of this questionnaire is to collect information on research, design practice, committee, code development, or federal/state/local government program activities related to functional recovery. Please complete one questionnaire for each activity you wish to report. Information will be used to inform workshop discussions and may be shared with workshop participants.

Contact:

Name: David Bonowitz	Email: dbonowitz@att.net
Affiliations: (*list organizations you are involved with*) EQFR Roundtable, FEMA-ATC SCSC, NEHRP PUC, SEAONC/SEAOC Resilience Coms, EERI coms, ASCE 41 com	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Code development, Public policy development, Structural engineering consulting

Activity:

Title:	NEHRP Resource Paper: Resilience Based Design
Brief Description: (*e.g., what problem is being solved*)	Problem: NEHRP Provisions needed a guide to resilience-based design Solution: A 2020 Provisions Part 3 resource paper, as well as a chapter in the Examples manual and the Training materials, explaining key concepts and outlining how future Provisions can be developed to support FR design.
Timeline: (*e.g., start and end dates*)	2020 Provisions are complete. But the Resource paper was a reference for FEMA P-2090 and will likely be one for the next edition of the Provisions, which should be complete in 2025.
Deliverable and Intended Audience:	Deliverable: Existing paper, Example chapter, and training presentation. Primary audience: NEHRP PUC members as they develop the next edition of the provisions, hopefully with new provisions for FR design (to be led by Ryan Kersting).
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

Yes	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
Yes	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	Yes, through the NEHRP PUC.
How to Learn More: (*e.g., website, report, or contact information*):	https://www.nibs.org/reports/2020-nehrp-recommended-seismic-provisions https://www.nibs.org/events/nehrp-webinar-series

FEMA-Sponsored Workshop on Functional Recovery

Pre-Workshop Questionnaire

Objective: The purpose of this questionnaire is to collect information on research, design practice, committee, code development, or federal/state/local government program activities related to functional recovery. Please complete one questionnaire for each activity you wish to report. Information will be used to inform workshop discussions and may be shared with workshop participants.

Contact:

Name: Mary Comerio	Email: mcomerio@berkeley.edu
Affiliations: (*list organizations you are involved with*) UC Berkeley	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Academic Research

Activity:

Title:	INVESTING IN HOUSING CAPACITY FOR CRISIS PREPAREDENESS.
Brief Description: (*e.g., what problem is being solved*)	Policy Report for the World Bank GFDRR Global Program for Resilient Housing to create new approaches to increasing housing capacity in client countries, as part of a resilient housing strategy.
Timeline: (*e.g., start and end dates*)	October 2021 to September 2022
Deliverable and Intended Audience:	Policy Paper in publication by the World Bank Audience: World Bank leaders and client country leaders
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	These overlaps with functional recovery are at the policy level to establish programs and technical assistance within the World Bank.

	Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives
✓	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
✓	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
	Providing Education and Outreach to Enhance Awareness and Understanding
✓	*Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives*

Opportunities for Collaboration with others?	UC Berkeley Seismic Review Committee developing resilience design guidelines for the design of new housing and critical facilities--currently in progress
How to Learn More: (*e.g., website, report, or contact information*):	World Bank Report will be on line when completed UC Seismic resilience guidelines will be public when formally adopted.

FEMA-Sponsored Workshop on Functional Recovery

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Contact:

Name: Dustin Cook	Email: dustin.cook@nist.gov
Affiliations: (*list organizations you are involved with*) NIST	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Government

Activity:

Title:	Improve nonstructural performance data for recovery-based PBEE
Brief Description: (*e.g., what problem is being solved*)	Functional recovery depends heavily on nonstructural performance. However, data on the damage and consequences for nonstructural components is very limited in state of the art methods. The Earthquake Engineering group at NIST, in Collaboration with Oregon State University and Colorado State University, is currently conducting a project to improve nonstructural performance data using finite element analysis to model component fragility. The project will be conducted by Dustin Cook, Siamak Sattar, Andre Barbosa, and John van de Lindt.
Timeline: (*e.g., start and end dates*)	Current to June 2024
Deliverable and Intended Audience:	NIST report/database and Journal Paper(s); Researchers and Practicing Engineers
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	
	Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives
Opportunities for Collaboration with others?	Yes. Specifically, benchmarking outcomes from nonstructural component models to experimental data
How to Learn More: (*e.g., website, report, or contact information*):	

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Contact:

Name: Dustin Cook	Email: dustin.cook@nist.gov
Affiliations: (*list organizations you are involved with*) NIST	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Government

Activity:

Title:	Prescriptive design requirements for functional recovery
Brief Description: (*e.g., what problem is being solved*)	The Earthquake Engineering group at NIST is currently conducting a project to investigate potential prescriptive design requirements and guidelines targeting improved functional recovery for buildings. This project will leverage performance-based functional recovery frameworks (e.g., the ATC 138 method) to develop prescriptive design requirements to meet selected recovery-based performance objectives. The project will result in both a framework that can be applied to sets of archetype building models to generalize recommended design requirements. The project will be conducted by Dustin Cook and Siamak Sattar.
Timeline: (*e.g., start and end dates*)	Current to June 2023
Deliverable and Intended Audience:	NIST report and Journal Paper; Researchers and Practicing Engineers
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	
X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
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Opportunities for Collaboration with others?	Yes. Specifically, the identification of key design parameters as well as the application of the framework to various systems and design spaces.
How to Learn More: (*e.g., website, report, or contact information*):	

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Contact:

Name: Dustin Cook	Email: dustin.cook@nist.gov
Affiliations: (*list organizations you are involved with*) NIST	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Government

Activity:

Title:	Exploring correlations between building-level and regional functional recovery performance
Brief Description: (*e.g., what problem is being solved*)	Functional recovery targets improved performance for individual buildings in order to improve community recovery. However, based on regional distributions in ground shaking for a given event, the recovery performance of all buildings within a region will not be uniform. The Earthquake Engineering group at NIST is currently conducting a project to establish correlations between building-level and community-level functional recovery performance, based on regional distributions in expected ground shaking. Outcomes form this study will be used to inform future decisions about "acceptable" recovery times for individual buildings. The project will be conducted by Dustin Cook and Siamak Sattar.
Timeline: (*e.g., start and end dates*)	Current - June 2023
Deliverable and Intended Audience:	NIST report and Journal Paper; Researchers and Practicing Engineers
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	
X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives
Opportunities for Collaboration with others?	Yes! Specifically, assessing various exposure models / building inventories
How to Learn More: (*e.g., website, report, or contact information*):	

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Contact:

Name: John Crofts	Email: jcrofts@utah.gov
Affiliations: (*list organizations you are involved with*) Utah Divivsion of Emergency Mangement, Utah EERI Chapter, Utah Seismic Safety Commission	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Govenment - Emergency Managment

Activity:

Title:	Utah credentialing of ATC-20 Evaluators
Brief Description: (*e.g., what problem is being solved*)	The Utah Seismic Safety Commission (USSC) oversees and supervises the Safety Assement Program for ATC-20, post earthquake evaluators. Currently Utah has fewer than 500 crediatialed evaluators. It is estimated that Utah will need at 5,000 evalators in large large earthquake event.
Timeline: (*e.g., start and end dates*)	This is a muli-year effort that continuing into the foreseeable future.
Deliverable and Intended Audience:	The deliverable is providing ATC-20 credentialing.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	The Funcitonal Recovery Area of Emphasis includes Building Evaluation, Built Environment, Community Recovery, Reoccupancy, green, yellow and red tag Safety designations.

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
	Designing New and Existing Buildings to Meet Recovery-Based Objectives
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
X	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
X	*Providing Education and Outreach to Enhance Awareness and Understanding*
X	*Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives*

Opportunities for Collaboration with others?	The USSC and their 15 partnering government, private, and association groups involvement. This includes the Emergency Management key ESFs.
How to Learn More: (*e.g., website, report, or contact information*):	earthquakes.utah.gov John Crofts, jcrofts@utah.gov or 801.560.2637

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Contact:

Name: Craig Davis	Email: cadavisengr@yahoo.com
Affiliations: (*list organizations you are involved with*) CA Davis Engineering	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) lifelines research and design, professional association volunteer

Activity:

Title:	Frameworks for Lifeline Infrastructure System Functional Recovery
Brief Description: (*e.g., what problem is being solved*)	FEMA Funded (ATC-150 Project): develop framework for establishing recovery time for lifeline infrastructure system basic service NIST Funded (ATC-152 Project): develop framework for system and component-level
Timeline: (*e.g., start and end dates*)	FEMA: 2020-2022; NIST 2020-2023
Deliverable and Intended Audience:	Deliverables: reports describing frameworks & how to use; Intended Audience: lifeline infrastructure systems, service users, engineering designers, owners/ operators
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
	Designing New and Existing Buildings to Meet Recovery-Based Objectives
X	*Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives*
X	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
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Opportunities for Collaboration with others?	Yes
How to Learn More: (*e.g., website, report, or contact information*):	Contact ATC, FEMA, &/or NIST

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Contact:

Name: Emily Guglielmo	Email: eguglielmo@martinmartin.com
Affiliations: (*list organizations you are involved with*) ASCE 7	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Design Practice/ Consulting

Activity:

Title:	ASCE 7-28 Seismic Subcommittee
Brief Description: (*e.g., what problem is being solved*)	TBD pending outcome of PUC FR work.
Timeline: (*e.g., start and end dates*)	January 2023-2027
Deliverable and Intended Audience:	ASCE 7-28
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

	Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives
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Opportunities for Collaboration with others?	
How to Learn More: (*e.g., website, report, or contact information*):	

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Contact:

Name: Selim Gunay	Email: selimgunay@berkeley.edu
Affiliations: (*list organizations you are involved with*) Pacific Earthquake Engineering Research Center (PEER), Structural Extreme Events Reconnaissance (StEER) Network	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Research

Activity:

Title:	BRACE2
Brief Description: (*e.g., what problem is being solved*)	Objective of BRACE2 is to develop a data & simulation framework for real time rapid & near real-time comprehensive assessments of Caltrans designed & operated bridges making use of bridge sensors to evaluate bridge conditions following earthquakes. Using these assessments, BRACE2 provides bridge operation recommendations to Caltrans (e.g., close the bridge to traffic, bridge can remain open with follow-up inspection, etc.). These bridge operations can be directly linked to different recovery states.
Timeline: (*e.g., start and end dates*)	June 2020-January 2024
Deliverable and Intended Audience:	Decision making platform for providing bridge operation recommendations to Caltrans in real and near-real time.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
	Designing New and Existing Buildings to Meet Recovery-Based Objectives
X	*Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives*
X	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
X	*Providing Education and Outreach to Enhance Awareness and Understanding*
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Opportunities for Collaboration with others?	Potential use of instrumented bridges of BRACE2 for validating and improving numerical recovery-based assessment methods
How to Learn More: (*e.g., website, report, or contact information*):	https://stairlab.berkeley.edu/projects/ Contact: Khalid M. Mosalam, PI, mosalam@berkeley.edu

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Contact:

Name: Selim Gunay	Email: selimgunay@berkeley.edu
Affiliations: (*list organizations you are involved with*) Pacific Earthquake Engineering Research Center (PEER), Structural Extreme Events Reconnaissance (StEER) Network	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Research

Activity:

Title:	PEER TSRP Program
Brief Description: (*e.g., what problem is being solved*)	The purpose of the PEER (Pacific Earthquake Engineering Research) TSRP (Transportation Research Program) is to reduce the impacts of earthquakes on California's transportation systems, including highways and bridges, port facilities, high speed rail, and airports. This is directly in line with the FEMA P-2090/ NIST SP-1254 Report emphasis focusing on lifeline infrastructure systems
Timeline: (*e.g., start and end dates*)	Ongoing program with funding provided to new projects every year
Deliverable and Intended Audience:	PEER reports documenting numerical and experimental methods and designs contributing to resilience of infrastructure systems and components
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	
X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
	Designing New and Existing Buildings to Meet Recovery-Based Objectives
X	*Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives*
X	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
X	*Providing Education and Outreach to Enhance Awareness and Understanding*
X	*Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives*
Opportunities for Collaboration with others?	Potential funding opportunities to projects that can advance recovery-based design of transportation systems. PEER is also interested in collaborations that apply and develop recovery-based assessment and design methods to residential buildings and tall buildings.
How to Learn More: (*e.g., website, report, or contact information*):	https://peer.berkeley.edu/, https://peer.berkeley.edu/research/transportation-systems, https://peer.berkeley.edu/peer-reports. Contact: Khalid M. Mosalam, PEER Director, mosalam@berkeley.edu

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Contact:

Name: Selim Gunay	Email: selimgunay@berkeley.edu
Affiliations: (*list organizations you are involved with*) Pacific Earthquake Engineering Research Center (PEER), Structural Extreme Events Reconnaissance (StEER) Network	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Research

Activity:

Title:	StEER and ATC-155 Reconnaissance Activities
Brief Description: (*e.g., what problem is being solved*)	Objective of the StEER (Structural Extreme Events Reconnaissance) Network is to increase resilience of communities by (i) collecting data via agile, efficient, and effective reconnaissance activities, (ii) generating high-value knowledge through in-depth forensic evaluations of the collected data, and (iii) improving communications of knowledge gained through reconnaissance to affected communities, researchers, practicing engineers, and policy makers. The ATC 155 project entitled "Plan to Coordinate NEHRP Post-Earthquake Investigations" presents the NEHRP plan to coordinate domestic and international post-earthquake investigations. It also identifies pre-event activities necessary to ensure that post-earthquake investigations are executed effectively. Our contribution to StEER and ATC-155 is to incorporate data collection regarding the recovery states, including time to return to re-occupancy, functional recovery, and full recovery. This data is especially important to validate and improve the methodologies used to determine recovery states using analytical models and numerical methods. Furthermore, we are using Natural Language Processing (NLP), a form of Artificial Intelligence, such that recovery data can be collected also directly from experiences of affected communities and individuals and from news.
Timeline: (*e.g., start and end dates*)	StEER: 2021-2024, ATC-155: 2022
Deliverable and Intended Audience:	Reconnaissance apps and data related to recovery states of structures, Natural Language Processing (NLP) methodologies
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	
X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
X	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
X	*Providing Education and Outreach to Enhance Awareness and Understanding*
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives
Opportunities for Collaboration with others?	Collaborations and feedback in reconnaissance activities for effective data collection regarding functional recovery
How to Learn More: (*e.g., website, report, or contact information*):	https://www.steer.network/ Contact: Khalid M. Mosalam, StEER Associate Director for Seismic Hazards, mosalam@berkeley.edu

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Contact:

Name: Ron Hamburger	Email: rohamburger@sgh.com
Affiliations: (*list organizations you are involved with*) Simpson, Gumpertz & Heger ATC-138 Project Team	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Practice

Activity:

Title:	ATC 138 Project
Brief Description: (*e.g., what problem is being solved*)	Development of a tool that will assess the time to achieve post-earthquake functional recovery based on FEMA P58 methodology
Timeline: (*e.g., start and end dates*)	Ongoing, however, Beta release of methodology is now available
Deliverable and Intended Audience:	A methodology and companion software to asses the post-earthquake functional recover time for buildings
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

x	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
x	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
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Opportunities for Collaboration with others?	The ATC-138 tool can be used to asses various functional recovery design options and determine their effectiveness
How to Learn More: (*e.g., website, report, or contact information*):	ATC 138 report, at www.atcouncil.org

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Contact:

Name: Jon A. Heintz	Email: jheintz@atcouncil.org
Affiliations: (*list organizations you are involved with*) ATC, FEMA	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Design Practice - Structural Engineering

Activity:

Title:	ATC-138 Project, Performance-Based Seismic Design Support
Brief Description: (*e.g., what problem is being solved*)	Ongoing support for the FEMA P-58 Seismic Performance Assessment Methodology, including expansion of the methodology to estimate reoccupancy and functional recovery for individual buildings.
Timeline: (*e.g., start and end dates*)	2019-2022
Deliverable and Intended Audience:	An updated FEMA P-58 methodology, including computational logic and default assumptions, for estimating reoccupancy and functional recovery time for buildings. Deliverables include a report and supporting materials intended for use by engineering practitioners, professional practice committees, and code-development organizations.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
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Opportunities for Collaboration with others?	Yes, through methodology beta testing and feedback
How to Learn More: (*e.g., website, report, or contact information*):	http://femap58.atcouncil.org/

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Contact:

Name: Ayse Hortacsu	Email: ayse@atcouncil.org
Affiliations: (*list organizations you are involved with*) ATC, FEMA	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) research/design

Activity:

Title:	ATC-150 Project, Improving the Nation's Lifeline Infrastructure the Achieve Seismic Resilience
Brief Description: (*e.g., what problem is being solved*)	Development of a framework to establish national lifeline infrastructure system performance and restoration goals for seismic resilience.
Timeline: (*e.g., start and end dates*)	2019-2022
Deliverable and Intended Audience:	Final report coming in late September 2022, intended audience includes: Lifeline operators, critical and general consumers, emergency managers, regulatory agencies, design engineers
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

x	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
	Designing New and Existing Buildings to Meet Recovery-Based Objectives
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Opportunities for Collaboration with others?	The framework can continue evolving with feedback from system operators and users.
How to Learn More: (*e.g., website, report, or contact information*):	ayse@atcouncil.org

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Contact:

Name: Ayse Hortacsu	Email: ayse@atcouncil.org
Affiliations: (*list organizations you are involved with*) ATC, NIST	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) research, design

Activity:

Title:	ATC-152 Project, Developing a framework for design of lifeline infrastructure systems for functional recovery
Brief Description: (*e.g., what problem is being solved*)	To develop a preliminary framework for functional recovery of lifeline infrastructure systems after earthquake events to help avoid extended loss of critical system services. The framework will provide necessary definitions for design and retrofit of lifeline infrastructure systems to meet objectives measured in terms of acceptable losses and time to recover basic services provided by the lifeline infrastructure systems after an earthquake.
Timeline: (*e.g., start and end dates*)	2020-2023
Deliverable and Intended Audience:	Final report in September 2023. Intended audience includes owners and operators of lifeline infrastructure systems, and lifeline infrastructure system service users.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	
x	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
	Designing New and Existing Buildings to Meet Recovery-Based Objectives
x	*Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives*
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives
Opportunities for Collaboration with others?	The framework can continue evolving with feedback from system operators, users, and system designers.
How to Learn More: (*e.g., website, report, or contact information*):	ayse@atcouncil.org

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Contact:

Name: Carlos Molina Hutt	Email: carlos.molinahutt@civil.ubc.ca
Affiliations: (*list organizations you are involved with*) University of British Columbia	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Research

Activity:

Title:	Development and use of analytical frameworks to assess earthquake-induced downtime and model recovery of buildings. Exploration of design strategies to enhance the seismic resilience of buildings.
Brief Description: (*e.g., what problem is being solved*)	Sample publications: Molina Hutt, C., Vahanvaty, T. and Kourehpaz, P. (2022). "An analytical framework to assess earthquake induced downtime and model recovery of buildings." Earthquake Spectra. https://doi.org/10.1177/87552930211060856 Molina Hutt, C., Hulsey, A. M., Kakoty, P., Deierlein, G. G., Eksir Monfared, A., Yen, W. Y. and Hooper, J. D. (2022). "Towards functional recovery performance in the seismic design of modern tall buildings." Earthquake Spectra. https://doi.org/10.1177/87552930211033620
Timeline: (*e.g., start and end dates*)	Ongoing
Deliverable and Intended Audience:	Research community + practicing engineers
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
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X	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
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	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	I am very open to collaborate on the above topics. The tools and data developed by my research group are available online (see link below). I would be particularly interested in comparative studies that use a range of downtime assessment tools to evaluate functional recovery performance of buildings.
How to Learn More: (*e.g., website, report, or contact information*):	https://www.carlosmolinahutt.com/publications

FEMA-Sponsored Workshop on Functional Recovery

Pre-Workshop Questionnaire

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Contact:

Name: Omar Issa	Email: oissa@stanford.edu
Affiliations: (*list organizations you are involved with*) Blume Earthquake Engineering Research Center, Stanford University	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Research

Activity:

Title:	Development of an optimization framework to support recovery-based design
Brief Description: (*e.g., what problem is being solved*)	Methodology couples ATC-138 with machine learning and optimization tools to isolate design alternatives that meet target recovery times and hazard levels. Optimality in the framework is designed to accommodate stakeholder-specific priorities.
Timeline: (*e.g., start and end dates*)	January 2021 to July 2023
Deliverable and Intended Audience:	Deliverable: (1) source code with example + documentation, (2) publication(s) covering methodology and case study. Audience: researchers, engineers, code development committees.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	
X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives
Opportunities for Collaboration with others?	Prototype complete, moving into refinement stage. Industry insight regarding cost-ofenhancement / feasibility-of-enhancement for nonstructural component improvements would be helpful at this stage. Open to discussions on follow-up studies and collaboration.
How to Learn More: (*e.g., website, report, or contact information*):	Please reach out to Omar Issa (oissa@stanford.edu) or Jack Baker (bakerjw@stanford.edu) for questions, feedback, and opportunities to collaborate. 2022 conference paper can be found at: https://www.jackwbaker.com/Publications/Issa_Baker_RSL_12NCEE_FunctionalRecovery.pdf

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Contact:

Name: Katherine Johnson	Email: katherine.johnson@nist.gov
Affiliations: (*list organizations you are involved with*) National Institute of Standards and Technology	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Government

Activity:

Title:	Framework for Lifelines Functional Recovery
Brief Description: (*e.g., what problem is being solved*)	External contract with ATC (ATC project #152) to develop a framework for application of functional recovery times and categories to water, wastewater, and electric power infrastructure systems.
Timeline: (*e.g., start and end dates*)	Oct 2021- Oct 2023
Deliverable and Intended Audience:	NIST report; researchers and practitioners of lifelines infrastructure functional recovery
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	Lifelines Infrastructure

	Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives
	Designing New and Existing Buildings to Meet Recovery-Based Objectives
X	*Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives*
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	
How to Learn More: (*e.g., website, report, or contact information*):	NIST SP 1254, NIST SP 1269, email katherine.johnson@nist.gov.

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Contact:

Name: Anna Lang Ofstad	Email: anna@zylient.com
Affiliations: (*list organizations you are involved with*) FEMA National Advisory Council	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Government Advisory

Activity:

Title:	Identify reach opportunities beyond the SE community to advance FR & CR concepts
Brief Description: (*e.g., what problem is being solved*)	Identify programmatic opportunities beyond the structural engineering profession - within FEMA and state departments of emergency management - to advance community resilience and functional recovery concepts, and to increase building code adoption and enforcement.
Timeline: (*e.g., start and end dates*)	2017 - present
Deliverable and Intended Audience:	Recommend improvements to FEMA programs to the FEMA Administrator.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

	Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives
	Designing New and Existing Buildings to Meet Recovery-Based Objectives
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
X	*Providing Education and Outreach to Enhance Awareness and Understanding*
X	*Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives*

Opportunities for Collaboration with others?	Open to ideas to increase FEMA's ability to improve building code adoption & enforment
How to Learn More: (*e.g., website, report, or contact information*):	Contact anna@zylient.com

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Contact:

Name: Anna Lang Ofstad	Email: anna@zylient.com
Affiliations: (*list organizations you are involved with*) Zylient	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Practice & Government

Activity:

Title:	Automated building inventory collection for disaster mitigation & civil projects
Brief Description: (*e.g., what problem is being solved*)	We simplify the execution of seismic risk reduction programs by streamlining the identification of seismically vulnerable buildings using computer vision and AI.
Timeline: (*e.g., start and end dates*)	2019-present
Deliverable and Intended Audience:	Identification of seismically vulnerable buildings for local/state governments and insurance carriers.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

	Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives
	Designing New and Existing Buildings to Meet Recovery-Based Objectives
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
X	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	Partner engineering & consulting firms; local/state governments
How to Learn More: (*e.g., website, report, or contact information*):	Contact anna@zylient.com

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Contact:

Name: Anna Lang Ofstad	Email: anna@zylient.com
Affiliations: (*list organizations you are involved with*) SEAOC, EERI	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Professional Associations

Activity:

Title:	Educate design professionals and advance FR legislation
Brief Description: (*e.g., what problem is being solved*)	Advancing the state of awareness of functional recovery concepts to structural engineering practitioners in California and beyond. Advance legislative actions in support of FR actions.
Timeline: (*e.g., start and end dates*)	2018-present
Deliverable and Intended Audience:	Provide educational resources to design practitioners. Advocate FR to lawmakers.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
	Designing New and Existing Buildings to Meet Recovery-Based Objectives
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
X	*Providing Education and Outreach to Enhance Awareness and Understanding*
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	Professional organizations with shared vision for a more resilient built environment
How to Learn More: (*e.g., website, report, or contact information*):	anna@zylient.com for SEAOC Resilience Committee and EERI advocacy/legislative actions

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Contact:

Name: Nicolas Luco	Email: nluco@usgs.gov
Affiliations: (*list organizations you are involved with*) U.S. Geological Survey	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Federal government research and development

Activity:

Title:	2023 Update of the USGS National Seismic Hazard Model (NSHM)
Brief Description: (*e.g., what problem is being solved*)	The current 2018 NSHM for the 48 conterminous United States, 2009 NSHM for Alaska, and 1998 NSHM for Hawaii are being updated for a 2023 50-state NSHM. The Hawaii part of this update has already been published, in 2021. Structural and geotechnical engineers of the USGS "Engineering & Risk Project" are serving as liaisons between these NSHM updates and engineering applications such as building codes and risk modeling.
Timeline: (*e.g., start and end dates*)	Mostly started in January 2021, scheduled to end in December 2023.
Deliverable and Intended Audience:	A forecast of the earthquake ground motion hazard across the United States, for a wide audience ranging from the public to earthquake engineers and others.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
X	*Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives*
X	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
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Opportunities for Collaboration with others?	The aforementioned USGS liaisons are available to collaborate on the use of the NSHM for functional recovery, which might affect how the NSHM and forecasts for other natural hazards are developed.
How to Learn More: (*e.g., website, report, or contact information*):	https://www.usgs.gov/programs/earthquake-hazards/nshmp-workshops https://www.usgs.gov/programs/earthquake-hazards/science/request-hazard-modeling-contributions

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Contact:

Name: David Mar	Email: david.mar@marstructuraldesign.com
Affiliations: (*list organizations you are involved with*)	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Design practice

Activity:

Title:	Concrete Wall Typology Study with Rocking and Conventional Walls.
Brief Description: (*e.g., what problem is being solved*)	The study seeks to understand requirements for optimal performance of different flexural wall systems (rocking, hybrid, conventional), as measured from the perspective of repair cost and downtime. It looks at varying heights, hazards, and occupancies.
Timeline: (*e.g., start and end dates*)	Project start was in early 2022 and this phase will conclude at the end of year. A second and longer phase is likely.
Deliverable and Intended Audience:	The deliverable will be a NIST report for researchers and practitioners.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	Recommendation 2: Design New Buildings to Meet Recovery-Based Objectives

	Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	Yes. USGS. HB-Risk
How to Learn More: (*e.g., website, report, or contact information*):	Future report.

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Contact:

Name: Therese McAllister	Email: therese.mcallister@nist.gov
Affiliations: (*list organizations you are involved with*) ASCE, ICC, DHS CRC, NIBS, NASEM	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) research, government, code development

Activity:

Title:	Design Criteria for Critical Facilities for Resilience (includes recovery of functions)
Brief Description: (*e.g., what problem is being solved*)	To advance resilience design and assessment methods for buildings and infrastructure and to improve their ability to support the social and economic functions and community resilience.
Timeline: (*e.g., start and end dates*)	2019-2025
Deliverable and Intended Audience:	Develop resilience performance objectives and assessment criteria to improve building and infrastructure performance.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

	Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives
x	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
x	*Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives*
x	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	Critical facilities and infrastructure performance and recovery for all hazards; IN-CORE modelings of buildings and infrastructure in community-scale models; improvements to best practices, standards and codes
How to Learn More: (*e.g., website, report, or contact information*):	https://www.nist.gov/programs-projects/community-resilience-program; http://resilience.colostate.edu/in_core/; https://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.2209.pdf; https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1190GB-16.pdf

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Contact:

Name: Brian Meacham	Email: brian.meacham@meachamassociates.com
Affiliations: (*list organizations you are involved with*) ICC, NFPA, SFPE, IAFSS, IRCC	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Research on codes and risk-informed performance-based fire design

Activity:

Title:	Reimagining the ICCPC
Brief Description: (*e.g., what problem is being solved*)	I led a research effort for the ICC on 're-imagining' the ICC Performance Code (ICCPC). The research involved stakeholder discussions on aspects to be add to the ICCPC. Functional recovery was an area that resonated with several stakeholder groups as a means to facilitate community resilience efforts. In June the ICC Board approved the initiation of a multi-year project to update the ICCPC, which includes using the Code Council standards development process to update the ICCPC and considering a limited number of co-developers to support the project. For the remainder of 2022, this work will focus on planning, partnership development and committee development, and the main standards development work will begin in 2023.
Timeline: (*e.g., start and end dates*)	Phase 1: June 2021 - April 2022. Phase 2: now-2025
Deliverable and Intended Audience:	Outcome of the 'phase 2' effort will be a re-imagined ICCPC. The ICCPC will be a model code available for adoption. It may be used administratively as well to guide performance-based designs and approvals. Audiences include the building design, engineering and enforcement communities. Applicability may extend to aspects of critical infrastructure as well.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	The focus is on functional recovery objectives that could be incorporated into a future ICCPC.
X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives
Opportunities for Collaboration with others?	Yes. Input on this and related topics welcome.
How to Learn More: (*e.g., website, report, or contact information*):	https://www.iccsafe.org/products-and-services/performance-code/

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Contact:

Name: Rachel Minnery	Email: rminnery@gmail.com
Affiliations: (*list organizations you are involved with*) The American Institute of Architects	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Building codes, design practice / contractual guide

Activity:

Title:	Hazard and Climate Risk Acknowledgement Form
Brief Description: (*e.g., what problem is being solved*)	Documentation of hazards and owner's resulting choice for building performance requirements. For new construction and alteration projects
Timeline: (*e.g., start and end dates*)	complete
Deliverable and Intended Audience:	building design teams
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

	Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
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Opportunities for Collaboration with others?	
How to Learn More: (*e.g., website, report, or contact information*):	https://www.aia.org/resources/6465619-hazard-and-climate-risk-a-users-guide-and-

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Contact:

Name: Rachel Minnery	Email: rminnery@gmail.com
Affiliations: (*list organizations you are involved with*) ASTM	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Standards

Activity:

Title:	ASTM Resilience Property Assessment Guide
Brief Description: (*e.g., what problem is being solved*)	All hazards property assessment to identify hazards, risk and resilience.
Timeline: (*e.g., start and end dates*)	2022
Deliverable and Intended Audience:	Building owners and building design professionals
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

	Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
X	*Providing Education and Outreach to Enhance Awareness and Understanding*
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	Yes
How to Learn More: (*e.g., website, report, or contact information*):	contact Rachel Minnery

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Contact:

Name: Peter Morris	Email: peter.morris@aecom.com
Affiliations: (*list organizations you are involved with*) RICS	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Capital and Lifecycle costing, risk, sustainability/NZC

Activity:

Title:	Working with ATC-138 project team on functional recovery
Brief Description: (*e.g., what problem is being solved*)	Cost and duration of functional recovery - working to define what constitutes temporary and permanent fix, what is acceptable level of service - what is meant by occupiable, and are there levels to occupiable.
Timeline: (*e.g., start and end dates*)	July 2022 to September 2022
Deliverable and Intended Audience:	
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

x	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
	Designing New and Existing Buildings to Meet Recovery-Based Objectives
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Opportunities for Collaboration with others?	
How to Learn More: (*e.g., website, report, or contact information*):	

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Contact:

Name: Robert Pekelnicky	Email: RPekelnicky@degenkolb.com
Affiliations: (*list organizations you are involved with*) ASCE 7, ASCE 41, NEHRP PUC, FEMA SCSC, ICCPC Update, NIBS Functional Recovery, NIST Resilience, and ATC 140	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Design Practice, Code Development, Applied Research

Activity:

Title:	ASCE 41
Brief Description: (*e.g., what problem is being solved*)	The 2029 edition of the standard will at a minimum need to consider developing a path to any functional recovery performance objectives that are developed for ASCE 7-28.
Timeline: (*e.g., start and end dates*)	Begin in 2025 and end in 2028.
Deliverable and Intended Audience:	Updated ASCE 41 Standard for inclusion in the 2030 IBC. Audience of practicing engineers.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	
	Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives
Opportunities for Collaboration with others?	Yes. The ASCE 7 standards committee, the NEHRP PUC, and FEMA SCSC. Potential collaboration with the reimagnied ICCPC.
How to Learn More: (*e.g., website, report, or contact information*):	Contact Jennifer Goupil and Robert Pekelnicky

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Contact:

Name: Robert Pekelnicky	Email: RPekelnicky@degenkolb.com
Affiliations: (*list organizations you are involved with*) ASCE 7, ASCE 41, NEHRP PUC, FEMA SCSC, ICCPC Update, NIBS Functional Recovery, NIST Resilience, and ATC 140	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Design Practice, Code Development, Applied Research

Activity:

Title:	ATC 140 Project, Update Seismic Retrofit Design Guidance
Brief Description: (*e.g., what problem is being solved*)	Provide funded research to tackle ASCE 41 issues too complex for volunteer efforts at properly address. One of the identified topics for the 2029 edition of the standard is to adapt any functional recovery performance objectives that are proposed by the NEHRP PUC for ASCE 7 into ASCE 41.
Timeline: (*e.g., start and end dates*)	Start next federal fiscal year
Deliverable and Intended Audience:	ASCE 41 Standards Committee
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
X	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
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	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	Yes. The ASCE 41 standards committee, the NEHRP PUC, and FEMA SCSC. Potential collaboration with the reimagnied ICCPC.
How to Learn More: (*e.g., website, report, or contact information*):	Contact Justin Moresco, Terry Lundeen, and Robert Pekelnicky.

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Contact:

Name: Robert Pekelnicky	Email: RPekelnicky@degenkolb.com
Affiliations: (*list organizations you are involved with*) ASCE 7, ASCE 41, NEHRP PUC, FEMA SCSC, ICCPC Update, NIBS Functional Recovery, NIST Resilience, and ATC 140	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Design Practice, Code Development, Applied Research

Activity:

Title:	ATC-136 Project, FEMA Seismic Code Support Committee (SCSC)
Brief Description: (*e.g., what problem is being solved*)	FEMA's Seismic Code Support Committee advocates for improved building codes. The group proposes some changes for the 2024 IBC and ICCPC related to functional recovery and will undoubtedly be doing the same for the 2027 and 2030 IBC, IRC, ICCPC and IEBC.
Timeline: (*e.g., start and end dates*)	Likely starting in the next federal fiscal year and then ongoing.
Deliverable and Intended Audience:	Change proposals for the 2027 and 2030 IBC, IRC and IEBC
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
X	*Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives*
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	Yes. The ASCE 7 standards committee and the ASCE 41 standards committee. Potential collaboration with the reimagnied ICCPC.
How to Learn More: (*e.g., website, report, or contact information*):	Contact Mike Mahoney and Jon Heintz

FEMA-Sponsored Workshop on Functional Recovery

Pre-Workshop Questionnaire

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Contact:

Name: Robert Pekelnicky	Email: RPekelnicky@degenkolb.com
Affiliations: (*list organizations you are involved with*) ASCE 7, ASCE 41, NEHRP PUC, FEMA SCSC, ICCPC Update, NIBS Functional Recovery, NIST Resilience, and ATC 140	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Design Practice, Code Development, Applied Research

Activity:

Title:	ICCPC
Brief Description: (*e.g., what problem is being solved*)	ICC has launched an effort to re-imagine their Performance Code. Given this effort will occur in parallel with efforts to introduce functional recovery objectives in ASCE 7, it is very likely that the ICCPC will have functional recovery objectives.
Timeline: (*e.g., start and end dates*)	TBD
Deliverable and Intended Audience:	Change proposals for the 2027 or 2030 ICCPC
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
X	*Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives*
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	Yes. The ASCE 7 standard's committee, the ASCE 41 standard's committee, and FEMA SCSC.
How to Learn More: (*e.g., website, report, or contact information*):	Brian Meachum and ICC Staff

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Contact:

Name: Robert Pekelnicky	Email: RPekelnicky@degenkolb.com
Affiliations: (*list organizations you are involved with*) ASCE 7, ASCE 41, NEHRP PUC, FEMA SCSC, ICCPC Update, NIBS Functional Recovery, NIST Resilience, and ATC 140	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Design Practice, Code Development, Applied Research

Activity:

Title:	NEHRP Provisions Update Committee (PUC)
Brief Description: (*e.g., what problem is being solved*)	The NEHRP PUC has a functional recovery issue team that will be developing change proposals to introduce functional recovery performance objectives to ASCE 7.
Timeline: (*e.g., start and end dates*)	Started in April 2022 and ends in 2025.
Deliverable and Intended Audience:	Change proposals for the ASCE 7 Seismic Subcommittee.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
X	*Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives*
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	Yes. The ASCE 7 standards committee, ATC 140, and FEMA SCSC. Potential collaboration with the reimagnied ICCPC.
How to Learn More: (*e.g., website, report, or contact information*):	Contact JQ Yuan and Ryan Kersting.

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Contact:

Name: Siamak Sattar	Email: siamak.sattar@nist.gov
Affiliations: (*list organizations you are involved with*) NIST	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Research / Government

Activity:

Title:	Recovery Categories and Times for Functional Recovery Framework
Brief Description: (*e.g., what problem is being solved*)	This project aims to establish recovery categories and times required for developing the functional recovery framework. The project is being conducted by Siamak Sattar, Katherine Johnson, and Dustin Cook.
Timeline: (*e.g., start and end dates*)	2020-2024
Deliverable and Intended Audience:	Report, papers - practicing engineers, ...
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

x	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
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	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	Yes
How to Learn More: (*e.g., website, report, or contact information*):	contact siamak.sattar@nist.gov

FEMA-Sponsored Workshop on Functional Recovery

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Contact:

Name: Jon Siu	Email: jonsiuconsulting@gmail.com
Affiliations: (*list organizations you are involved with*) WABO, WAsafe, SEAW, ATC	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Code Development, Bldg Dept Admin (ret.)

Activity:

Title:	FEMA P-2055-1 - Guidance for Accelerated Building Reoccupancy Programs
Brief Description: (*e.g., what problem is being solved*)	ATC 137-5 project to develop guideline to aid acceptance and development of building occupancy resumption programs.
Timeline: (*e.g., start and end dates*)	In progress, scheduled to finish in September
Deliverable and Intended Audience:	Guideline document, with building officials as primary audience
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	Task 5.5: develop & implement building occupancy resumption programs

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X	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	
How to Learn More: (*e.g., website, report, or contact information*):	ATC (Ayse Hortescu)

FEMA-Sponsored Workshop on Functional Recovery

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Contact:

Name: Jon Siu	Email: jonsiuconsulting@gmail.com
Affiliations: (*list organizations you are involved with*) WABO, WAsafe, SEAW	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Code Development, Bldg Dept Admin (ret.)

Activity:

Title:	WAsafe Building Safety Evaluators
Brief Description: (*e.g., what problem is being solved*)	Train, enroll, and dispatch qualified volunteers to aid local building departments conducting building safety evaluations.
Timeline: (*e.g., start and end dates*)	Ongoing
Deliverable and Intended Audience:	Cadre of qualified volunteer BSEs for local building officials in WA
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	Task 5.4: staffing to expedite post-EQ recovery

	Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives
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X	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
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	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives

Opportunities for Collaboration with others?	
How to Learn More: (*e.g., website, report, or contact information*):	Jon Siu (email above or jon.wabo@wasafecoalition.org)

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Contact:

Name: J. G. (Greg) Soules	Email: greg.soules@mcdermott.com
Affiliations: (*list organizations you are involved with*) SEI (ASCE 7), BSSC PUC	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Design Practice

Activity:

Title:	BSSC/PUC Functional Recovery Task Committee
Brief Description: (*e.g., what problem is being solved*)	It is envisioned that 5 teams will be formed looking at the following areas: Define key terms and concepts related to Functional Recovery, Define Functional Recovery Categories with appropriate ranges of recovery time targets, Develop functional recovery time objectives for various occupancies/services, Develop prescriptive provisions that meet functional recovery category objectives, and Develop hazard level(s) applicable for functional recovery performance objectives
Timeline: (*e.g., start and end dates*)	2022 to 2026
Deliverable and Intended Audience:	2026 NEHRP Provisions; Code writing bodies, practicing structural engineers, researchers
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	
X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
X	*Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives*
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives
Opportunities for Collaboration with others?	Yes.
How to Learn More: (*e.g., website, report, or contact information*):	Contact Jiqiu Yuan <jyuan@nibs.org>

FEMA-Sponsored Workshop on Functional Recovery

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Contact:

Name: Ron Takiguchi	Email: rtakiguchi@cityofpasadena.net
Affiliations: (*list organizations you are involved with*) CALBO, ICC, IEEE, NFPA	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Code Dev, Building Dept Admin

Activity:

Title:	Buildings: New: Higher structural-resiliency standards and utility infrastructure. Existing: Funding and regulation to require strengthening at functional recovery levels.
Brief Description: (*e.g., what problem is being solved*)	Allows increased probability for Immediate Occupancy and Operational Continuity. Minimize financial effects from business operational loss, building damage, human injury. Minimize need for mutual aid. Incorporate the above into national building standards.
Timeline: (*e.g., start and end dates*)	Start development with next ICC building code cycle. Standards based on ATC, FEMA-NIST.
Deliverable and Intended Audience:	Resiliency and Functional Recovery Standards to be incorporated into model building codes. Technical professionals to develop standards. Government political branches to promote and require standards.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	Buildings, Building Utility Infrastructure, Building Communication Network, Building Emergency Systems

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
X	*Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives*
X	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
X	*Providing Education and Outreach to Enhance Awareness and Understanding*
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Opportunities for Collaboration with others?	Outreach at professional organization meetings and conferences
How to Learn More: (*e.g., website, report, or contact information*):	Top level disseminate information to branch levels - i.e. ATC, FEMA, NIST, ICC contact professional groups: SEAOC, CALBO, etc with standards development and legislative updates

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Contact:

Name: Jakub Valigura	Email: jakub.valigura@arup.com
Affiliations: (*list organizations you are involved with*) Arup, SEAONC Resilience Committee	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Design Practice, Code Development

Activity:

Title:	Functional Recovery Times of Code-Compliant Buildings
Brief Description: (*e.g., what problem is being solved*)	Testbed "real" buildings Epistemic uncertainty of different methods
Timeline: (*e.g., start and end dates*)	8/2022 - 8/2023 with possible extension
Deliverable and Intended Audience:	Testbed buildings, Researchers and Code Writters
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
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Opportunities for Collaboration with others?	Yes, NIST (Dustin Cook), BSSC PUC (Ryan Kersting), practicing engineers
How to Learn More: (*e.g., website, report, or contact information*):	jakub.valigura@arup.com

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Contact:

Name: John W. van de Lindt	Email: jwv@colostate.edu
Affiliations: (*list organizations you are involved with*) Colorado State University NIST Center for Risk-Based Community Resilience Planning	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Research and some code development

Activity:

Title:	Center for Risk-Based Community Resilience Planning
Brief Description: (*e.g., what problem is being solved*)	Modeling whole communities with interacting recovery across physical-social-economic systems. Specific relevance is need to identify functionality during recovery to know when building begin contributing to economy, support habiration, employment, etc.
Timeline: (*e.g., start and end dates*)	2015-2025
Deliverable and Intended Audience:	Researchers and communities
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
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Opportunities for Collaboration with others?	Yes, definitely.
How to Learn More: (*e.g., website, report, or contact information*):	Contact me and I can put people in touch with team working directly on it.

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Contact:

Name: Joel Villamil	Email: joel.villamil@ubs.com
Affiliations: (*list organizations you are involved with*) NAREIM; ASTM	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Bldg. Owner/Investor; EQ risk analyst

Activity:

Title:	Automated Structure Alert Program
Brief Description: (*e.g., what problem is being solved*)	Development of an in-house post-event damage predictor to deliver real-time information to investment managers and prioritize inspection to multiple properties
Timeline: (*e.g., start and end dates*)	Ongoing
Deliverable and Intended Audience:	
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
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Opportunities for Collaboration with others?	
How to Learn More: (*e.g., website, report, or contact information*):	Developed process via consultant: www.marxokubo.com/automated-structure-alert-program

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Contact:

Name: Jia Wang-Connelly	Email: jia.wang-connelly@caloes.ca.gov
Affiliations: (*list organizations you are involved with*) California Seismic Safety Commission	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Government, research, public policy

Activity:

Title:	California Seismic Safety Commission
Brief Description: (*e.g., what problem is being solved*)	Seismic Safety Commission advises California Strong Motion Instrumentation Program (CSMIP), whose data has contributed to building code improvement and confirmation of the effectiveness of base isolation technology. The Commission is also on the managing committee of California's Earthquake Clearinghouse. By participating in the workshop, I hope to learn and report back to the Commission how we could support the functional recovery-based building code development efforts through the activities we engage in, such as CSMIP and EQ Clearinghouse.
Timeline: (*e.g., start and end dates*)	Ongoing
Deliverable and Intended Audience:	
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	
	Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives
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	Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives
Opportunities for Collaboration with others?	
How to Learn More: (*e.g., website, report, or contact information*):	

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Contact:

Name: Steven R Winkel, FAIA, PE, CASp	Email: swinkel@preview-group.com
Affiliations: (*list organizations you are involved with*) AIA, ASCE, ICC, NFPA	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Building code and disabled access consulting, code development

Activity:

Title:	ATC-138-4 development - Project Review Panel member
Brief Description: (*e.g., what problem is being solved*)	The ATC-138-4 Project is expanding the FEMA P-58 Methodology to estimate time for post-earthquake reoccupancy and functional recovery in buildings. Expansion of the methodology requires specialized input related to the time it takes to inspect, clean up/secure, design, permit, mobilize, and implement repairs in buildings in the immediate aftermath of a damaging earthquake.
Timeline: (*e.g., start and end dates*)	Ongoing
Deliverable and Intended Audience:	FEMA methodology handbook. Municipalty mangers, political leaders, concerned citizens.
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

x	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
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x	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
x	*Providing Education and Outreach to Enhance Awareness and Understanding*
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Opportunities for Collaboration with others?	Yes, as a peer reviewer and interpreter for lay person understanding of complex structural and other functional recovery issues. Also commentary on ADA impacts on recovery requirements.
How to Learn More: (*e.g., website, report, or contact information*):	email, cell # 415-317-0559

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Contact:

Name: Janell Woodward	Email: janell.woodward@dem.nv.gov
Affiliations: (*list organizations you are involved with*) NV Division of Emergency Management	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Government, Emergency Management

Activity:

Title:	Nevada Statewide Community Outreach and Education
Brief Description: (*e.g., what problem is being solved*)	Statewide community outreach for awareness of earthquake risk and understanding of what to do in an earthquake and how to prepare surroundings before an earthquake occurs.
Timeline: (*e.g., start and end dates*)	Continuous
Deliverable and Intended Audience:	Entire state (community + emergency management)
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	Education and Outreach

X	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
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X	*Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives*
X	*Providing Education and Outreach to Enhance Awareness and Understanding*
X	*Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives*

Opportunities for Collaboration with others?	State and private agencies partner with emergency management to get the message out and educate about earthquakes.
How to Learn More: (*e.g., website, report, or contact information*):	State Hazard Mitigation Officer and Earthquake Program Manager - janell.woodward@dem.nv.gov

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Contact:

Name: Jiqiu (JQ) Yuan	Email: jyuan@nibs.org
Affiliations: (*list organizations you are involved with*) National Institute of Building Sciences	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) non-profit

Activity:

Title:	National committees
Brief Description: (*e.g., what problem is being solved*)	Support related national committees in advancing resilience conversation, code development and stakeholder engagement.
Timeline: (*e.g., start and end dates*)	ongoing
Deliverable and Intended Audience:	code developer, building owner, policy maker, financial service
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	

yes	*Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives*
yes	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
	Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
	Providing Education and Outreach to Enhance Awareness and Understanding
yes	*Facilitating Access to Financial Resources Needed to Achieve Recovery-Based Objectives*

Opportunities for Collaboration with others?	
How to Learn More: (*e.g., website, report, or contact information*):	https://www.nibs.org/bssc; https://www.nibs.org/mmc

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Contact:

Name: Kent Yu	Email: kentyu@seftconsulting.com
Affiliations: (*list organizations you are involved with*) SEFT Consulting Group; BSSC (as board liaison for its FR task group)	Practice Areas: (*e.g., Research, Design Practice, Prof. Assoc., Government, Code Development, Building Dept. Admin.*) Design practice; Code development

Activity:

Title:	Seismic/Resilience Support for a large water infrastructure project in Portland, Oregon
Brief Description: (*e.g., what problem is being solved*)	Develop seismic design criteria for a large water infrastructure project (including buildings and utility lifelines) in Portland, Oregon to meet post-event level of service goals (per the Oregon Resilience Plan) Perform design review of the water infrastructure for compliance
Timeline: (*e.g., start and end dates*)	July 2020 thru July 2023
Deliverable and Intended Audience:	Deliverables (a) seismic design criteria for the owner to adopt and implement; (b) Review comments for design team to incorporate into final design
Functional Recovery Area of Emphasis: (*from FEMA P-2090/ NIST SP-1254 Report; check all that apply*)	Develop seismic design criteria to help meet recovery-based goals for buildings and lifeline infrastructure systems

	Developing a Framework for Post-Earthquake Reoccupancy and Functional Recovery Objectives
X	*Designing New and Existing Buildings to Meet Recovery-Based Objectives*
X	*Designing New and Existing Lifeline Infrastructure Systems to Meet Recovery-Based Objectives*
	Developing and Implementing Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives
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Opportunities for Collaboration with others?	Yes, only if the owner provides permission.
How to Learn More: (*e.g., website, report, or contact information*):	

References

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