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Fragility of a Structure, System, or Component for Seismic Performance

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Mahendra Shah
U.S. Nuclear Regulatory Commission

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DISCLAIMER

The NRC staff views expressed herein are preliminary, and do not constitute a final judgment, nor determination of the matters addressed, nor of the acceptability of a license application for a geologic repository at Yucca Mountain

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Purpose

- The purpose of the study was to gain insights into potential safety margins of a concrete shear-wall against the unacceptable performance during a seismic event

- This paper examines a Monte-Carlo method of analysis to develop a fragility curve for a low-rise concrete shear-wall component of a building structure

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Seismic Risk

- The probability of occurrence of a seismically initiated event sequence depends on the performance of structures, systems, or components (SSCs) in the event sequence

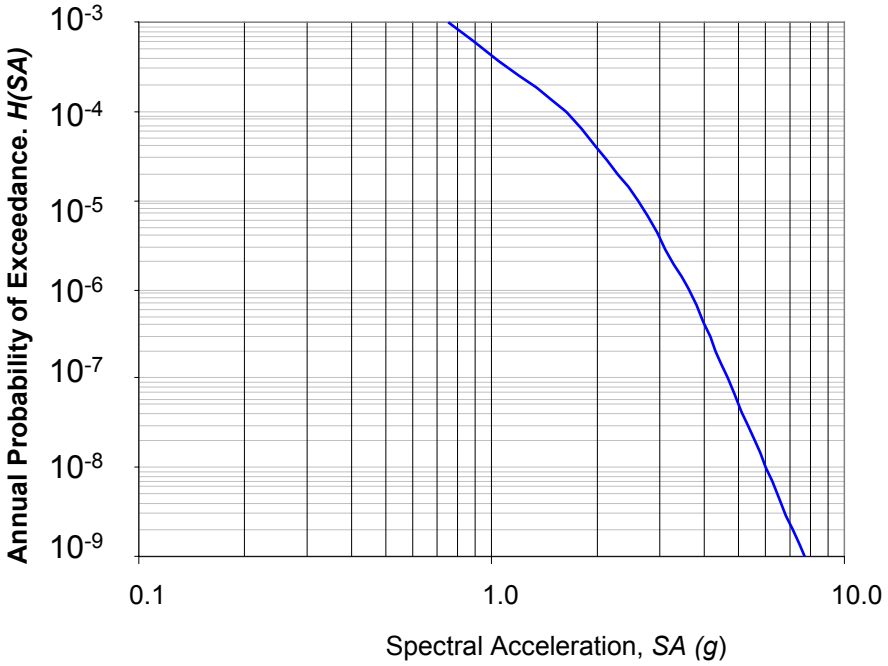
- The mean annual probability of unacceptable performance, or seismic risk, of an SSC during a seismic event, is determined by convolving the mean seismic hazard curve with the mean fragility curve of the SSC

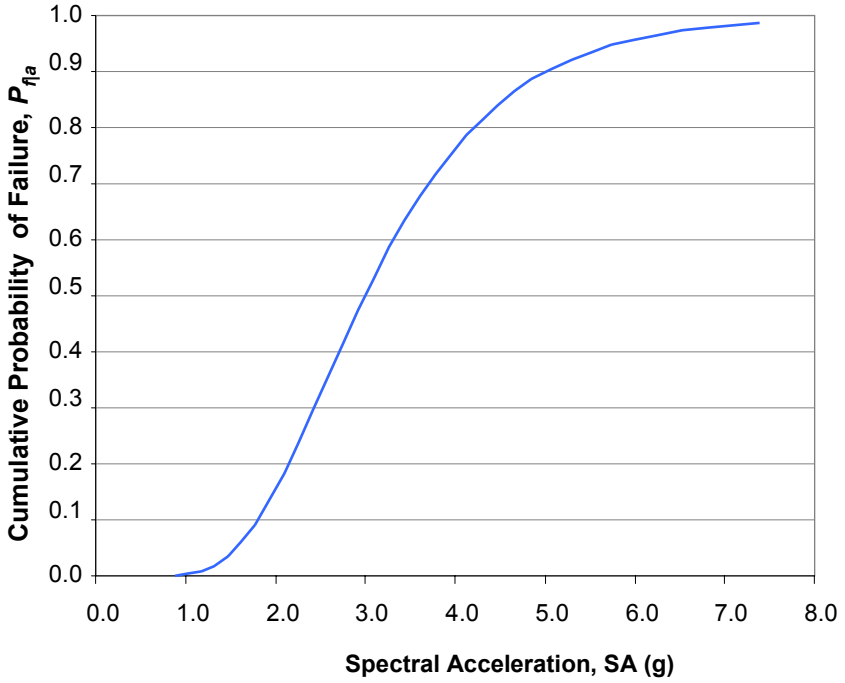
Regulatory Context

- The *Code of Federal Regulations*, Title 10, Part 63, for licensing of the potential repository at Yucca Mountain, NV, requires U.S. Department of Energy (DOE) to
  - comply with dose performance objectives
  - perform preclosure safety analysis and evaluate potential event sequences for hazards, including seismic events

- Dose performance objectives can be met by showing that:
  - a potential event sequence, that may release radioactivity has a chance of less than 1 in 10,000 of occurring before permanent closure; or
  - radiological dose resulting from the event sequence is less than the regulatory dose performance objective

Seismic Hazard and Fragility Curves





An Example Seismic Hazard Curve, *H(a)*, for Spectral Acceleration at 10 Hz

(*a* represents spectral acceleration *SA*)

An Example Fragility Curve, $P_{f|a}$ with $C_{50\%}$ = 3.0 g and β = 0.4 for Spectral Acceleration at 10 Hz

$C_{50\%}$ - median capacity
β - log standard deviation

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Fragility Curve Example

- Low-rise concrete shear-wall component of a building structure (NUREG/CR-6715, 2001)
- Limit state – ultimate strength defined by
  - Empirical equations based on tests (Barda et al., 1996)
  - Theoretical equations based on the truss and arch mechanisms for shear failure (Mori & Ellingwood, 2006)
- Monte-Carlo Method of analysis
  - Probability density functions for concrete and reinforcing steel (NUREG/CR-6715)

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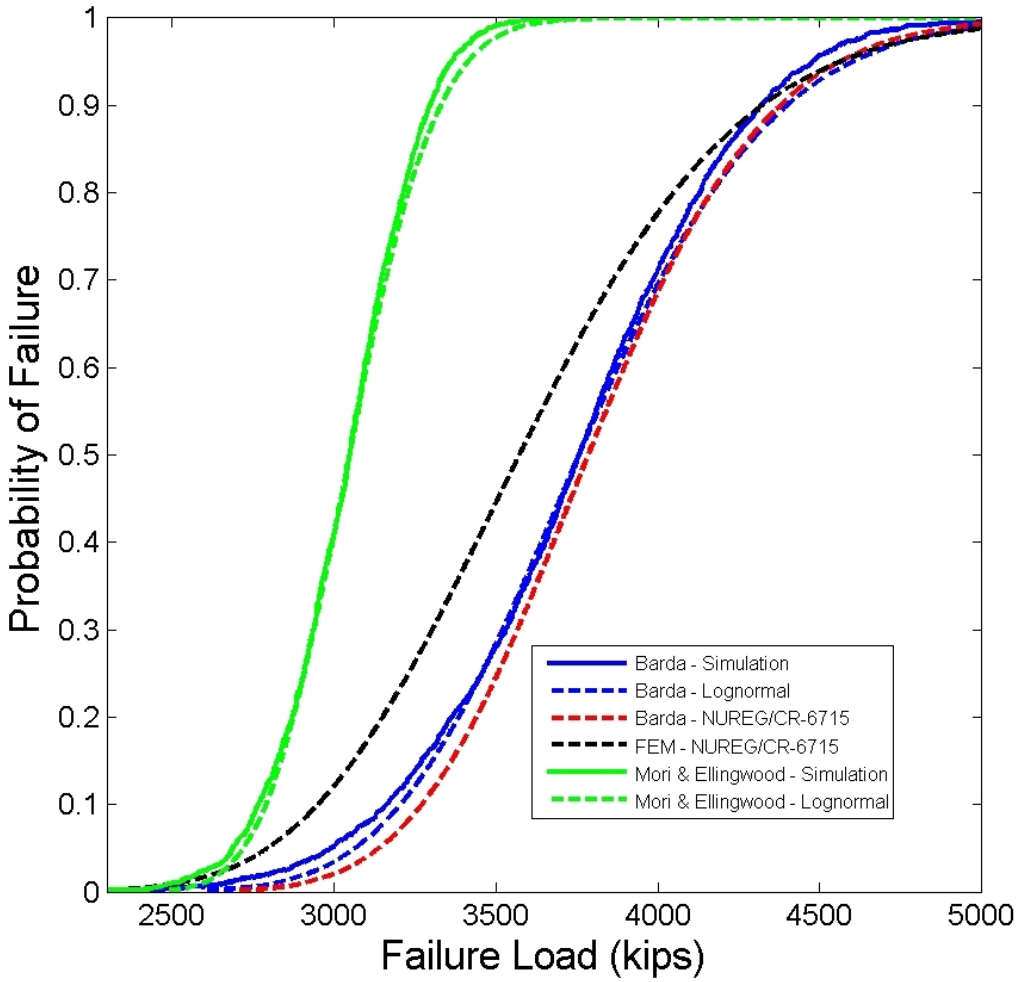
Results



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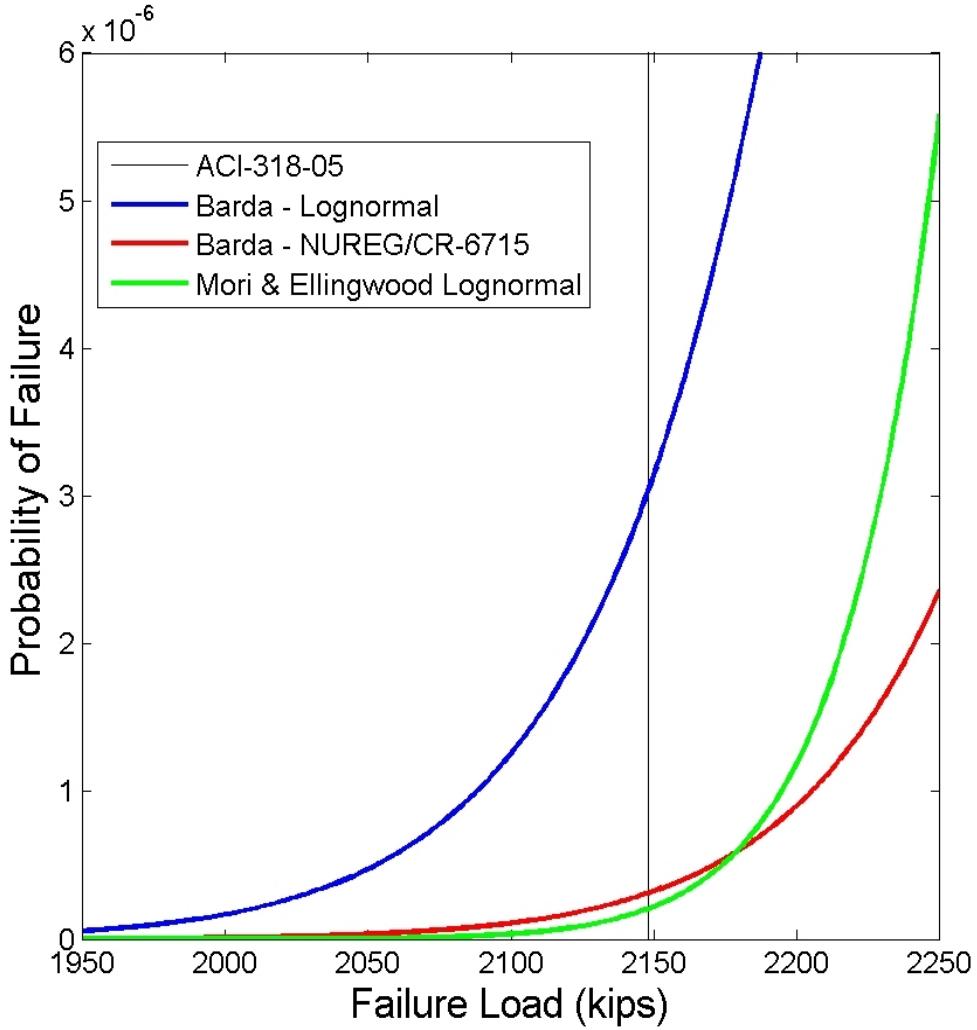
Results (continued)



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Conclusions

- The example illustrates a methodology for developing a fragility curve, for a concrete shear-wall, using the Monte Carlo method of analysis

- Results of the study provide insights on potential safety margins from probabilistic perspective against the unacceptable performance of a concrete shear-wall during a seismic event.

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Potential areas of future work

- Examine assumptions in the theoretical equation for the limit strength of a shear-wall, to understand reasons why it predicts strength that is lower than those based on empirical equations and finite-element method analysis

- Perform sensitivity analyses to understand the effects of various parameters (e.g., concrete strength, amount of reinforcement, axial load) on the fragility curve

- Examine other methods, such as the conservative-deterministic-failure-margin approach, and the finite-element analysis, to develop fragility curves for a concrete shear wall, and other SSCs