

# Resilience-Based Design & Risk Management using FEMA P-58

## FEMA P-58 and SP3: Resilient Design Case Study and SP3 Demo/Training

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- **This Session:**
  - ✓ Resilient design case study
  - ✓ Demo and training: Interactive resilient design using FEMA P-58 and SP3

- Project: Municipal office building
- Building: Design a 10-story RC Wall (coupled core), office occupancy
- Site: LA high-seismic,  $S_{DS} = 1.1g$ ,  $S_{D1} = 0.6g$ .
- Design Objectives: USRC five-star performance in all categories
  - Repair Cost < 5%
  - Functional Recovery Time < 5 days
  - Safety – high (low collapse, no/few injuries, good egress)
- Showing example for *design*, but also applicable to *risk*

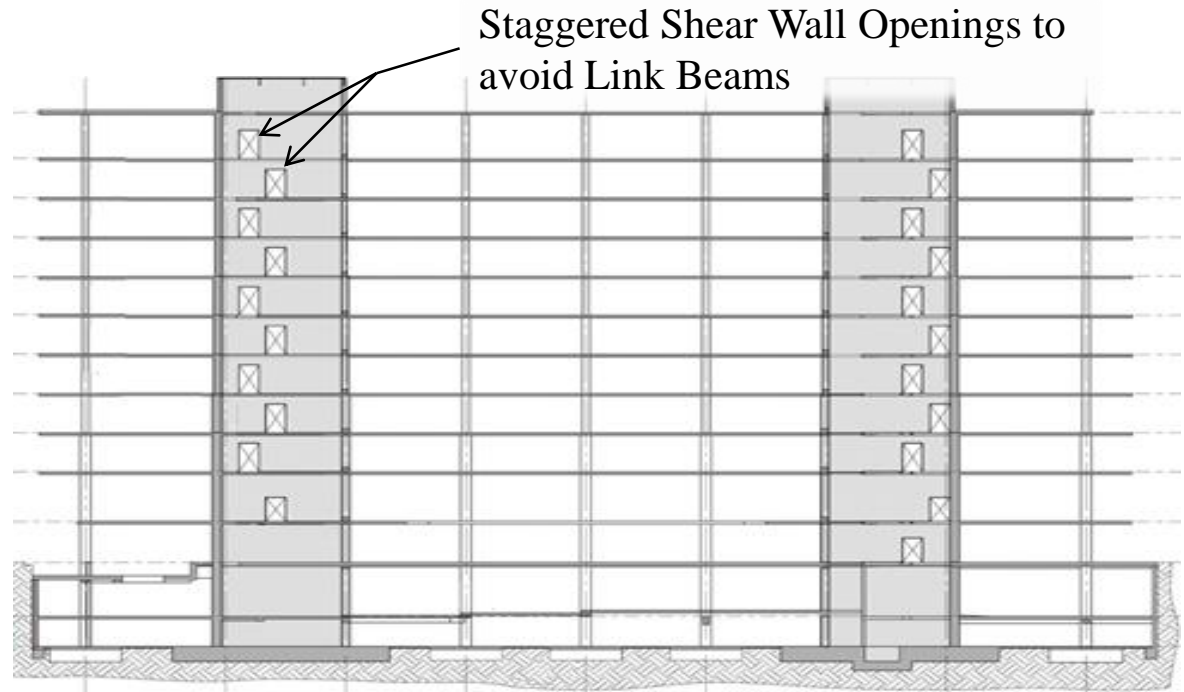
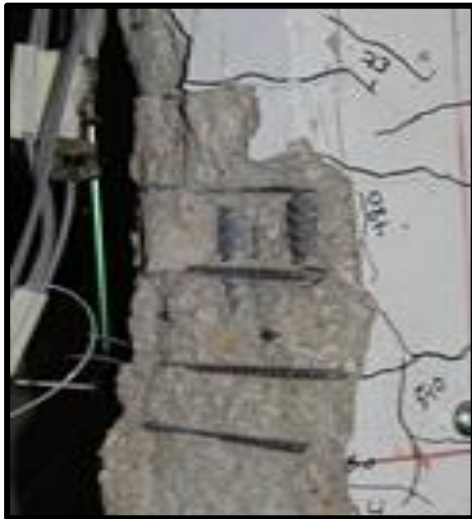


Figure Source: SOM/NYASE 2016 SEAOC presentation

- **Step #1:** Start with code-compliant design to see where that gets us...
  - Repair Cost = 8% [4-star]
  - Recovery Time = 6.5 months [3-star]
    - 3.0 months – mechanical and electrical (HVAC, lighting, switchgear)
    - 2.0 months – structural (mostly walls)
    - 1.5 months – non-structural drift-sensitive (partitions, stairs, piping, fire sprinklers)
  - Safety [3-star]  
(discussed at the end)



- **Step #2:** Design wall to be “essentially elastic” (very strong) and remove coupling beams.



**Step #3:** Design mechanical and electrical components to be functional at the 10% in 50 year (anchorage, equipment, lighting, etc.).

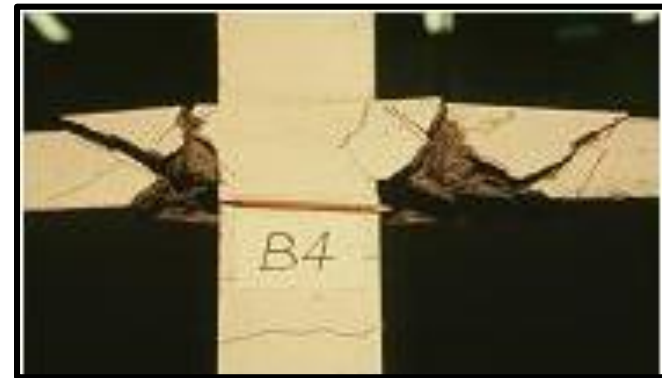
- Result for Steps #2-3:
  - Repair Cost = 5.5% [still 4-star]
  - Recovery Time = 2.5 months [still 3-star]
    - 1.0 month – slab-column connections
    - 1.5 months – partition walls



**Step #4:** Reduce the shear on the slab-column connections.

**Step #5:** Use less damageable partition walls.

- Result:
  - Repair Cost = 3.5% [now a 5-star]
  - Recovery Time = 6 weeks [still a 3-star]
    - 3 weeks – slab-column connections
    - 3 weeks – partition walls



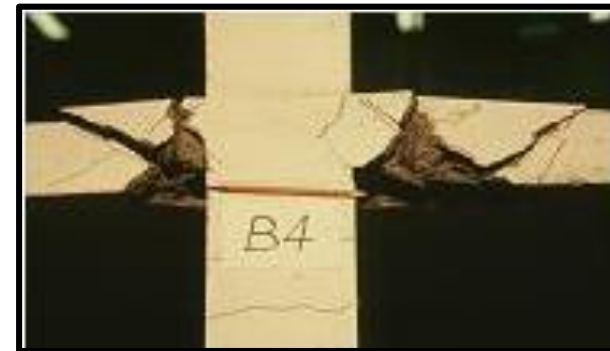
**Step #6:** Stiffen the building (longer walls, more coupling, etc.). Reduces the maximum drifts from around 1.4% to 1.0%.

- Result:
  - Repair Cost = 2% [5-star]
  - Recovery Time = 2 days [moved from 3-star to 5-star]



**Step #7:** Now that building has less drift, move back to higher shear slab-column connections.

- Result:
  - Repair Cost = Still 2% [still a 5-star]
  - Recovery Time = Still 2 days [still a 5-star]





- **Step #8:** Now that building has less drift, see if we can move back more damageable partition walls.
  - **Result:**
    - Repair Cost = 2.5% [5-star]
    - Recovery Time = 2 weeks [would moved down to 4-star]
- \*\*Move back to less damageable partition walls to keep a 5-star recovery time.



- **Step #9: Safety checks**
- Overview of safety checks:
  - **Fatalities.** Show good collapse safety (limit fatalities).
  - **Injuries.** Check injury prediction from FEMA P-58 (would require additional non-structural bracing to get to 5-star).
  - **Residual Drifts.** Very low (essentially elastic).
  - **Stairs and Egress.** Check probability of non-functionality (direct outputs from the FEMA P-58 detailed results).



Figure Source: SOM/NYASE 2016 SEAOC presentation

- Final Design Outcomes (for 10% in 50 year motion):
  - **Repair Cost: 2% [5-star]** (*Typically 10-20% for new code*)
  - **Recovery Time: ~0 days [5-star]** (*Typically 6-9mo. for new code*)
  - **Safety: Low fatality+injury risk and good egress [5-star]**
- This example was for **new resilient design**, but FEMA P-58 offers this same level of building-specific detail when doing **risk assessments**.

- This Session:
  - ✓ Resilient design case study
  - ✓ **Demo and training: Interactive resilient design using FEMA P-58 and SP3**

- Let's design a building together at this site (approximate design)!
- Let's do a building as follows:
  - 8-story building
  - Office occupancy
  - Reinforced Concrete Special Moment Frame
  - Perimeter frame with PT slabs for gravity system
  - Footprint of 120' x 210' (and do 30' bays)
- Design targets:
  - "Safe" building (e.g. at least code-compliant)
  - Design motion level: Requirement is > **5%** repair cost, and **2 weeks** of repair time (without impeding factors)
  - 2% in 50 year motion: Requirement is > **20%** repair cost, and **3 months** of repair time (without impeding factors)

- Some notes for context:
  - For office occupancy, most damage is to drift-sensitive components.
  - To protect drift-sensitive components, we will need to reduce drift (so make building stiffer), even though this will increase floor accelerations.
  - For other occupancies (e.g. medical care), there are more acceleration-sensitive components, so the resilient design strategy would differ.
- Let's jump in!

SP3 | Seismic Performance

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A whole new way to calculate and understand building-specific seismic risk.

272,049,220 simulated earthquakes to date

### Resilient Design & Retrofit

SP3 enables engineers to consider damage and loss reduction directly in the design process, to achieve more resilient buildings.

[SP3 for Design](#)

### Advanced Seismic Risk Assessment (PML+)

SP3 provides a consistent and credible method for a seismic risk assessment report. SP3 provides the basic results needed for a PML study, and unique additional building-specific risk information.

[SP3 for PML+](#)

### Insurance

SP3 provides high-fidelity building-specific vulnerability curves. These can be used for an owner to negotiate insurance premiums and for an insurance company to better understand building-specific risk.

[SP3 for Insurance](#)

#### SP3 is Comprehensive & Credible

SP3 distills years of cutting-edge research to equip engineers to comprehensively assess seismic damage, loss, and building repair time.

#### SP3 is Fast

SP3 provides a streamlined workflow to give results in hours (rather than days or weeks), with the ability to refine the analysis at any step.

#### SP3 is Transparent

SP3 is based on the open-source FEMA P-58 methodology, providing unprecedented transparency for the basis of the risk assessment.

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- **Performance Results:**
  - Repair cost of ~2-4% rather than ~10-20%.
  - Repair time almost zero rather than ~6-24 months.
  - **\*\*With these methods, we can design buildings that are not disposable.**
- **Cost:** Recent resilience-based design projects have estimated that resilient seismic performance **costed between 0% and 2%** of the project budget.

***The Question for Us All:***  
*With these resilience-based design methods now available, and with costs being reasonable, why wouldn't we do resilience-based design as standard for most new buildings?*



- Thank you for your time.
- Our goal is to support adoption of resilience-based design and risk assessment, and we welcome feedback and suggestions.
- Time for questions and discussion!

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