SEAONC Training Webinar

Resilient Design for Functional Recovery: Recent Progress and State of Practice

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Work by: Many Groups

SEAOC Functional Recovery Committee, the ATC-138 team, ideas from many others, and supported with studies by the SP3 research team (D. Jared DeBock, Edward Almeter, Katherine Wade, Jack Baker, Shaunt Kojabashian, Mike McGlone, Tracy Rice, and Dustin Cook)

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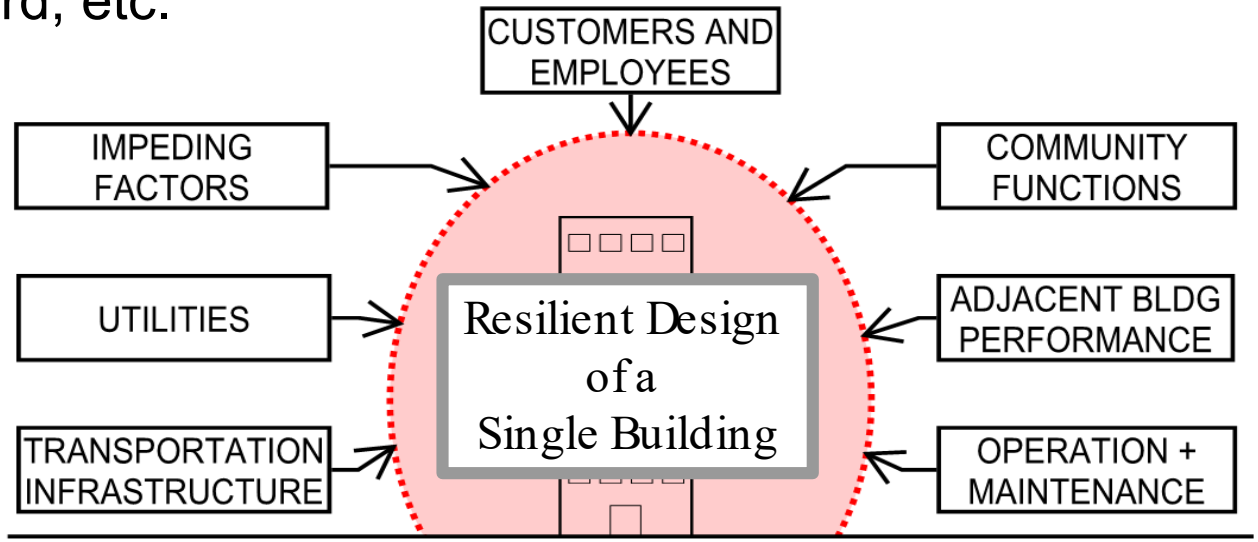
SEAONC Training Webinar | July 8, 2021

Motivation/Background

- The public/legislators have become aware that the Code goal is just safety and they want more than “safe but disposable” (stemming from a lot of the work in Los Angeles).
- All levels of government are looking at “design for Functional Recovery”:
  - ✓ **Federal:** NIST/FEMA mandate and report to Congress earlier this year. [and many discussions around this about creating a Functional Recovery Design Standard]
  - ✓ **State:** California AB-1329 on a Functional Recovery Standard
  - ✓ **Local:** San Francisco tall building study and ongoing discussions
- We now also have the technology to quantify resilience using FEMA P-58 (in terms of repair costs and repair times), and use directly for design.
- **Opportunity:** The combination of this societal desire/interest and new technology creates a remarkable situation and opportunity. Structural engineers are well-equipped to meet this new challenge of design for Functional Recovery (and can do it with a quantitative analysis method).
- These are unprecedented times and our SE profession is rising to the occasion.

The Focus for Today

- **Focus for Today:**
  - ✓ Resilient design of new buildings (not existing, no externalities).
  - ✓ Resilient design of individual buildings (not community resilience).
  - ✓ Focus on what we can do right now to make buildings more resilient (and also discuss the future a bit, e.g. code development).
  - ✓ Focus on design, but same methods used for risk assessment (PML+).
- **Not in Scope (though important):** Community-wide resilience, factors outside building footprint, Functional Recovery design Standard, etc.



[Reference: Jonathan Buckalew, SEAOC Resilience Committee]

Outline

- The Anatomy of the Resilient Design Movement
- FEMA P-58 and use for Resilient Design
- Structural Engineering Leadership
- Defining and Assessing Functional Recovery
- Summary and Next Steps
- Q&A

Anatomy of the Resilient Design Movement

Code Goals and the Motivation for Resilient Design:

- Building code goal (RC II) is to protect life safety.
- The goal is not for buildings to function after an earthquake, and not even to be repairable.
- The effective Code goal is to design as “safe but disposable”.

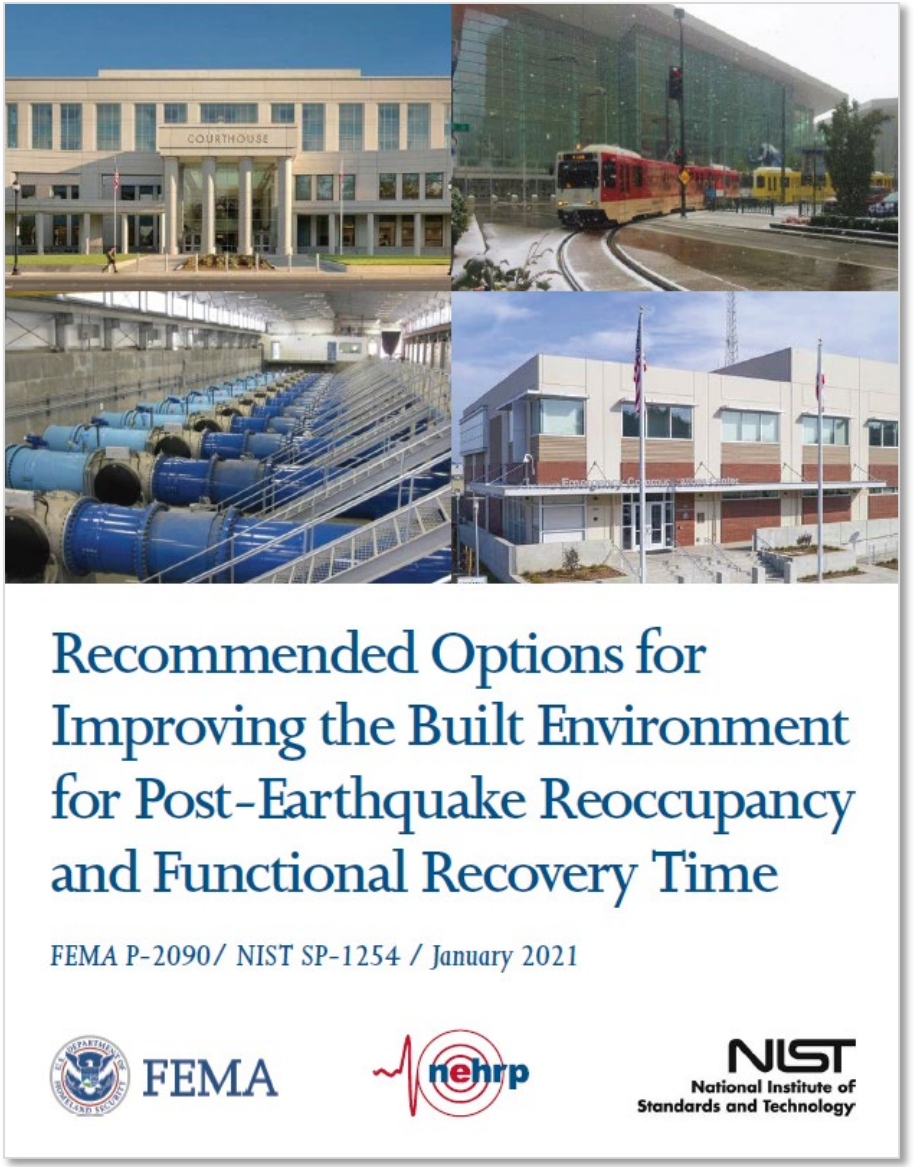
- **Safe:** Job well done by the structural engineering community (1971 concrete frames, 1994 steel frames, 1994 tilt-up, etc.). Our level of structural safety in the U.S. is notable.
- **Disposable:**
  - The public (lawmakers) have become aware that the Code is only aiming for safety, and they are asking for more.
  - The structural engineering profession is now also stepping up to solve this new design challenge and to deliver buildings that are both safe and functional soon after an earthquake.

Anatomy of the Resilient Design Movement

Top-Down Push for Resilient Design:

- **Federal:** NEHRP Reauthorization with mandate to look at building function, NIST Immediate Occupancy report, NIST/FEMA Functional Recovery report.

*"**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…"*

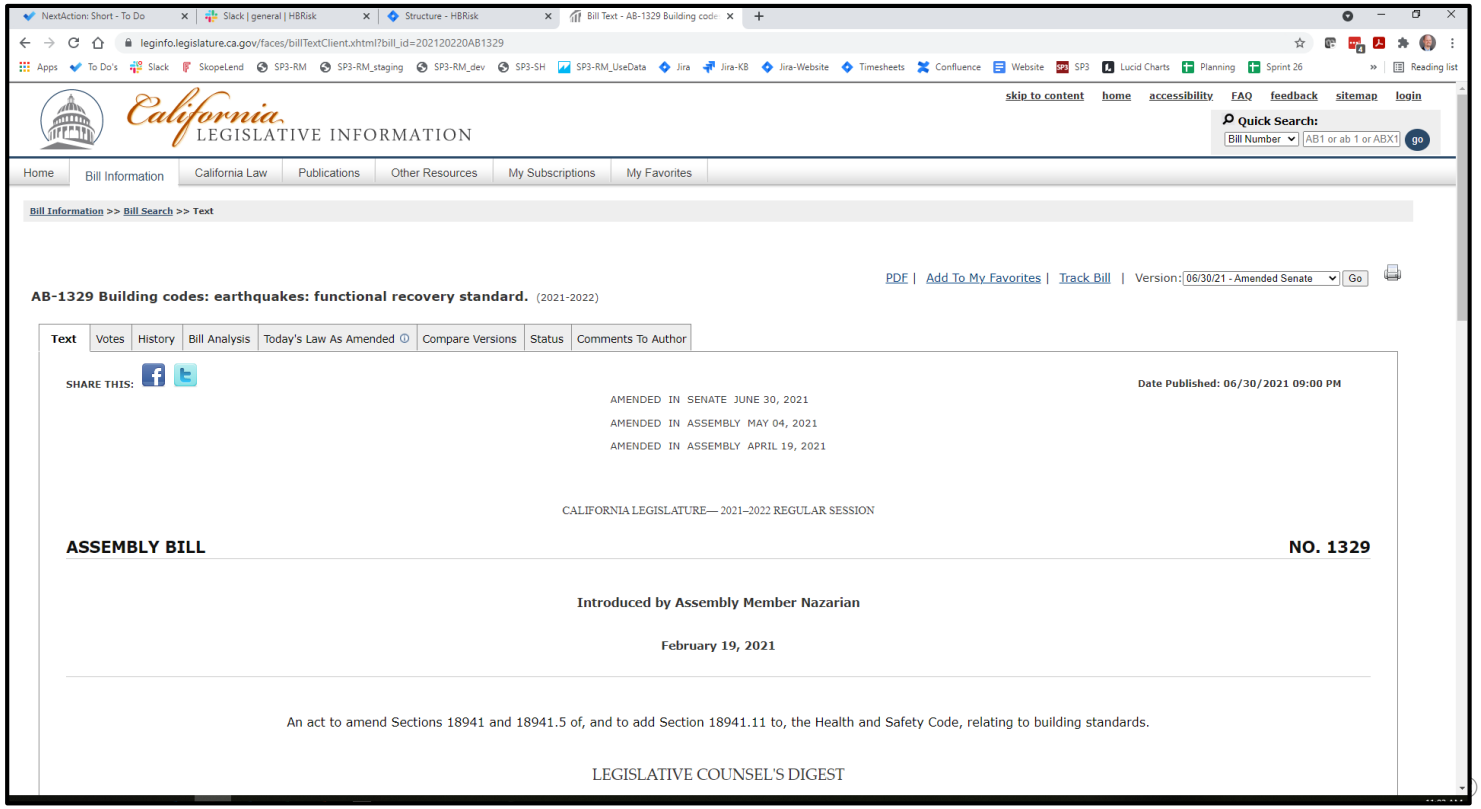


Anatomy of the Resilient Design Movement

Top-Down Push for Resilient Design:

- **State:** California Assembly Bill AB-1329, entitled *"Functional Recovery Standard"*.

"(b) (1) During the 2024 triennial code adoption cycle, the California Building Standards Commission and the Department of Housing and Community Development, acting in accordance with Section 17921, shall develop, adopt, approve, codify, and publish building standards that require buildings not already under the authority of a different state agency to be designed and built to a functional recovery standard for earthquake loads."



leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220AB1329

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AB-1329 Building codes: earthquakes: functional recovery standard. (2021-2022)

Text | Votes | History | Bill Analysis | Today's Law As Amended | Compare Versions | Status | Comments To Author

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Date Published: 06/30/2021 09:00 PM

AMENDED IN SENATE JUNE 30, 2021

AMENDED IN ASSEMBLY MAY 04, 2021

AMENDED IN ASSEMBLY APRIL 19, 2021

CALIFORNIA LEGISLATURE— 2021–2022 REGULAR SESSION

ASSEMBLY BILL **NO. 1329**

Introduced by Assembly Member Nazarian

February 19, 2021

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

LEGISLATIVE COUNSEL'S DIGEST

Anatomy of the Resilient Design Movement

Bottom-Up Push for Resilient Design:

- The structural engineering community has not just been waiting around for a building code requirement change.
- Visionary structural engineers are already pushing ahead and leading in this area by designing for post-earthquake function electively on projects.
- Day 2 (next week) will focus on four examples in detail and here is a quick overview of a subset of recent projects!

Ex #1: UCSF Center for Vision Neurosciences

- **Project:** 12-story office/out-patient
- **Engineers:** Forell Elsesser

Example #2: Stanford Biomedical Building

- **Project:** Stanford Biomedical Innovations Building
- **Engineers:** Rutherford & Chekene

Example #3: Watson Land Company

- **Project:** Portfolio of tilt-up warehouse buildings
- **Engineer:** HSA Associates
- **Owner:** Watson Land Company

Example #4: Electric Utility Operation Center

- **Project:** EOC, data center, and office
- **Engineers:** KPFF (Portland)

Example #5: CA State Office in Sacramento

- **Project:** 11-story office for State of California
- **Engineer:** KPFF

Example #6: Long Beach Civic Center

- **Project:** Long Beach Civic Center (two 11-story buildings – city offices, city council, Port of Long Beach)
- **Engineers:** Nabih Youssef and SOM

Figure Source: SOM/NYASE 2016 SEAOC presentation

Example #7: SF Affordable Housing

- **Project:** Casa Adelante (9-story affordable housing)
- **Engineers:** Mar Structural Design

Example #8: 181 Fremont

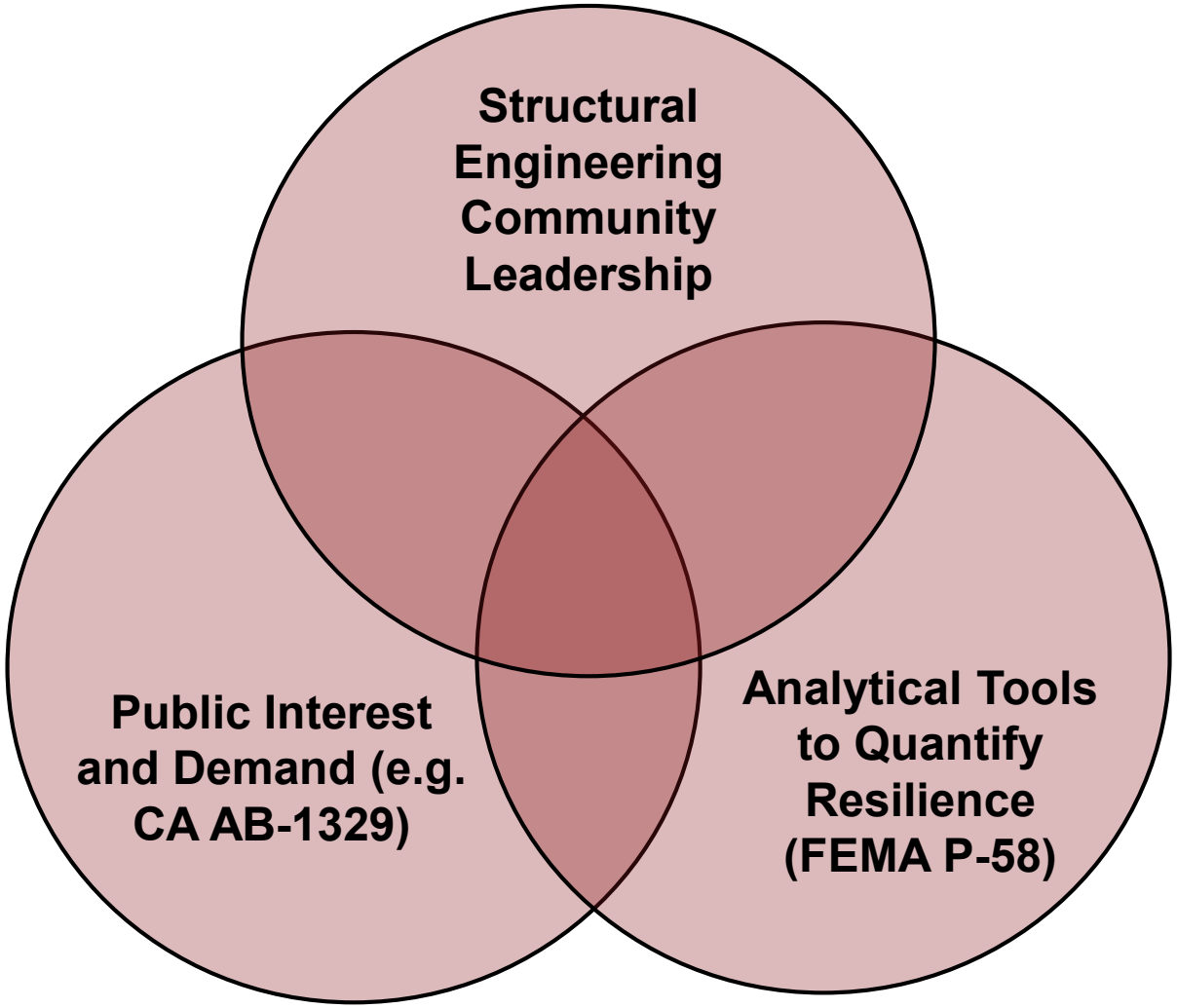
- **Project:** 57-story mixed use
- **Engineer:** Arup

Example #9: Bluxome SF Offices

- **Project:** 5-Story SF Office
- **Engineers:** ZFA

Anatomy of the Resilient Design Movement

Summary of Anatomy of the Resilient Design Movement:



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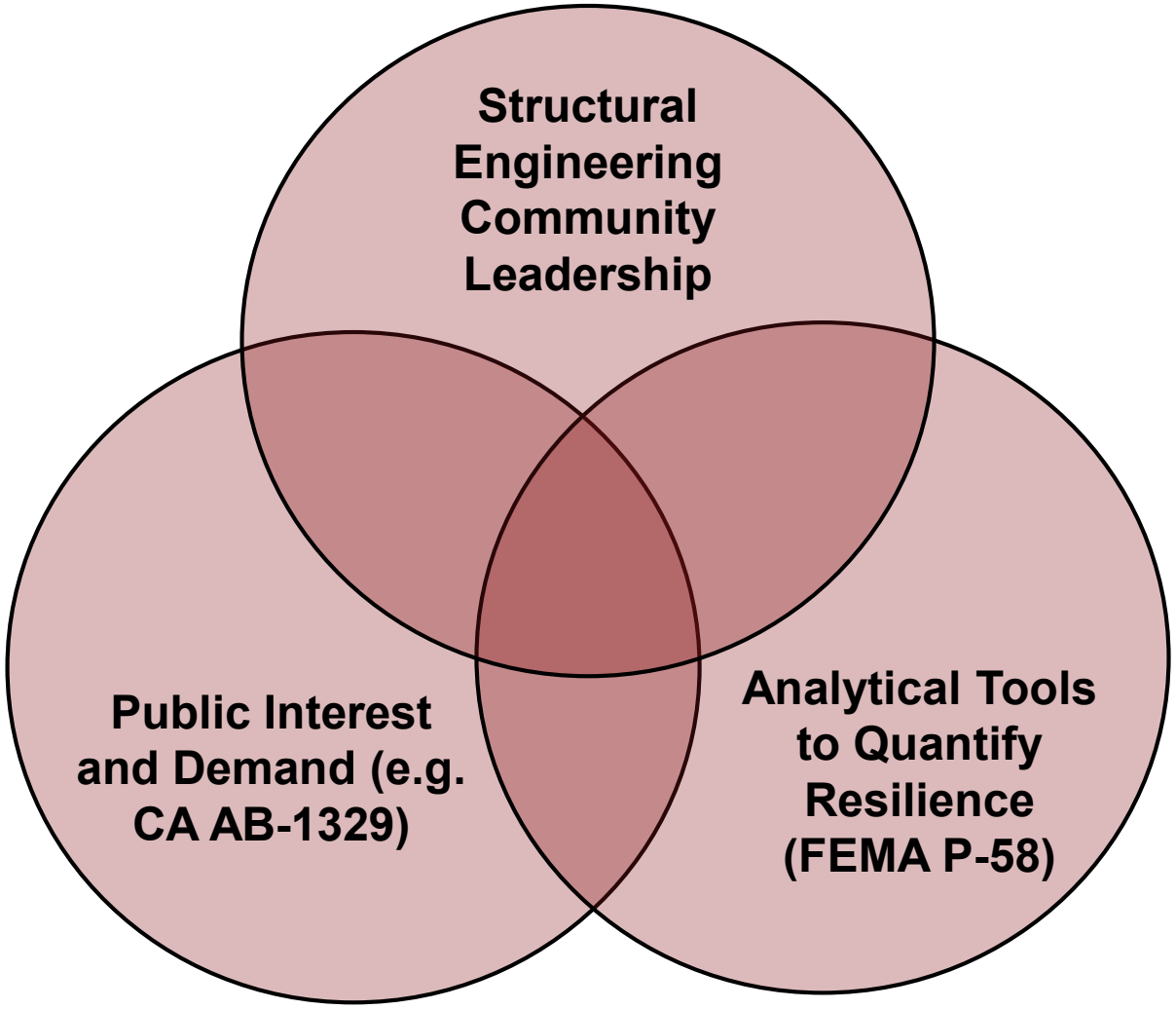

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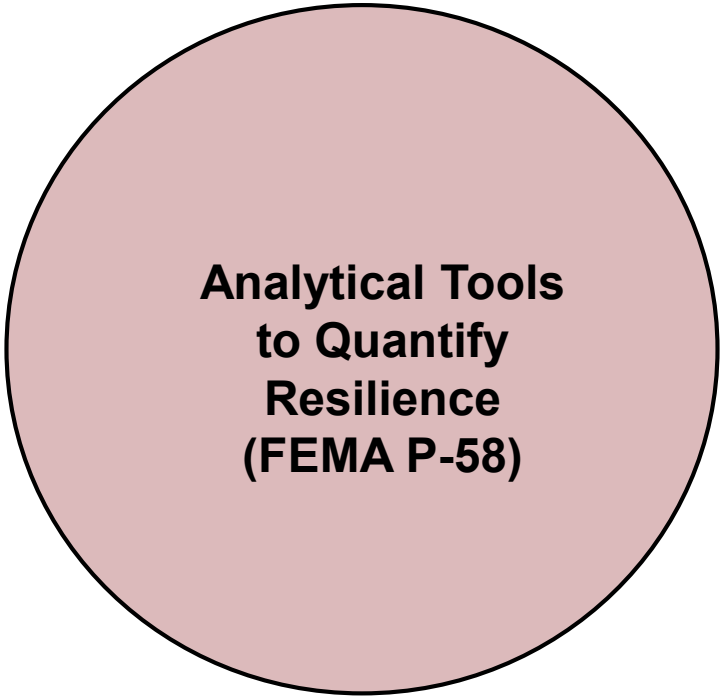
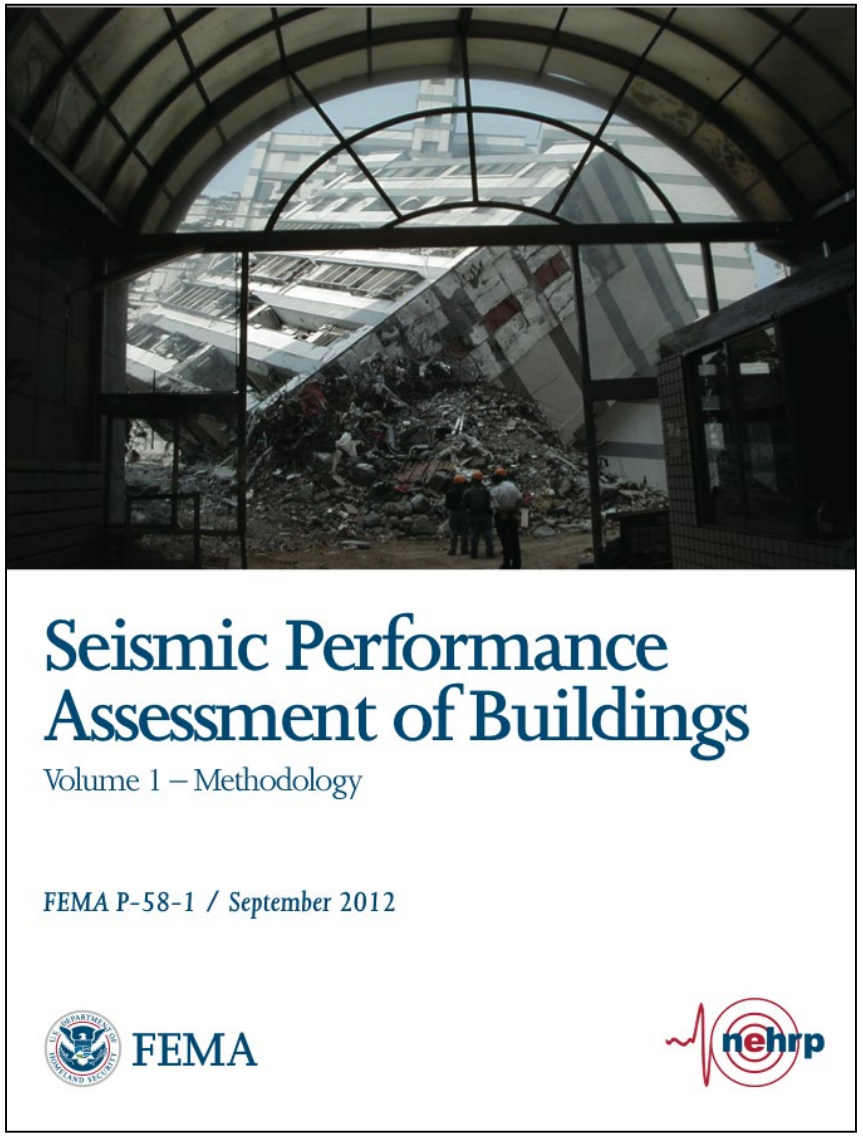
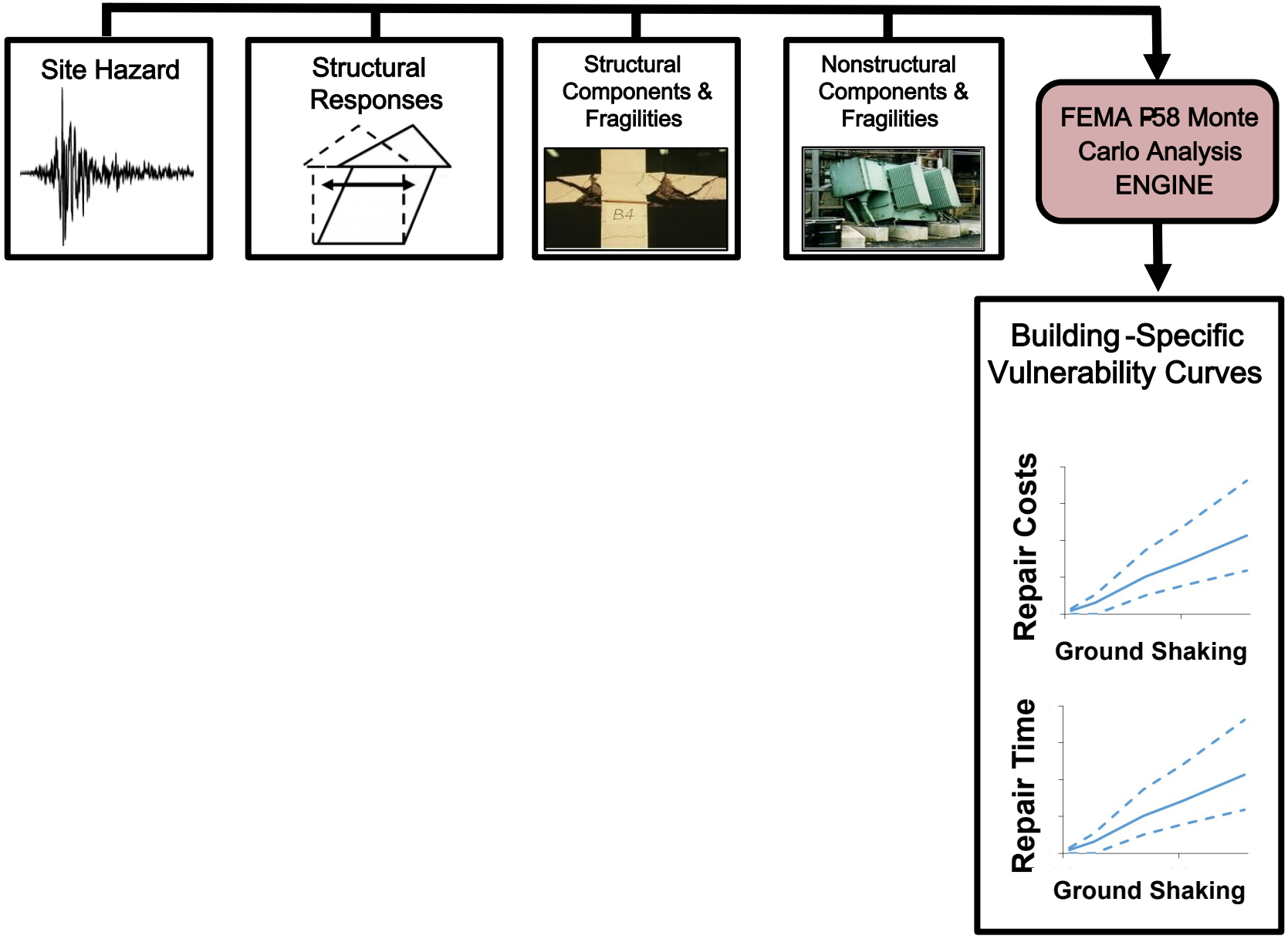


FEMA P-58 and Use for Resilient Design

- FEMA P-58 is a probabilistic performance prediction methodology (15 year, $16M+ invested, ~100+ on the team)
- FEMA P-58 is tailored for building-specific analysis (in contrast to most risk assessment methods)
- FEMA P-58 was released in 2012, then used/vetted in structural engineering industry from 2014 to present (~7 years of vetting and refinement).
- FEMA P-58 output results:
  - Repair costs
  - Repair time (recovery time)
  - Safety: Fatality & Injury

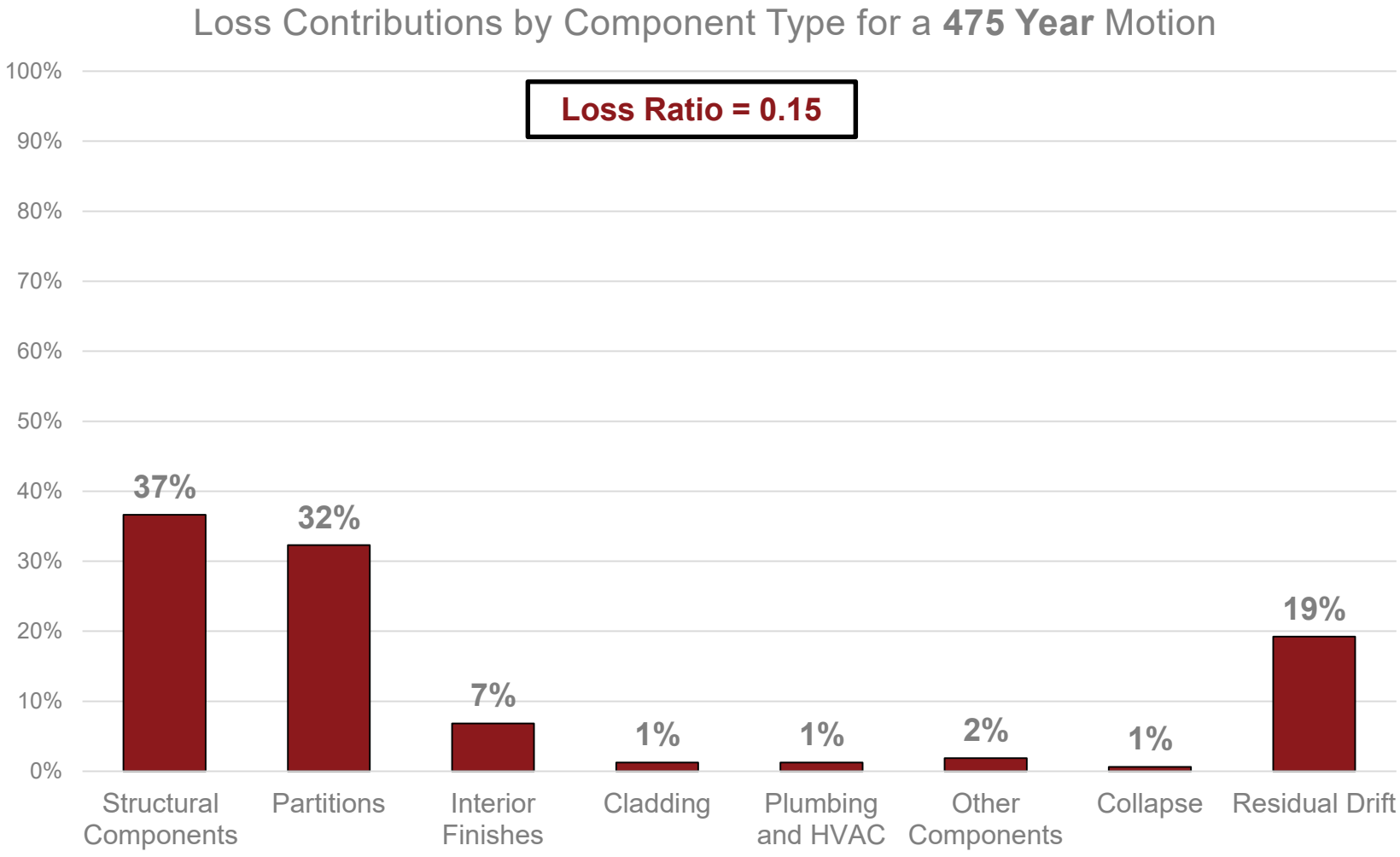


FEMA P-58 and Use for Resilient Design



FEMA P-58 and Use for Resilient Design

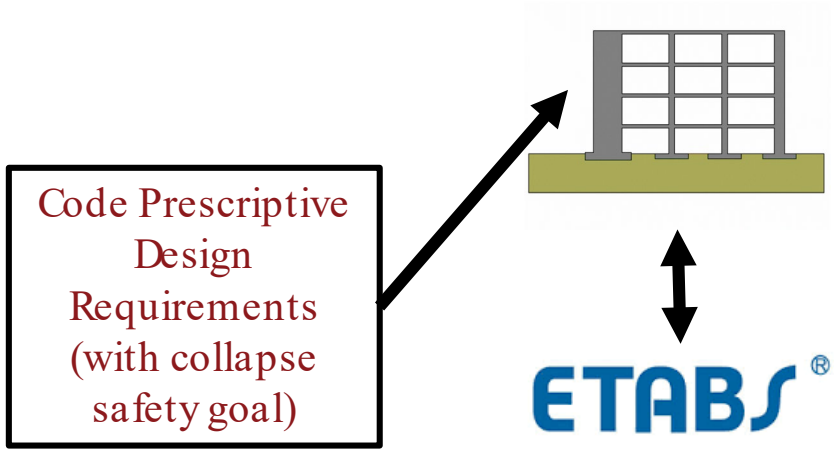
8-story concrete frame in Los Angeles



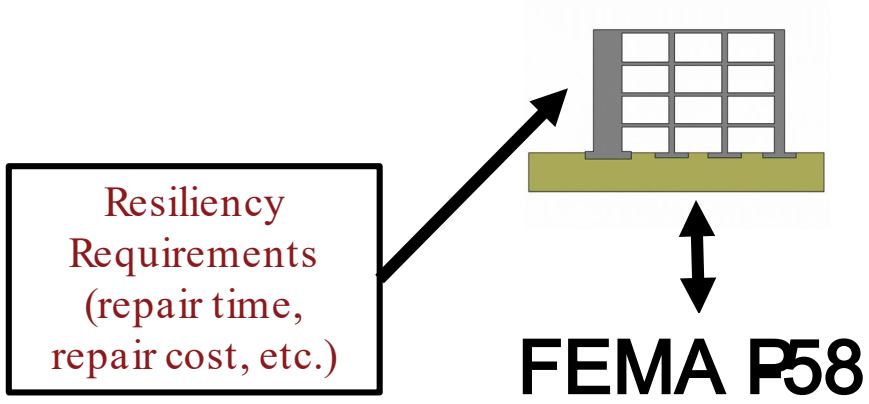
FEMA P-58 and Use for Resilient Design

- What Resilient Design is not:
  - What we typically call performance-based design (uses better analysis, but the goal is still code compliance, focused on safety) – e.g. LA Tall Buildings, PEER TBI, etc.
  - Designing for enhanced code (e.g. Risk Category IV) and then praying that it gives us what we want.
- Resilient Design is:
  - Setting performance goal beyond just safety (e.g. building functional in a week).
  - Iteratively designing until you meet your resilience goals (using FEMA P-58 analysis to quantify effects of design changes).

Code Design Process:



Resilient Design Process (same with different goals):



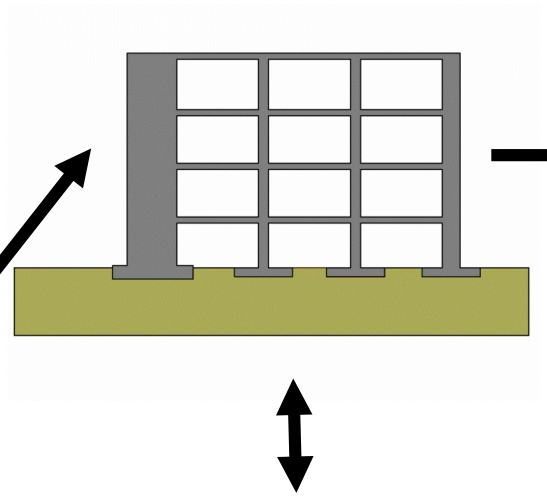
FEMA P-58 and Use for Resilient Design

- Common Resilient Design goals are:
  - The building can be quickly reoccupied (e.g. in one week after a DE)
  - The building can quickly regain function (e.g. “Functional Recovery” in month)
  - The repair costs are limited (e.g. less than 5% repair cost for a DE)
  - The goal is not “no damage.” Damage is accepted but needs to be controlled such that building can be reoccupied and can regain basic function quickly.
- In general, resilient design requires the following:
  - Structural: No structural damage that requires repair before building can function (not no structural damage). [selection of structural system, more strength, lower drift limits]
  - Non-structural (drift): Non-structural drift-sensitive damage is low enough that building can function. [lower drift limits, higher capacity components]
  - Non-structural (acceleration): Non-structural acceleration-sensitive damage is low enough that building can function. [stronger anchorages, reduce floor accelerations]
  - Residual Drifts: Residual drifts are low enough that building can function. [selection of structural system, strength and drift design]

FEMA P-58 and Use for Resilient Design

- Let's look in more detail at direct resilient design using FEMA P-58…

Resiliency Requirements (for DE):
- Reoccupancy in a week
- Building functional in a month
- Repair cost < 5%



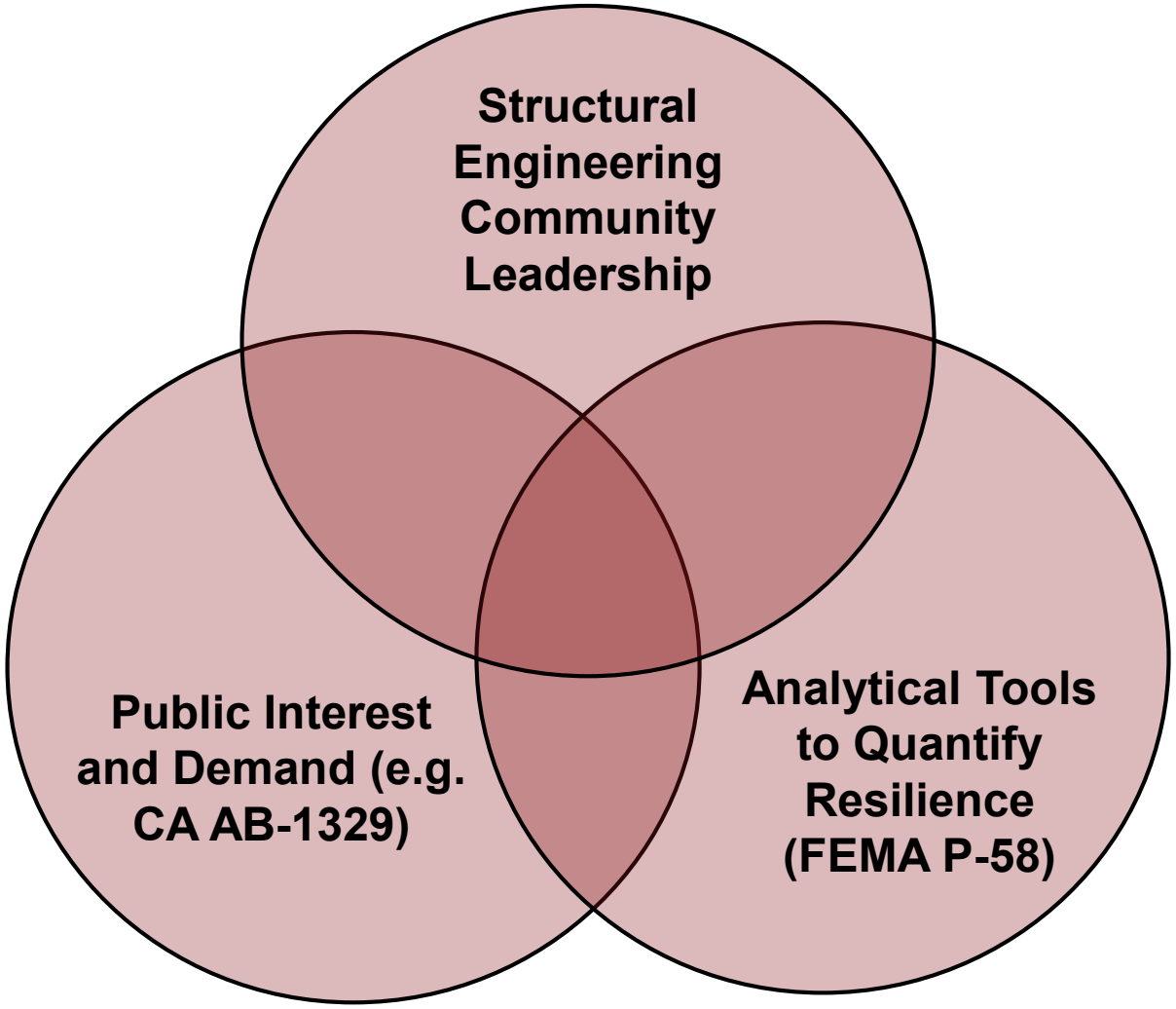
FEMA P58

Design "knobs":
- Structural system selection
- Design strength (Ie)
- Design drift limit
- Anchorage and equipment design (Ip)

- Gravity system design
- Cladding design
- Elevator design
- More design of anchorage and equipment
- …can go as deep as you like…

Structural Engineering Leadership

Summary of Anatomy of the Resilient Design Movement:



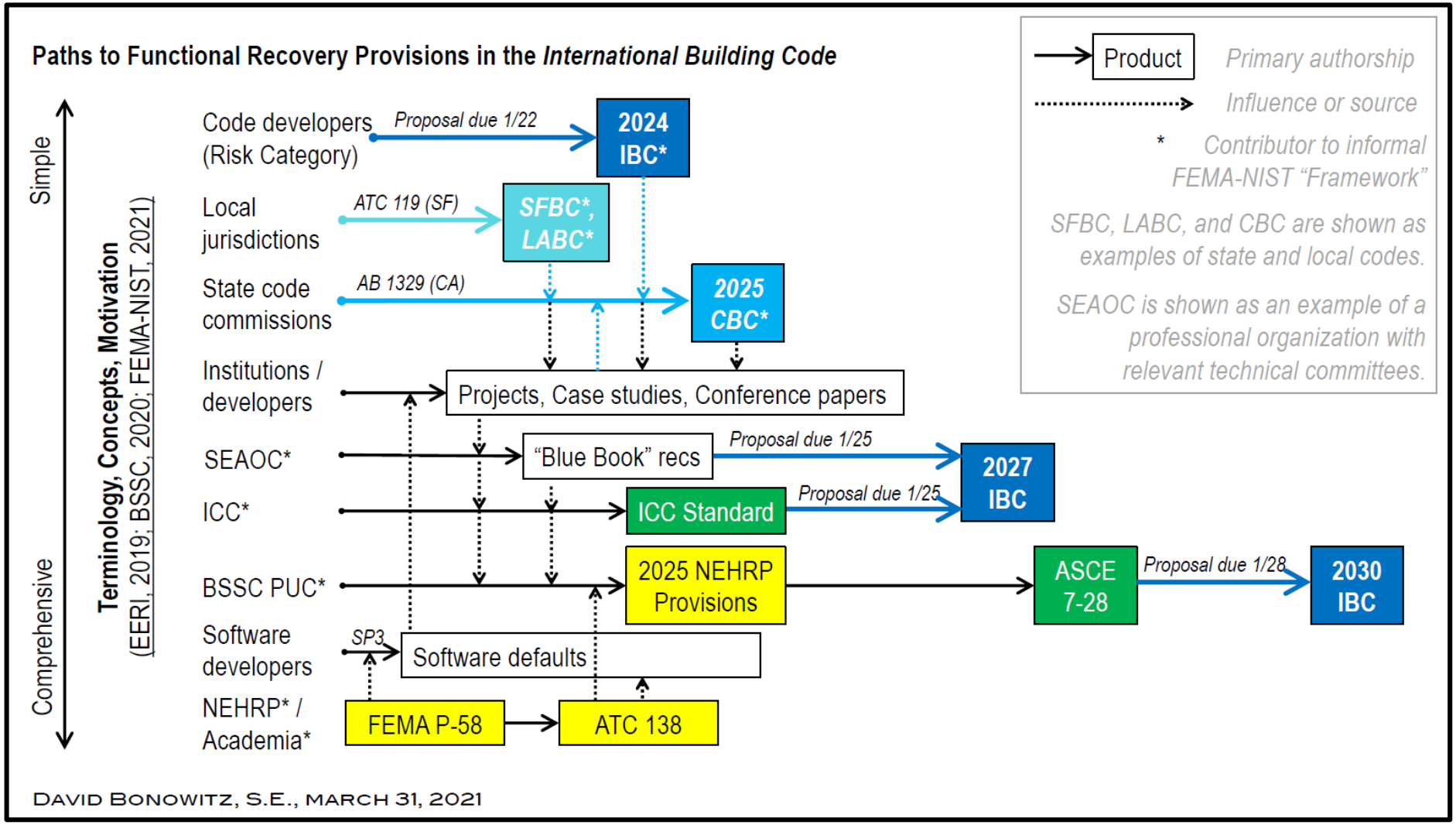
Structural Engineering Leadership

Structural Engineers are Leading this Charge

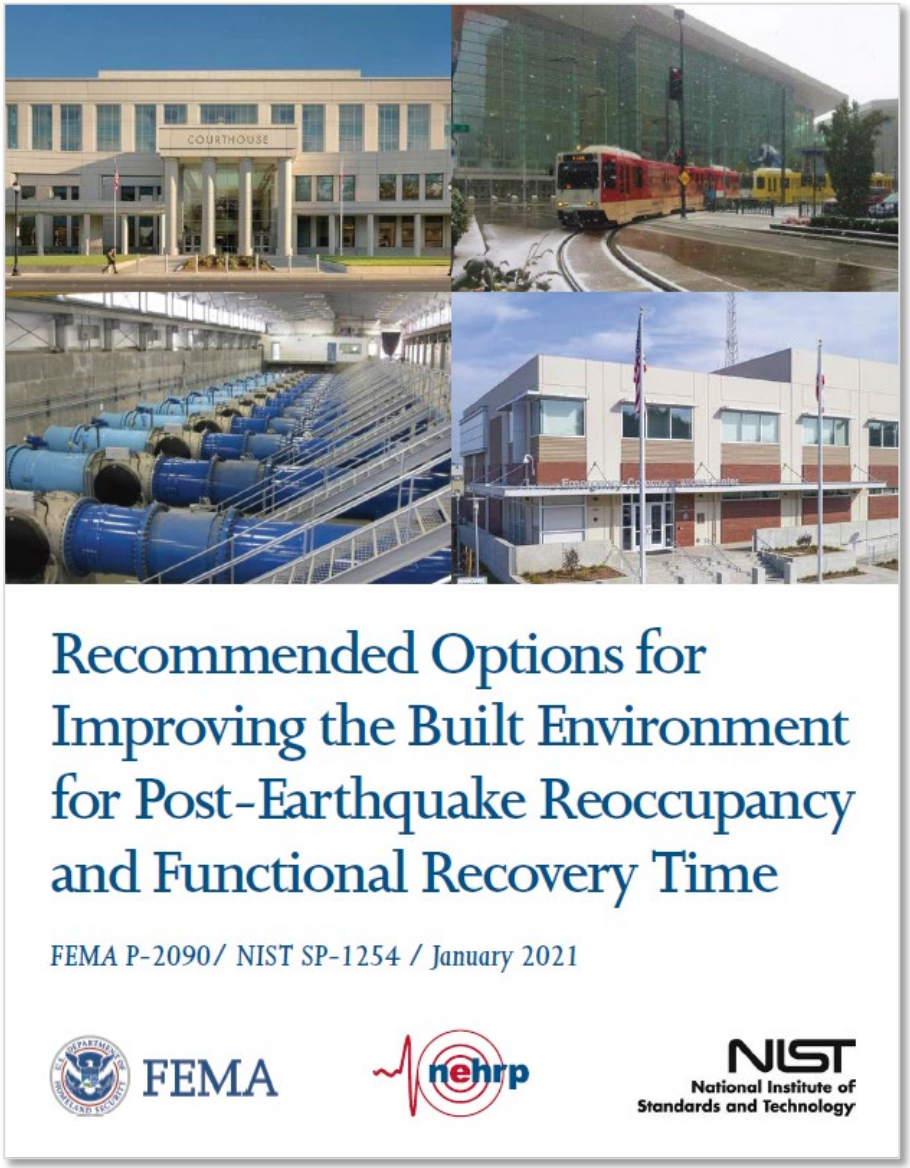
- Elective use on projects (as discussed)
- Thought leadership – e.g. David Bonowitz EERI paper
- AB-1329 support (e.g. SEAOC Public Policy Committee – Kersting, Bonowitz, etc.
- Analytical method development
  - FEMA P-58
  - REDi
  - USRC ratings
  - NIST/FEMA Functional Recovery effort/report
  - Extensions to directly assess building function
- Building code development (planning approaches)
- Lots of other things I am sure I am missing!

Structural Engineering Leadership

Structural Engineers are Leading this Charge



Defining and Assessing Functional Recovery



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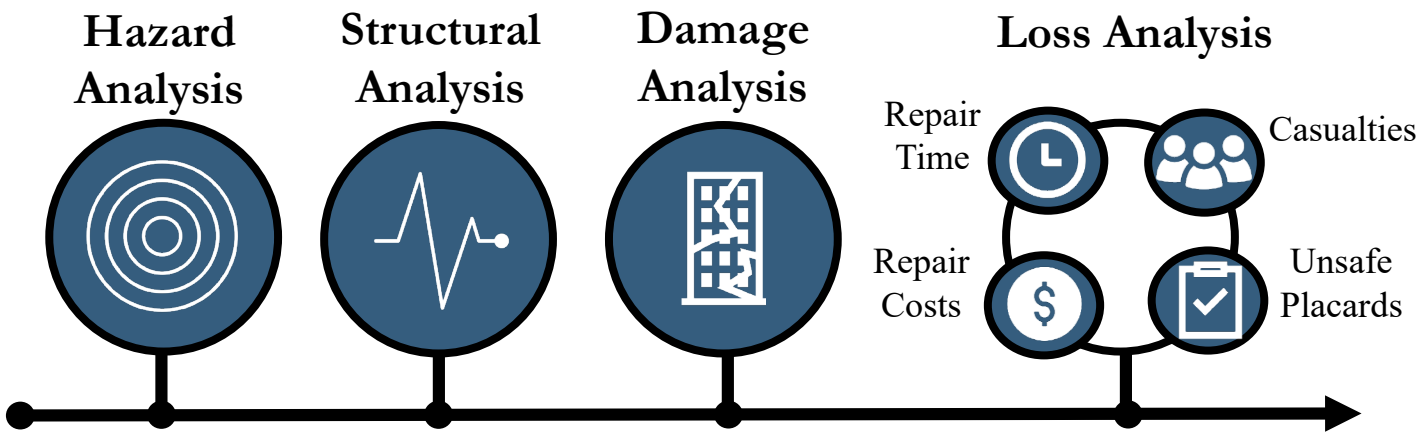
Defining and Assessing Functional Recovery



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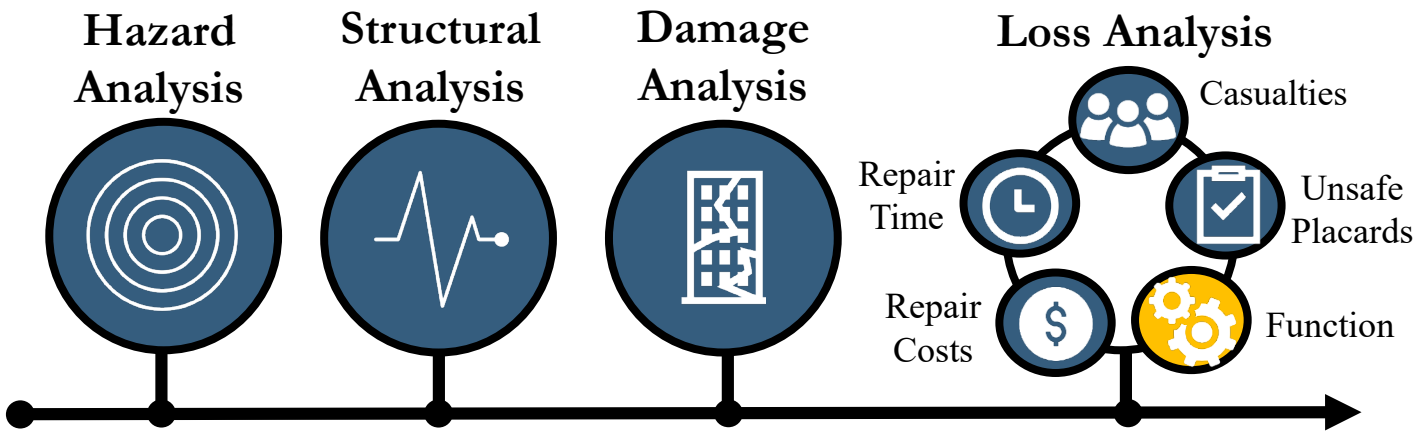

Summary

- Code design achieves the safety goals well (per past EQ history), but has not aimed to provide post-earthquake function (so results in ~ 4-12 months downtime for a design earthquake).
- FEMA P-58 can be used to design directly to meet resilience goals (and this can be done either simply with structural system selection and code knobs, or with a lot of detail in the design).
- Even though not mandated, engineers are electively designing for resilience right now (less damage, quicker recovery, less repair cost). [also using FEMA P-58 extensively for risk assessment (PML+)]
- Engineers are creative people, so we are finding that they can provide quicker recovery times with minimal (or no) added costs. They just need to add quick recovery to their design goals and be intentional to design for it!
- Efforts are ongoing to:
  - Codify and require resilient design for functional recovery.
  - Extend analytical methods to more directly assess building function (e.g. Dr. Cook's talk next!).

Next Step for Structural Engineering Leadership

- What can we do right now on current projects?
  - Use FEMA P-58 for upfront system selection (e.g. BRBF over SCBF), then do design as usual.
  - Use FEMA P-58 to set “code knobs” to use for the project (e.g. 1% drift limit), then do design as usual.
  - Use FEMA P-58 in more detail to look at design of non-structural components (e.g. what if make cladding better, what if make elevator stronger, etc.).
- What can we do right now/soon to support longer-term efforts:
  - Do resilient design electively on projects! This is really helping “show the way” to how it may be codified in the future.
  - Participate in SEAOC and other committees and activities focused on resilient design.
  - Participate in upcoming building code efforts on resilient design for functional recovery.

Questions and Discussion!

- Thank you for your time.
- Our goal is to support adoption of resilience-based design for Functional Recovery, and overall seismic risk assessment, and we welcome feedback and suggestions.

- Time for questions and discussion (probably will do all at the end)!

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