

Update on USRC Usage of the FEMA P-58 Methodology and the Seismic Performance Prediction Program (SP3)

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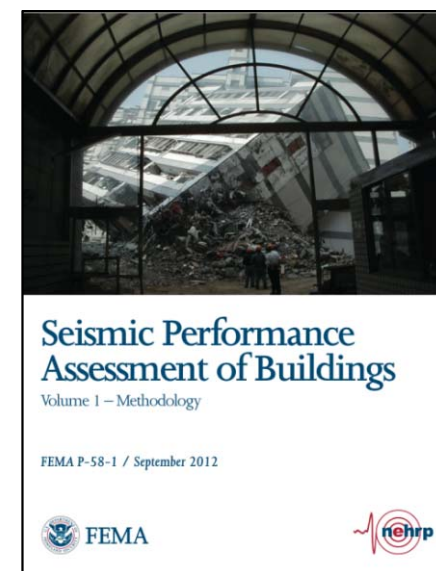
Co-Founder, HB-Risk Group (SP3) [www.hbrisk.com]

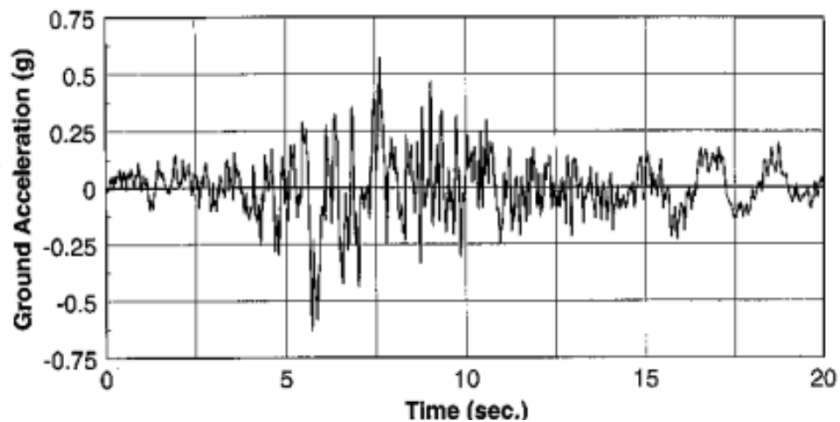
USRC Stakeholders

June 15, 2015

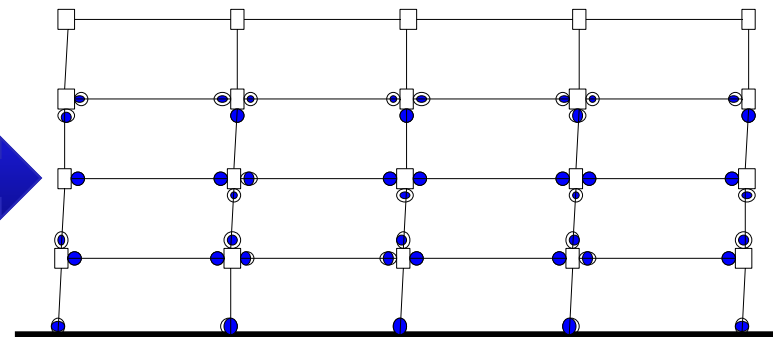
- Update the group on the USRC use of FEMA P-58 (and some notes on supporting SP3 software)
- This is a follow-up to the previous discussion at the February 23rd meeting.

- P-58 is a performance prediction methodology based on a 10-year FEMA study (enabled by much previous research).
- P-58 is an alternative to experience-based or judgment-based methods not made to be building-specific.
- P-58 is tailored for building-specific analysis (not averages).
- ATC is currently working on another 5-year effort to further advance the methodology, implementation, ease of use.
- FEMA P-58 Output Results:
 - Losses [\$] [USRC: Repair Cost]
 - Fatalities & injuries [USRC: Safety]
 - Repair time & red tagging
[business disruption] [USRC: Repair Time]
 - Soon: Energy and carbon consequences.

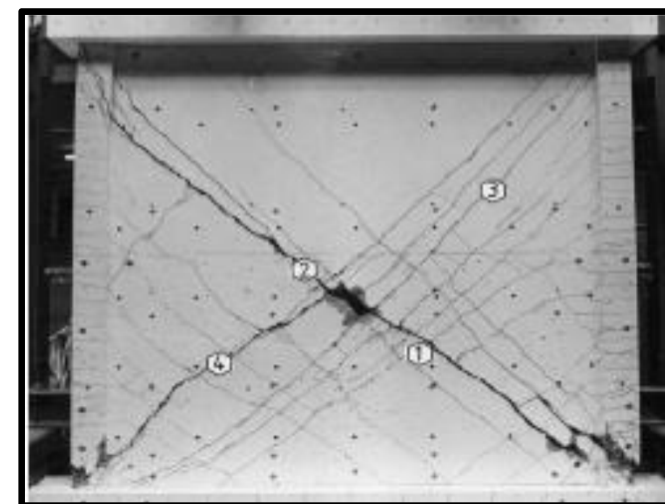




Ground Motion Hazard



Structural Response



Component Damage



Economic Loss



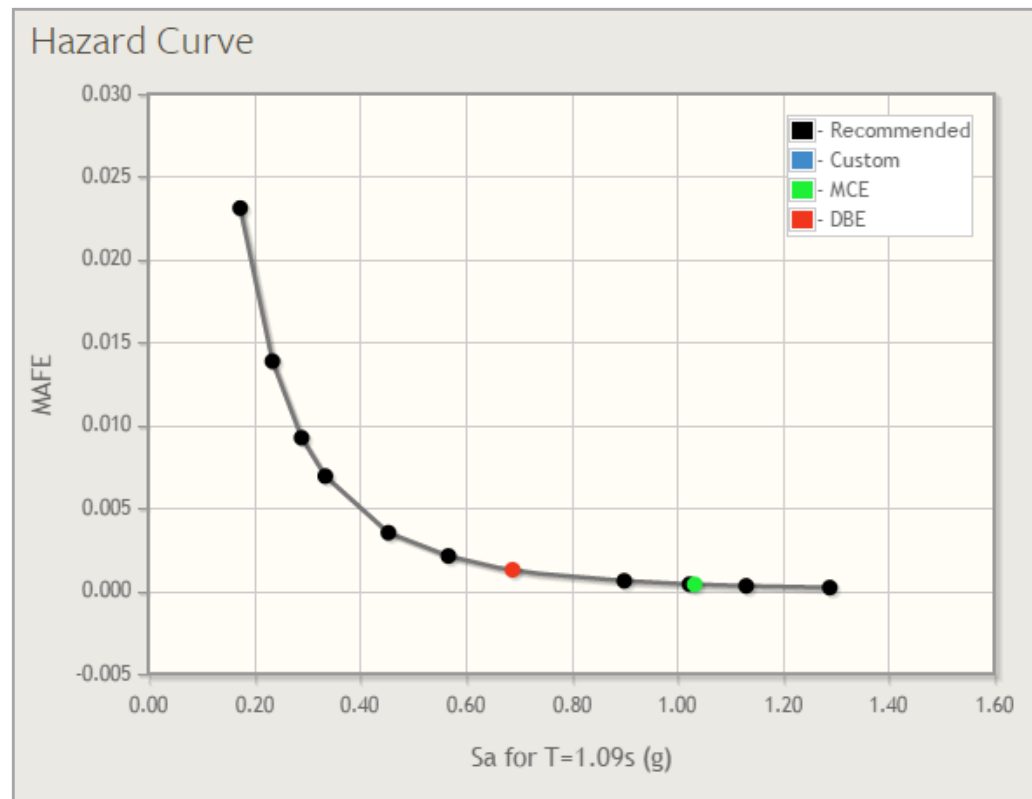
Casualties



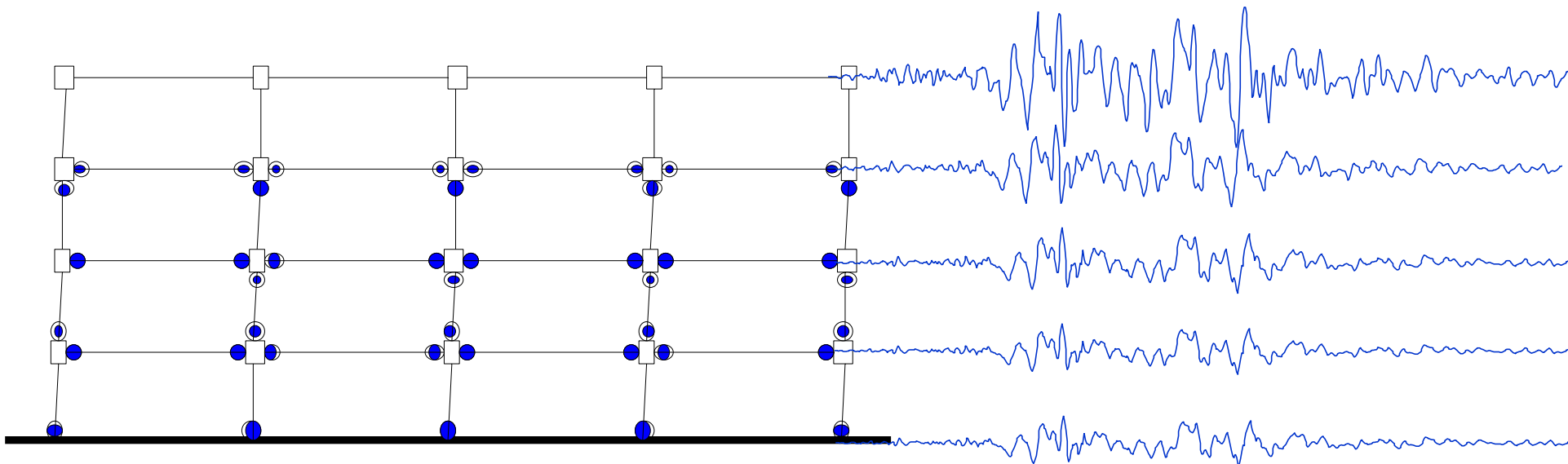
Repair Time

- The FEMA P-58 method is **probabilistic** rather than **deterministic**.
- It is impossible to predict performance precisely.
- Each step of the process entails many uncertainties.
- FEMA P-58 provides a mathematically rigorous framework to assess performance while formally tracking the significant uncertainties.













- Hazard and Ground Motions
 - Soil and hazard curve
 - Ground motions (if needed)

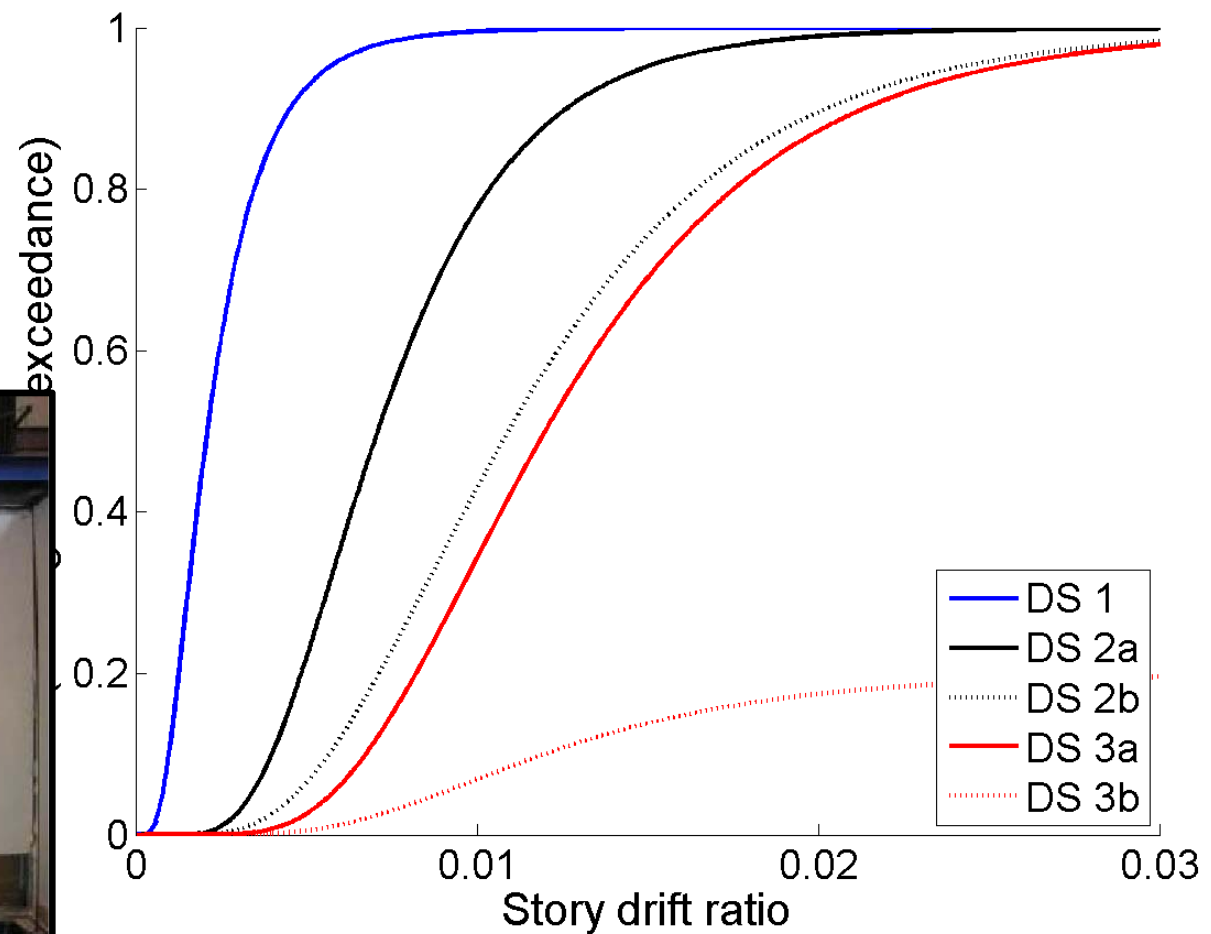


- Hazard and Ground Motions
 - Soil and hazard curve
 - Ground motions (if needed)
- Structural Responses
 - Option #1: Complex method
 - Option #2: Simplified method

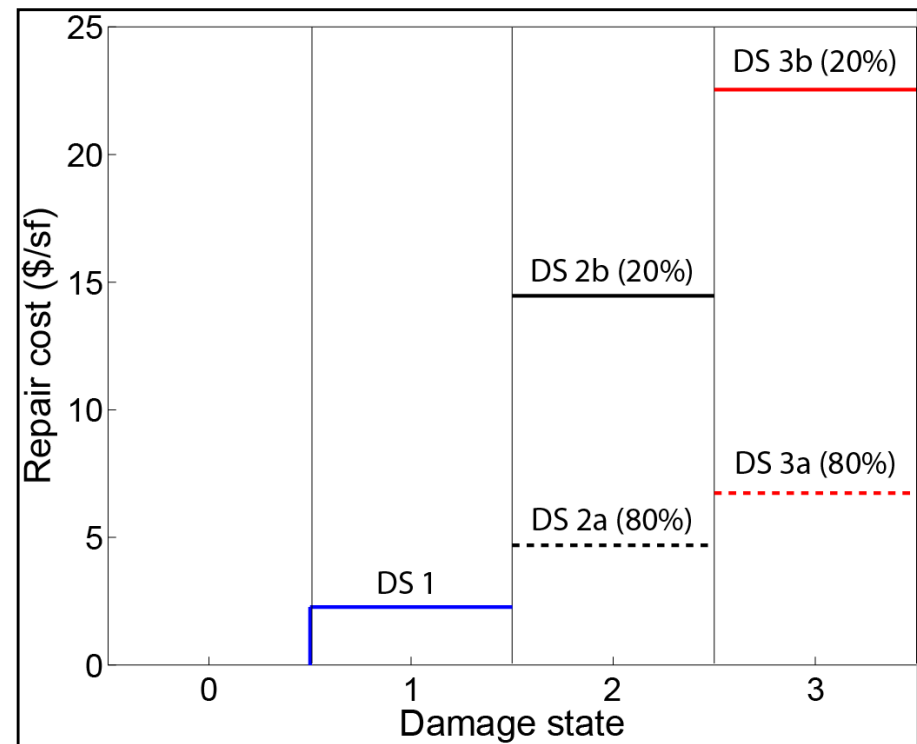


- Hazard and Ground Motion
 - Soil and hazard curve
 - Ground motion
- Structural Response
 - Option #1: Com
 - Option #2: Sim

Building Contents				
	FRAGILITY ID	FRAGILITY NAME	FRAGILITY QUANTITY	FRAGILITY LOCATION
   	B2022.001a	Concrete tile roof, tiles secure...	<input type="text" value="1"/>	11 floors selected
   	B3011.011	Concrete tile roof, tiles secure...	<input type="text" value="38"/>	Roof only
   	C1011.001a	Wall Partition, Type: Gypsum w...	<input type="text" value="14"/>	11 stories selected



- Hazard and Ground Motions
 - Soil and hazard curve
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- Structural Responses
 - Option #1: Complex method
 - Option #2: Simplified method
- Damage Prediction
 - Contents (str. and non-str.)
 - Fragility curves
- Loss Estimation (loss curves) and other consequences



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Thousands of simulations (Monte Carlo).

All of the “dice rolls” provides solid statistical information on building performance.

(e.g. 10,000 at 14 levels = 140,000 runs)

Bottom Line: It is a rigorous method with a lot of homework behind it.

- Dig as deep as you like in the output information...



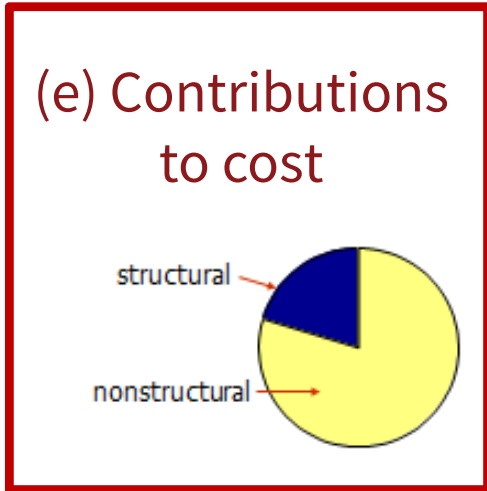
- Rich statistical information about performance (and need to decide which results you want)...

(a) Average cost expected for a Magnitude 7.0 earthquake
\$3.0M

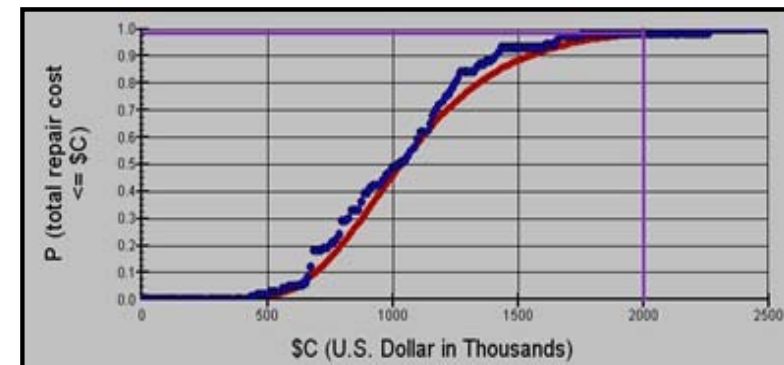
(b) Average cost for a 500-year event.
\$5.2M

(c) 90th percentile cost for a 500-year event.
\$8.0M

(d) Average annual cost of damage
\$240,000

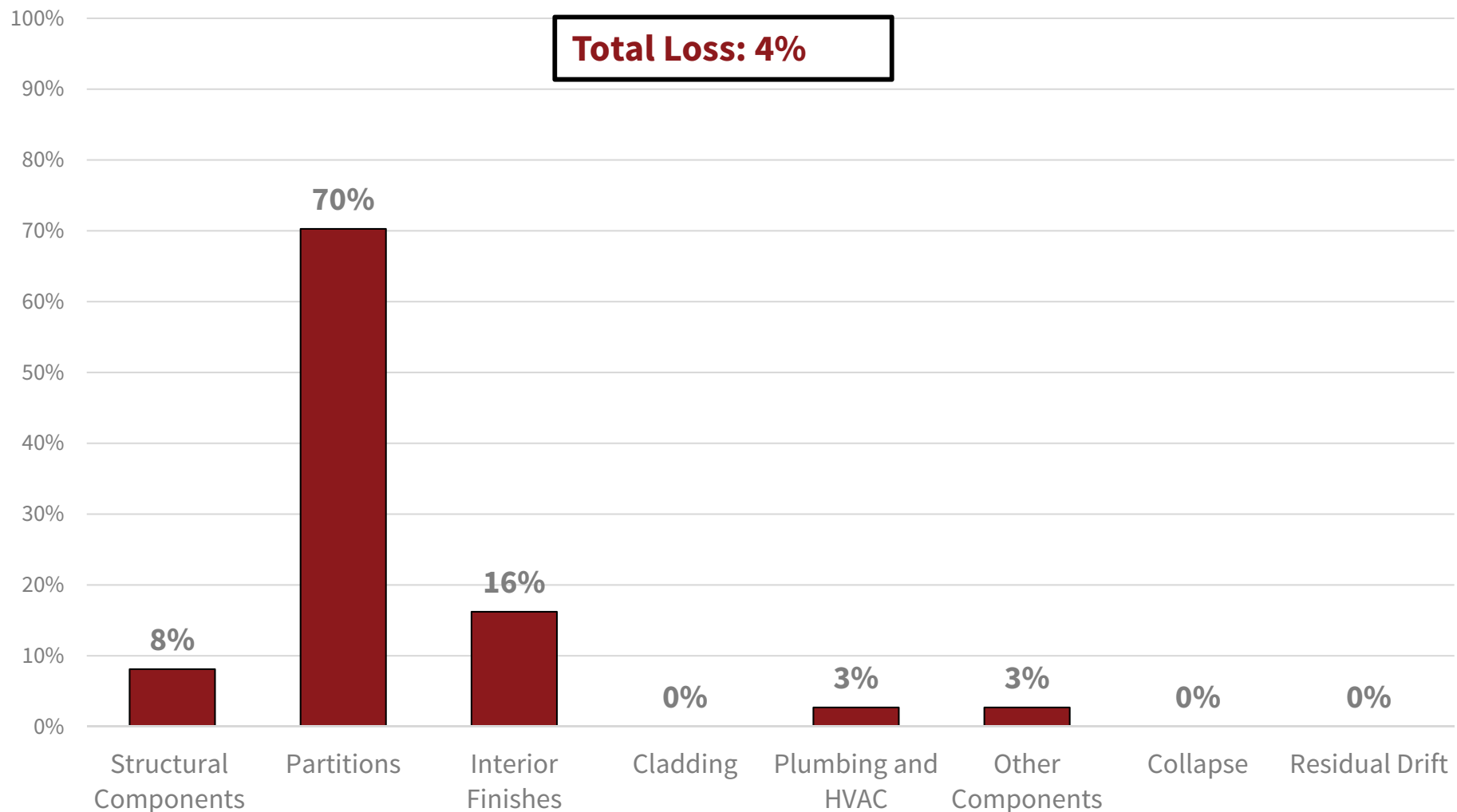


(f) Detailed loss distribution



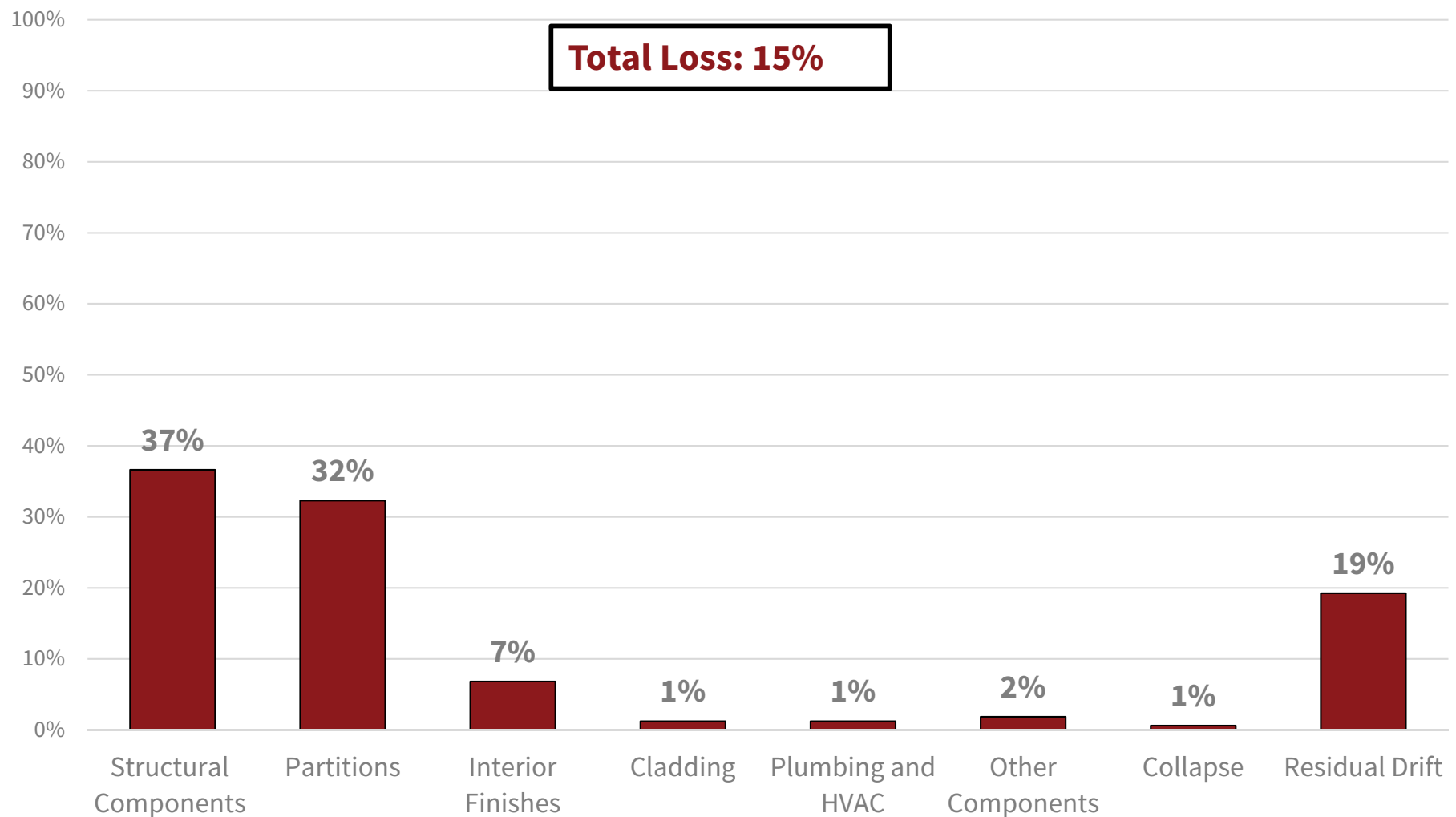
- Sample results for Repair Cost (8-story concrete frame, LA):

Breakdown of Losses by Component at a **50 Year** Earthquake



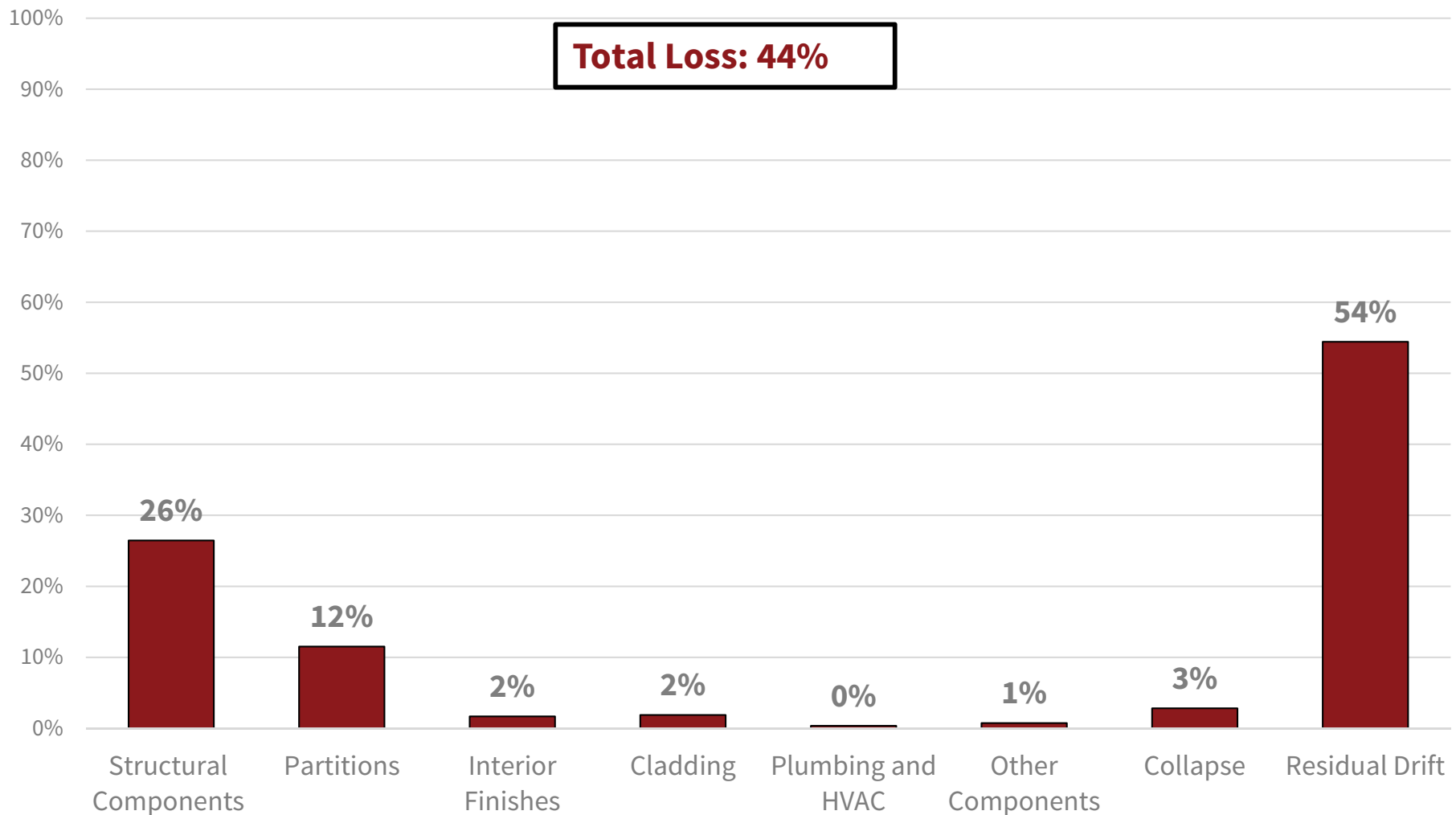
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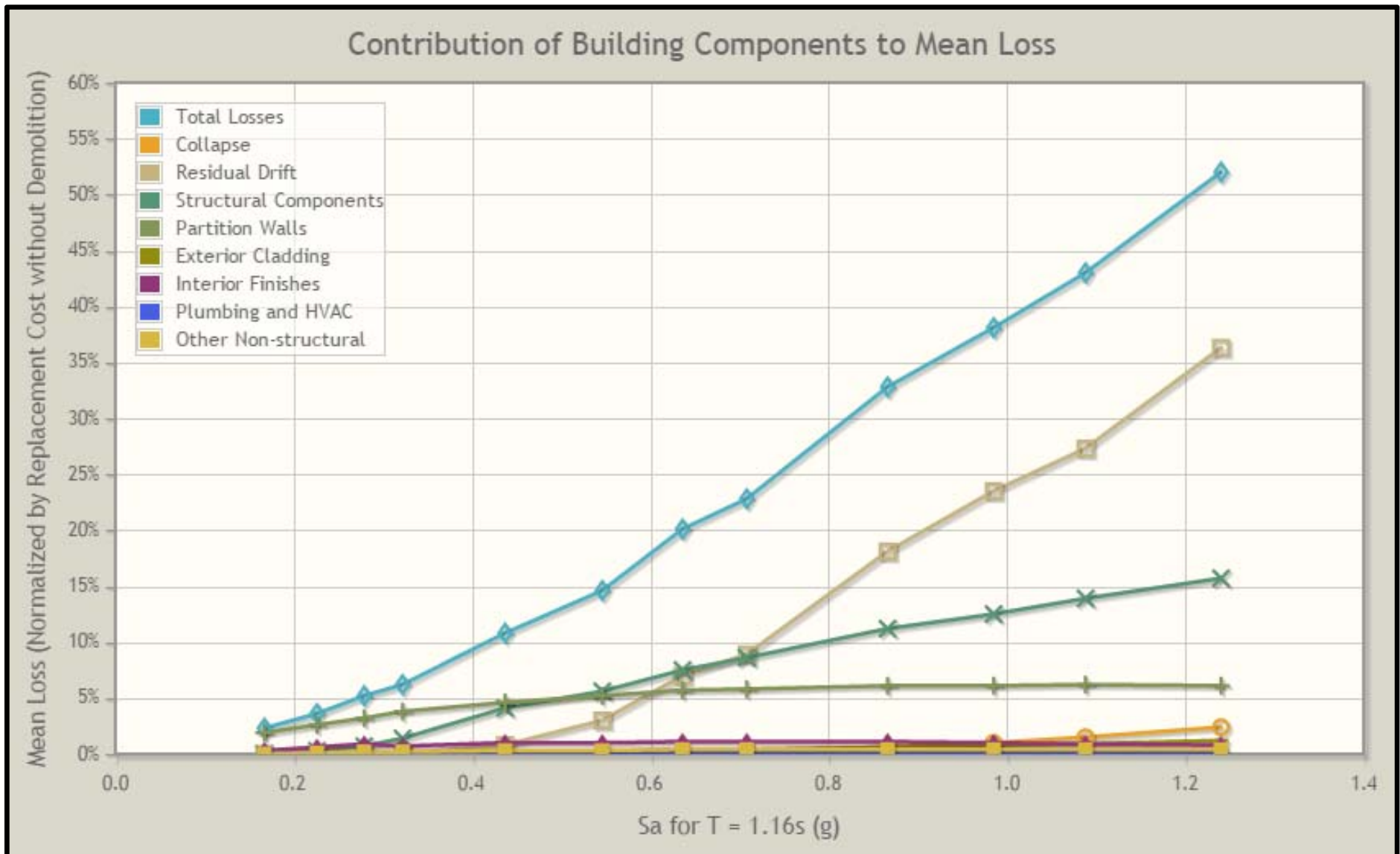


- Sample results for Repair Cost (8-story concrete frame, LA):

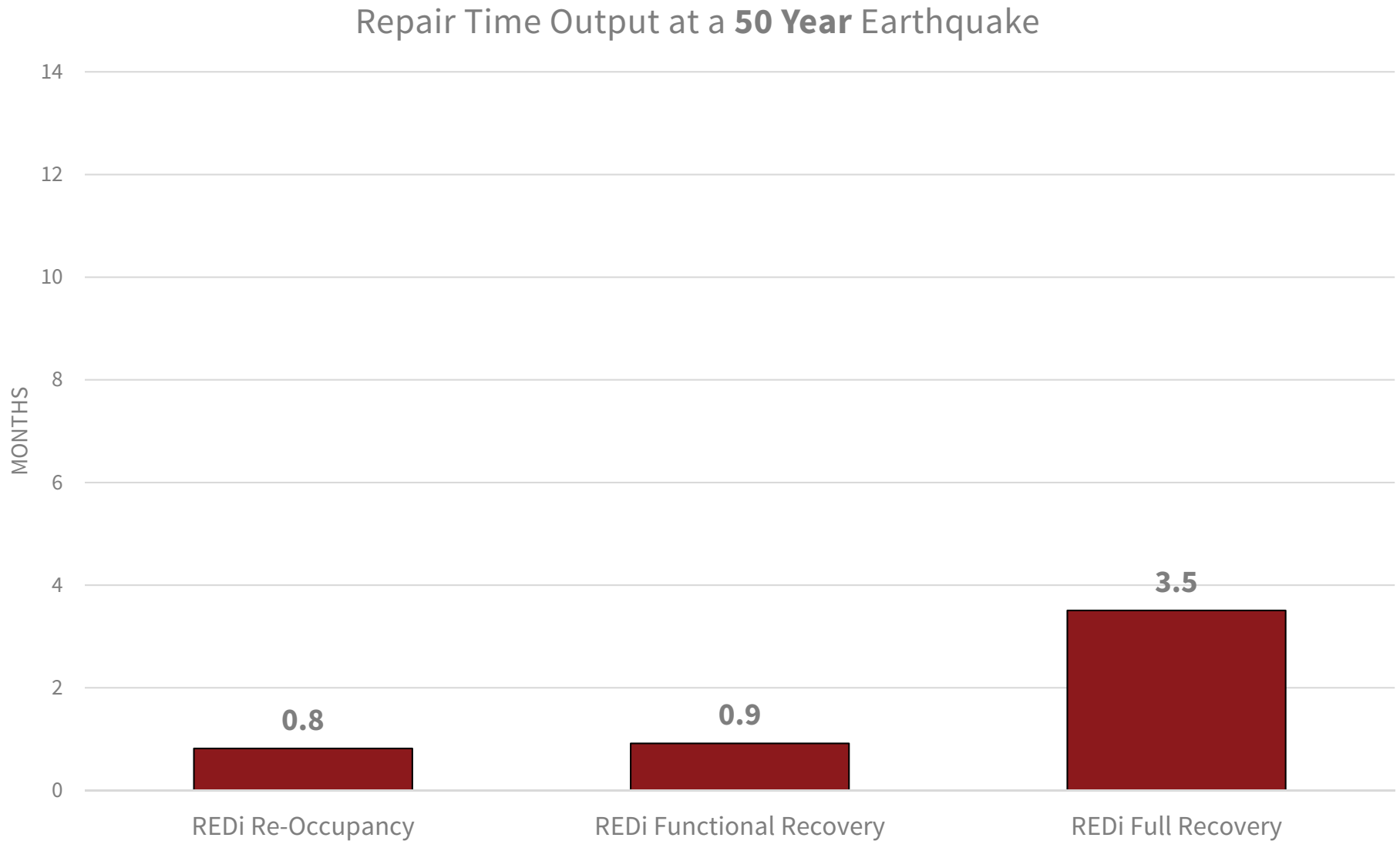
Breakdown of Losses by Component at a **2500 Year** Earthquake



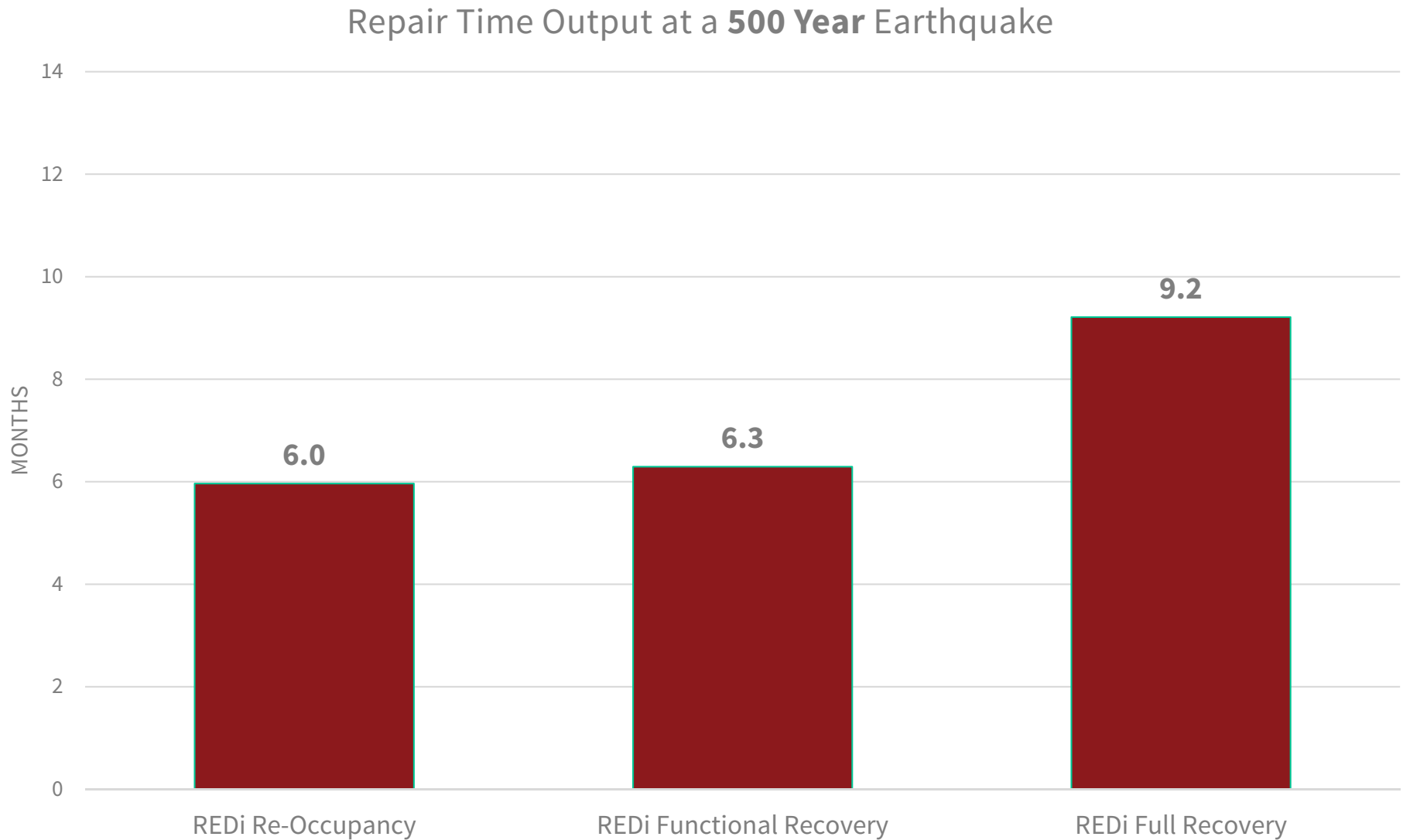
- Sample results for Repair Cost (8-story concrete frame, LA):



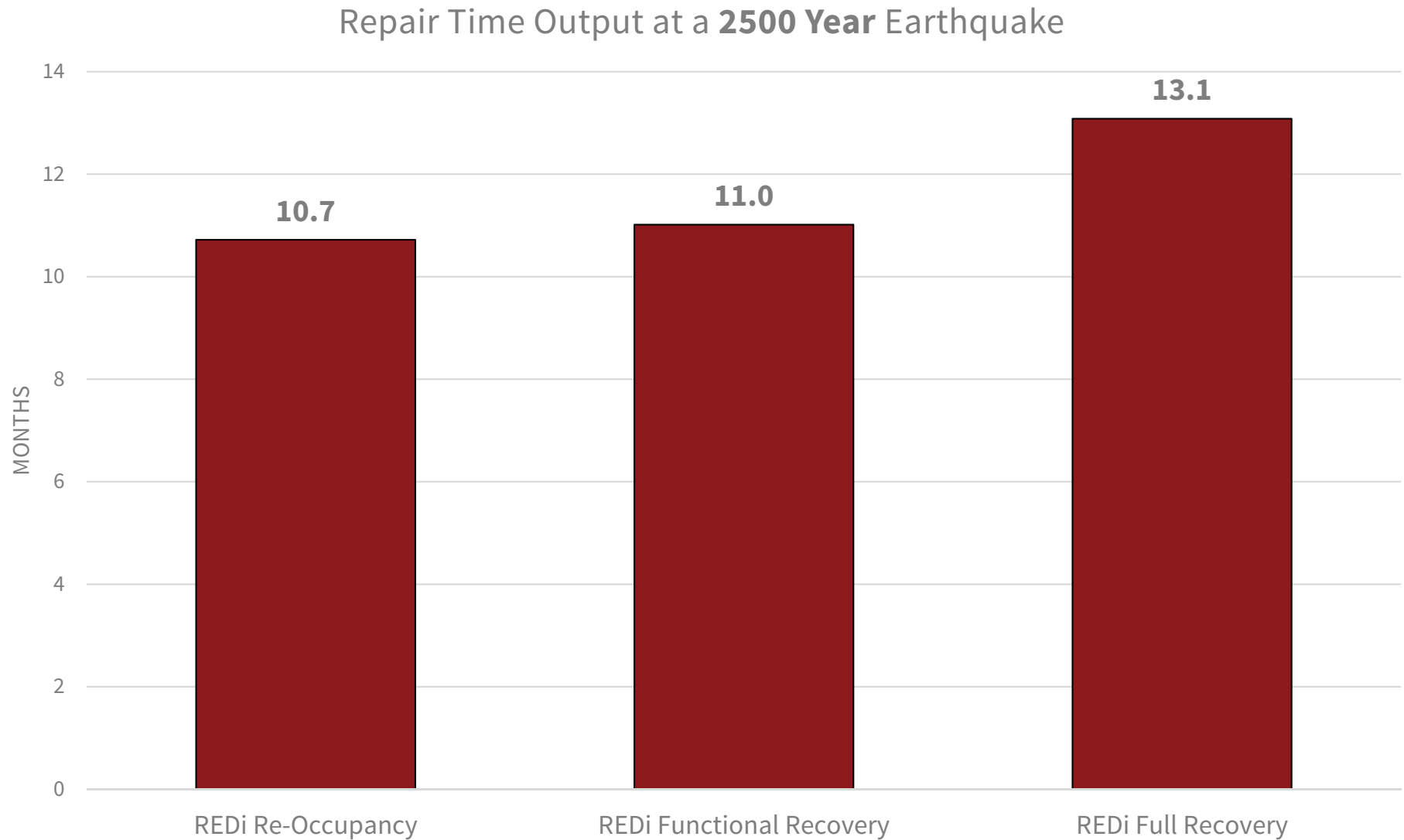
- Sample results for Repair Time (REDi, 2013):



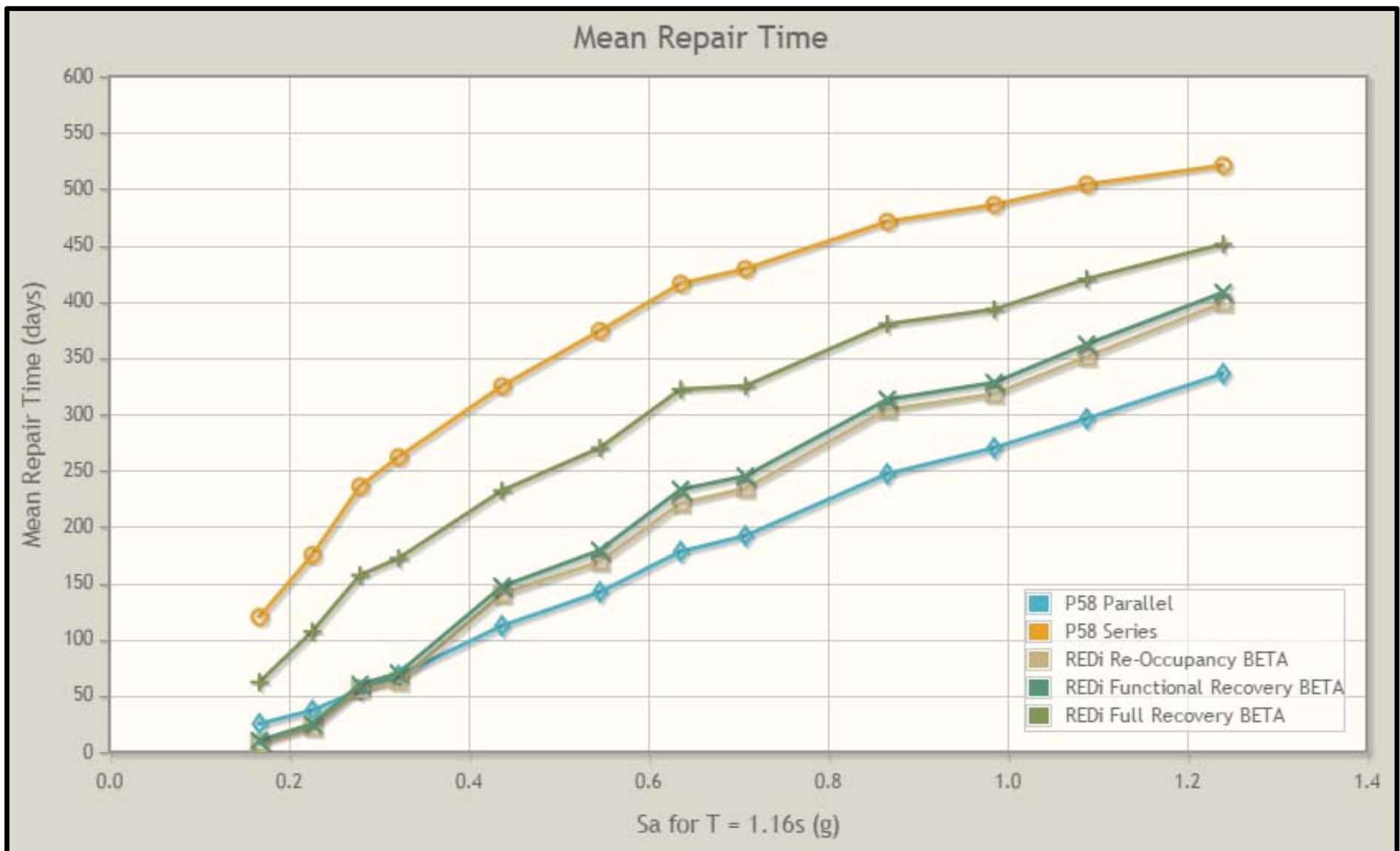
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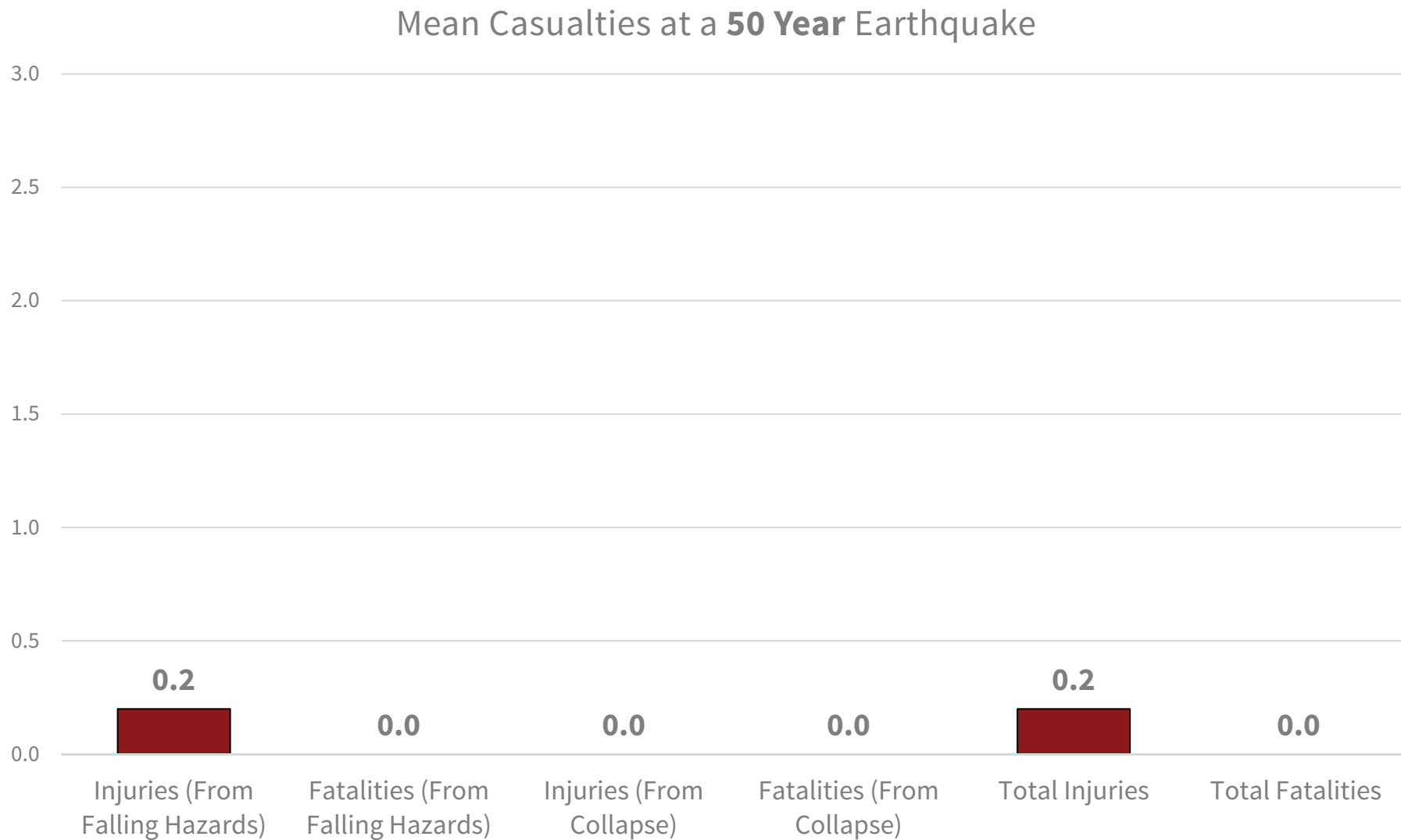
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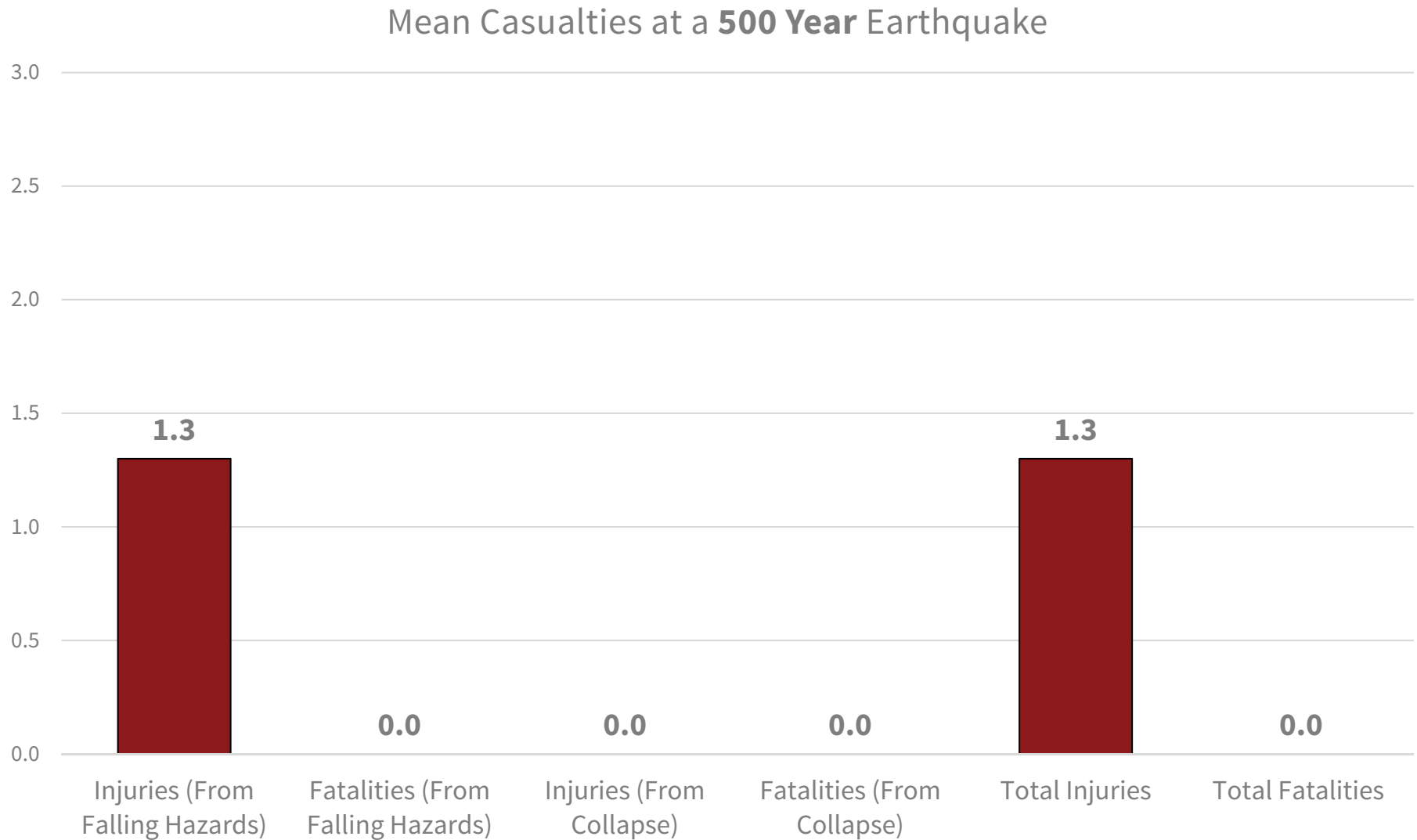
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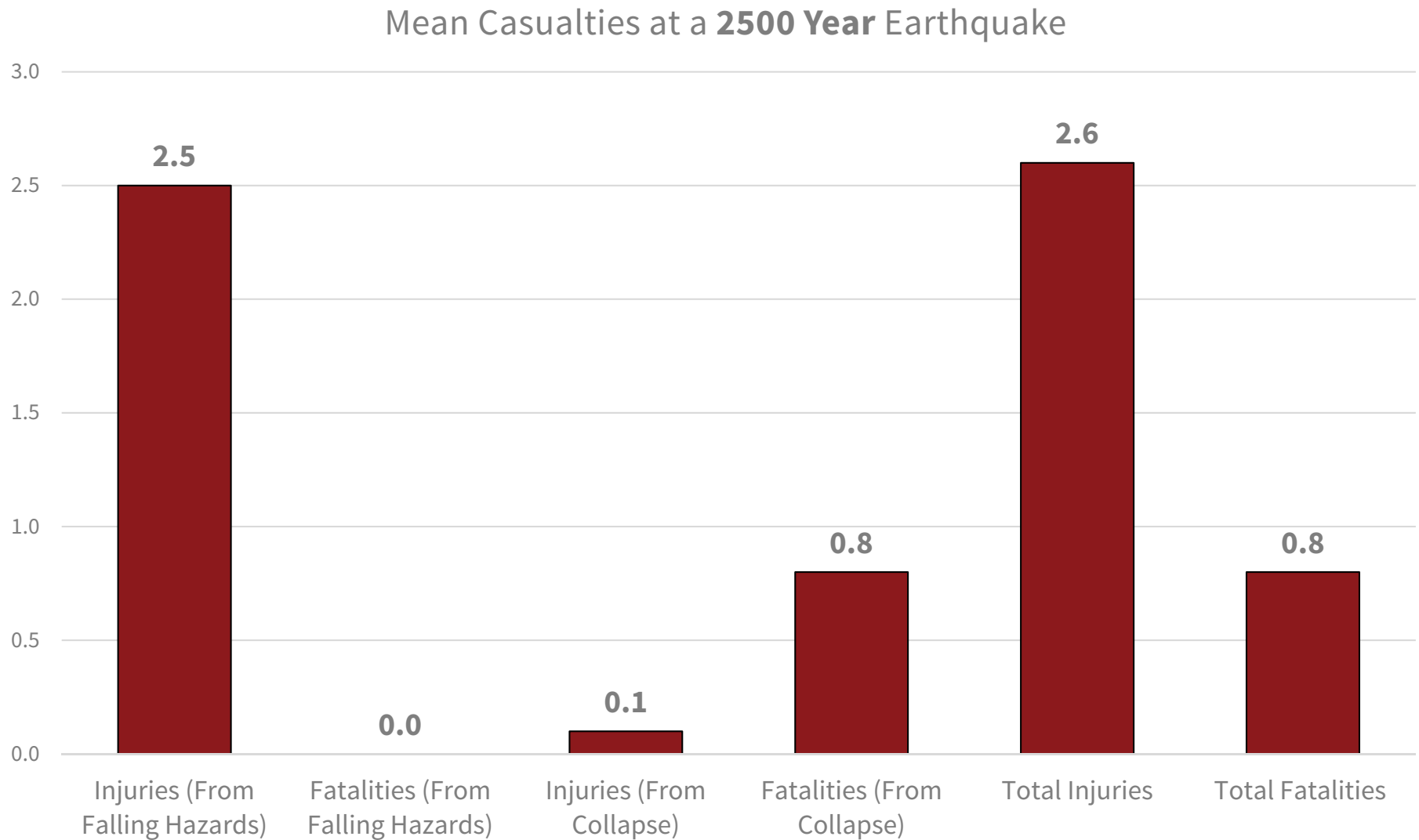
- Sample results for Safety (fatalities and injuries):



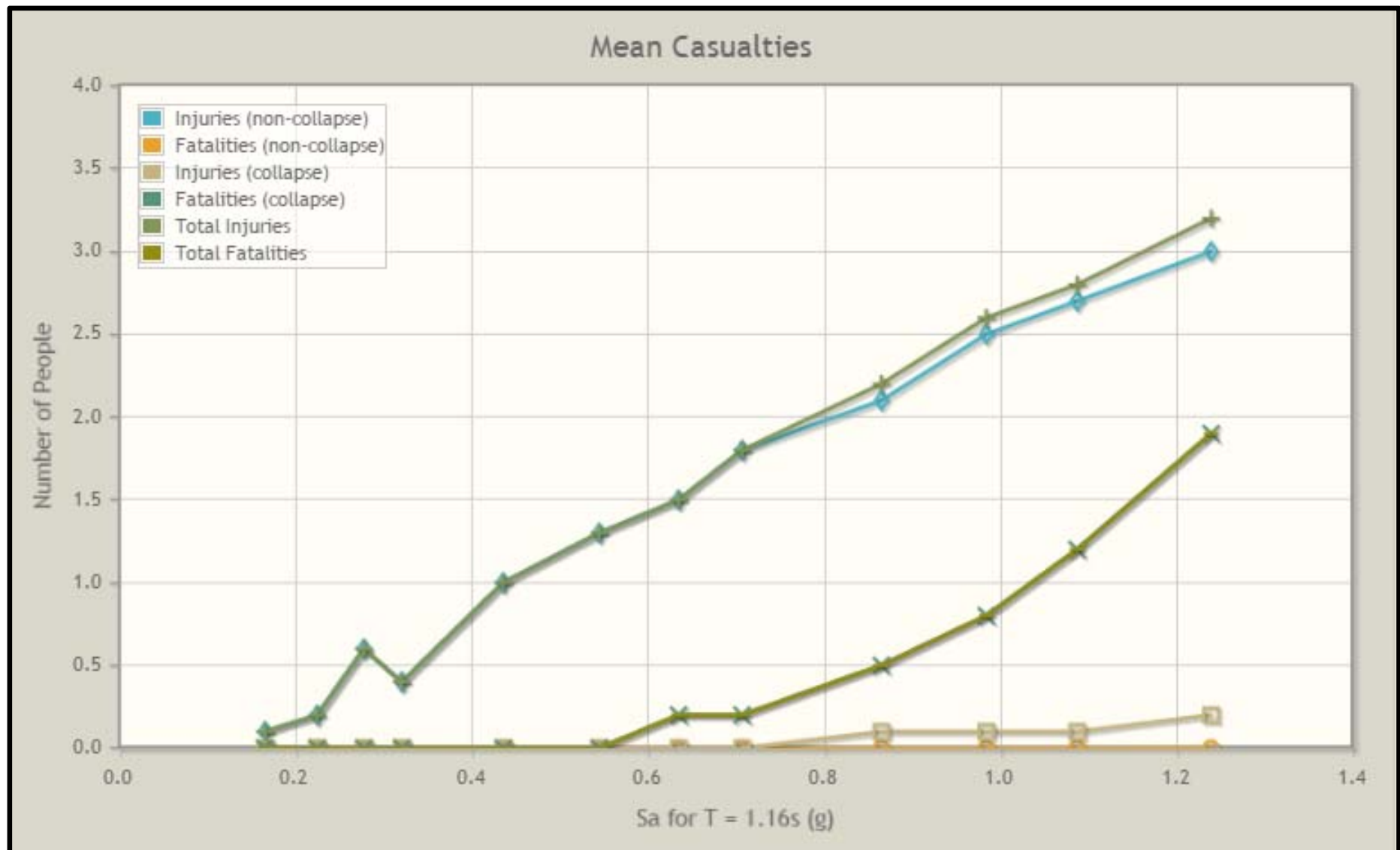
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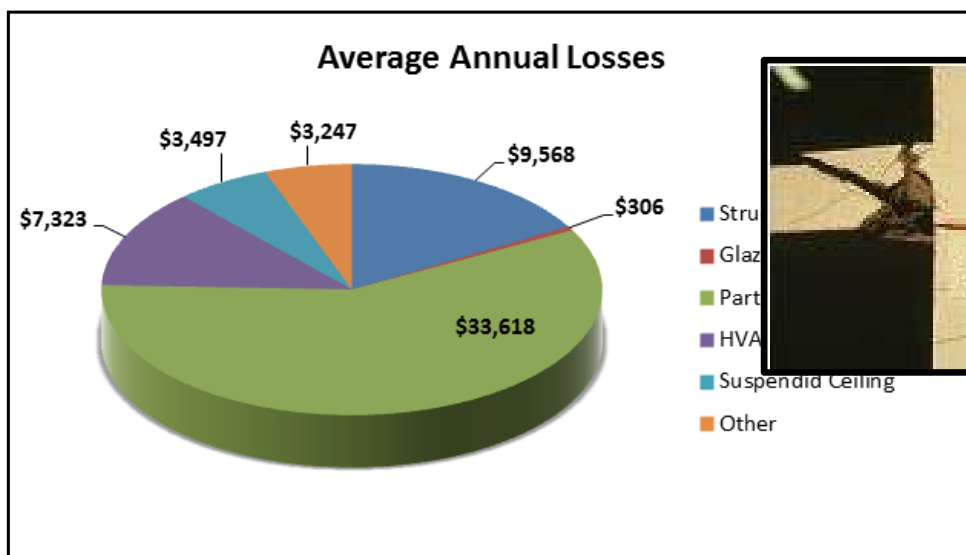
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- Sample results for Safety (fatalities and injuries):



- Objective process based on data and research.
- Quantitative performance information:
 - Solid basis for assessment (research data and solid statistics).
 - Sensitive/detailed enough to account for building specifics.
 - Tools to communicate with owners (and for reports).
 - Dig as deep as you like (and can decide what data are of use).



- Hazard and Ground Motions
 - Soil and hazard curve
 - Ground motions (if needed)
- Structural Responses
 - Option #1: Response-history
 - Option #2: Simplified method
- Damage Prediction
 - Contents (str. and non-str.)
 - Fragility curves
- Loss Estimation (loss curves)

Typical Reaction:
Looks extremely
complicated!

- Hazard and Ground Motions
 - Soil and hazard curve
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- Structural Responses
 - Option #1: Response-history
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- Damage Prediction

Soil and ground motion database information embedded.

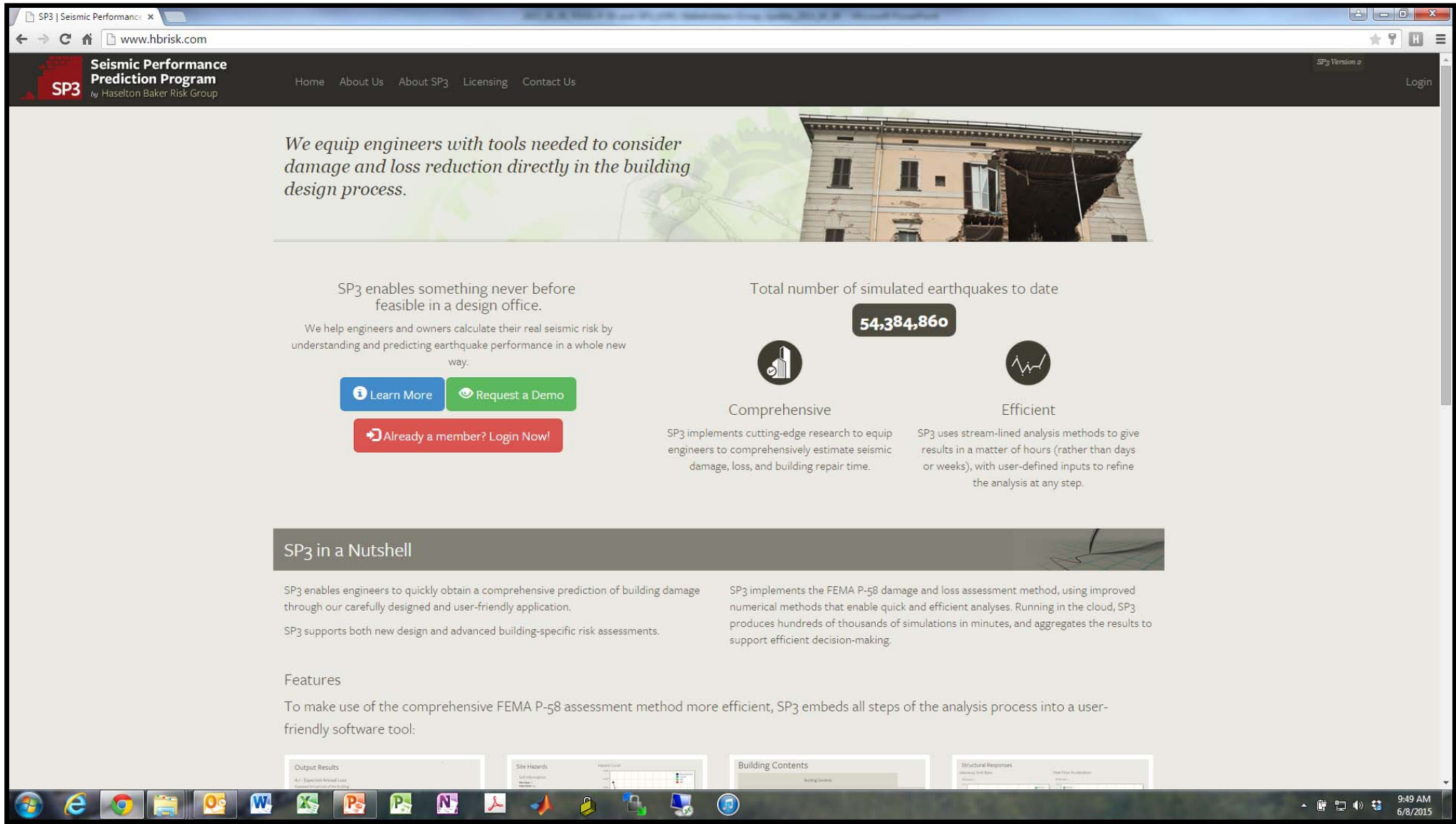
Simplified structural response method embedded.

Building contents are auto-populated.

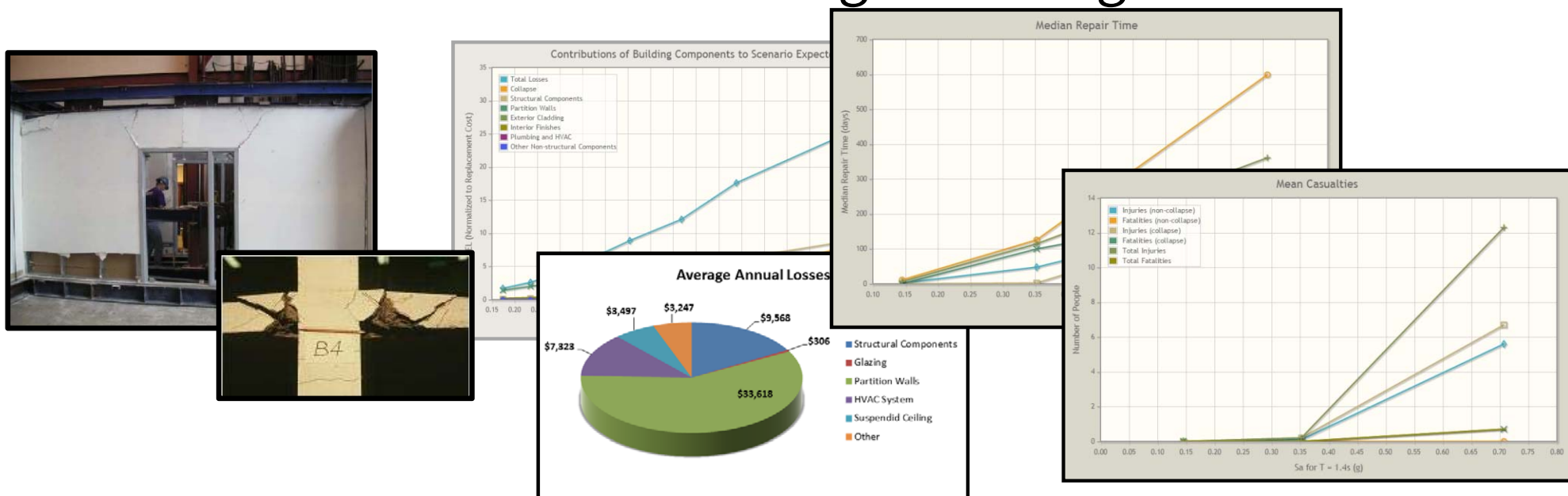
Two-level structure:

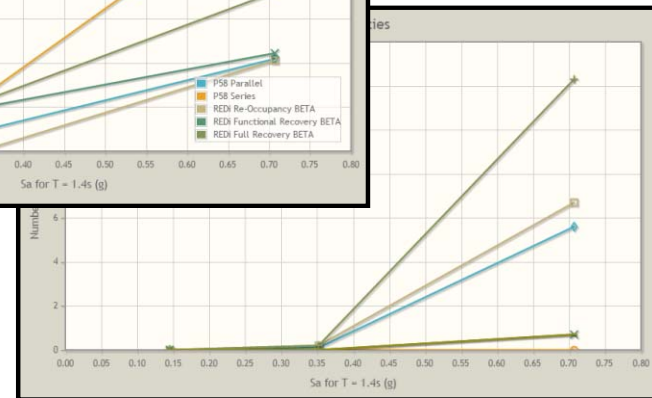
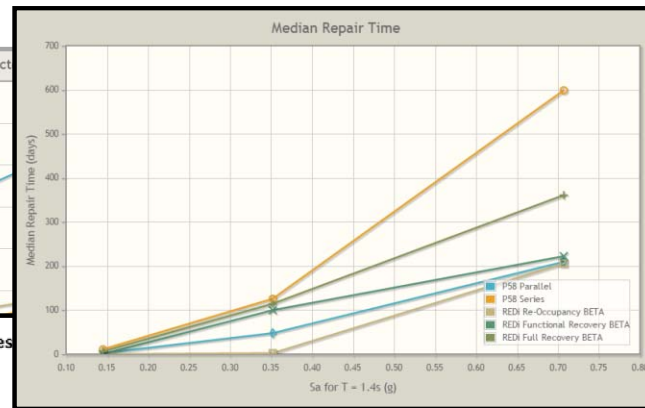
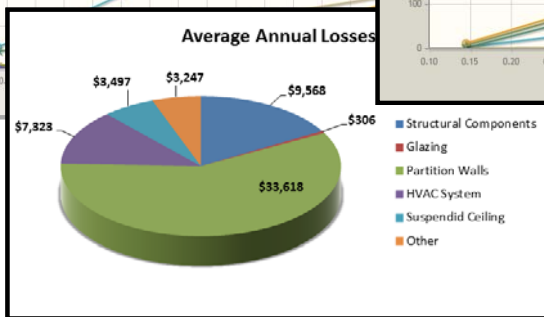
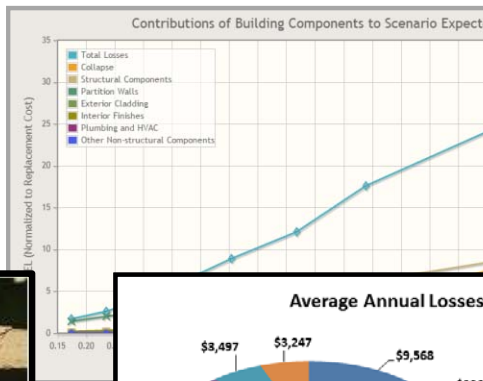
- (1) Use initial pre-populated values (e.g. start of a USRC rating).
- (2) Modify inputs and go as deep as you like.

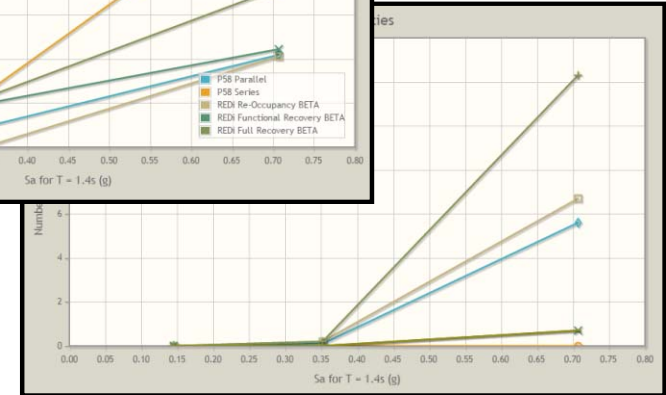
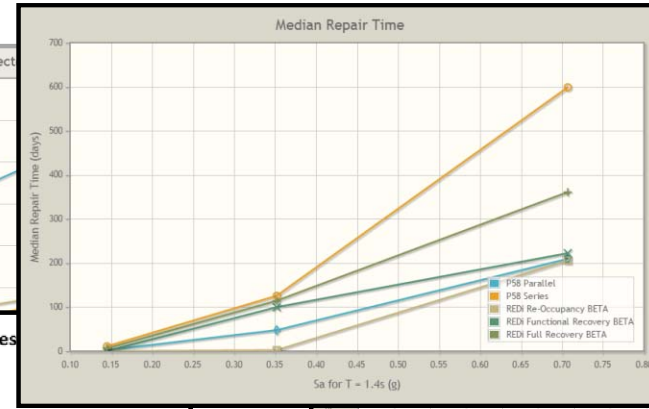
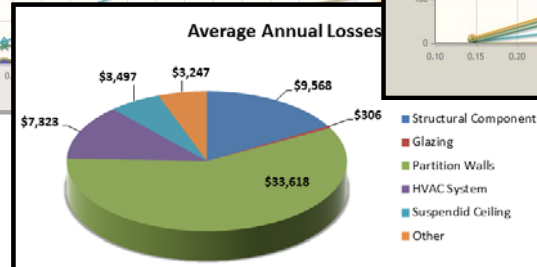
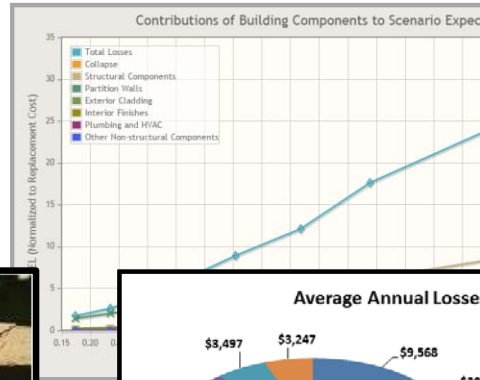
Overall: Web deployed, automated PDF output reports, review mode.



- The FEMA P-58 analysis methodology gives us a lot of information that we want about a building.
- The SP3 software was made so engineers can adopt and use the FEMA P-58 method (within normal project constraints).
- But what about communicating and using the results?







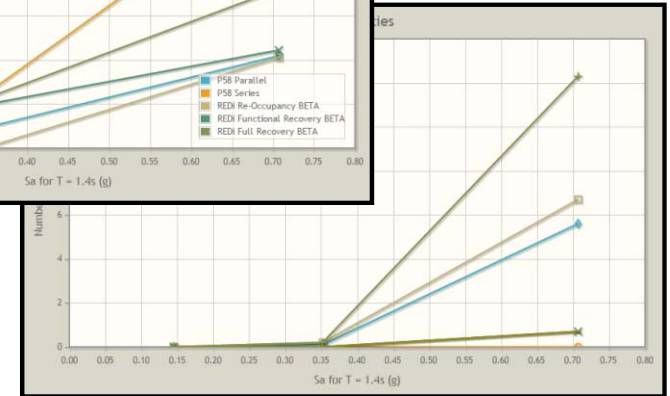
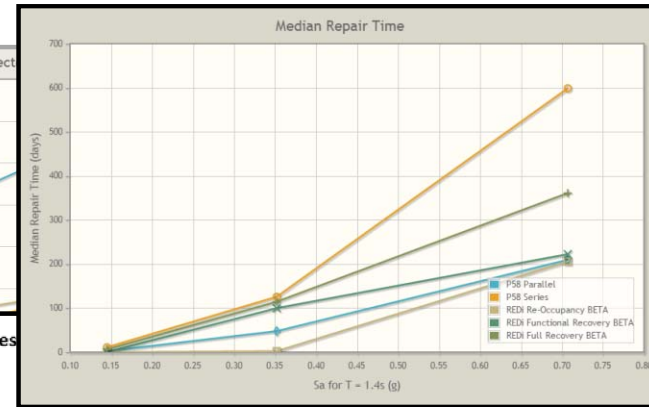
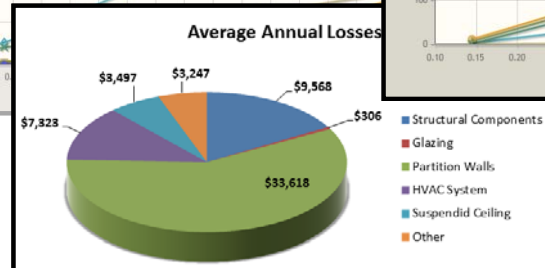
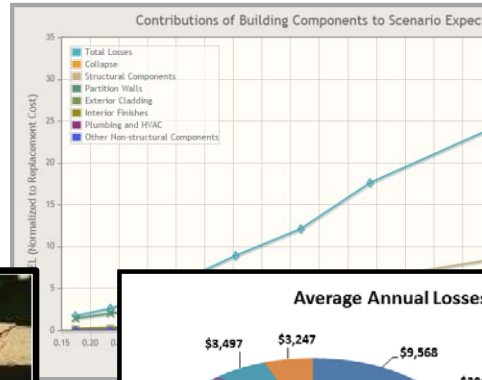
Research

FEMA P-58

SP3

<http://accesspeerreviews.com.au/>

Safety		
RATING	EXPECTED SAFETY PERFORMANCE	FEMA P-58 CRITERIA
★★★★★	Injuries and blocking of exit paths unlikely Expected performance results in conditions unlikely to cause injuries or to keep people from exiting the building.	Egress routes are expected to be intact, with the following requirements being met: Stairs, Ceilings, HVAC ducting, Hazardous piping, and Parapet in egress routes shall have less than a 5% chance of hindering egress. Stairs and ramps that are not integral with the structural system shall be detailed to accommodate the seismic relative displacements according to ASCE7 Section 13.3.2. Masonry partitions around stairs are not permissible unless capable of accommodating the mean drift and acceleration demands. Doors are expected to be functional; mean residual story drifts shall be less than 0.0025.
★★★★	Serious injuries unlikely Expected performance results in conditions that are unlikely to cause serious injuries.	The likelihood of a building occupant being fatally injured, considering both building collapse and other non-collapse falling hazards, is less than 0.00016 for a 475 year ground motion. And the likelihood of a building occupant being injured, considering both building collapse and other non-collapse falling hazards, is less than 0.005 for a 475-year ground motion.
★★★	Loss of life unlikely Expected performance results in conditions that are unlikely to cause loss of life.	The likelihood of a building occupant being fatally injured due to building collapse is less than 0.00008 for a 475 year ground motion.

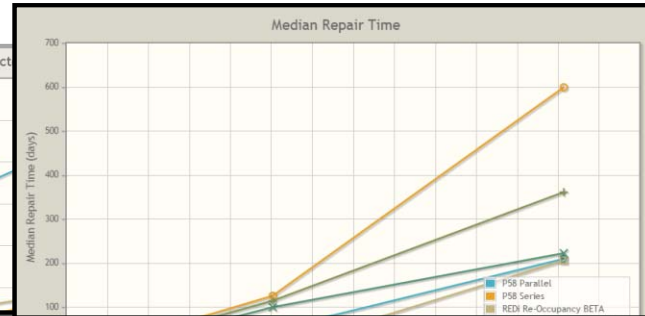
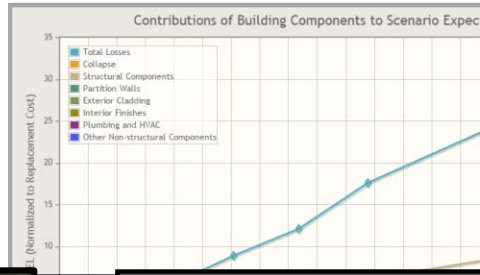


Research
FEMA P-58
SP3
USRC Rating

RATING	EXPECTED SAFETY PERFORMANCE	FEMA P-58 CRITERIA
Safety	★★★★	
Damage	★★★★★	
Recovery	★★★★	

Loss of life unlikely
 Expected performance results in conditions that are unlikely to cause loss of life.

The likelihood of a building occupant being fatally injured due to building collapse is less than 0.00008 for a 475 year ground motion.



Safety	★ ★ ★
Damage	★ ★ ★ ★ ★
Recovery	★ ★ ★

- The FEMA P-58 Methodology:
 - Well-suited for building-specific analysis (info. for USRC)
 - Rigorous approach (years of research, statistical basis)
 - One of the two USRC rating methods will be based on this
- The Seismic Performance Prediction Program (SP3):
 - Harnesses the power of the FEMA P-58 Methodology and support widespread use of the method
 - Make the USRC FEMA P-58 rating efficient for both the *rating process* and the *review process*
- USRC FEMA P-58 Building Rating method:
 - Rating method puts all of the information into an understandable format, so that a wider audience can use it.
 - USRC provides review and quality assurance of the rating system.

- Please contact me if you have any questions or would like any additional information.
- Contact Information:
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 - Haselton Baker Risk Group (SP3): www.hbrisk.com
 - CSU Chico: www.csuchico.edu/structural