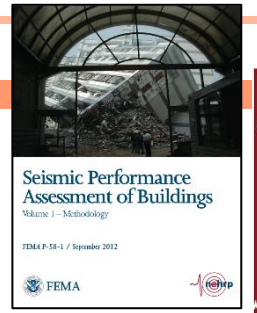
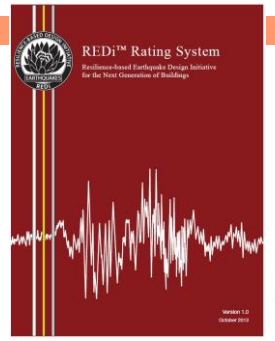
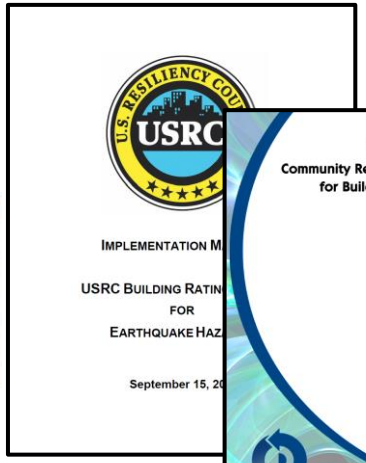
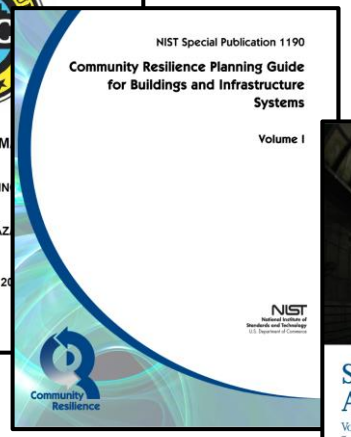
The Resilient Design Movement

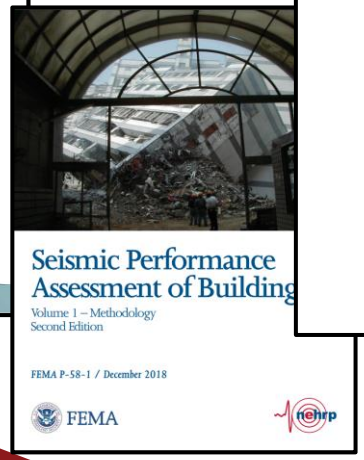
The Resilient Design Movement

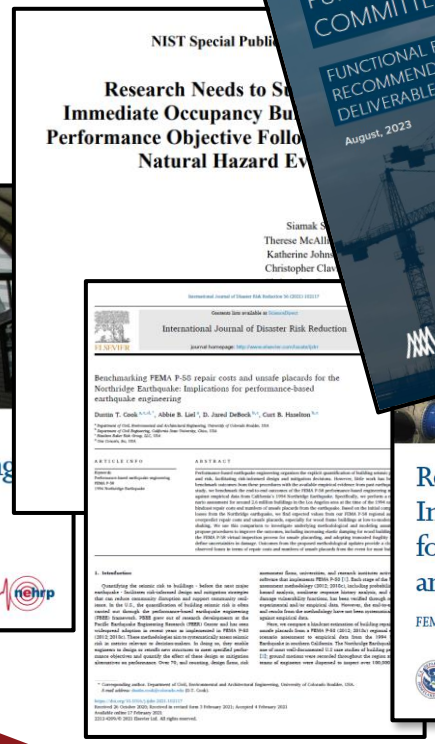


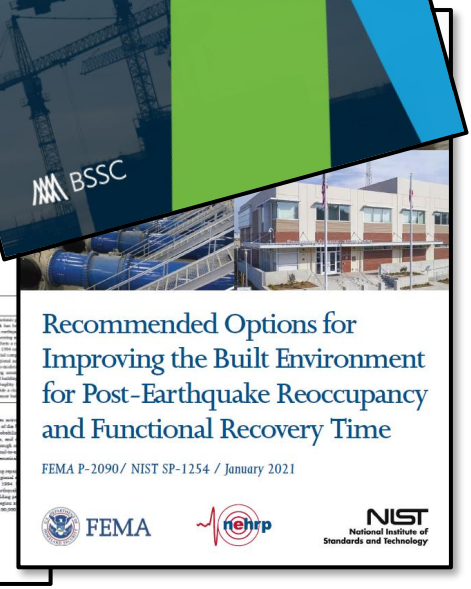












~1997…

2001

FEMA/ATC Start FEMA P-58

2012

2013

2014

2015

2016

2018

2019-2020

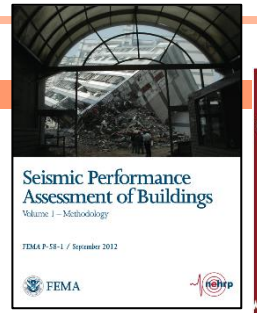
2020-2021

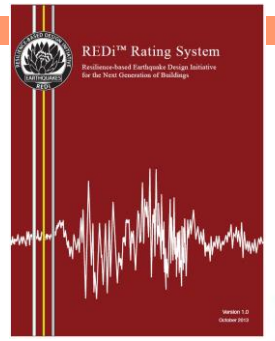
2022

Resilient Design Codification process begins

~10 years of use/vetting by visionary early-adopter in SE industry

The Resilient Design Movement





~1997…

2001

2012

FEMA/ATC

2013

2014

2015

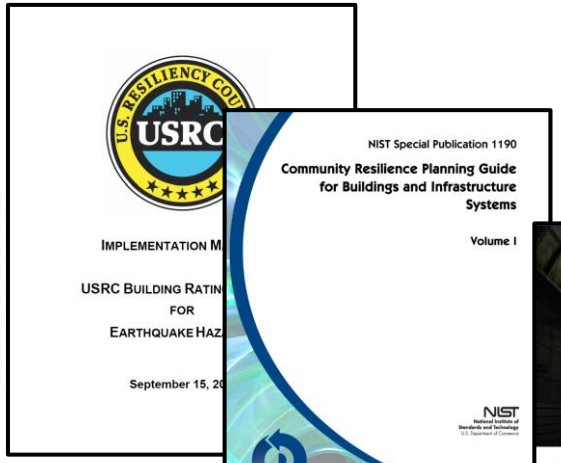
2016

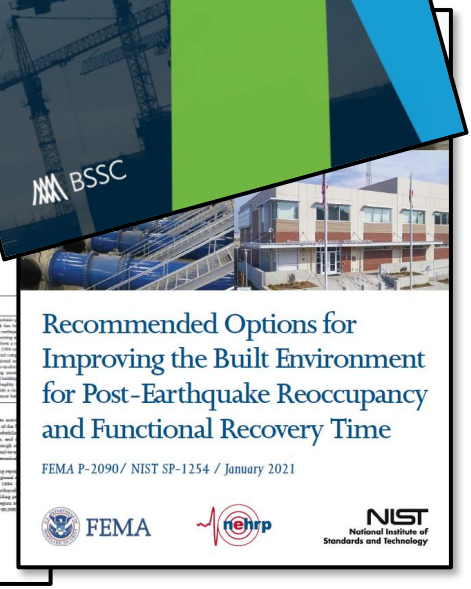
2018

2019-2020

2020-2021

2022



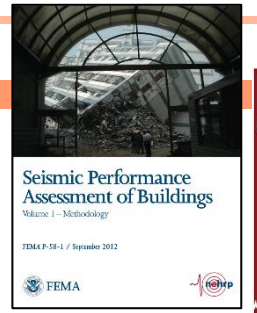


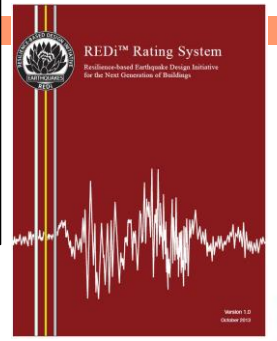
g by visionary
industry

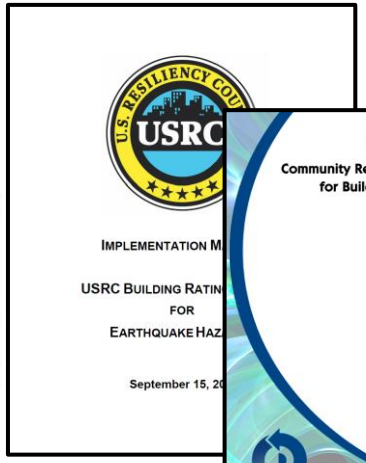
Resilient Design Codification process begins

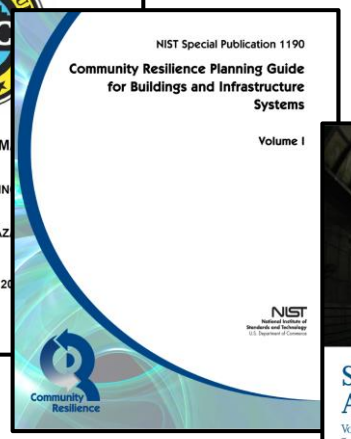
≠

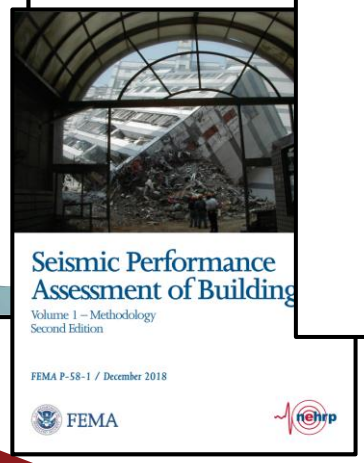
The Resilient Design Movement

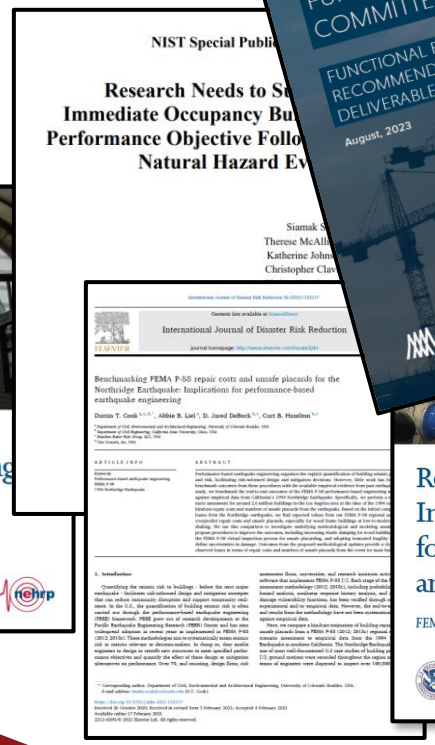


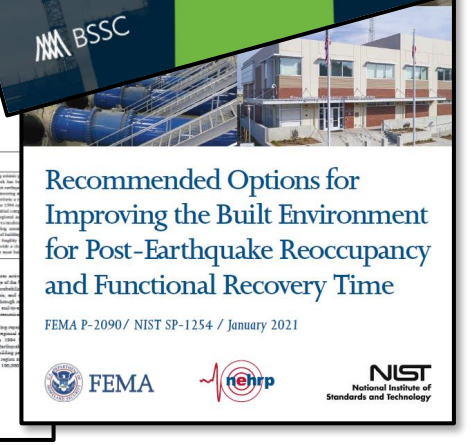












~1997…

2001

FEMA/ATC Start FEMA P-58

2012

2013

2014

2015

2016

2018

2019-2020

2020-2021

2022

Resilient Design Codification process begins

2022

50% draft

Q3 2023

90% draft

Q4 2023

100% draft

Q2 2024

Final to ASCE7, published

Q1 2025

Likely further expansion in elective resilient design, since now codified guidance

Where to next…!?!?!?

~10 years of use/vetting by visionary early-adopter in SE industry

Resilient Design Codification process begins

2022

≠

The Resilient Design Movement

Bottom-Up Push for Resilient Design:

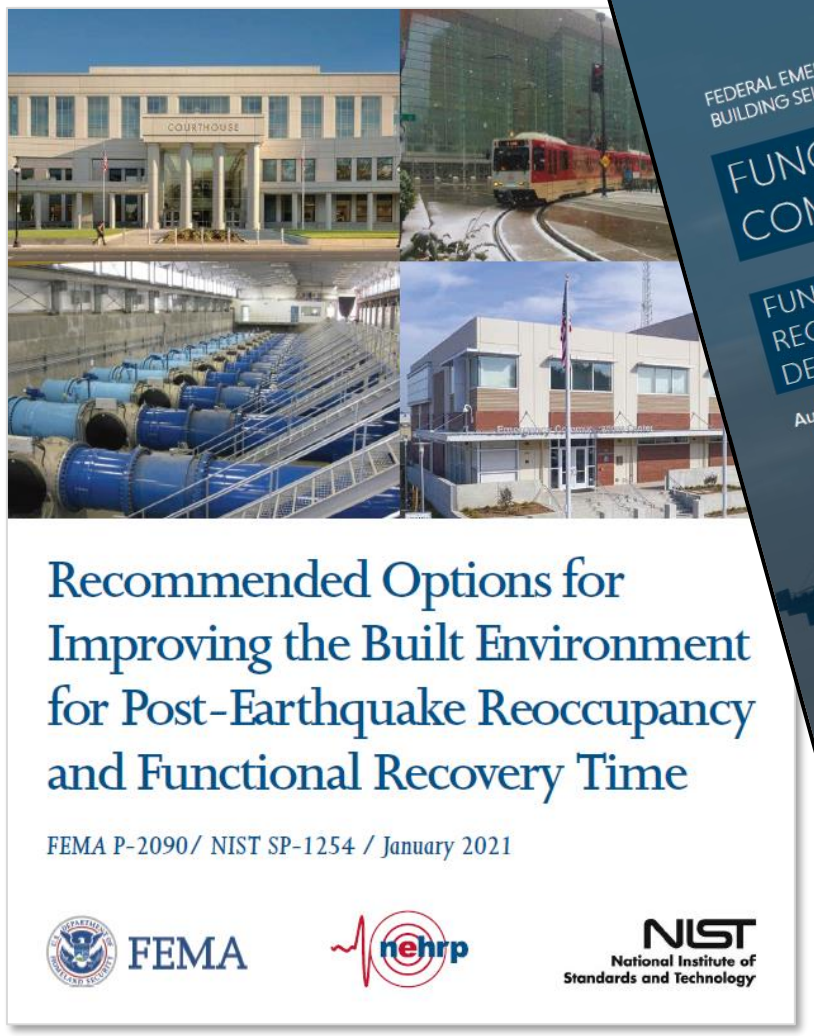
- Visionary structural engineers are leading by doing this electively on projects, to both differentiate themselves in the market, and to better serve their clients.
- Typical goals of resilient design projects:
  - ✓ **Time:** Building quickly regains function (in days to weeks).
  - ✓ **Cost:** Reduce damage and repair costs (below 5% of building value).
- These elective/visionary projects have been a <u>critical component</u> of the Resilient Design Movement, showing us that:
  - ✓ Resilient design is **feasible**.
  - ✓ Resilient design is **cost effective**, ~0-1% cost.
  - ✓ Resilient design **can be done quickly** at the rapid pace of a design office.
  - ✓ Overall, just need to target quick function in design and let engineers be creative and do at no/little cost!
- Learning from these projects is also informing the **resilient design building code efforts** (showing how prescriptive requirements can be created, and creating confidence/comfort with these new design methods).

The Resilient Design Movement

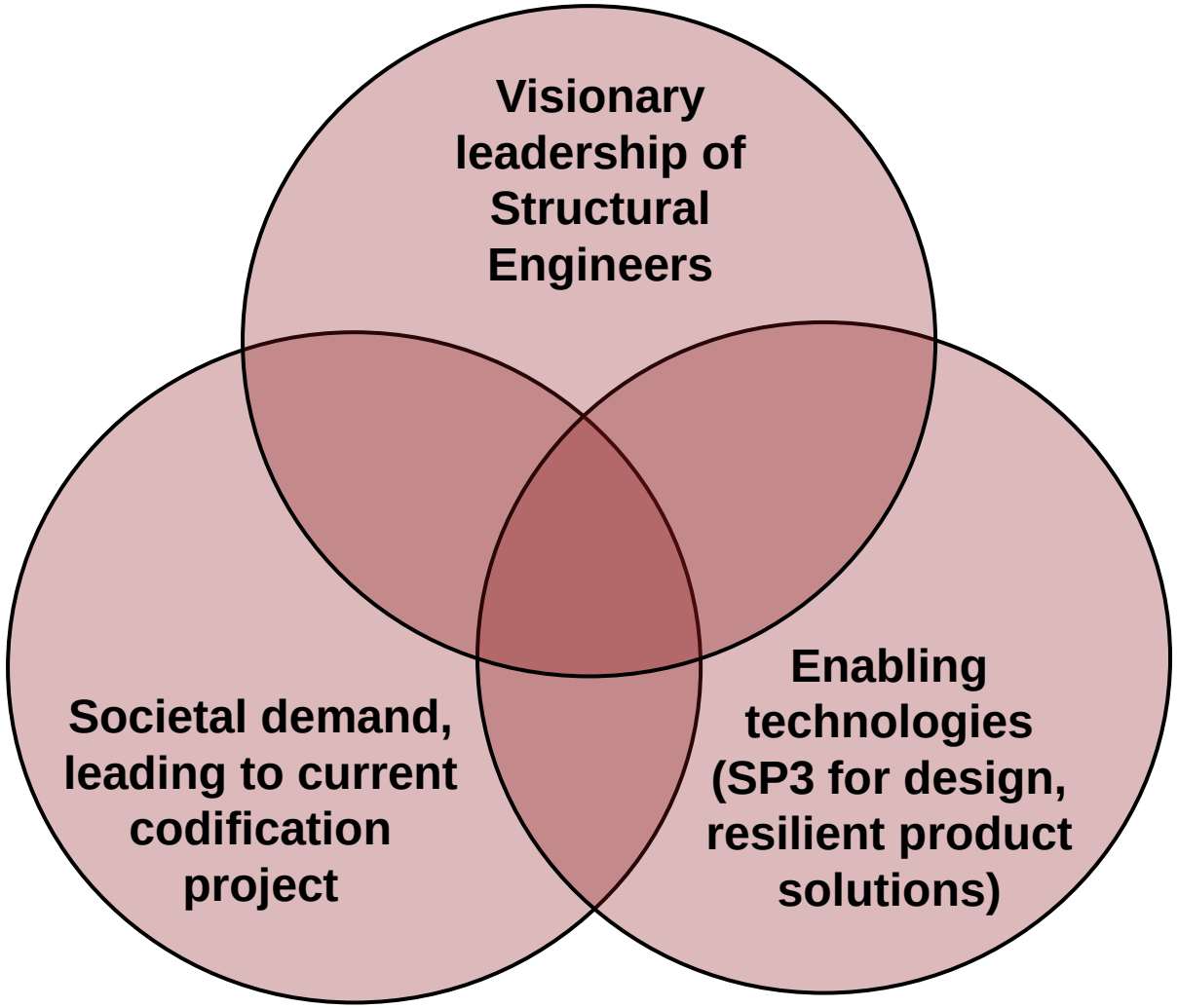
Top-Down Push for Resilient Design:

- **Federal:** NEHRP Reauthorization with mandate to look at building function, resulting in NIST/FEMA Functional Recovery report.
- **Federal:** FEMA-funded Building Seismic Safety Council building code development (being done 2022-2025, more on this later)
- **State:** California AB 1329 in 2021

  "…require buildings…to be designed and built to a functional recovery standard for earthquake loads.."



The Resilient Design Movement



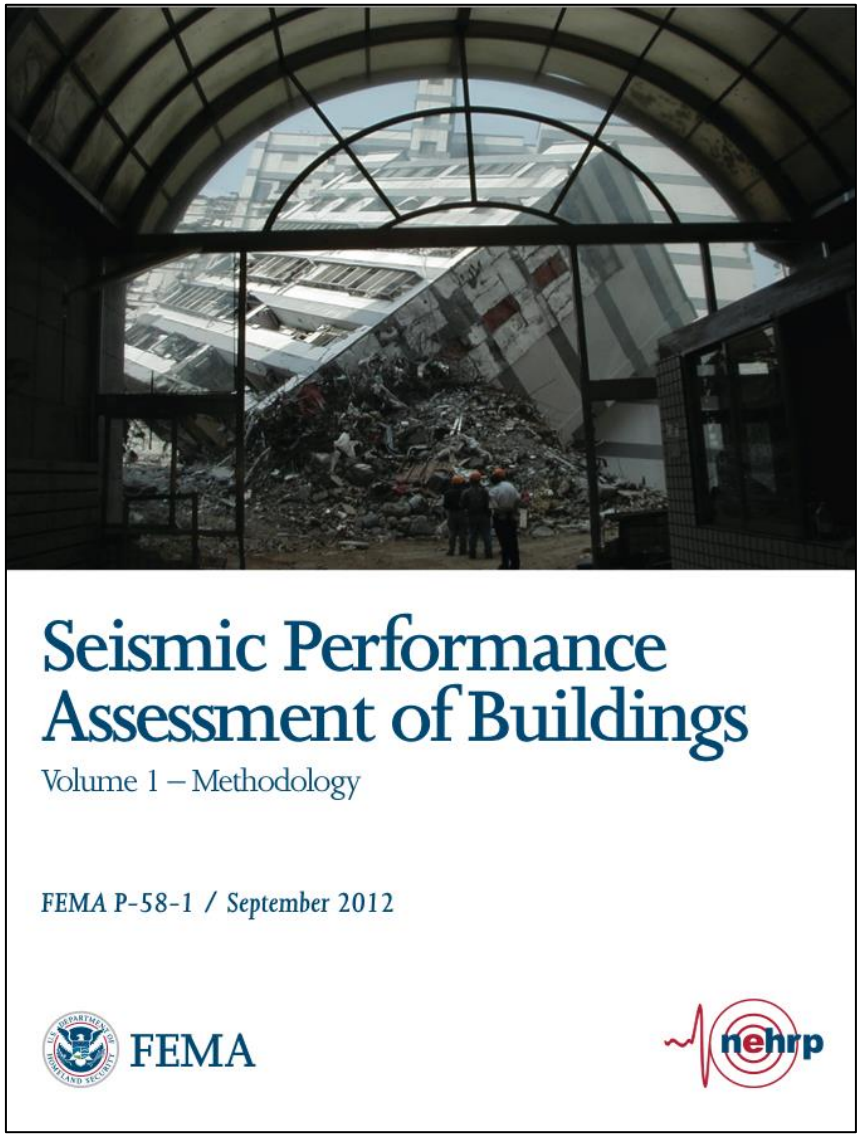
[Poll #3]

≠

Enabling FEMA P-58 and SP3 Technologies

Enabling FEMA P-58 and SP3 Technologies

- FEMA P-58 is an analysis method to predict building resilience (15 years, 2012 release, $16-18M).
- FEMA P-58 is tailored for building-specific analysis and resilient design.
- FEMA P-58 output results:
  - Repair costs
  - Repair time (with reoccupancy and functional recovery times)
- Implemented in SP3 in 2014 and been used/vetted by structural engineers for nearly a decade.

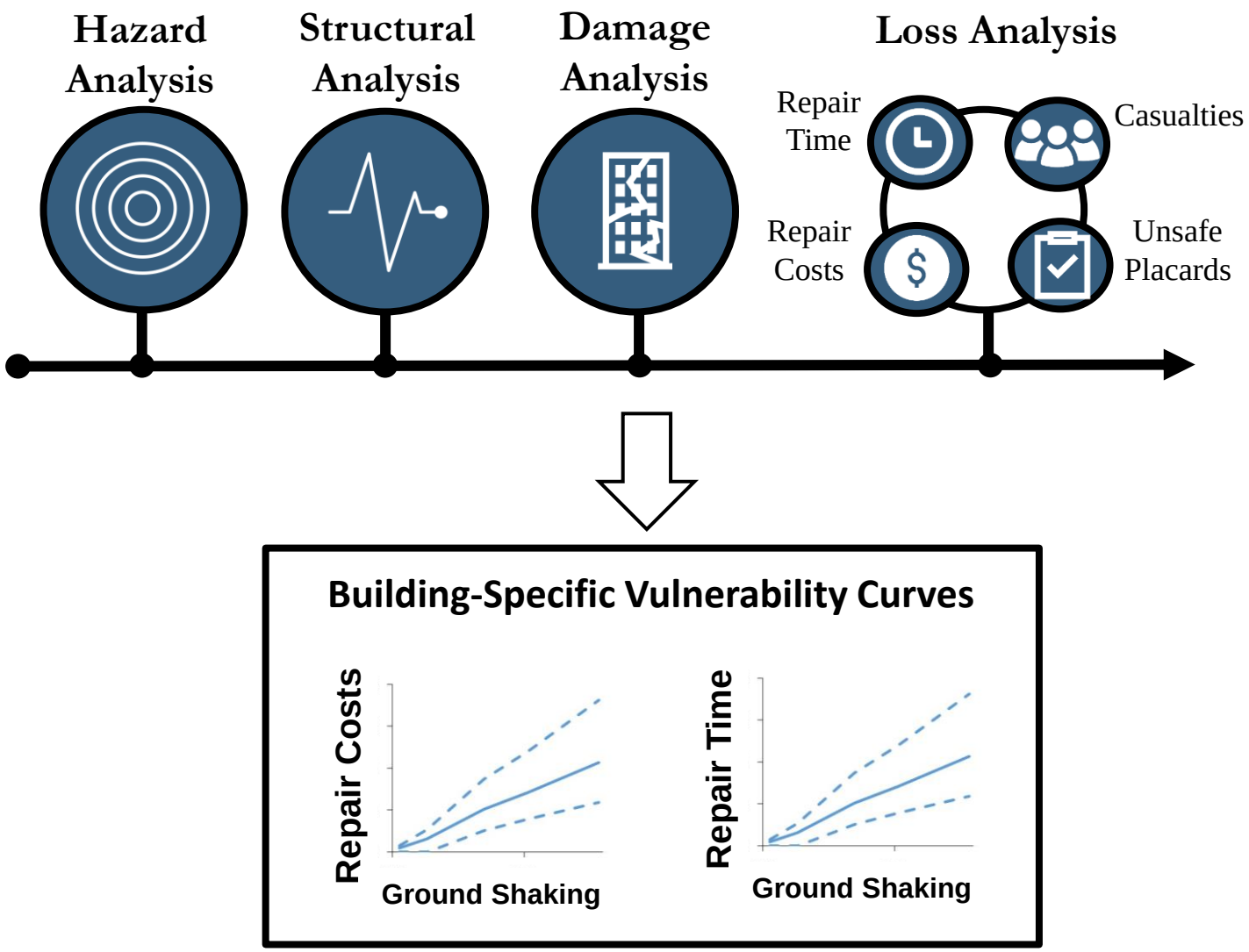


Enabling FEMA P-58 and SP3 Technologies

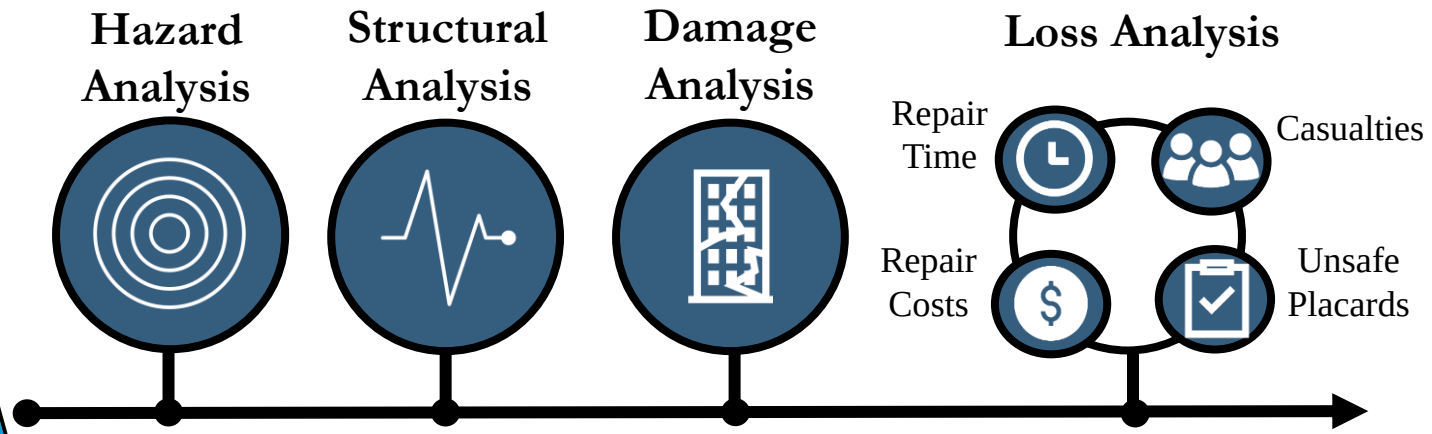
FEMA P-58 provides the **standardized** and **consensus-based** resilience analysis method (~$16-18M and 15yrs to develop).

SP3 provides a **complete solution** resilient design software that has been **vetted by structural engineers** (additional $10M and 10yrs invested).

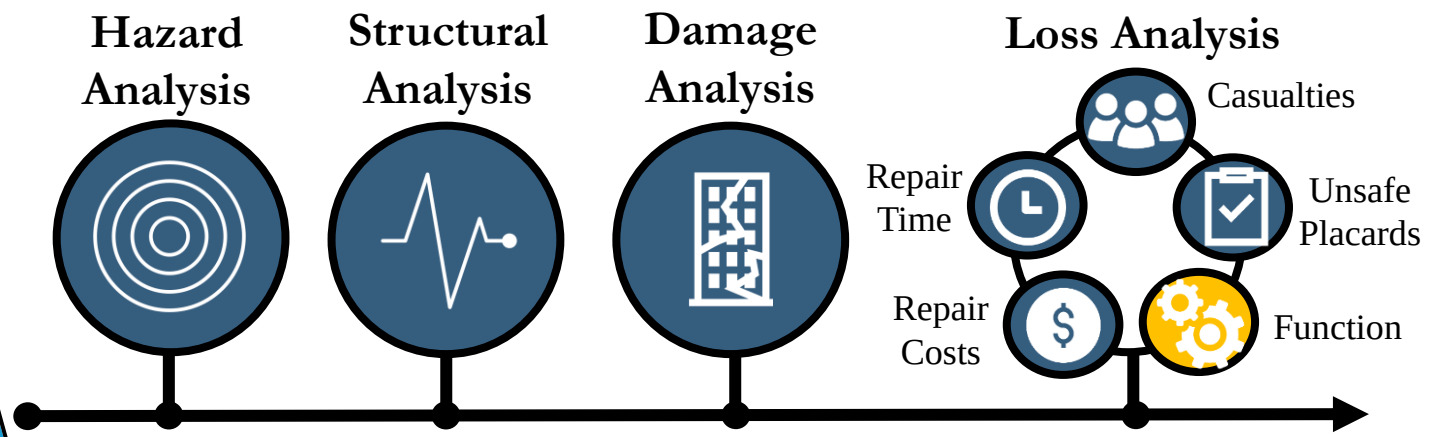
Enabling FEMA P-58 and SP3 Technologies



Enabling FEMA P-58 and SP3 Technologies



Enabling FEMA P-58 and SP3 Technologies

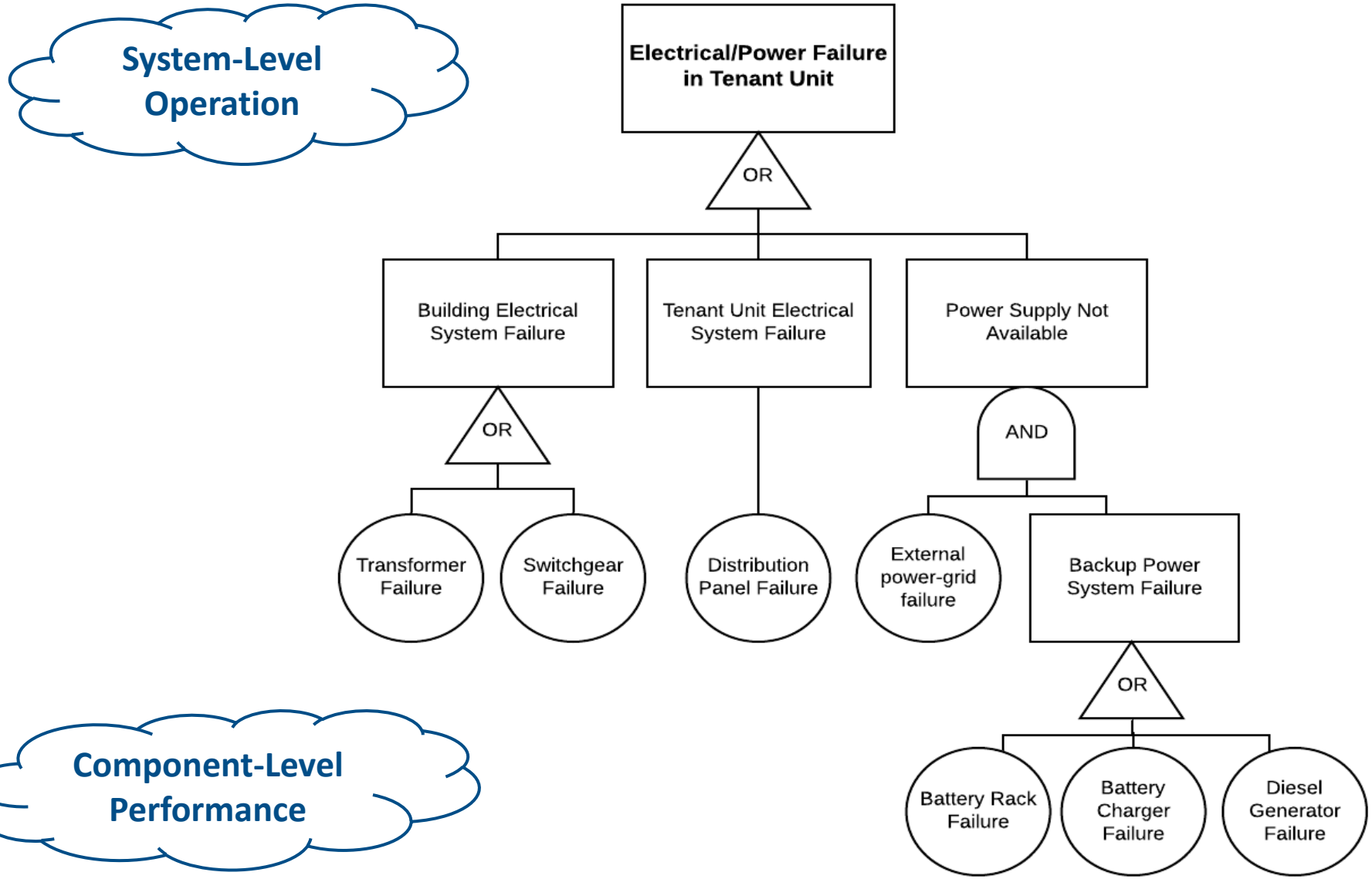


The FEMA P-58 method extensions now assesses:

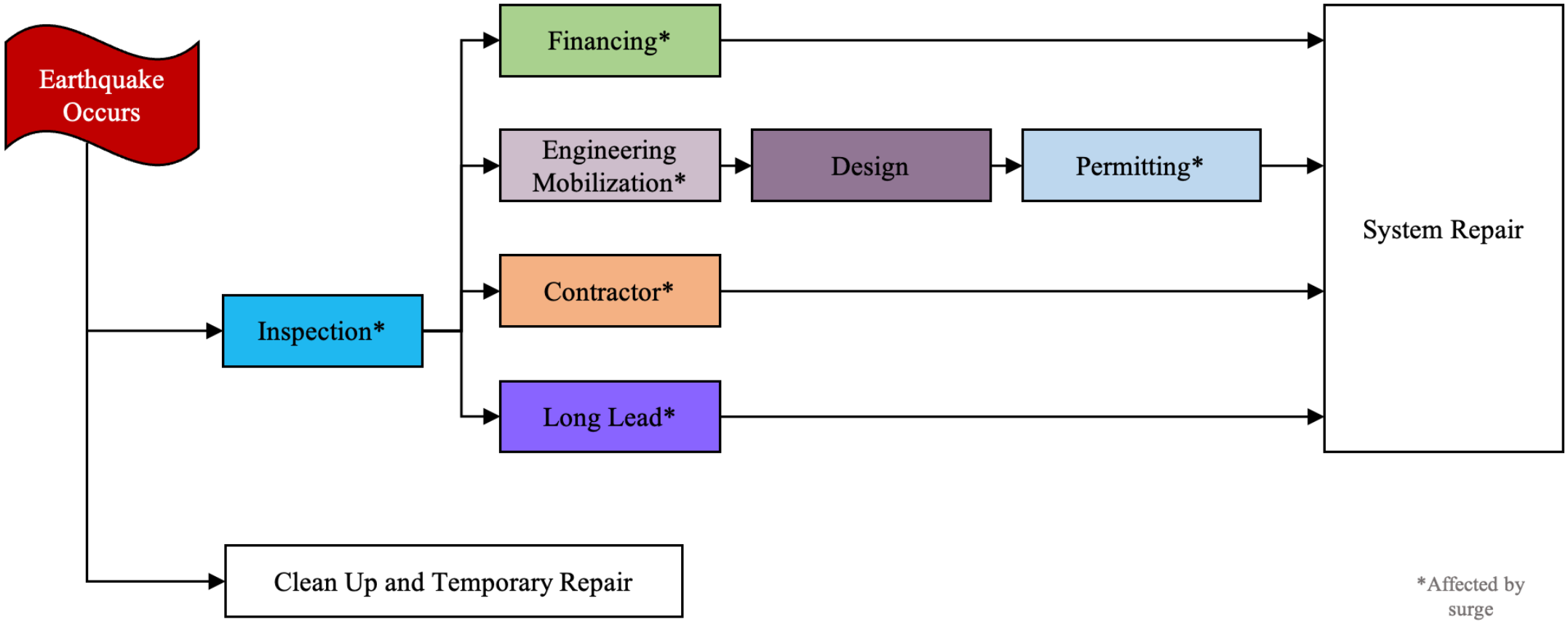
(a) Reoccupancy time, and

(b) Functional Recovery time.

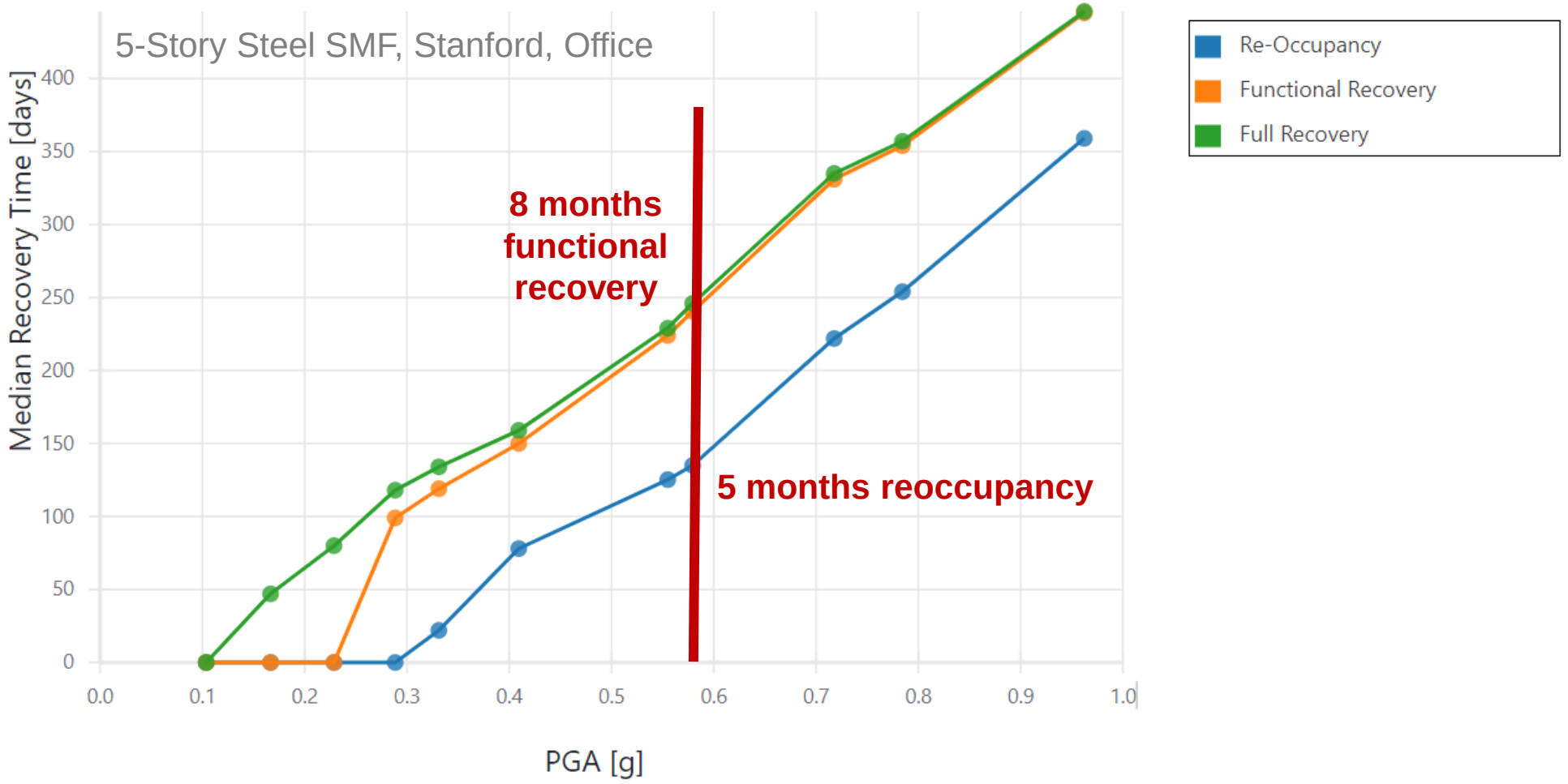
Enabling FEMA P-58 and SP3 Technologies



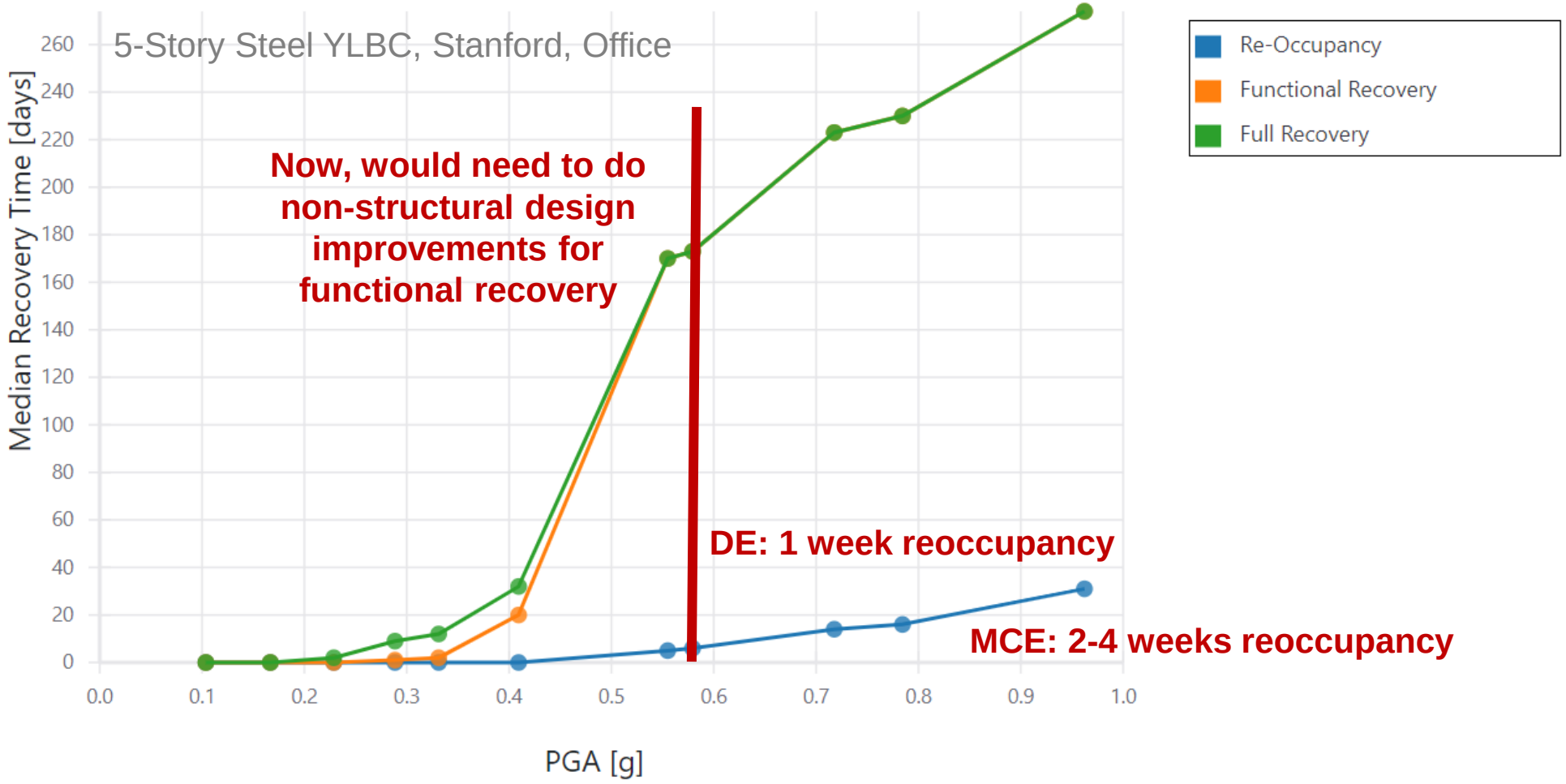
Enabling FEMA P-58 and SP3 Technologies



Enabling FEMA P-58 and SP3 Technologies



Enabling FEMA P-58 and SP3 Technologies



Enabling FEMA P-58 and SP3 Technologies

FEMA P-58 provides the **standardized** and **consensus-based** resilience analysis method (~$16-18M and 15yrs to develop).

SP3 provides a **complete solution** resilient design software that has been **vetted by structural engineers** (additional $10M and 10yrs invested).

Resilient Design with Simpson YLBC (and YLMC)

Resilient Design Needs

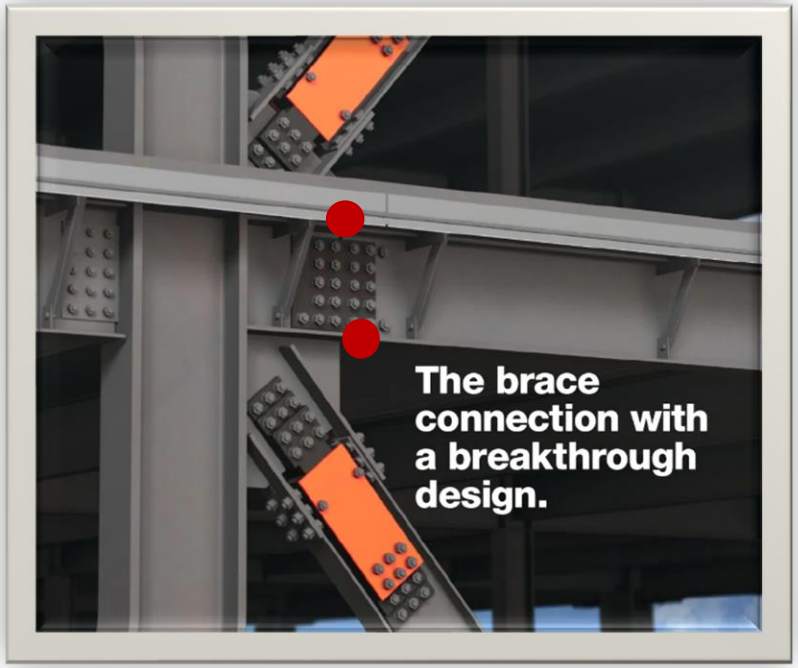
- Resilient design goals typically include (for Design Earthquake):
  - ✓ Fast post-earthquake reoccupancy (building is safe to enter), e.g. 1-4 wks. [mostly structural]
  - ✓ Fast post-earthquake functional recovery (building is functional), e.g. 1 mo. [mostly non-structural]
  - ✓ Low probability of unrepairable residual drifts.
  - ✓ Limited repair costs (becoming less of a focus, rarely a controlling factor).
- To achieve this:
  - ✓ Select and design structural system to deliver fast reoccupancy:
    - Have low chance of red tag (that can't be resolved quickly).
    - Have low chance of unrepairable residual drifts (above 1%).
  - ✓ Design non-structural components to function; outside of scope for today, but is critical – cladding connections, stronger equipment anchorages, ductile anchorage connections, stair connections, etc.).
- Note: Recovery times include both repair time and the delay times before repairs can start (so need to control the delay times too).

Resilient Design with the Simpson YLBC

- The YLBC is a **replaceable fuse**, created specifically for quick repair.
- The YLBC is also a **stocked component**, so no manufacturing delays.

- Residual drifts need to be controlled also (so building is not leaning over too much after the earthquake), similar to all other brace solutions.
  - ✓ The additional axial flexibility helps in reducing residual drifts (higher Δ_y than other similar braces with same steel strength).
  - ✓ Welded back-up frames create much lower residual drifts (important).
  - ✓ Without welded back-up frame, residuals comparable to other R = 8 braces.

- To fully leverage the **quick fuse repair**, have a **plan in place** to complete the repair quickly (engineer and contractor available, no permit delays).
- Note that planning for quick repair only helps if replacement components are available (i.e. doesn't matter is replacement component takes 3-4 months to manufacture).

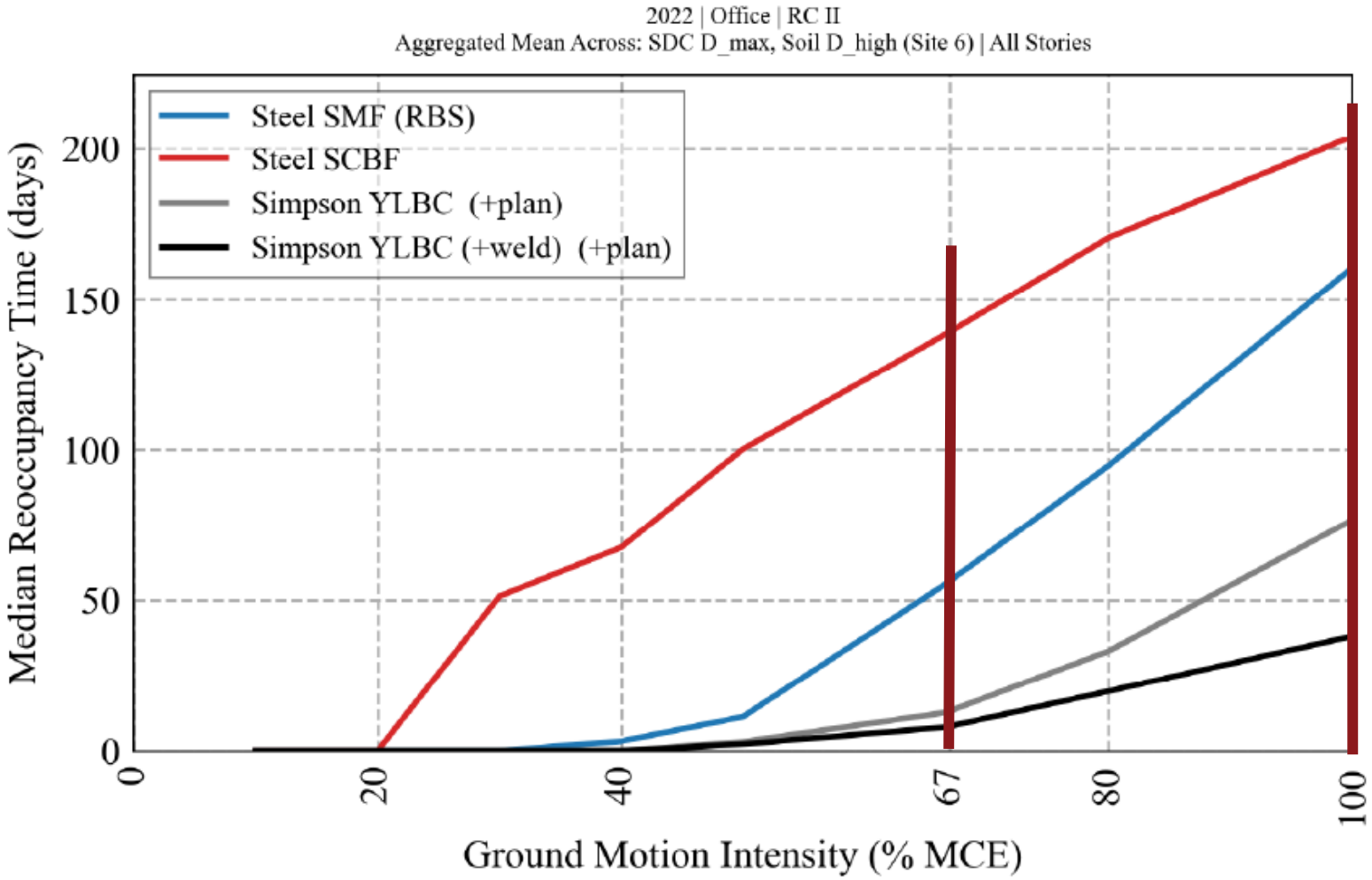


Resilient Design with the Simpson YLBC

- We ran many SP3 resiliency analyses to compare system and determine how best to position the Simpson YLBC (+YLMC) in terms of resilience.
  - ✓ The overall test matrix follows the current FEMA/ATC-138 studies that are being in support of the BSSC FRTC building code development.
  - ✓ **Site/Occupancy:** SDC D, Soil D, office occupancy, Risk Category II.
  - ✓ **Stories:** 3, 5, 8, 12
  - ✓ **YLBC Designs:** Chevron, 20’ bay, exposed brace, with planning for the repair
  - ✓ Comparisons included to non-proprietary systems (SCBF and SMF); direct comparison between proprietary systems is left to SP3 users!

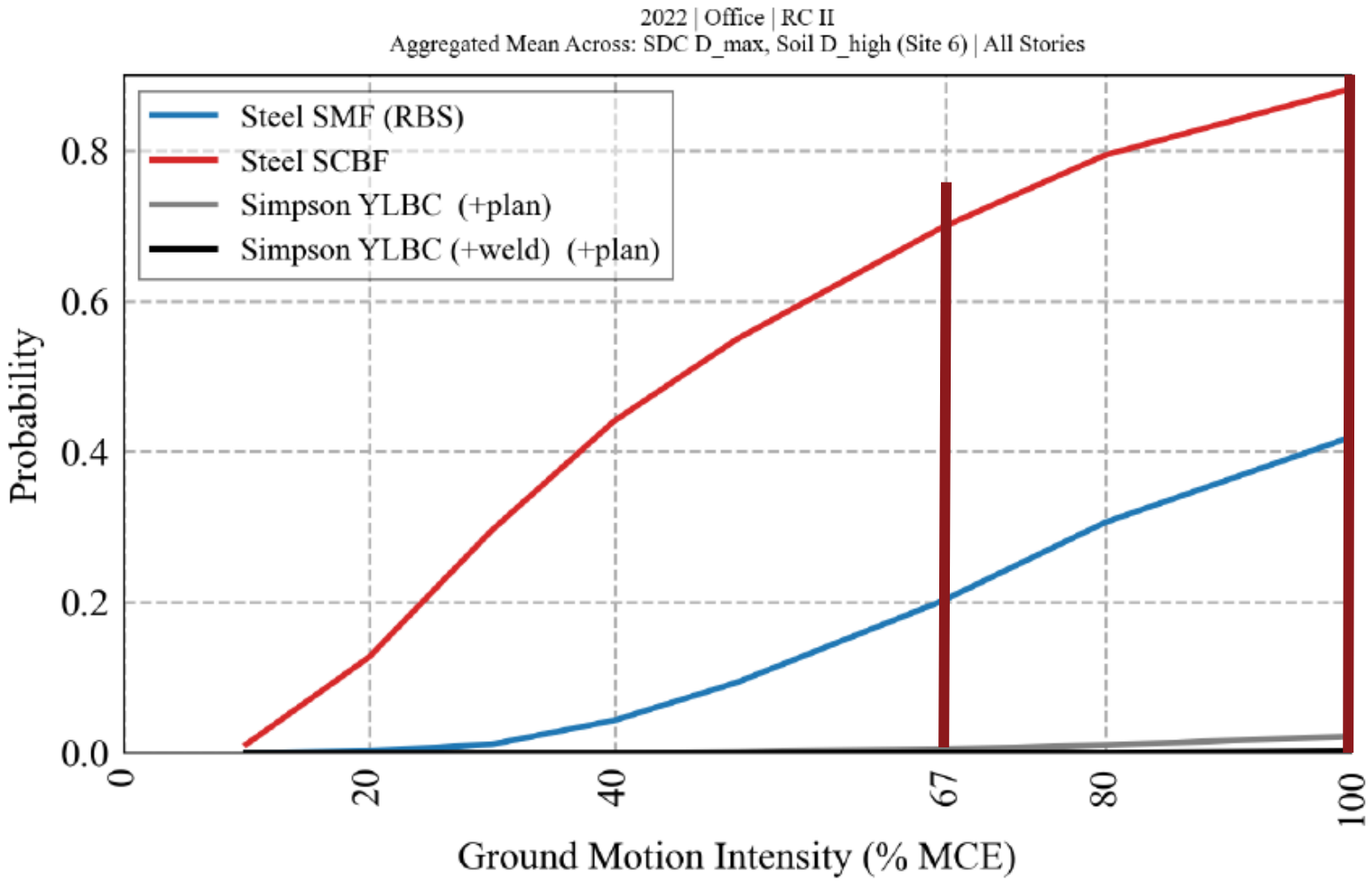
Resilient Design with the Simpson YLBC

Median Reoccupancy Time



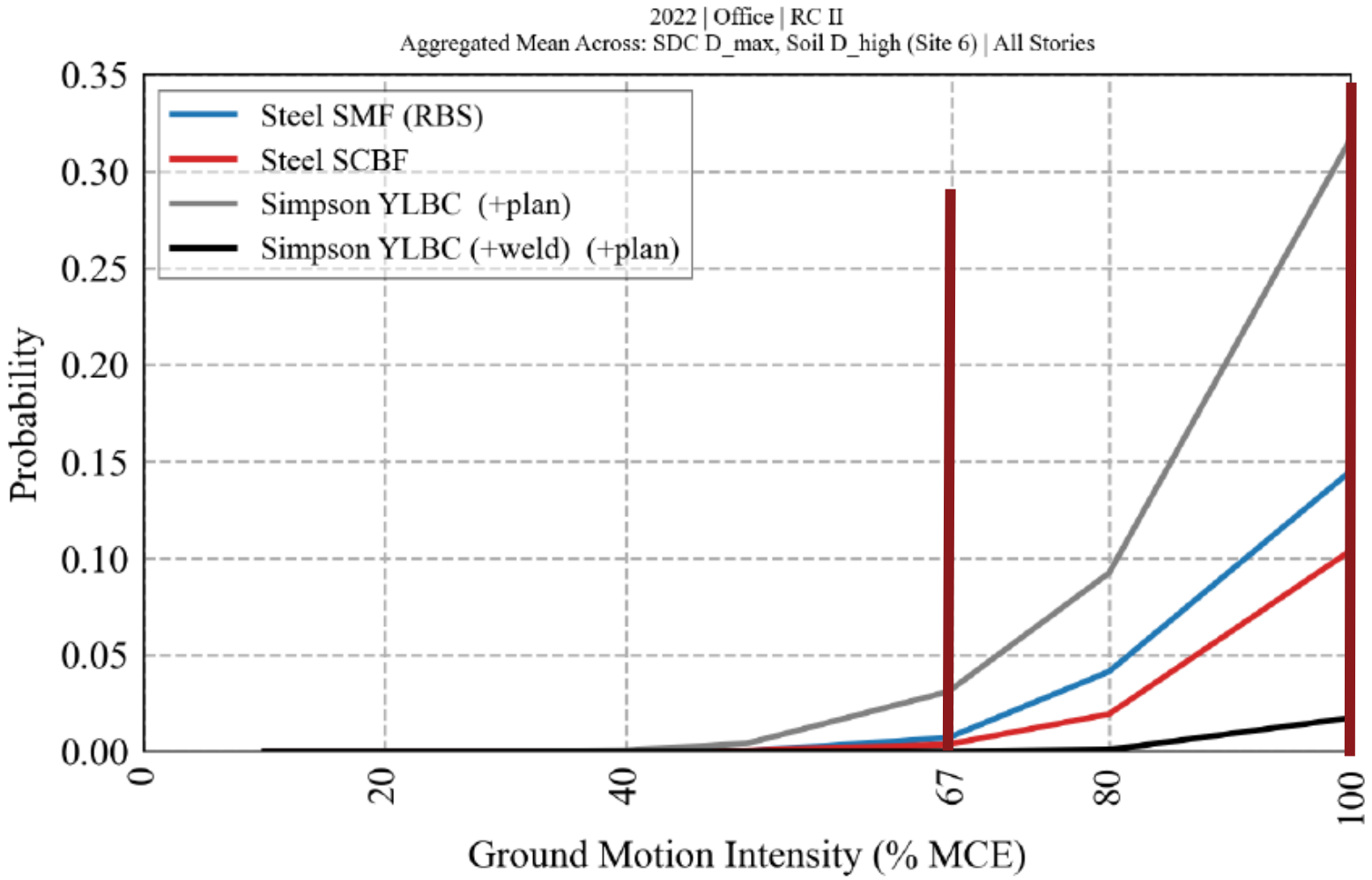
Resilient Design with the Simpson YLBC

Probability of Long Structural Repair Time (> 3 months)



Resilient Design with the Simpson YLBC

Probability of Excessive Residual Drift (> 1%)

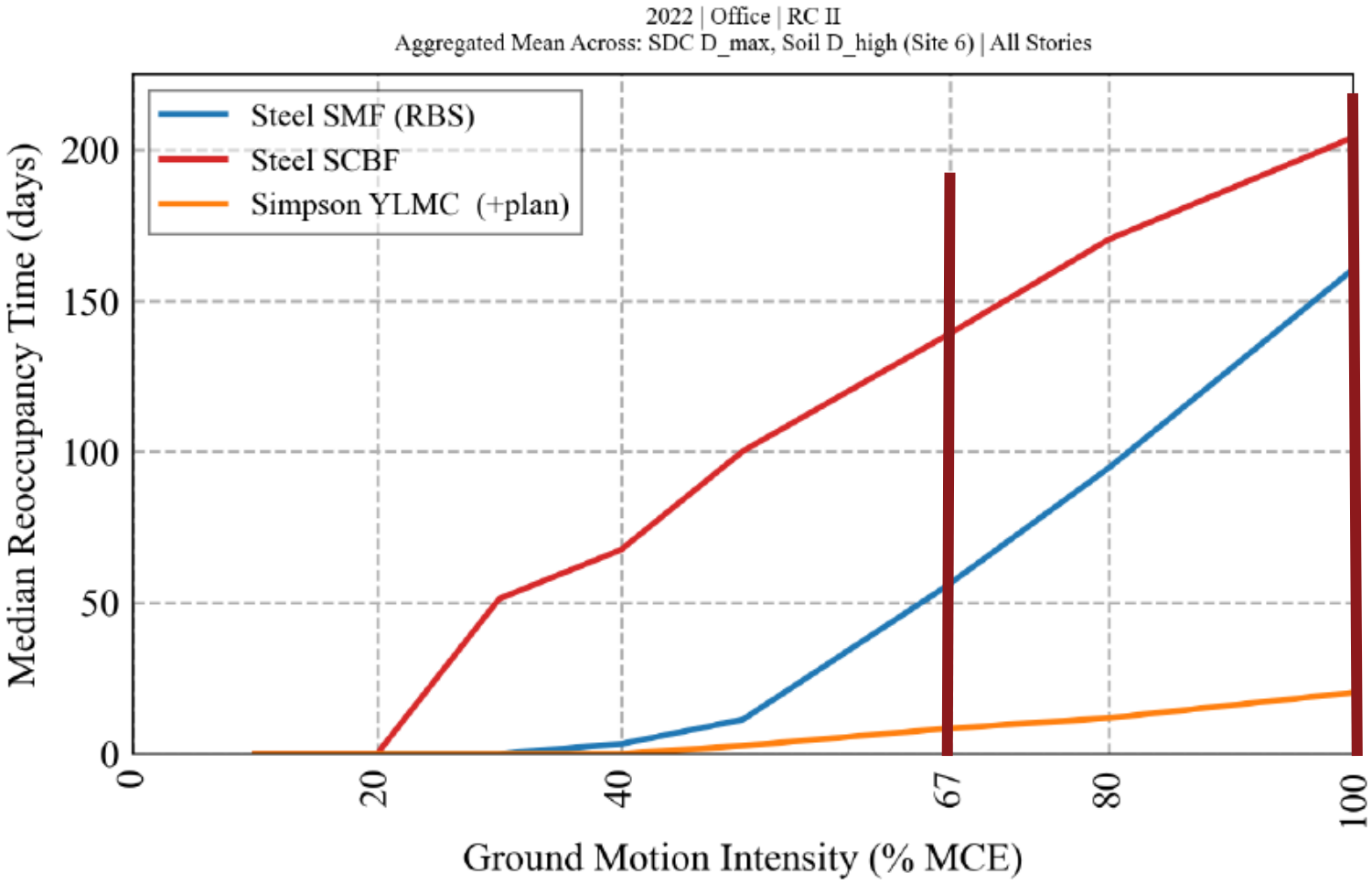


Resilient Design with the Simpson YLMC (moment connection)

- Similar resilient design benefits as the YLBC:
  - ✓ Also a replaceable fuse
  - ✓ Also a shelf-stocked component
  - ✓ Also, less issue with residual drifts (but for different reasons - less damage localization over height)

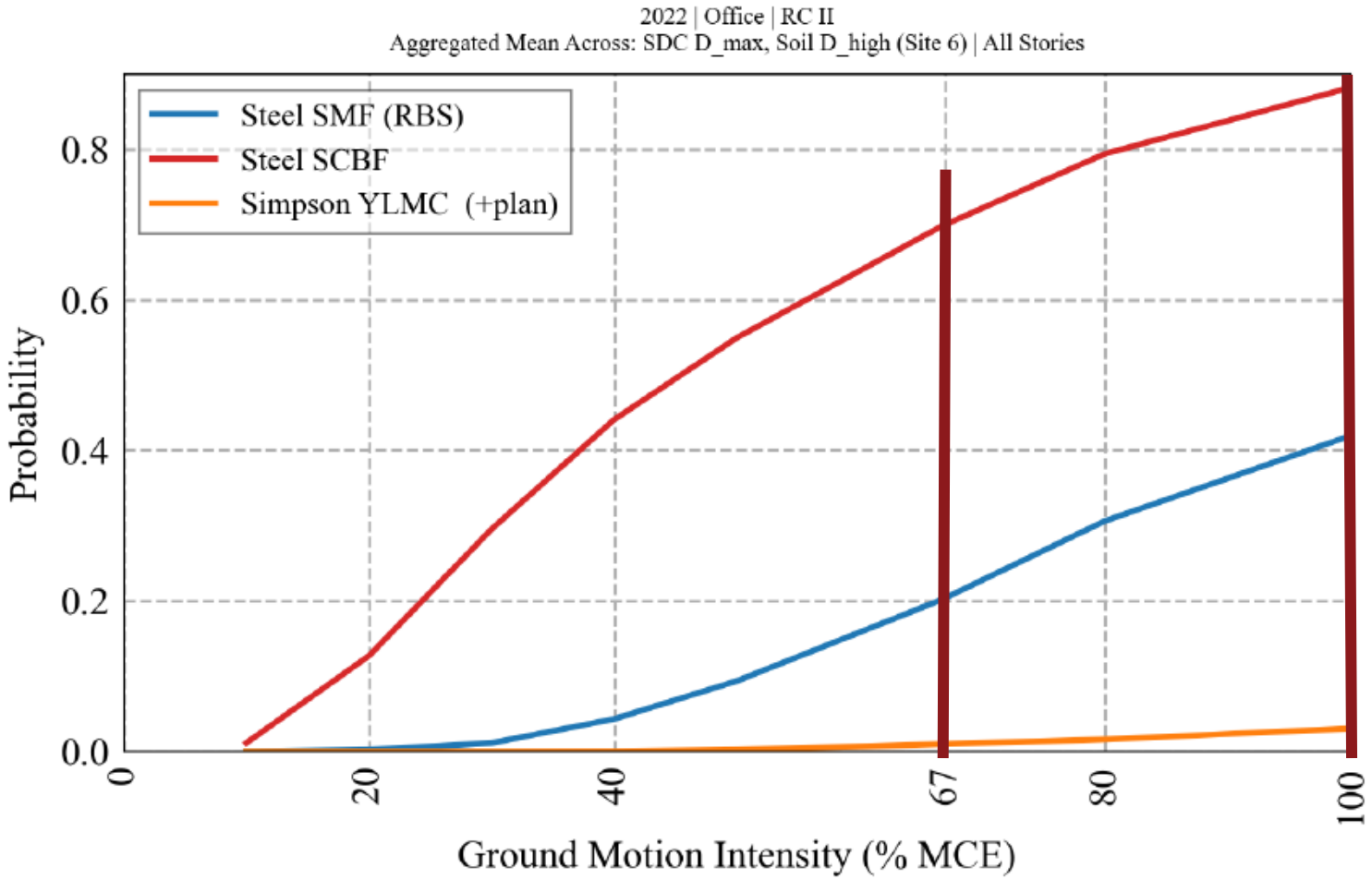
Resilient Design with the Simpson YLMC

Median Reoccupancy Time



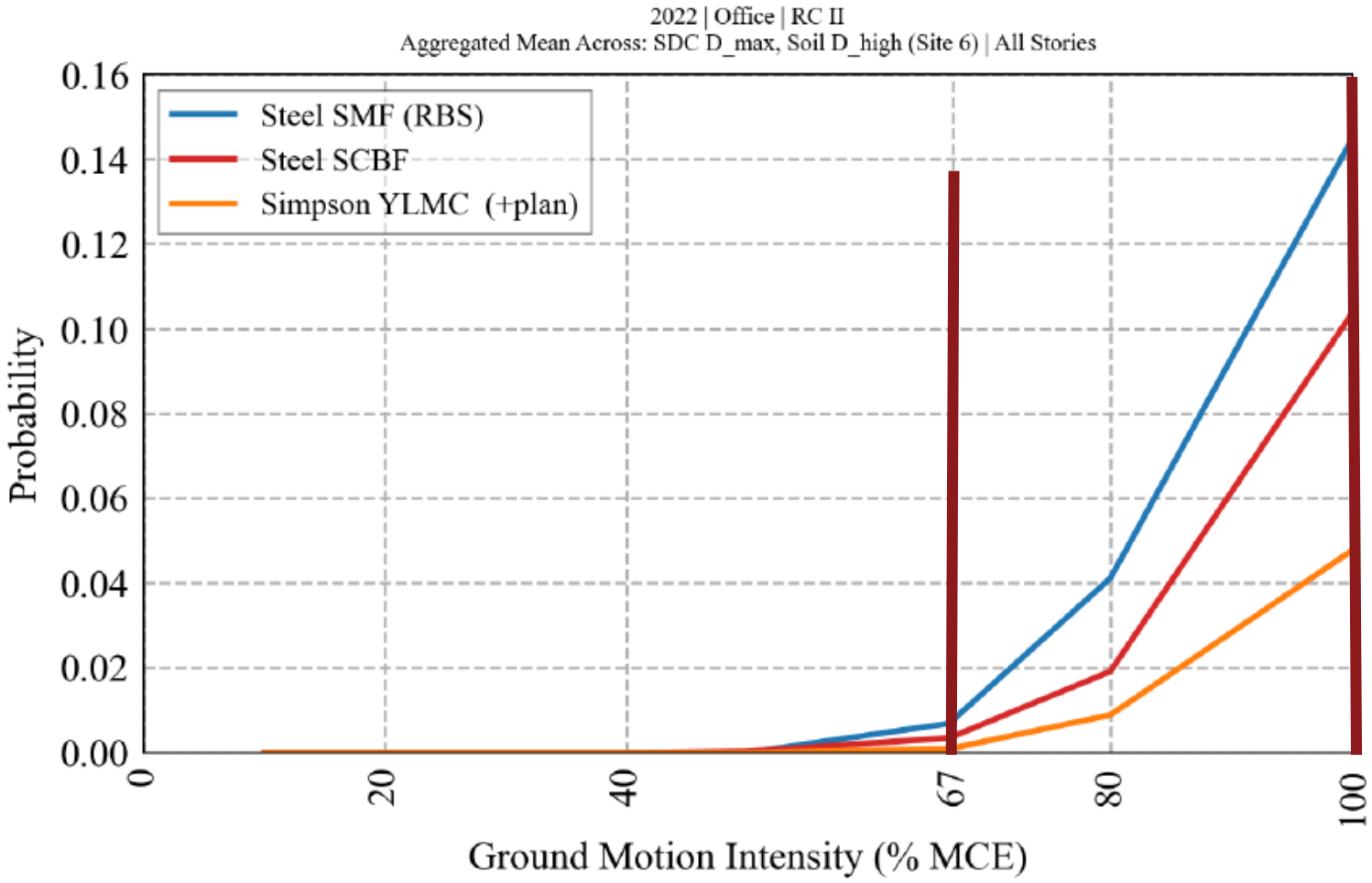
Resilient Design with the Simpson YLMC

Probability of Long Structural Repair Time (> 3 months)



Resilient Design with the Simpson YLMC

Probability of Excessive Residual Drift (> 1%)



SP3 Software Demo

SP3 Software Demo

- Engineers use SP3 for resilient design, just like Risa/Etabs/RAM for code design.
  - ✓ Risa/Etabs/RAM: Do analysis for force and drifts, iterate to meet code requirements.
  - ✓ SP3: Do analysis for reoccupancy and functional recovery times, iterate to meet resilience goals.

- Currently, structural engineers are doing this electively, to provide resilient buildings.
  - ✓ Structural system selection and design (with new rules for resilience)
  - ✓ Non-structural component design

- Typical design process:
  a) Quick automated analyses for initial structural system comparisons/selection (45-90 sec)
  b) More detailed analysis for the final design (structural and non-structural)

≠

SP3 Software Demo

risk-model.hbrisk.com/models/62751d16-fb3d-499f-becc-611258139950/outputs/repair-time

Risk Model
by Haselton Baker Risk Group

Admin | Models | Components | Help | Sign Out

Models > 5-Story Office, Stanford - Steel SMF

Advanced Model - Last Ran: 07/13/23 02:11 pm

Primary Inputs
- Model and Site Info
- Site Coordinates
- Primary Building Info

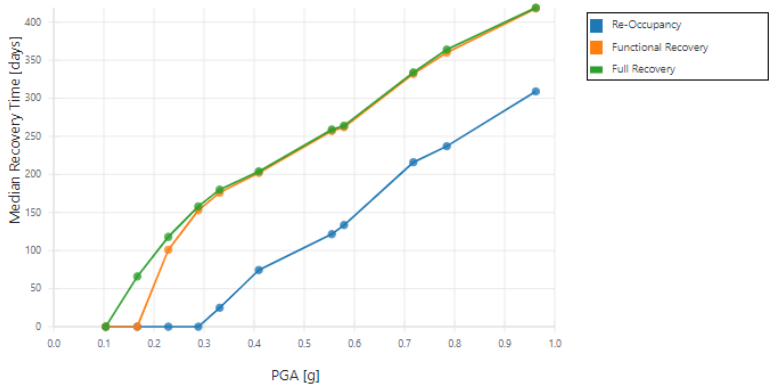
Risk Analysis Details
- Analysis Options
- Building Layout
- Building Design Info
- Ground Motion and Soil Info
- Building Modifiers Checklist
- Building Components Checklist
- Building Components Table
- Structural Properties
- Structural Responses
- Building Stability
- Recovery Time Options
- Additional Notes

Risk Analysis Results
- Repair Cost - by Intensity
- Repair Cost - Breakdown
- Repair Cost - Exposure
- Recovery Time
- Downloads

Update and Run Model

Recovery Time

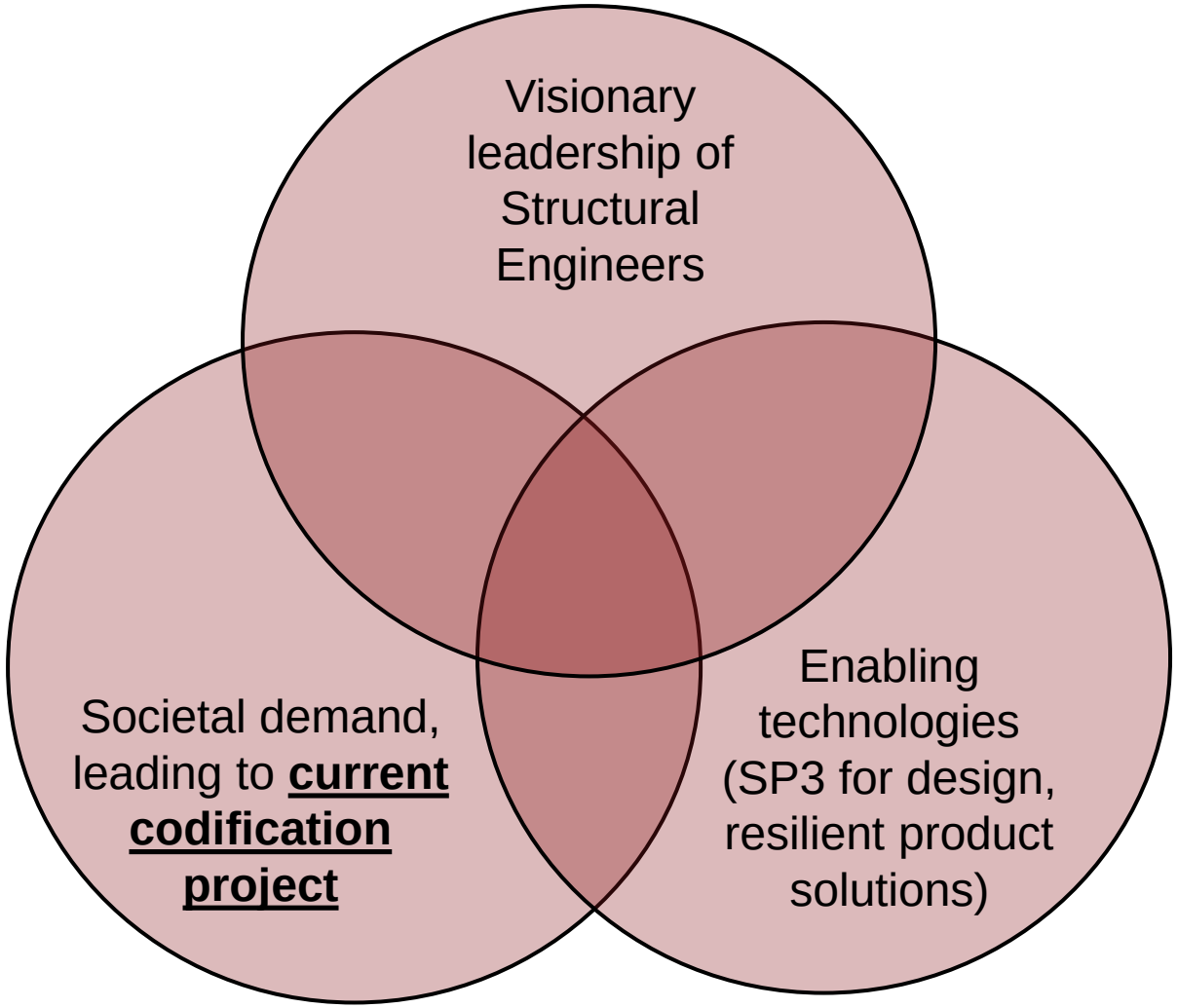
ATC-138 Recovery Time (Beta) (with selected impeding factors)



Intensity	Return Period	PGA	Re-Occupancy	Functional Recovery	Full Recovery
90% in 50 yrs	22	0.10	0 days	0 days	0 days
50% in 30 yrs	43	0.17	0 days	0 days	2.2 months
50% in 50 yrs	72	0.23	0 days	3.4 months	3.9 months
50% in 75 yrs	108	0.29	0 days	5.1 months	5.3 months
50% in 100 yrs	144	0.33	3.6 weeks	5.9 months	6.0 months
20% in 50 yrs	224	0.41	2.5 months	6.7 months	6.8 months
10% in 50 yrs	475	0.55	4.1 months	8.6 months	8.6 months
DE	530	0.58	4.5 months	8.7 months	8.8 months
5% in 50 yrs	975	0.72	7.2 months	11.1 months	11.1 months
MCE_R	1293	0.78	7.9 months	12.0 months	12.1 months
2% in 50 yrs	2475	0.96	10.3 months	13.9 months	14.0 months

Codification of Resilient Design (for broad use)

Codification of Resilient Design (for broad use)



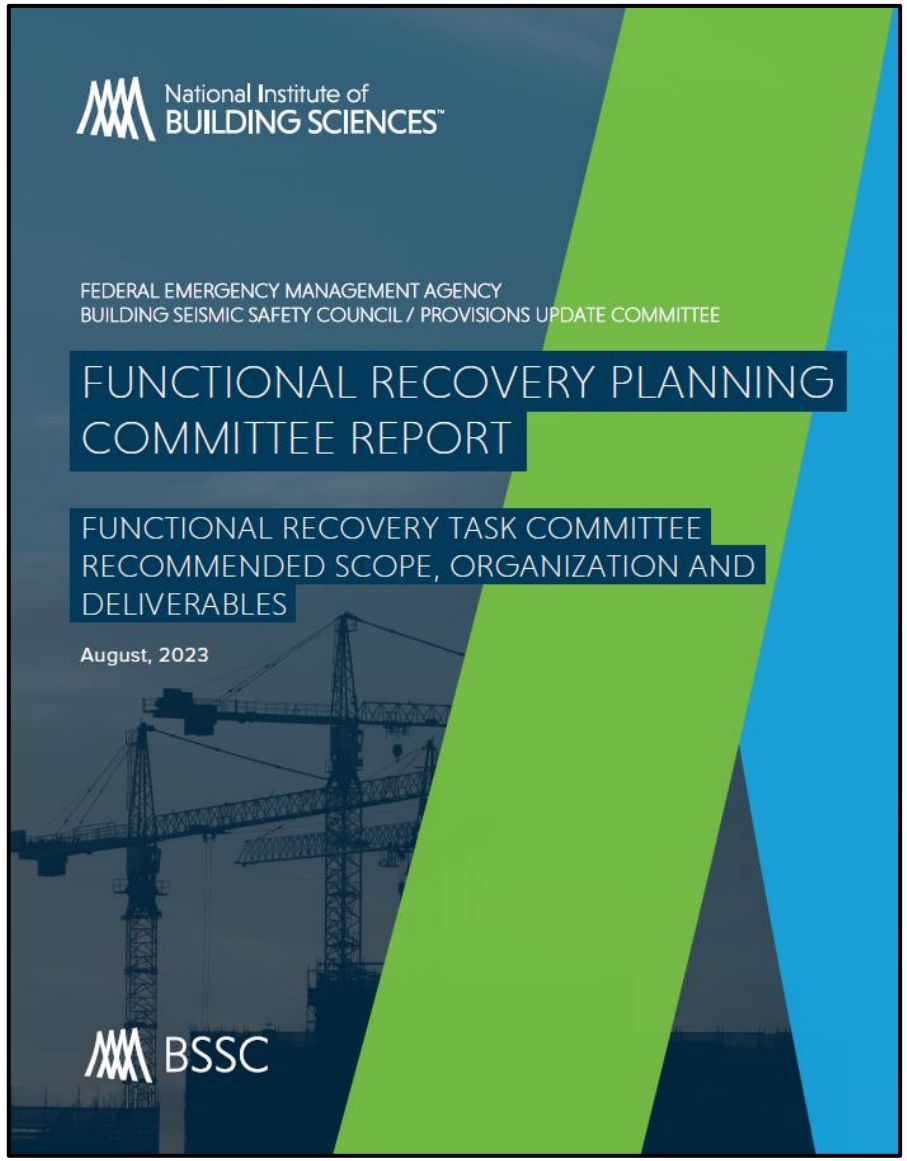
Codification of Resilient Design (for broad use)

Hurricane Ike, Houston 2008, Reuters Pictures, Dunya News

1) Our current **early-adopter projects** only help the building being designed to be resilient (kind of).
2) Community resilience **requires a majority** of buildings to remain functional.
3) Building **code requirements are necessary** for broad resilient design for most/all buildings!

Lahaina Maui Fire, 2023, Courtesy CBS News

Codification of Resilient Design (for broad use)



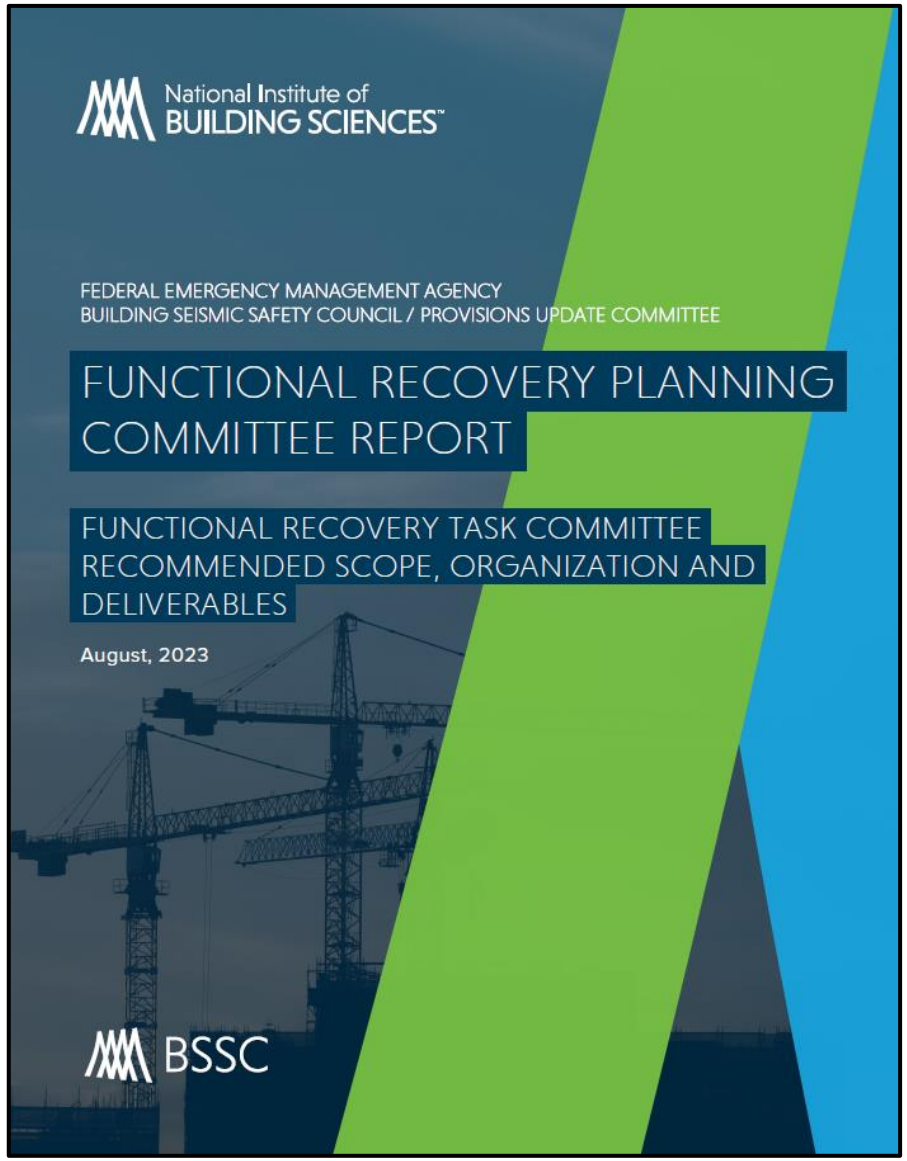
Building Seismic Safety Council (BSSC), FEMA-funded

nibs.org/bssc

To Do's | Slack | SkopeLend | SP3-RM | SP3-Portfolio | SP3-RM_staging | SP3-RM_dev | SP3-SH | QuickSight_UseData | Jira | Jira-KB

Name	Affiliation	Role
Ryan Kersting	Buehler Engineering	Chair
Abbie Liel	Univ. of Colorado - Boulder	Vice Chair
Bob Pekelnicky	Degenkolb Engineers	PUC Liaison
Lucy Arendt	St. Norbert's College - School of Business	Voting Member
David Bonowitz	Private Consulting	Voting Member
Phil Caldwell	Schneider Electric (ret.)	Voting Member
Emily Guglielmo	Martin/Martin	Voting Member
Ron Hamburger	Simpson Gumpertz & Heger	Voting Member
Curt Haselton	CSU-Chico & Haselton Baker Risk Group	Voting Member
Jon Heintz	Applied Technology Council	Voting Member
Bret Lizundia	Rutherford + Chekene	Voting Member
Kevin Moore	Simpson Gumpertz & Heger	Voting Member
Jon Siu	Private Consulting (ret. building official)	Voting Member

Codification of Resilient Design (for broad use)



- Large building code effort underway to codify resilient design for functional recovery (Building Seismic Safety Council Functional Recovery Task Committee, BSSC FRTC).
  - ✓ Planned in spring 2022, launched in fall 2022.
  - ✓ Composed of ~70-80 people in 7 teams.
  - ✓ Draft requirements are already done, completed requirement expected ~Q2 of 2024, final published 2025.
  - ✓ SP3 resilience assessment studies are being run now, for all structural systems, to determine necessary strength factors (R) and drift limits for each structural system.
- This is also being supported through analytical work funded by FEMA through the ATC-138 (FEMA P-58) project.
- Essentially extend code goals for both safety & quick function.
- Mainstream use expected after (or during) code adoption; in the meantime, early-adopter use continues to expand.

≠

Codification of Resilient Design (for broad use)

Current ASCE7 Safety Design	**New Design for Quick Functional Recovery**
R = 8 Drift Limit = 2%	R = ?? Drift Limit = ??
R = 8 Drift Limit = 2%	R = ?? Drift Limit = ??

≠

Summary and Next Steps

Summary and Next Steps

- Leaders keep leading! More structural engineers doing visionary projects to lead the way!

- The Resilient Design Movement has now moved to the **codification phase**.
- This is the key to move us from the early-adopter voluntary phase (still very few buildings) to the mainstream phase (most/all buildings), in order to achieve **community resilience**.
- We are using the learning from visionary SE projects to inform building code requirements.
- Resilient design code requirements are drafted now, 75-90% draft Q4, completed in 2024, and published in 2025 as BSSC NEHRP Seismic Provisions document.
- I see this movement having a huge impact on our society recovery after a large earthquake.

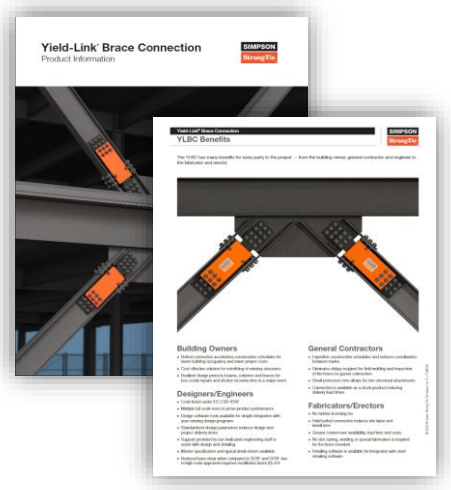
- Our role is to continue supporting resilient design with enabling technologies:
  - ✓ **SP3:** Provide software to enable resilient design (design decision effects, quantified benefits).
  - ✓ **Simpson / Manufacturers:** Provide resilient product solutions (structural and non-structural).

- Enabling resilient design has been my focus for the past 10+ years, so please reach out to collaborate and/or provide any constructive feedback. Thank you! (curt@hbrisk.com)

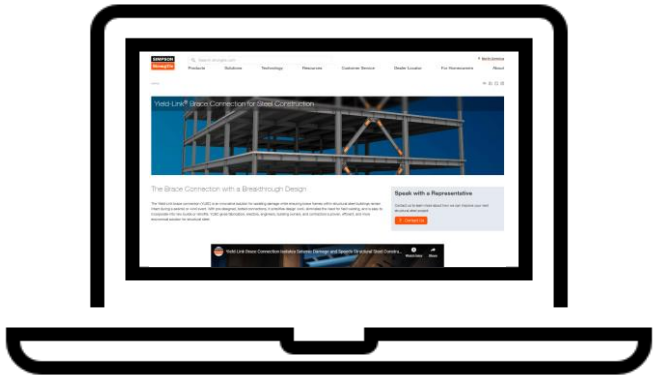
≠

Available Resources

Product Fliers

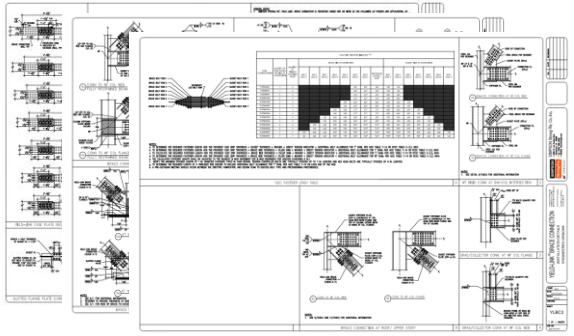


Visit strongtie.com/ylbc



Watch a recording of Part 1 of our webinar series in the Learning Center!

Installation Details



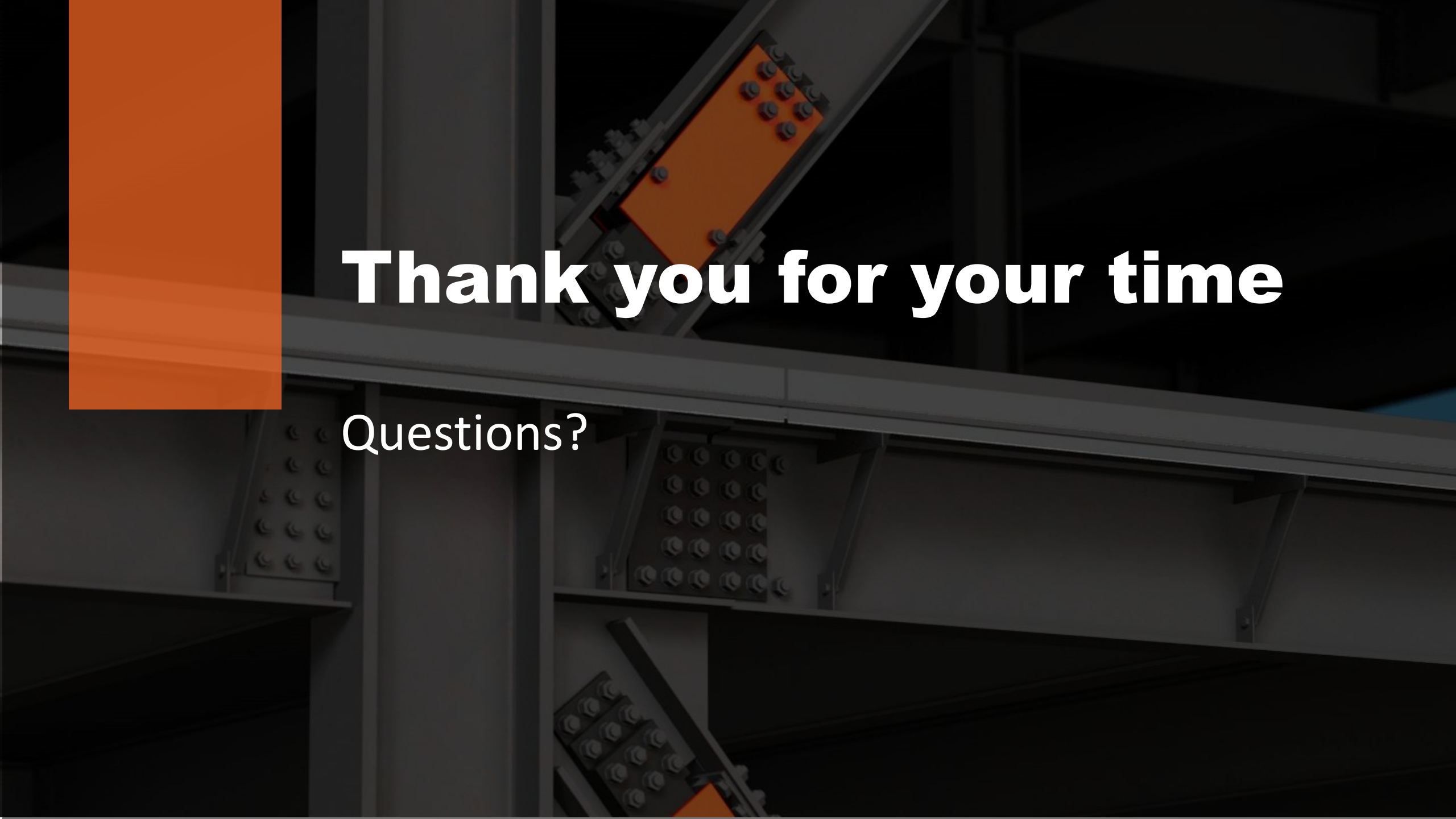
Watch a recording of Part 2 of our webinar series in the Learning Center!

Watch a recording of Part 3 of our webinar series in the Learning Center!

Credit Information

This ends the credit portion of the webinar.

We'll now have an Optional, Non-Credited Q&A session.



Thank you for your time

Questions?