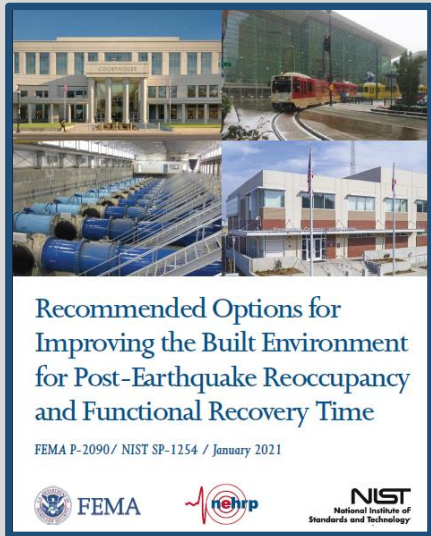


Functional Recovery of the Built Environment

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Earthquake Engineering Group
National Institute of Standards and Technology**



What is functional recovery?

Development of the report to Congress

Functional recovery stakeholder workshops

Ongoing efforts on functional recovery

NEHRP was reauthorized by Congress in **December 2018**, and a New Section on Seismic Standards with

Requirement for NIST and FEMA to:

“...jointly convene a committee of experts...to assess and recommend **options** for improving the **built environment** and **critical infrastructure** to reflect performance goals stated in terms of post-earthquake **re-occupancy** and **functional recovery time**”



Why Functional Recovery ?



Buildings and Lifeline systems may experience **extensive damage** during an earthquake

Widespread damage can have **severe social & economic** impacts:

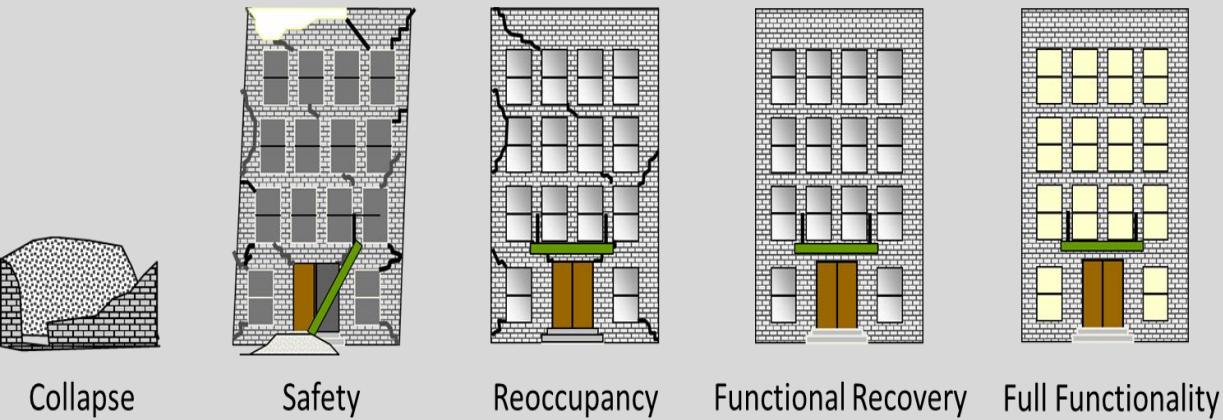
Disrupted access to **jobs and schools**

Displacement of **residents and businesses**

Functional recovery time: 6-12 months for DE and up to 2 years for MCE



Need to improve **design and retrofit** of both **buildings and lifeline** systems to allow **recovery of function** in an acceptable time



Possible Post-Earthquake States

“...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”

“...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 and Community Resilience **NIST**

Community resilience:

- “...the ability of a **community** to prepare and plan for, absorb, recover from, and more successfully adapt to adverse seismic events” (42 USC 7703)
- an attribute of a community/social unit:
- Requires long-term planning and implementation at the community level
- What can we do for design of individual buildings or lifeline systems?

Functional recovery:

- Functional recovery is the link between design, construction, and retrofit of individual assets and community resilience
- Depends less on resilience planning and relies more on codes and standards
- An attribute of individual building or lifeline system

Functional Recovery Report



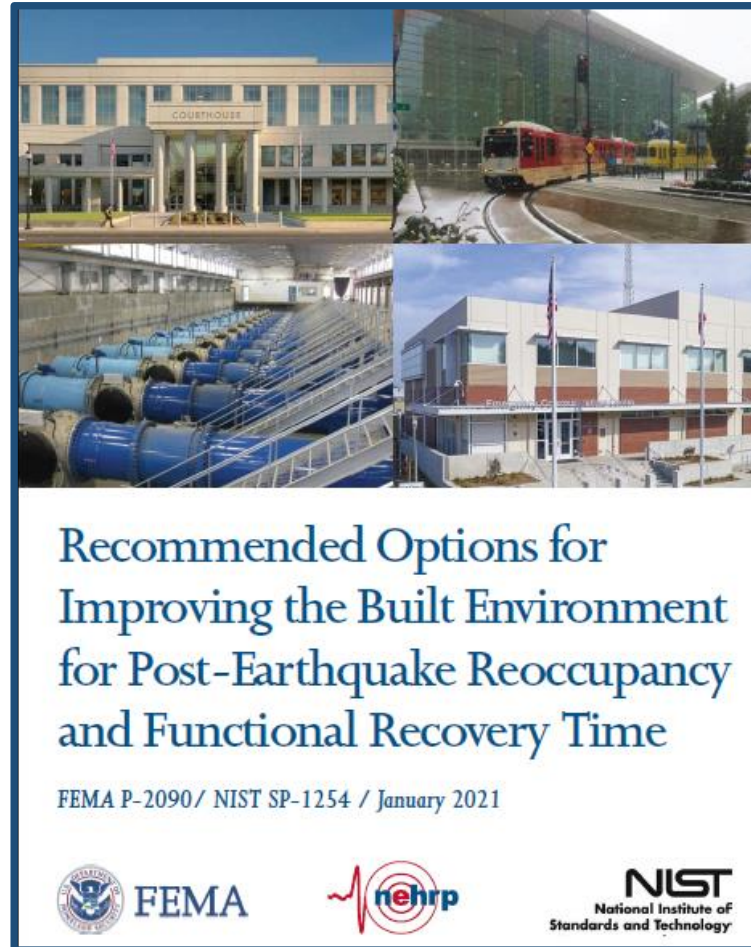
**Project Technical
Panel**
~20 members



Project Review Panel
~10 members



**5 Stakeholder
Workshops**
Across the US



NIST-FEMA Report FEMA P-2090/NIST SP-1254
nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1254

7 Key Report Recommendations

physical built environment

Rec 1: Develop Functional Recovery Framework

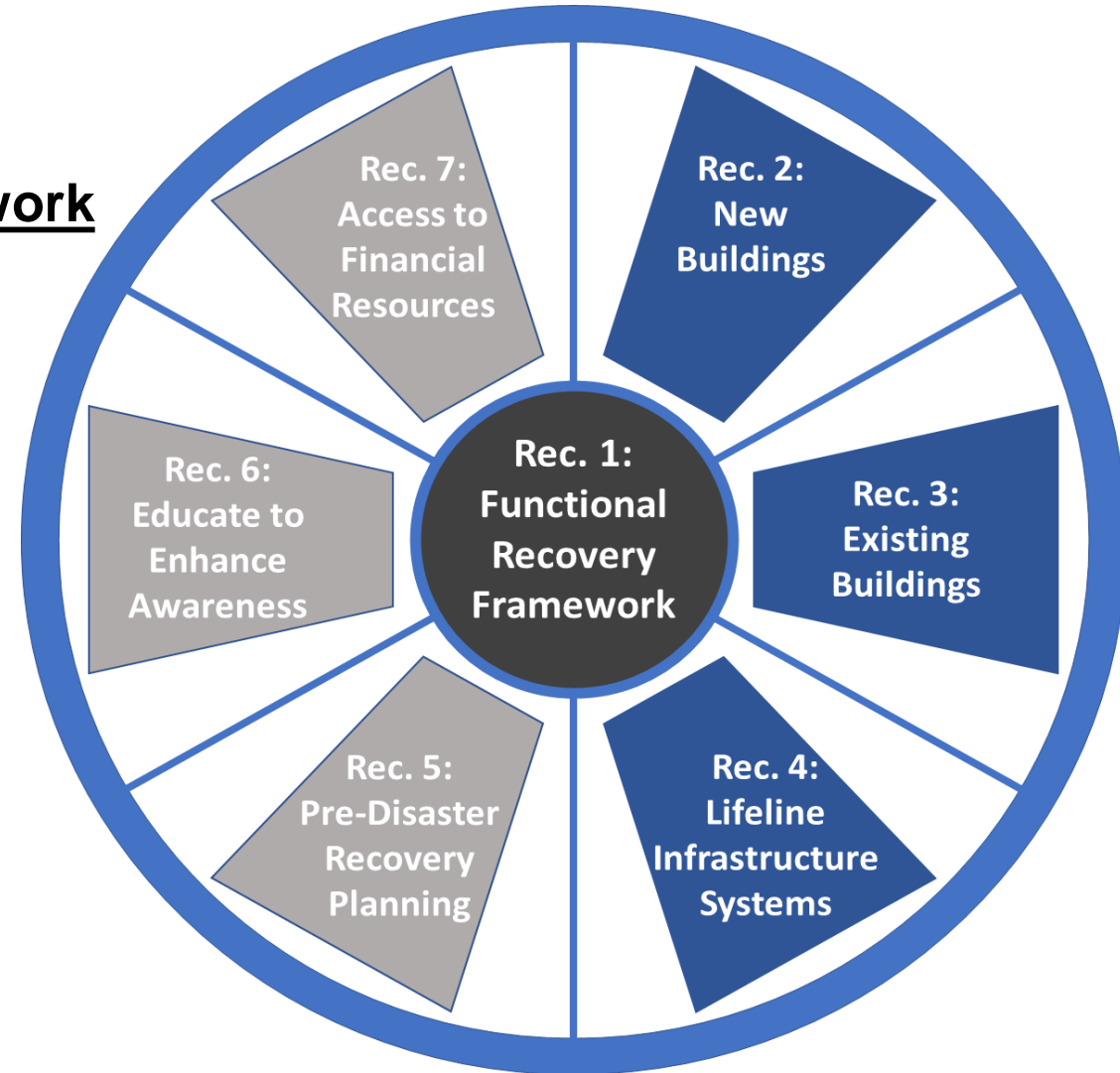
Meet Recovery-based Objectives for:

- Rec 2: Design New Buildings
- Rec 3: Retrofit Existing Buildings
- Rec 4: Design/Upgrade Lifeline Infrastructure

social environment

Focus on Recovery-based Objectives for:

- Rec 5: Pre-Disaster Recovery Planning
- Rec 6: Education and Outreach
- Rec 7: Access to Financial Resources



Rec 1: Develop a Functional Recovery Framework

- Primary objective of current building codes is **Life Safety**
- IBC categorizes building use or occupancy using a **Risk Category**
- New design paradigm:
meet specific **Recovery Time Goals** at specified hazard level
 - Policy for recovery-based objectives
 - Design Criteria development
 - Appropriate hazard level definition
- A **minimum standard** is recommended for consistency across the nation, while still allowing flexibility at the local level.
- **Costs and benefits** associated with selecting particular hazard levels or recovery times TBD

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

Rec 2 : Design New Buildings to Meet Recovery-based Objectives

physical built
environment

- New buildings should be designed for a specific **recovery-based objectives**
- Benchmark the recovery time that current buildings codes and standards deliver
- What building code provisions are needed?
 - National model code
 - Guidelines and standards
 - Design requirement for a higher Risk Category
- Implementation: **mandatory or voluntary?**



Rec 3 : Retrofit Existing Buildings to Meet Recovery-based Objectives

physical built environment

- Enhancing performance of existing buildings is critical aspect of improving community resilience
- Retrofit objectives are currently **safety-based**
- Need to retrofit for **recovery-based** objectives:
 - more challenging
 - adopt lower functional recovery goals
 - which buildings should be retrofitted to which recovery objectives using which provisions?
- Implementation: **mandatory or voluntary?**

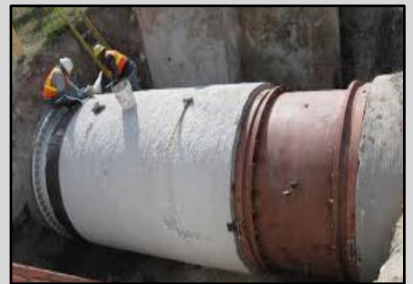


Rec 4 : Upgrade Lifeline Infrastructure Systems to Meet Recovery-based Objectives



physical built environment

- Lifelines are vital components of the built environment.
- Most regulations focus primarily on **public health + safe, reliable operations**
- Design criteria are **not consistent** among systems
- Critical need for a **shift in the design** paradigm of lifelines
- **National-level seismic design guidelines**, standards, and codes are needed
- Need for **regional coordination** among lifelines for integrated planning and interdependent operations



Rec 5 : Develop Pre-Disaster Recovery Planning Focused on Recovery-Based Objectives



social environment

- Codes and standards are necessary; but not sufficient
- Pre-disaster recovery planning: making decisions before a disaster about community recovery

Develop and Implement Pre-Disaster Recovery Plans

Incorporate the recovery-based objectives into existing plans
Develop and implement Community Resilience Plan

Improve existing guides for post-earthquake assessment and inspection to take into account recovery-based objectives



Rec 6 : Education and Outreach

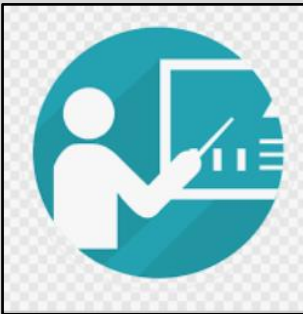
social
environment

- **Public awareness** is lacking with respect to earthquake risk and its consequences
- Awareness and understanding of the risk and benefits would enable communities to make more informed decisions
- Change in construction and design is driven, in part, by **public demand**

Recommended Activities :

school-based **education** or social media **campaign**

educate: building and lifeline infrastructure systems **stakeholders** as well as construction industry professionals about earthquake risk and recovery-based objectives



Rec 7 : Facilitate Access to Financial Resources Needed to Achieve Recovery-Based Objectives

NIST

social
environment

- Investigate **Pre-Disaster** Financial Mechanisms to support enhanced performance

Example: Incentive for building owners via lower insurance rates for structures designed for functional recovery

- Expedite recovery via **Post-Disaster** Financial Mechanisms

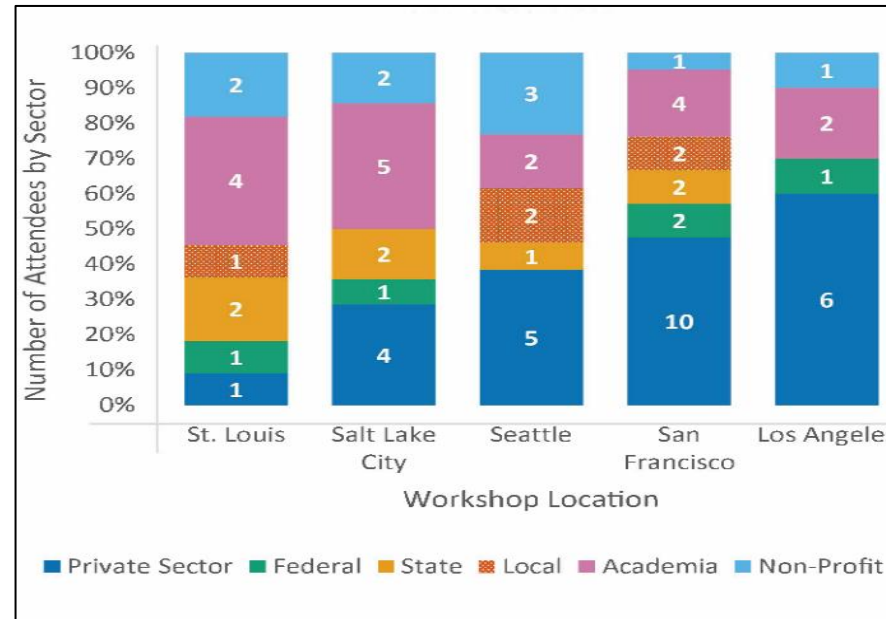
Example: improved processing time for claims and assistance and Pre-arranged/ pre-approved repair loans



Functional Recovery Workshops

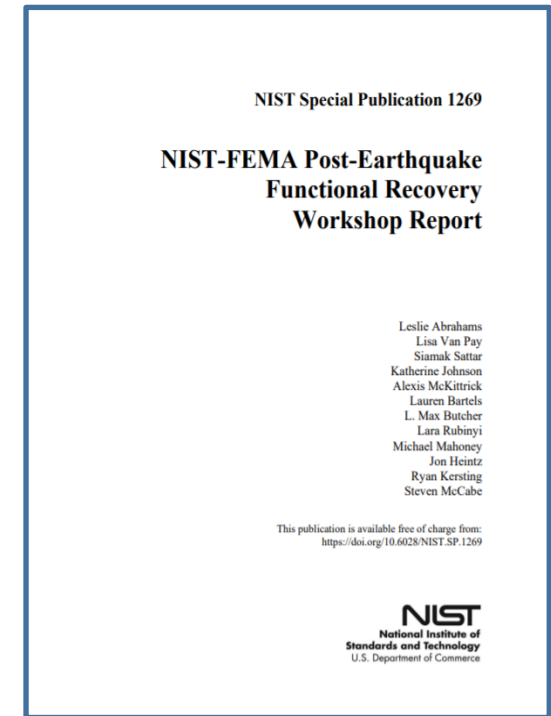


Supporting FR Report Development: Stakeholder Workshops



Objectives

- Explore **acceptable recovery times** for various components of the built environment
- Investigate **criteria for assessing / evaluating options** for achieving functional recovery



Developing a Functional Recovery Framework: Acceptable Recovery Times

Step 1

**Community-level
key functions?**



Education

Step 2

**Component of the
built environment?**



School



University

Step 3

**“need-by”
timeframe**

Hours



Days

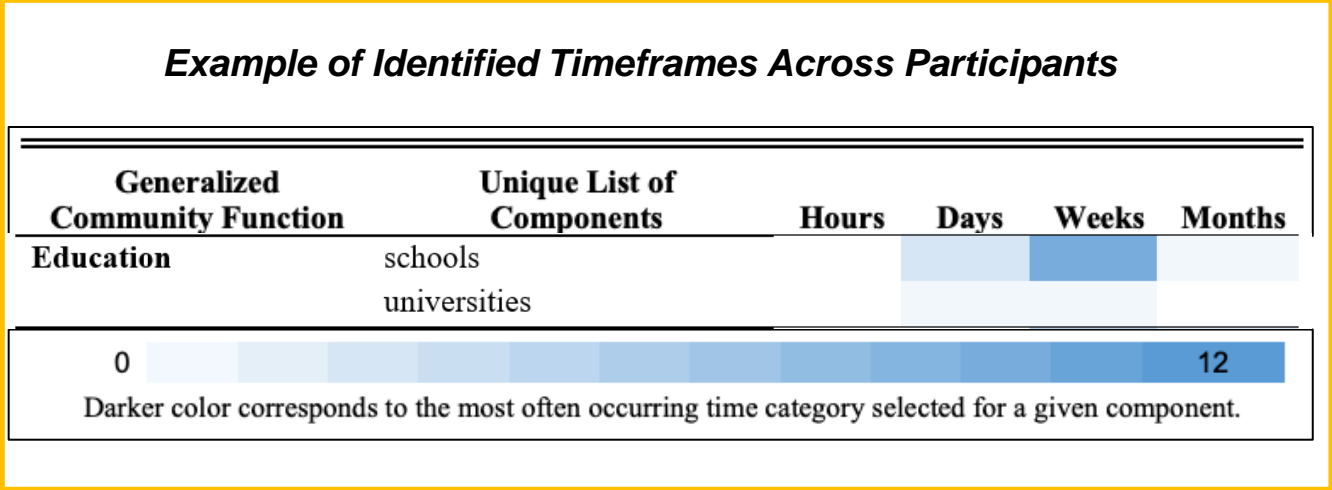
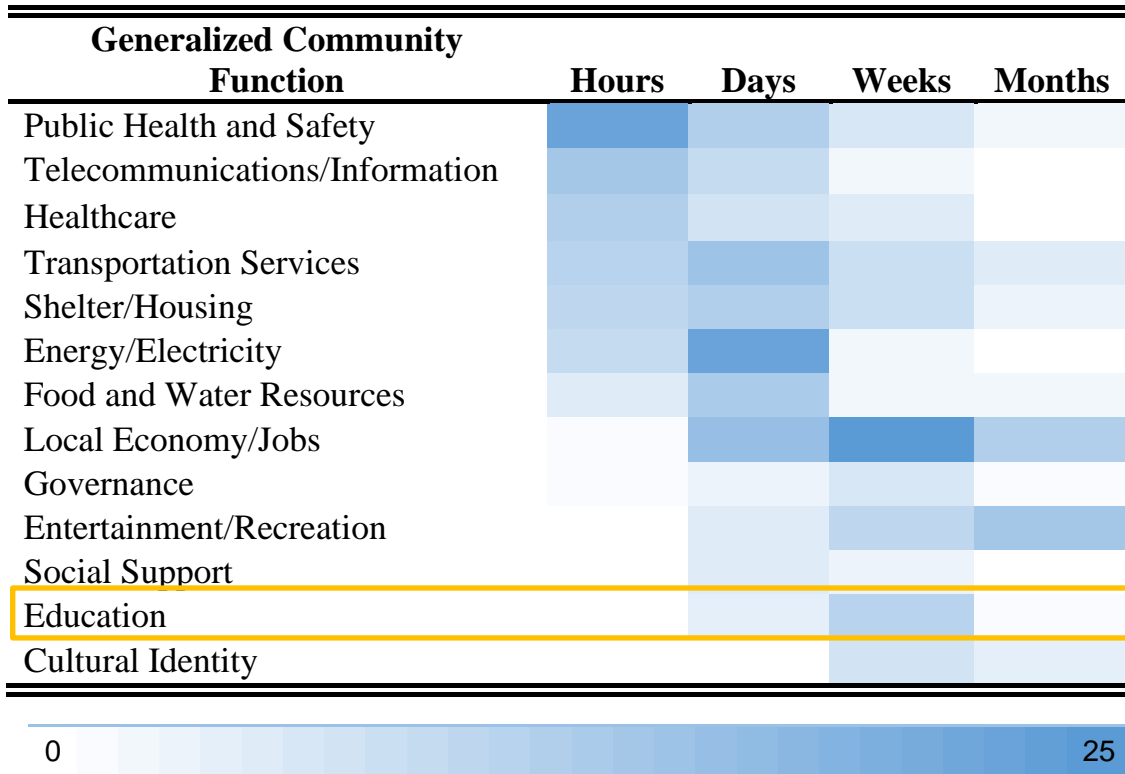
Weeks



Months



Developing a Functional Recovery Framework: Acceptable Recovery Times



Stakeholder Workshops: Session Takeaways

National applicability

- Support for a national FR framework; but should allow flexibility for local community needs and values

Timeframes

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

Challenges:

- Hazard level, realistic or idealistic, interdependency

Future Work:

- Research to better identify acceptable reoccupancy and functional recovery times

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

Implementation in Codes?

Implementation in Codes

Potential future development for NEHRP Provisions

- The idea is to design for recovery time instead of safety
- Use the strategies that we currently have and add new strategies and assign them to different recovery times
- To meet a specific recovery time you need to meet a set of requirements for :
 - Structural
 - Nonstructural
 - Recovery-critical content
 - Utility services

Functional Recovery Design Requirement	Target Functional Recovery Time, T_{target}			
	1 Hour	1 Day	1 Week	1 Month
Structural				
Limits on lateral system selection	Required	Required	Required	–
Limits on drift	Required	Required	Required	–
Factor on required strength	Required	Required	–	–
etc.	...	...	...	...
Nonstructural				
Increased bracing scope	Required	Required	Required	–
Reliability factors on design strength	Required	Required	–	–
Ruggedness certification	Required	Required	–	–
etc.	...	...	...	...
Recovery-critical contents				
<i>To be determined by user groups</i>	Required	Required	...	...
etc.	...	...	...	...
Utility service				
Electricity backup	Required	Required	Required	–

ACI Functional Recovery Subcommittee – 374A

Goal:

- Develop design guides/criteria for use in the first generation PBD (i.e., ASCE 41) to implicitly target improved functional recovery performance through avoiding structural damage that requires “**immediate repair**”

Scope: Design of new RC buildings

Research Method:

- 1) Develop acceptance criteria and inspection recommendations
 - Component criteria: (e.g., plastic or total deformation, fatigue & buckling check)
 - Global criteria: (e.g., drift limits)
- 2) Testing the recommendations at the building level



- Will lead to better recovery trajectories from earthquakes
- Requires a big shift in design philosophy
- Achieving functional recovery across a community requires a multi-faceted approach with parallel efforts on various physical and social aspects
- This effort could be leveraged and adapted to develop recovery-based approaches for other natural hazards
- The NIST-FEMA report is a first step toward achieving functional recovery goals

NIST-FEMA Report to Congress

- FEMA: Mike Mahoney
- Project Technical Panel and Project Review Panel members
- Stakeholder Workshop participants
- Applied Technology Council
- Science and Technology Policy Institute

Research Projects:

- Katherine Johnson, Dustin Cook, Juan Fung, Yalda Saadat, Yating Zhang, Curt Haselton, Dave Welch, Edward Almeter, Sissy Nikolaou

Questions?

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