

# Seismic Design for Functional Recovery

## Recovery-based Analysis Frameworks to Support the Development of Design Provisions: Overview of ATC-138

2024 EERI Annual Meeting  
April 11, 2024

Curt B. Haselton, PhD, PE

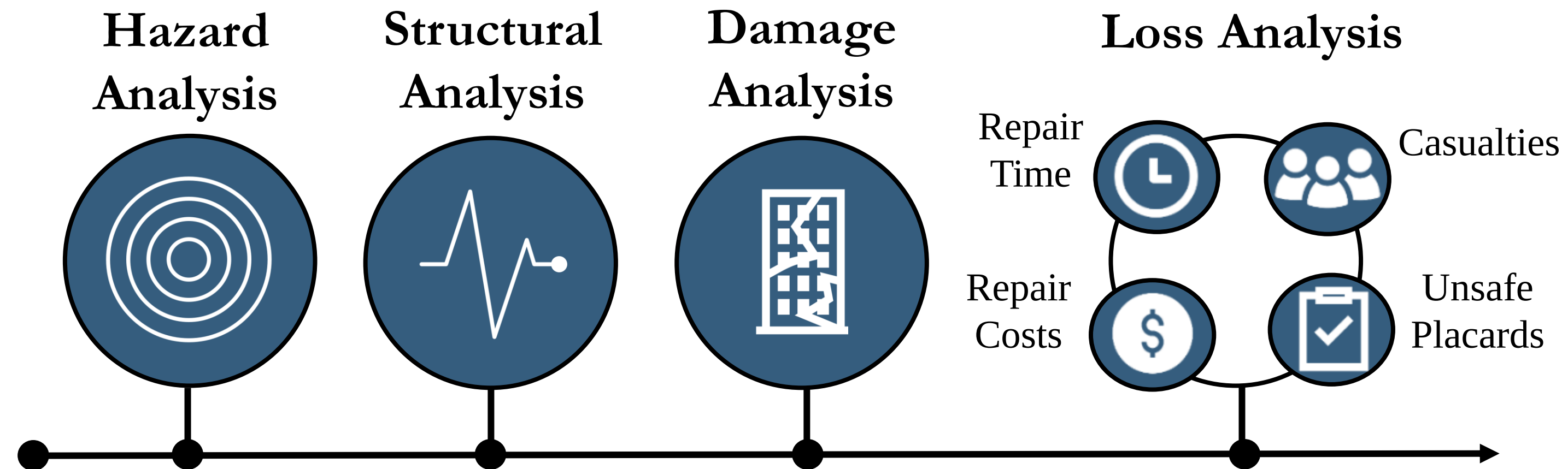
Contributors (countless):

- FEMA funding for past 20 years, NIST funding for FR Module
- FEMA P-58/ATC-138 (Almeter, Cook, Hamburger, Heintz, Hooper, Liel, Mahoney, Mar, etc.)
- HBRG/SP3 Team (e.g. Almeter, Baker, DeBock, Kojabashian, McGlone, Welch, etc.)
- Leading Structural Engineers (many!) using/vetting methods for elective resilient design

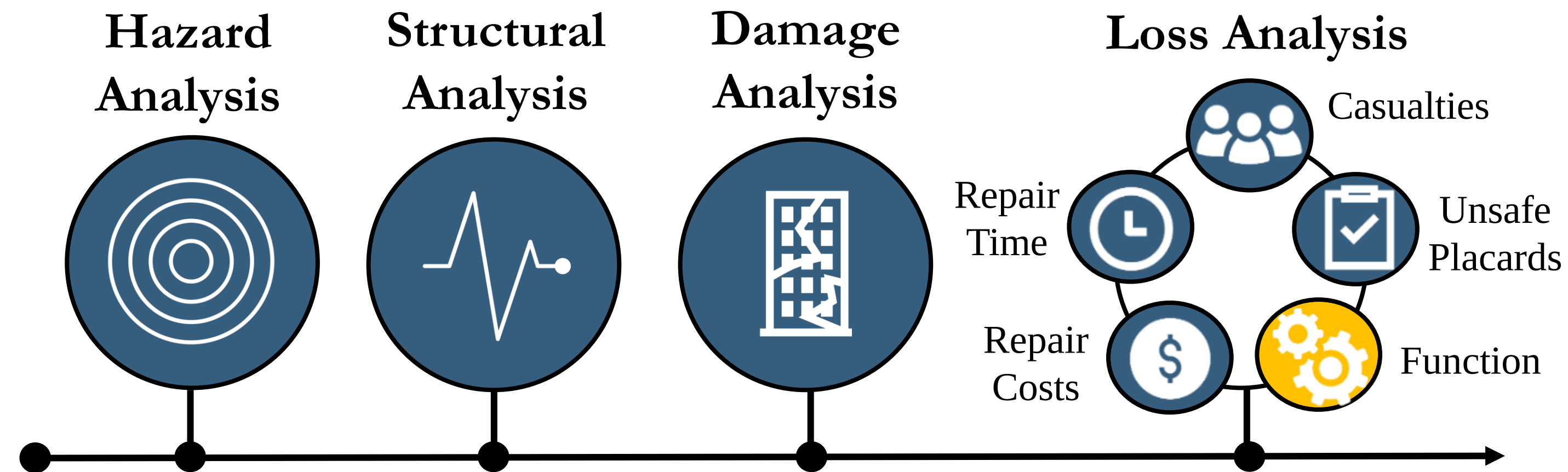
# Summary and Take-Away Messages Upfront!

- 1) Analysis Method:** Our profession has an analysis tool for resilient design for functional recovery (FEMA P-58 Functional Recovery Module, aka ATC-138 project).
  - ✓ Developed over last 20 years by FEMA and NIST (and 100+ ATC project participants).
  - ✓ Vetted over last 10 years in the structural engineering profession via elective resilient design. These projects have shown resilient design to be both feasible and not cost-prohibitive (0-1%).
- 2) Resilient Design for Functional Recovery for New Building:**
  - ✓ **Current:** Our design target is safety-only, studies show median ~3-6+ mo. recovery at DE.
  - ✓ **Future:** We can do better (and need to for community resilience). Elective resilient design projects are already doing better (successfully). We have learned that we just need to target safety+function and let creative engineers do it at minimal extra cost!
- 3) Prescriptive Provisions:** The FEMA P-58 Functional Recovery Module is being used to help develop prescriptive design requirements for functional recovery (via many iterative resilient designs).

# Analysis Method: FEMA P-58 with Functional Recovery Module



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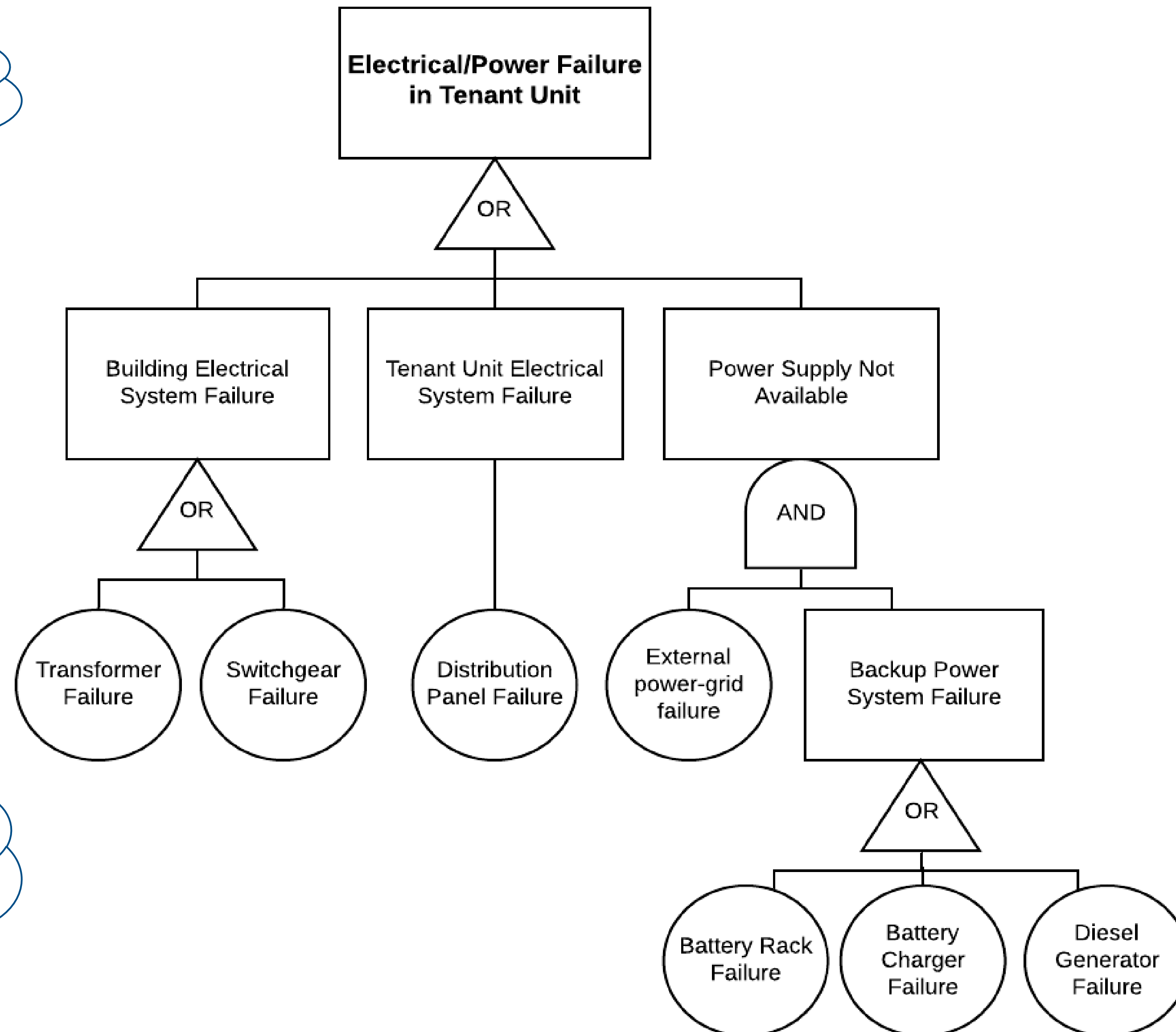
The **FEMA P-58 Functional Recovery Module** (via ATC-138 project) now directly assesses:

- (a) Reoccupancy time, and
- (b) Functional Recovery time.

This is the official FEMA P-58 extension, but note that several other FEMA P-58-based FR extensions are also available (e.g. REDi by Arup, PEER method by Vesna Terzic et al., TREADS by Carlos Molina Hutt et al., etc.).

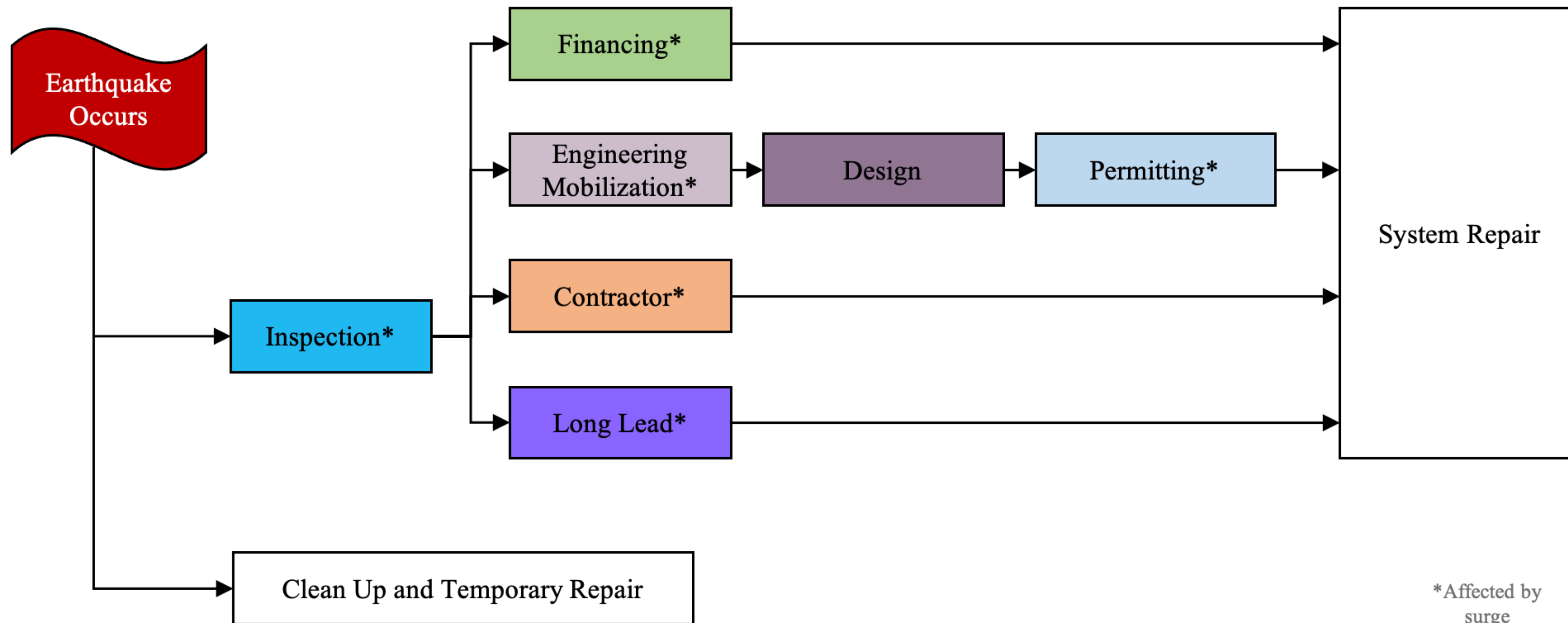
# Analysis Method: FEMA P-58 with Functional Recovery Module

System-Level  
Functionality



Component-  
Level  
Performance

# Analysis Method: FEMA P-58 with Functional Recovery Module

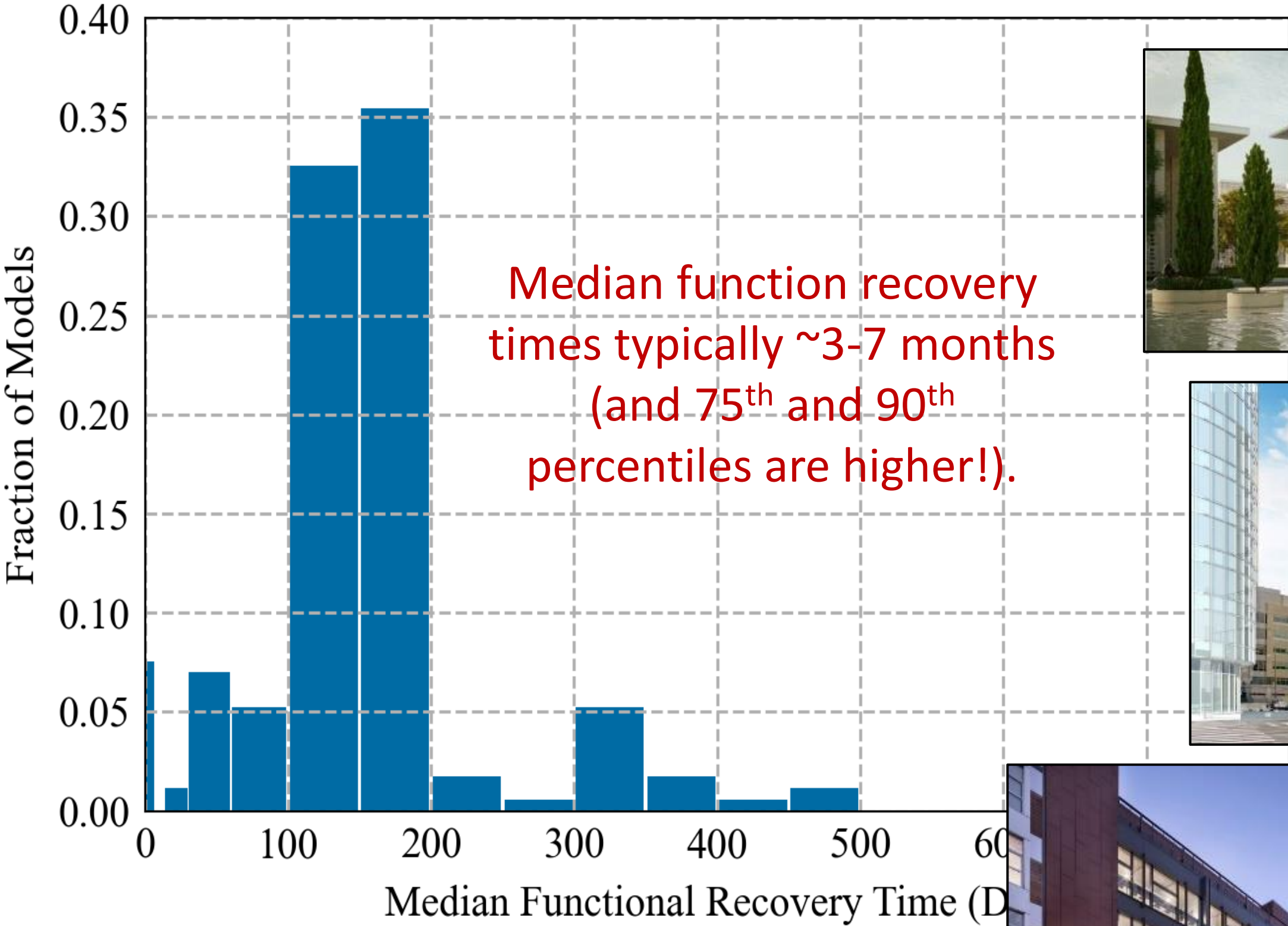


# New Building Resilient Design for Functional Recovery

Median Functional Recovery Time (DE)

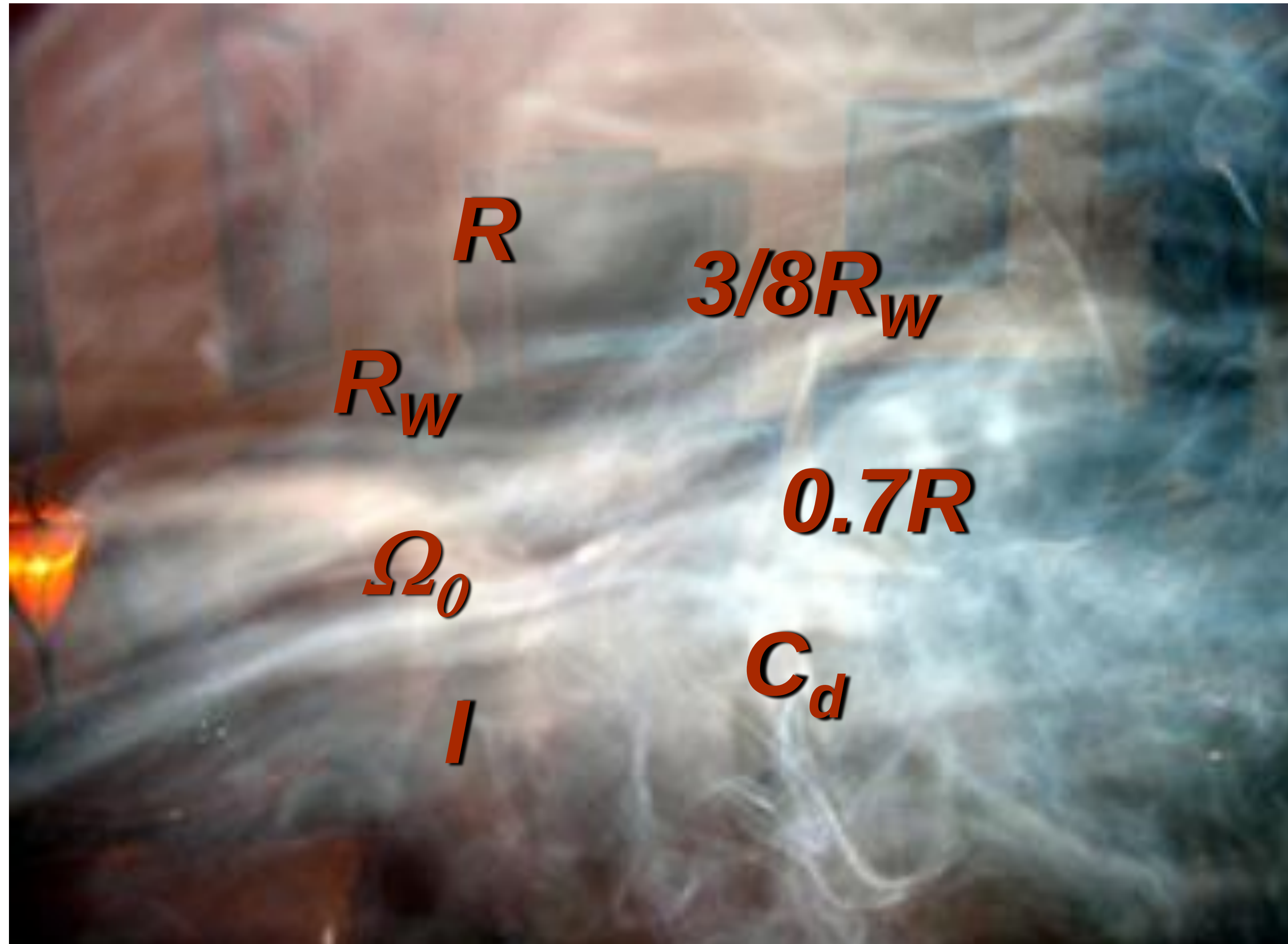
Constants: 2022 | SDC Dmax Site Class D | RC II

Shown for Various: Stories | Building Type | Occupancy | Medical Equipment | Stucco Y/N | Aspect Ratio  
Footprint



# Development of Prescriptive Provisions for Resilient Design

Review of Code Development Process for Safety (historical):



Slide Reference: Jon Heintz, FEMA P695 Workshop

# Development of Prescriptive Provisions for Resilient Design

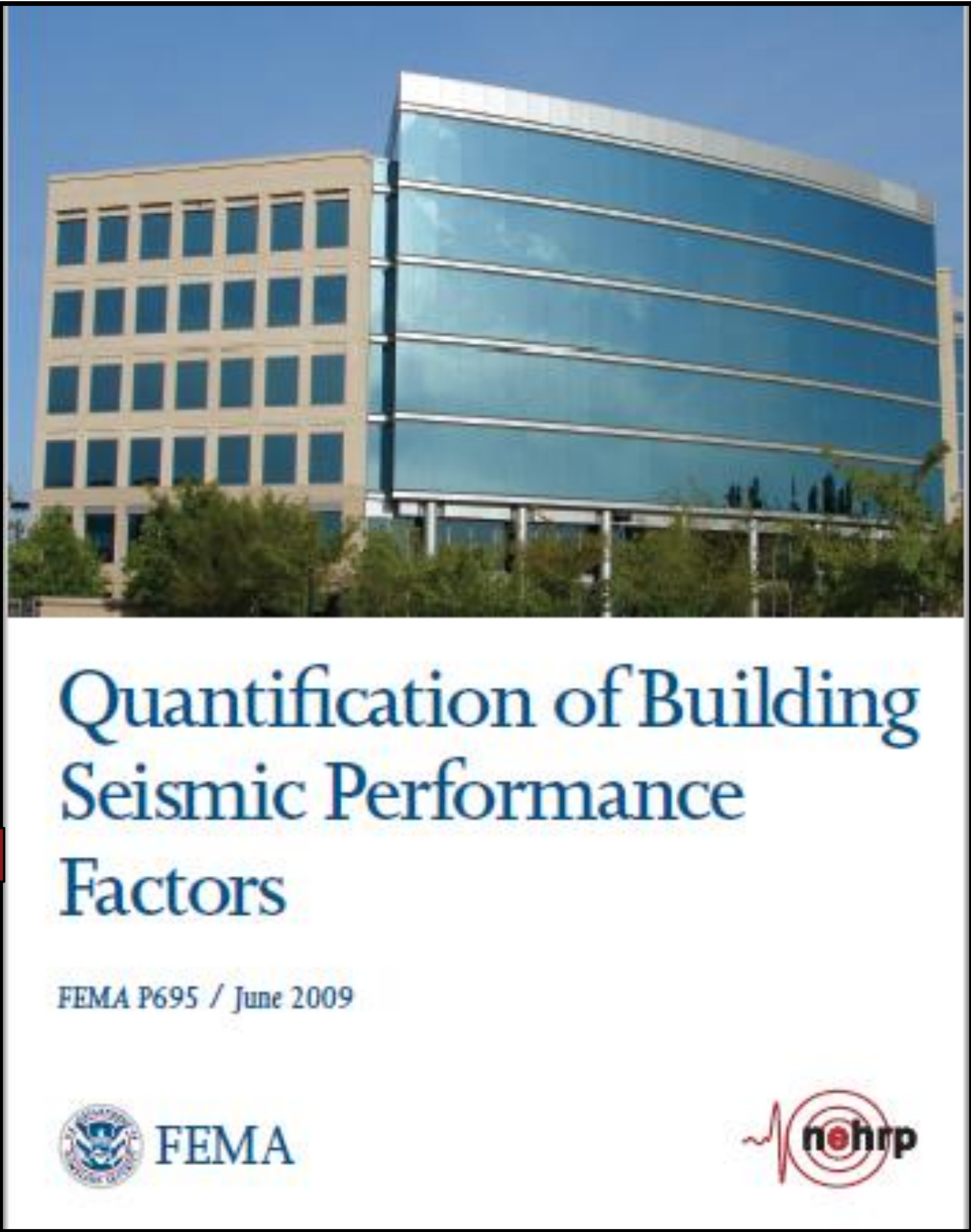
Review of Code Development Process for Safety (current, since soon after 2009):

Table 1.3-2 Target Reliability (Conditional Probability of Failure) for Structural Stability Caused by Earthquake

| Risk Category | Conditional Probability of Failure Caused by the $MCE_R$ Shaking Hazard (%) |
|---------------|-----------------------------------------------------------------------------|
| I & II        | 10                                                                          |
| III           | 5                                                                           |
| IV            | 2.5                                                                         |

Lots of Analysis Runs for Lots of Design Cases

Prescriptive Design Requirements for the Code



# Development of Prescriptive Provisions for Resilient Design

## Similar use of FEMA P-58 for Functional Recovery Provisions:

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 <sup>(1)</sup>                                     | 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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Prescriptive Design Requirements for the Code



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# Thank you

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