Understanding Community Resilience and Functional Recovery

By the SEAOC Resilience Committee

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This is the second of a series of monthly articles prepared to help structural engineers to become leaders in community resilience. In the previous article (click here) we noted that engineers can make a direct and immediate contribution toward improving community resilience by designing buildings with post-earthquake recovery time in mind, determined by the building's function, client desires, and expected hazards.

This article discusses the concept of Community Resilience and Functional Recovery. Structural engineers may have heard these emerging terms. A thorough explanation is presented here to offer understanding of what we envision the built environment should be and how it should serve society in the face of increasing disaster. While these concepts are applicable for all hazards and for both buildings and infrastructure, this article series addresses only the seismic performance of buildings.

Community Resilience

Community Resilience is defined by the National Earthquake Hazards Reduction Program (NEHRP) as "the ability of a community to prepare and plan for, absorb, recover from, and more successfully adapt to adverse seismic events."[1] In more measurable terms, resilient communities are those that recover their functions within a fast enough time frame to prevent, for example, people relocating or businesses closing.[2]

Other definitions of resilience have been proposed, but as the term applies to natural hazards, all of them share a few common ideas that might seem new to structural engineers:[3]

- Community Resilience is an attribute of an organization or social unit, not of individual buildings, structural systems, or materials. It can apply to a legal jurisdiction, a bounded geographic region sharing key resources, or organizations of any size, such as a family, neighborhood, business, university, city, or state. Community resilience is simply resilience at the community scale.
- Building Resilience is primarily concerned with the restoration of a building's function (i.e., use), as measured over time. Traditionally, building codes focused on safety, with post-disaster functionality (i.e., operability) considered only for buildings that provide essential services such as public safety. While both safety and functionality depend on

1 42 U.S.C. § 7704, 2018. "National Earthquake Hazards Reduction Program." United States Code. (2019). https://www.congress.gov/115/plaws/publ307/PLAW-115publ307.pdf
2 NIST. (2015). Community Resilience Planning Guide for Buildings and Infrastructure Systems.
3 Bonowitz, David, *Functional Recovery: What it Means to Design for Community Resilience*, Earthquake Engineering Research Institute, published by Youtube, 05/07/2020, https://youtu.be/cN7sbFWqI4c

the physical state of the building, the notion of “building resilience” implies a shift away from safety alone to the concept that recovery should be measured in terms of functional status, such as “reoccupancy” or “functional recovery.” Functional Recovery is discussed in more detail below.

- Resilience metrics must include time. Typically, a community’s functions recover over time, with some recovering faster than others. Resilience-based design *must* incorporate a time component into the performance objective, and the acceptable reoccupancy or functional recovery time need not be “immediate” for all buildings.

When a policy or design is described as “resilient,” that label should say something about how it will *expedite the restoration of functions*. Where the organization of interest is the community itself, the “resilient” label should mean that the policy or design will help the whole community meet its time-based resilience goals. Structural engineers should challenge claims of “resilience” that do not address the organization’s recovery goals or are not explicit about reoccupancy or functional recovery time. Just designing for lower damage or for enhanced safety is a good idea, but it is not necessarily resilient.

Functional Recovery

The built environment -- consisting of buildings, infrastructure, and lifelines -- facilitates community functions. The main contribution structural engineering can make now to community resilience is to focus more attention on the post-earthquake functionality of new buildings and retrofits. This functionality is represented by three performance levels:[4] 1) reoccupancy, 2) functional recovery, and 3) full recovery. A forthcoming report produced by NIST and FEMA is expected to build on previous work[5] that defined the first two levels as they relate to buildings, as follows:[6]

> *Re-occupancy is 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.*
> *Functional Recovery is a post-earthquake performance state in which the building is maintained, or restored, to safely and adequately support the basic intended functions associated with the pre-earthquake use or occupancy.*

Engineers will recognize some of the concepts covered by the two definitions above. For example, reoccupancy is associated with a green tagged building (ATC 20 safety assessment protocol), and functional recovery is similar to an operational building performance objective in

4 Bonowitz, David. "Resilience Criteria for Seismic Evaluation of Existing Buildings: A Proposal to Supplement ASCE 31 for Intermediate Performance Objectives.” ATC and SEI Conference on Improving the Seismic Performance of Existing Buildings and Other Structures (pp. 477-488). San Francisco: ASCE.
5 In addition to Bonowitz (ibid), see the definition of “functional recovery standard” developed by SEAOC and EERI committees for use in California Assembly Bill 1997 (2020) and its predecessors.
6 Recommended Options for Improving the Built Environment for Post-Earthquake Reoccupancy and Functional Recovery Time, 100% Draft March 31, 2020. The draft report has been submitted for review and is awaiting clearance for final submittal to Congress.

ASCE 41[7] and Risk Category IV from the building code. If these new terms are similar to terms engineers have already been using for years, why are they necessary?

The answer involves the element of *time*, mentioned above as fundamental to the concept of resilience. For buildings designed for Immediate Occupancy, Operational, or "RC IV" performance, the expectation is that the desired performance level will be achieved as soon as the earthquake shaking ends. By contrast, designing for reoccupancy or functional recovery contemplates that the desired performance need only be achieved within an anticipated amount of time, from immediate to weeks or longer. Figure 1 illustrates how a recovery timeline could vary for different groups of buildings. To build in the concept of time, the NIST-FEMA report is expected to separately define a functional recovery (or, similarly, reoccupancy) objective:

	PHASE 1			PHASE 2			PHASE 3		
	DAYS			WEEKS			MONTHS		
	0	1	2-5	1-4	4-8	8-12	4	4-24	24+
CRITICAL FACILITIES									
GROUP 1A	90%						X		
GROUP 1B	90%						X		
GROUP 1C	60%	90%						X	
INTERMEDIATE FACILITIES									
GROUP 2A	30%	60%	90%					X	
GROUP 2B		30%	60%	90%					X
GROUP 2C				30%	60%	90%			X
REMAINING BUILDINGS									
GROUP 3A				30%	60%		90%		X
GROUP 3B					30%	60%	90%		X
GROUP 3C						30%	60%	90%	X

30% 60% 90% DESIRED RESTORATION TIMES FOR PERCENTAGE OF ELEMENTS WITHIN EACH GROUP

X ANTICIPATED PERFORMANCE FOR 90% RESTORATION IN EXISTING CONDITION

FIGURE BASED ON NIST COMMUNITY RESILIENCE PLANNING GUIDE

Figure 1 – Building Recovery Diagram[8]

> 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.

Depending on the acceptable time, a functional recovery-based design might not be any more conservative (or expensive) than a current code-based design. The difference is that the recovery-based design will be more explicit and complete about the expected performance.

While the concept of functional recovery is meant to respect the traditional role of the structural engineer, it is important to recognize that actual functional recovery might still be limited by externalities – conditions outside the building footprint or other factors outside the designer's control that affect how quickly the building can be used again. Important externalities can include the availability of utilities, contractors, and a stable supply chain.

Impeding factors[9] are a subset of externalities that include all the activities for repairs such as engineering design, financing, permitting, and contractor mobilization. Figure 2 lays out a schematic recovery path for buildings damaged by natural disasters. While it is not possible for

7 In ASCE 41, Seismic Evaluation and Retrofit of Existing Buildings, Operational building performance combines Immediate Occupancy structural performance with Operational nonstructural performance.

8 Buckalew et. al. (2019), *SEAOC Resilience Committee Update and Report to the Membership*, Proceedings of Structural Engineers Association of California Annual Convention, Sacramento, SEAOC

9 Almufti, Ibrahim; Willford, Michael; et. al., *REDi Rating System, Resilience-based Earthquake Design Initiative for the Next Generation of Buildings*, ARUP, October 2013

the design team to account for all the externalities, the design should be such that the building itself is not the limiting factor. Structural engineers should be clear about externalities when communicating expected building performance to clients. Functional recovery must consider attributes of the building (structural and non-structural components and contents) and externalities.

Our engineering profession is now equipped with the experience, policy direction, and tools to allow structural engineers to design buildings to meet the recovery goals of our clients and our communities. It is not necessary to wait for development of so-called "resilient building codes" to begin integrating these improvements in our designs. It is critical we relay these advancements to our clients so that developers, owners, and design teams wanting to do resilient design today know they can.

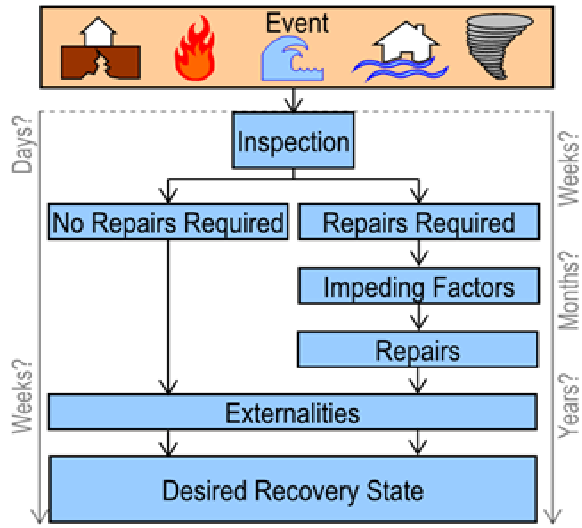

Figure 2 – Building Recovery Diagram[10]

For more information on community resilience and functional recovery, we recommend the following references:

- SEAOC Convention Paper[10]
- EERI White Paper on Functional Recovery[11]
- EERI Distinguished Lecturer[12]
- NEHRP Part III Resource Paper[13]
- The FEMA P-58 Methodology
- Arup's Downtime Assessment Methodology[14]
- NIST-FEMA Report to Congress (forthcoming)

If you are interested in joining the SEAOC Resilience Committee, please email Jonathan Buckalew (jbuckalew@nyase.com) and Anna Lang Ofstad (anna@zylient.com).

10 Buckalew et. al. (2019), *SEAOC Resilience Committee Update and Report to the Membership*, Proceedings of Structural Engineers Association of California Annual Convention, Sacramento, SEAOC
11 EERI, 2019, *Functional Recovery: A Conceptual Framework with Policy Options*, Earthquake Engineering Research Institute, 12/06/2019, https://www.eeri.org/wp-content/uploads/EERI-Functional-Recovery-Conceptual-Framework-White-Paper-201912.pdf
12 Bonowitz, David, *Functional Recovery: What it Means to Design for Community Resilience*, Earthquake Engineering Research Institute, published by Youtube, 05/07/2020, https://youtu.be/cN7sbFWqI4c
13 NEHRP, *Resilience-Based Design and the NEHRP Provisions*, National Institute of Building Sciences (NIBS) and Federal Emergency Management Agency (FEMA), February 2020; https://cdn.ymaws.com/www.nibs.org/resource/resmgr/bssc3/BSSC_Resilience_Based_Design.pdf
14 Almufti, Ibrahim; Willford, Michael; et. al., *REDi Rating System, Resilience-based Earthquake Design Initiative for the Next Generation of Buildings*, ARUP, October 2013, https://www.arup.com/-/media/arup/files/publications/r/redi_final-version_october-2013-arup-website.pdf