

Performance-based Analysis of a Healthcare Facility in California

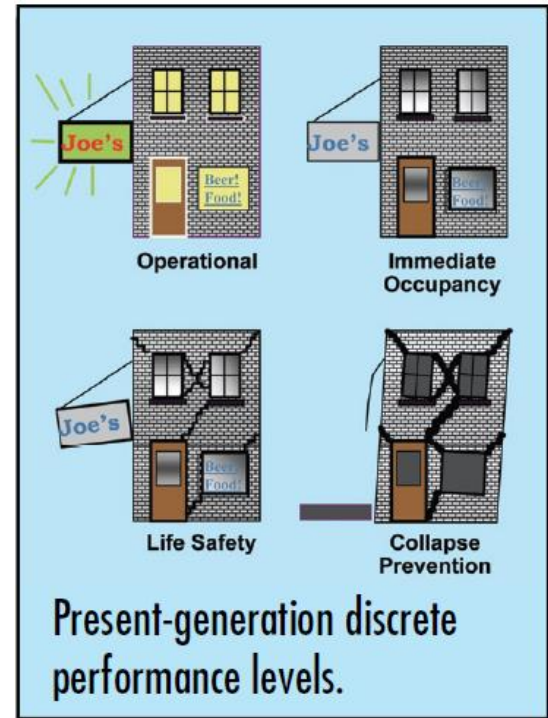
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Introduction

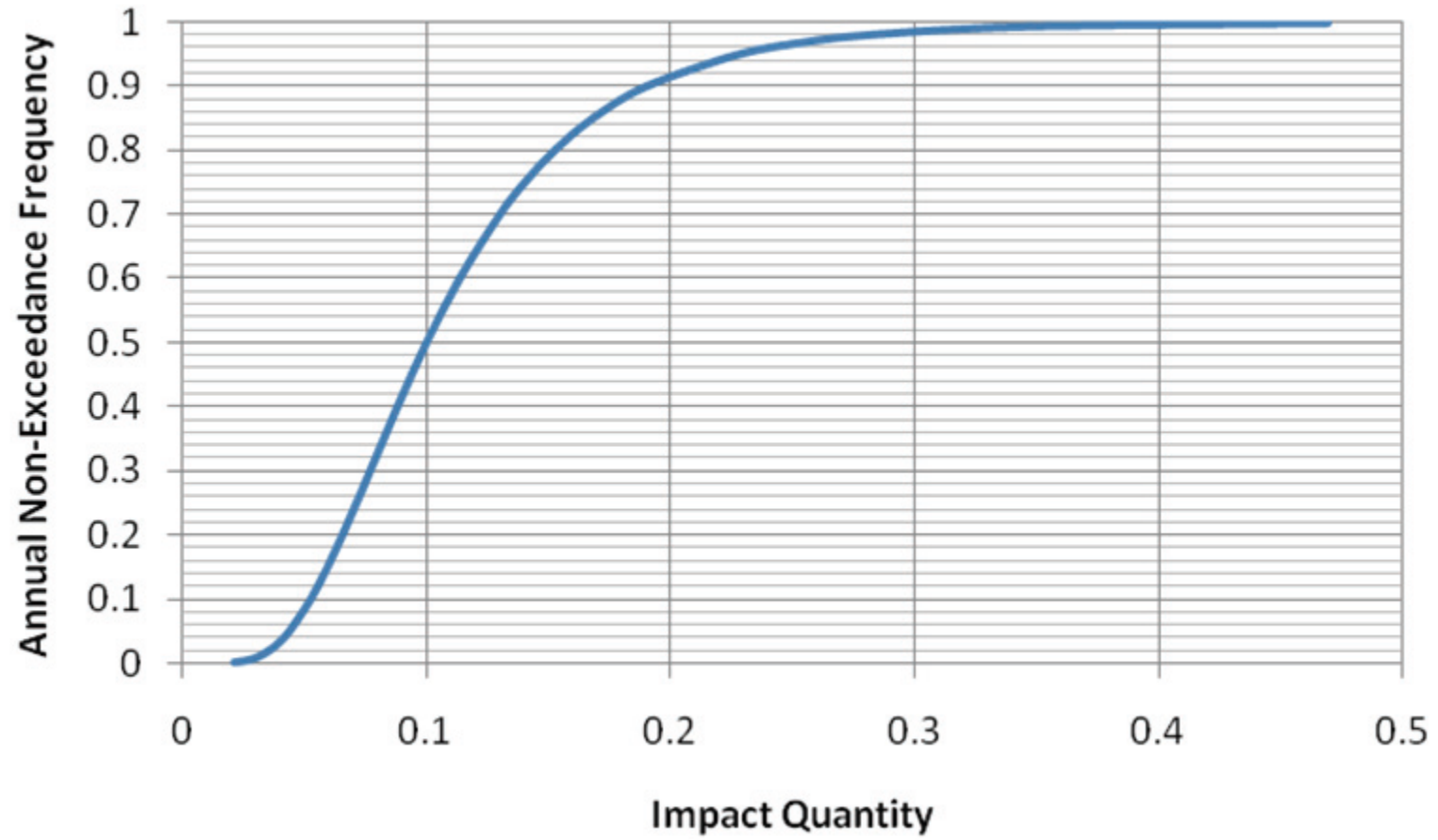
- Conventional design
 - Mostly deterministic
 - Discrete performance levels
- Performance-based design
 - Probabilistic
 - Performance measures
 - Casualties
 - Repair cost
 - Repair time
 - Unsafe placarding



Methodology

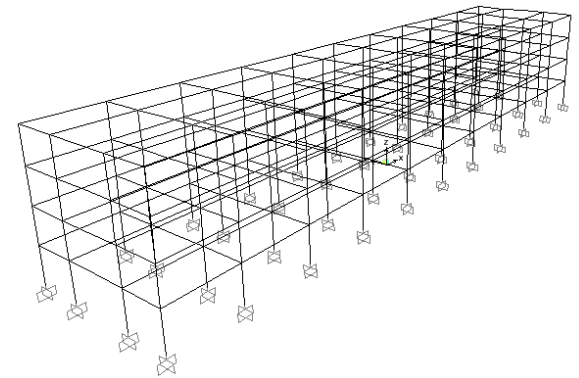
- Assemble building performance model
 - Structural details
 - Occupancy
 - Component fragility
- Define earthquake hazards
 - Probabilistic seismic hazard analysis
- Analyze building response
 - Nonlinear response history analysis
- Develop collapse fragility
- Calculate performance

Outcome



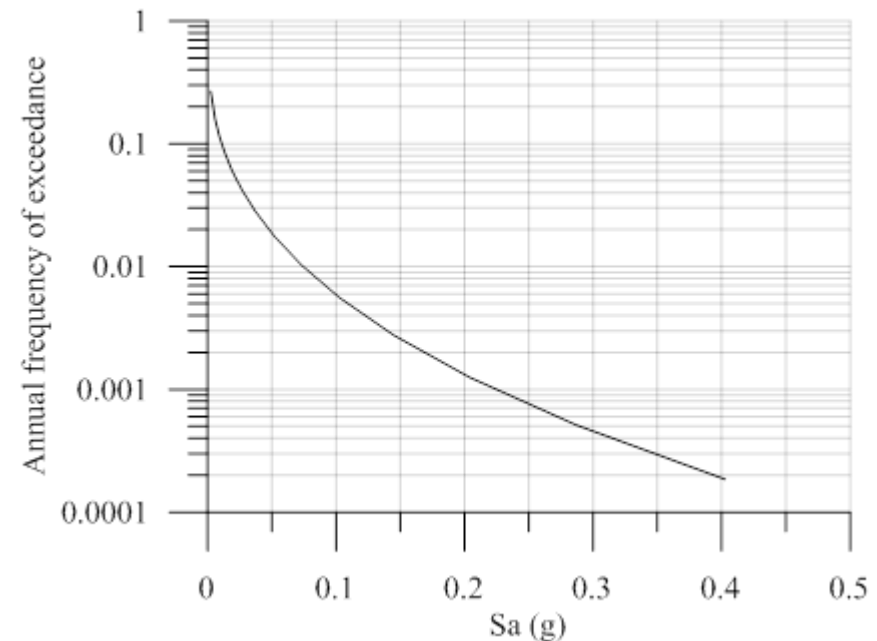
Case-study

- A healthcare facility
 - Four story steel moment frame
 - Conform to 1960s building design codes
 - Low stiffness and strength
 - Floor area: 15538 sqft
 - Replacement cost: \$9 m
- Modal properties
 - $T_x=1.86$ sec, $T_y=1.93$ sec
 - Reactive weight 10,000 kips
- Decision on continued operation of the building



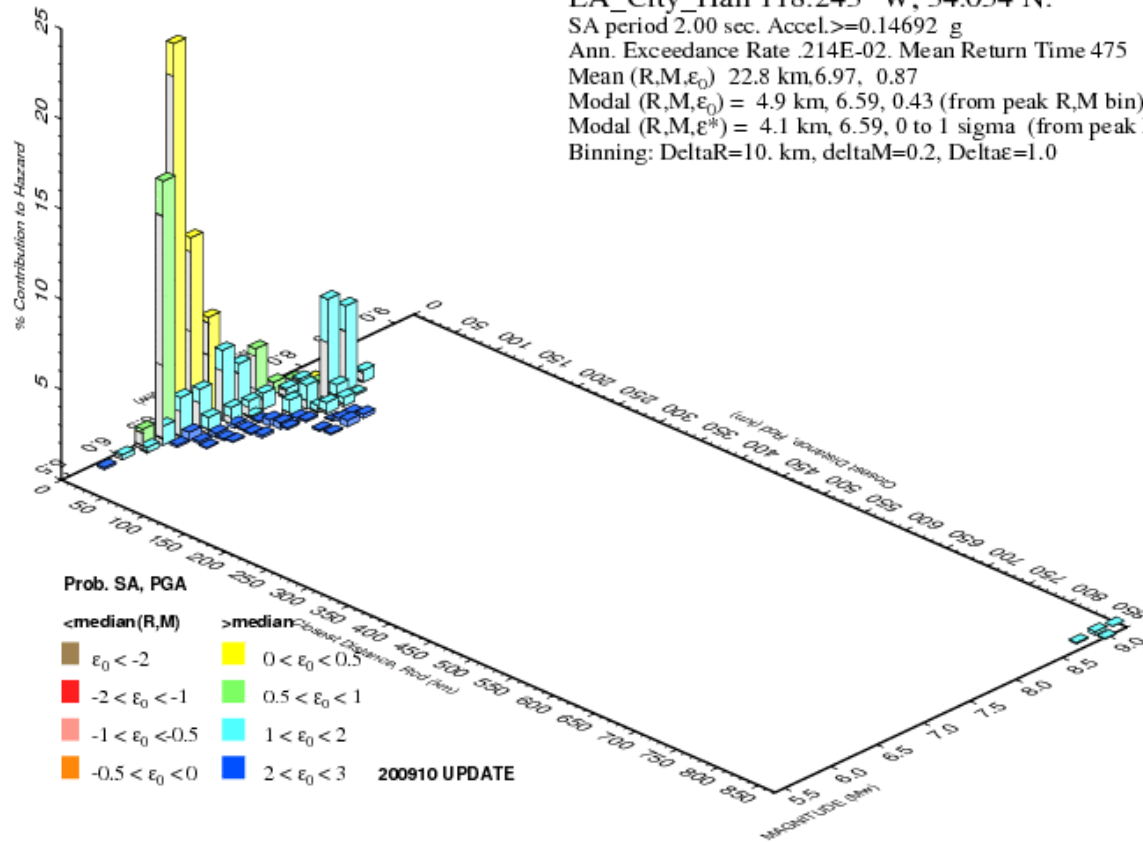
Earthquake hazard

- Probabilistic Seismic Hazard Analysis (PSHA)
 - Time-based assessment
- Eight intensity intervals
 - $S_{a,\min} = 0.0525g$
 - $S_{a,\max} = 0.1725g$



Seismic hazard curve of spectral acceleration at 1.88 sec

PSH Deaggregation on NEHRP BC rock
 LA_City_Hall 118.243° W, 34.054 N.
 SA period 2.00 sec. Accel.>=0.14692 g
 Ann. Exceedance Rate .214E-02. Mean Return Time 475 yrs
 Mean (R,M, ϵ_0) 22.8 km,6.97, 0.87
 Modal (R,M, ϵ_0) = 4.9 km, 6.59, 0.43 (from peak R,M bin)
 Modal (R,M, ϵ^*) = 4.1 km, 6.59, 0 to 1 sigma (from peak R,M, ϵ bin)
 Binning: DeltaR=10. km, deltaM=0.2, Delta ϵ =1.0



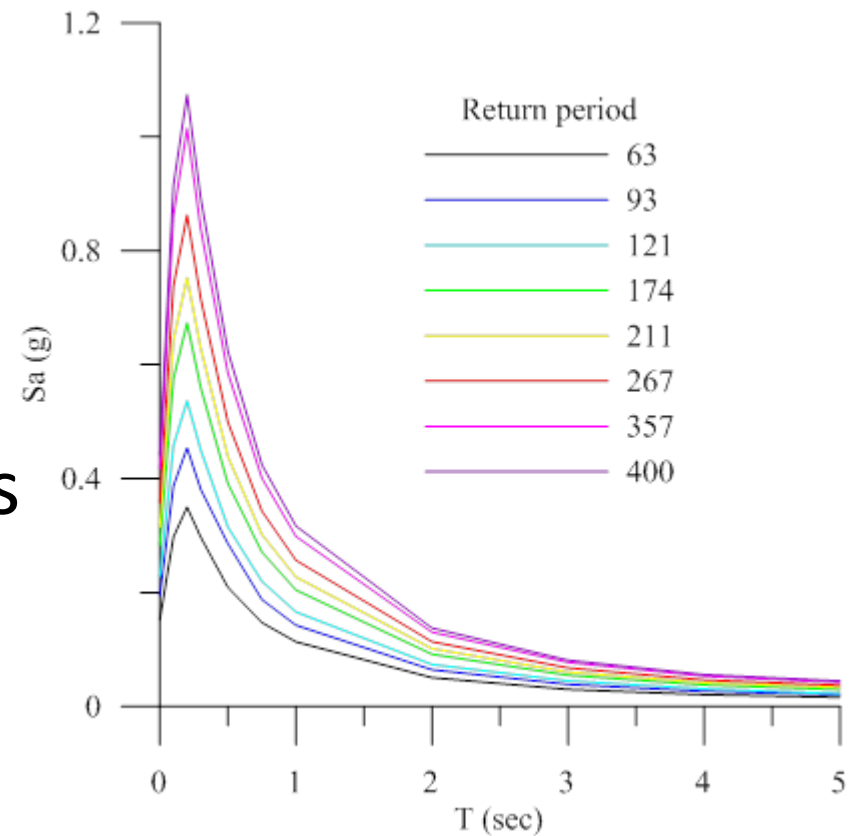
GMT 2013 Nov 3 18:01:02 Distance (R), magnitude (M), epsilon (E) deaggregation for a site on rock with average vs. 750. m/s top 30m. USGS CGHT PSHA2008 UP DATE Bins with 110.03% contrib. omitted

Deaggregation chart of seismic hazard at Sa=2 sec for 10% probability of exceedance in 50 years

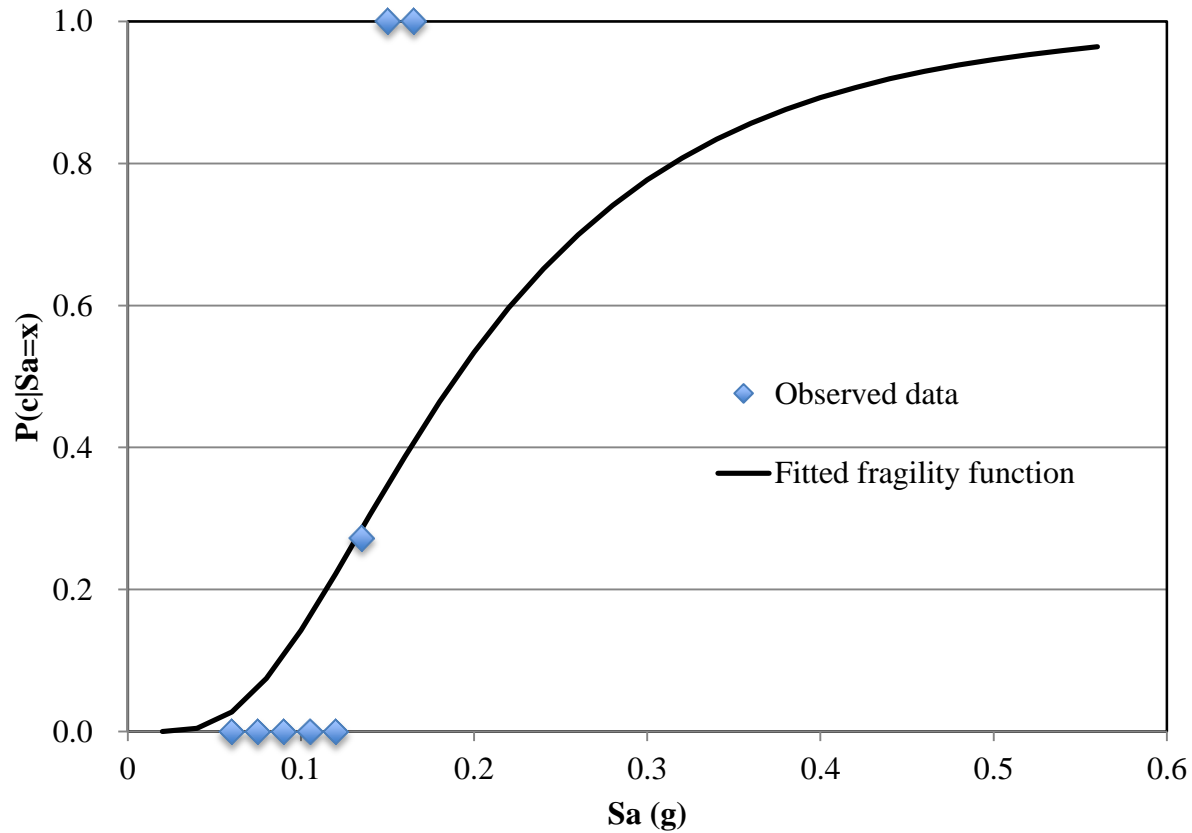
Building response

- Eight intensity levels
- Eight response spectra
- Ground motions
 - 11 for each, 88 total
- Failure at two intensities
- Conditional probability

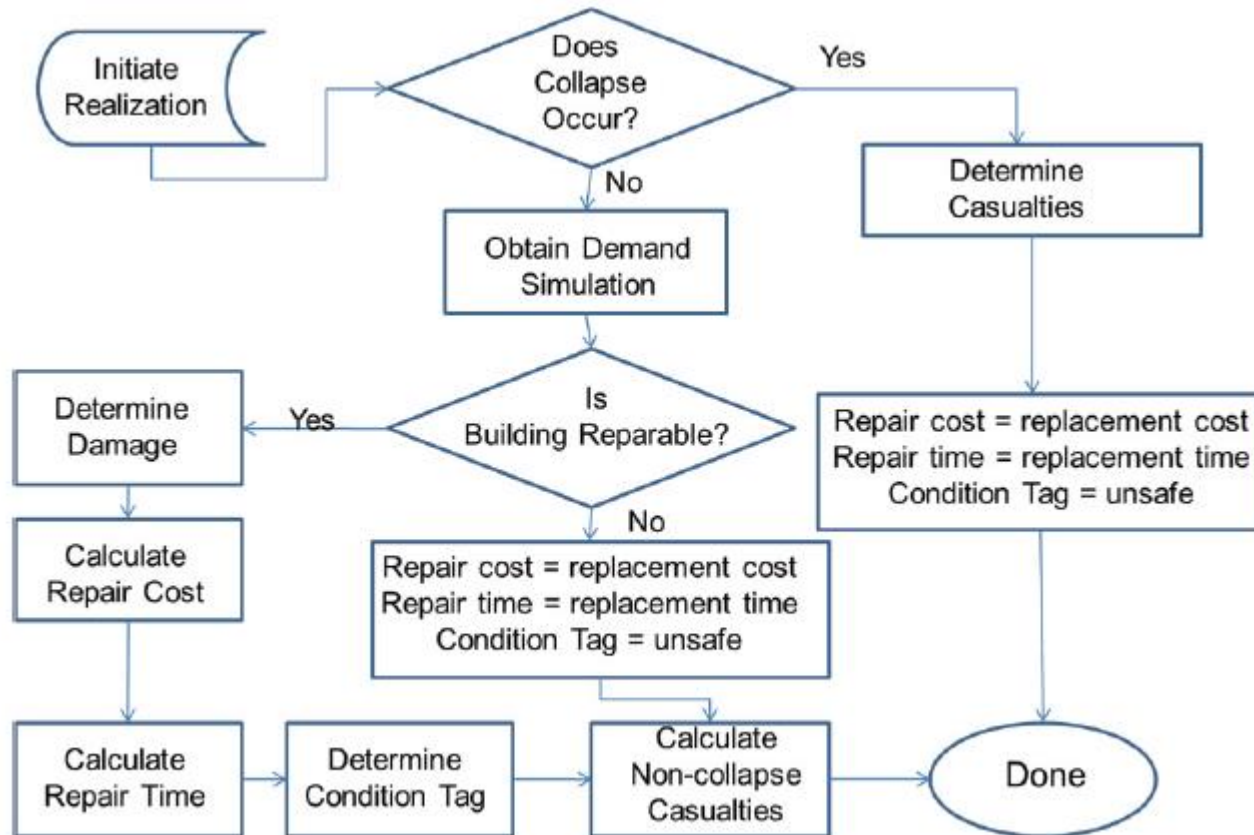
$$P(C | I) = \frac{n}{N}$$



Collapse fragility curve



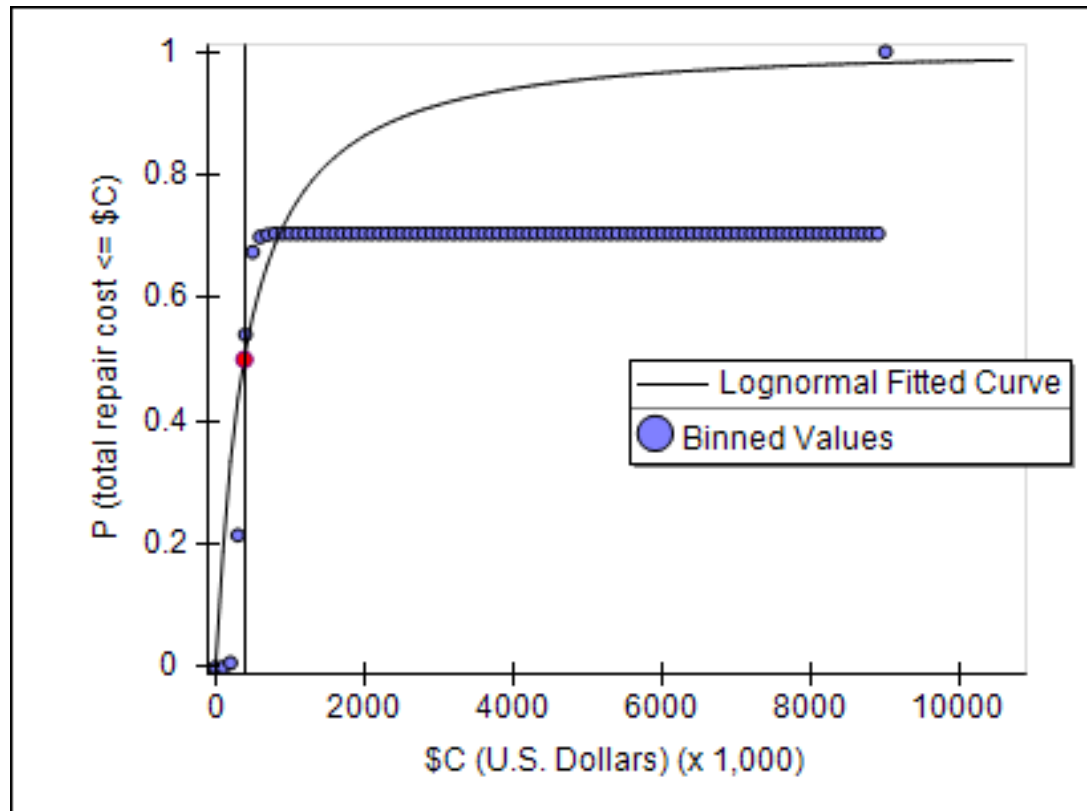
Performance assessment



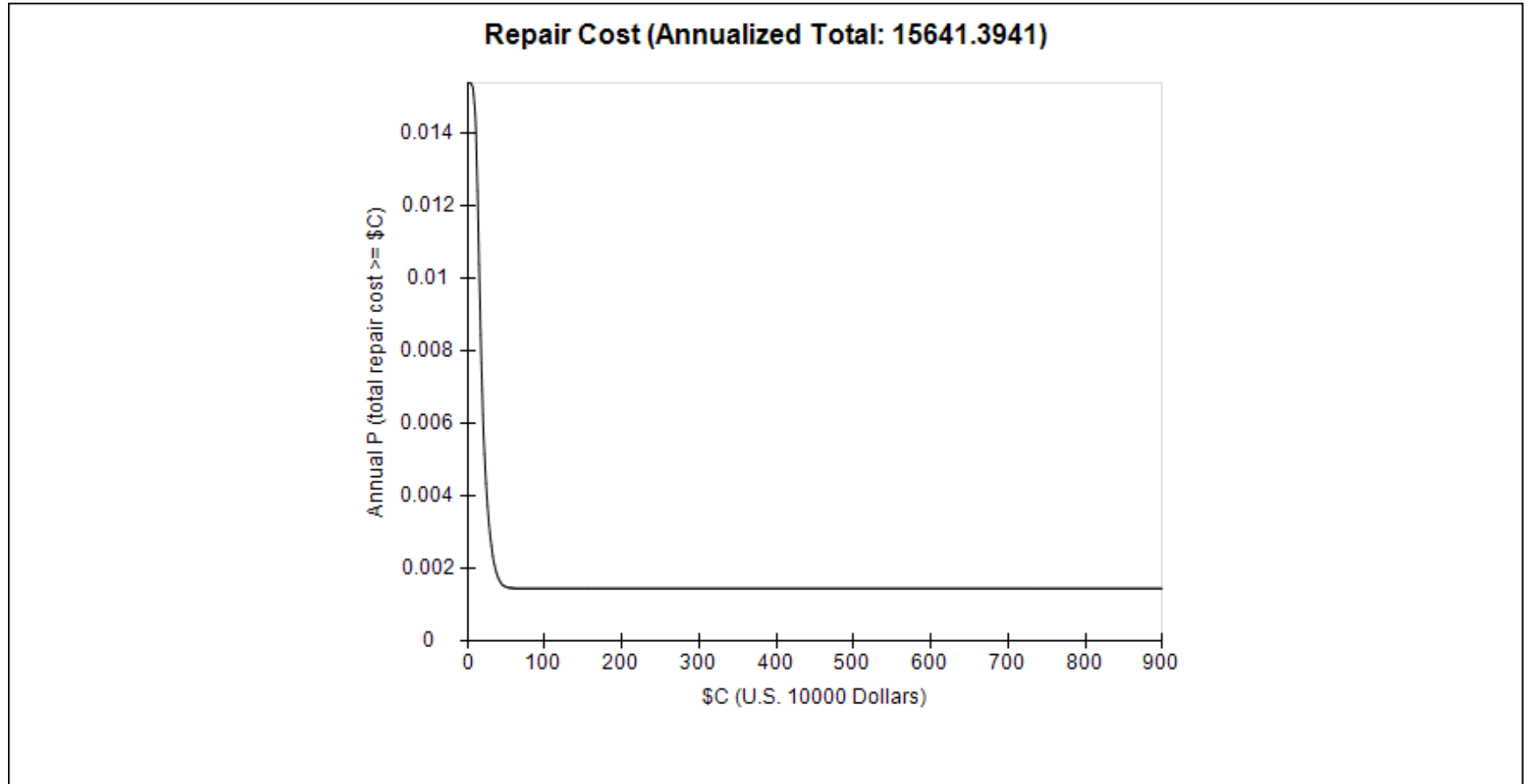
Performance assessment

- Annual probabilities
 - Collapse: 0.0012
 - Unsafe placard: 0.0014
 - Loss due to residual drift: 0
- The decision on continued operation
 - Not yet finished

Repair cost: intensity 6

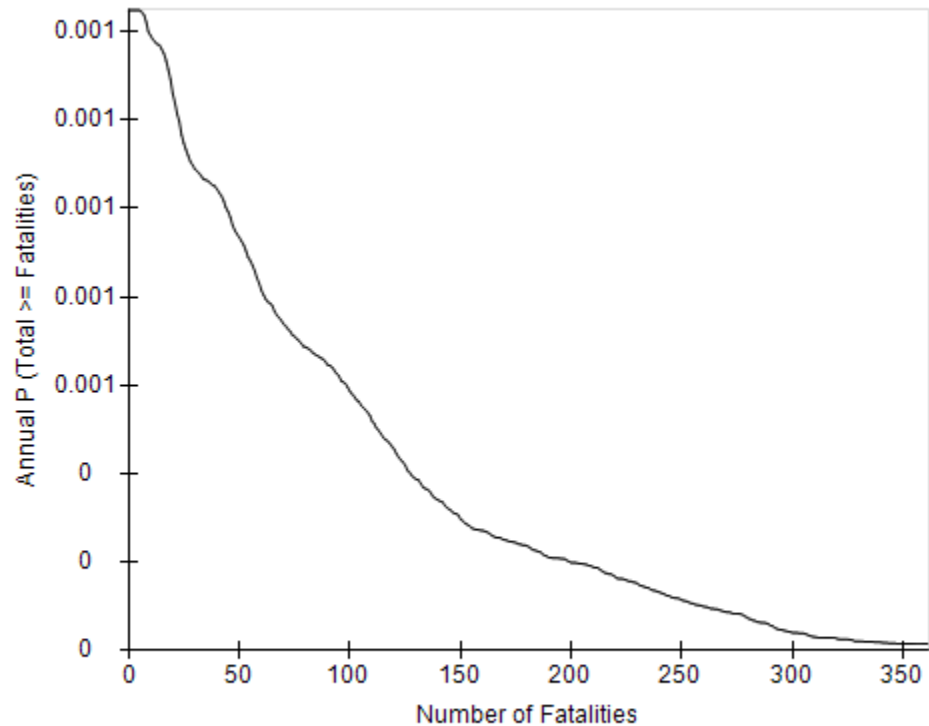


Repair cost: total



Fatalities: total

Fatalities (Annualized Total: 0.1443)



Conclusions

- An effective methodology for loss calculations
- Useful to clients and investors
- Requires nonlinear collapse simulation
 - SAP2000 is not appropriate
- PSHA is required
 - More than 30 ground motions for each intensity level are required

References

- Federal Emergency Management Authority (FEMA). (2013). "Seismic Performance Assessment of Buildings." *FEMA P-58, volume 1: methodology, volume 2: implementation guide, volume 3: supporting electronic materials, Washington, DC.*
- National Institute of Standards and Technology (NIST). (2011). "Standards of seismic safety for existing federally owned and leased buildings: ICSSC recommended practice 8 (RP 8)." *NIST GCR 12-917-21, Gaithersburg, MD.*

Thank You!

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