TS Webinar Series:

Fatality Risk Assessment

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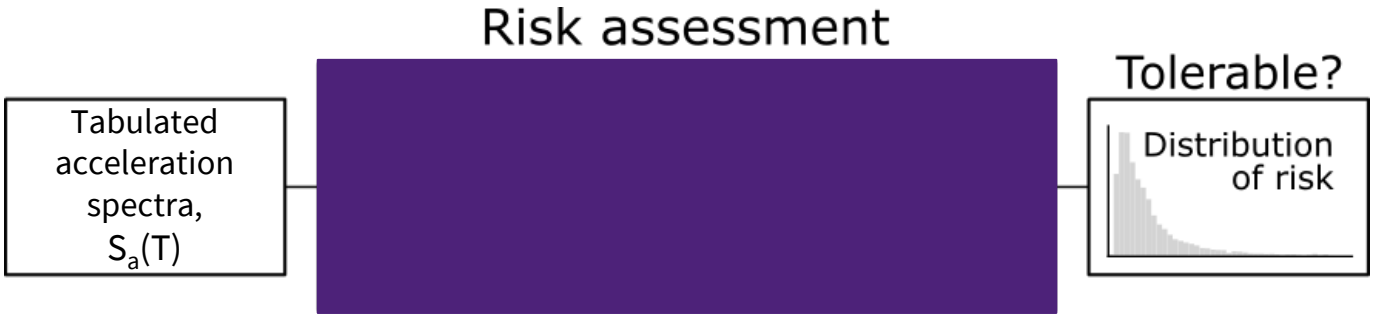
on behalf of the Seismic Risk Working Group

27 February, 2024

Motivation

"Risk-informed" approach for developing the acceleration spectra



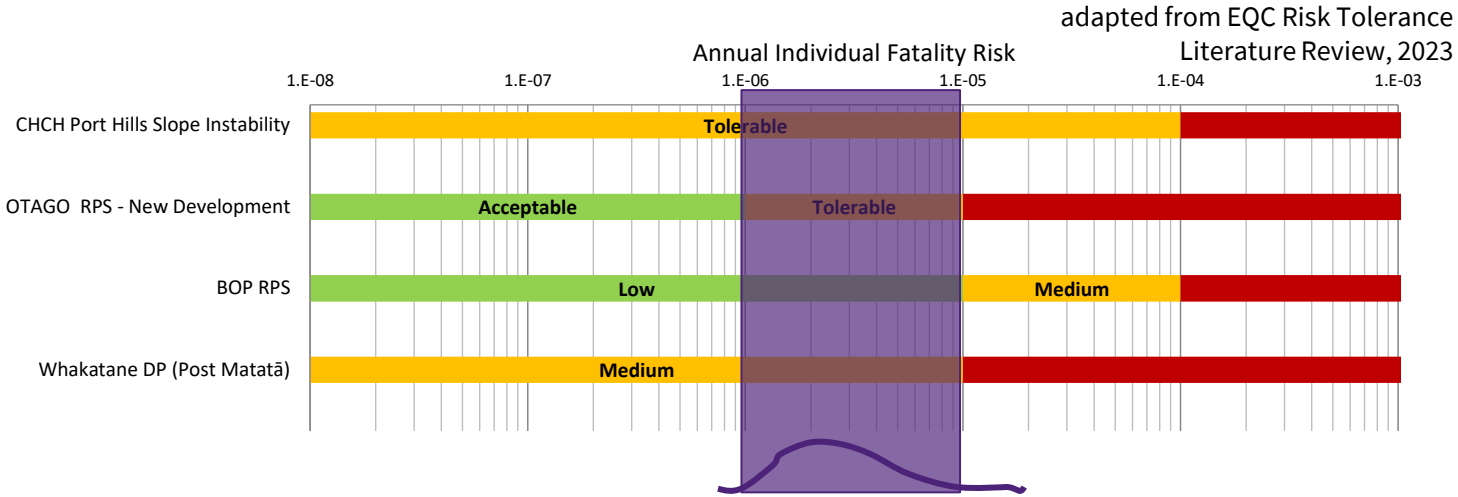
- risk is not the primary driver in developing the spectra, $S_a(T)$
  - assessed as a secondary step to test the risk tolerability

- risk is variable across buildings, informed by many things not just $S_a(T)$
  - not possible to select a strict risk value to target for all buildings

SRWG preliminarily selected a 1/500 annual probability of exceedance (APoE) for ULS, then checked whether the distribution of fatality risk was tolerable.

Fatality risk tolerability

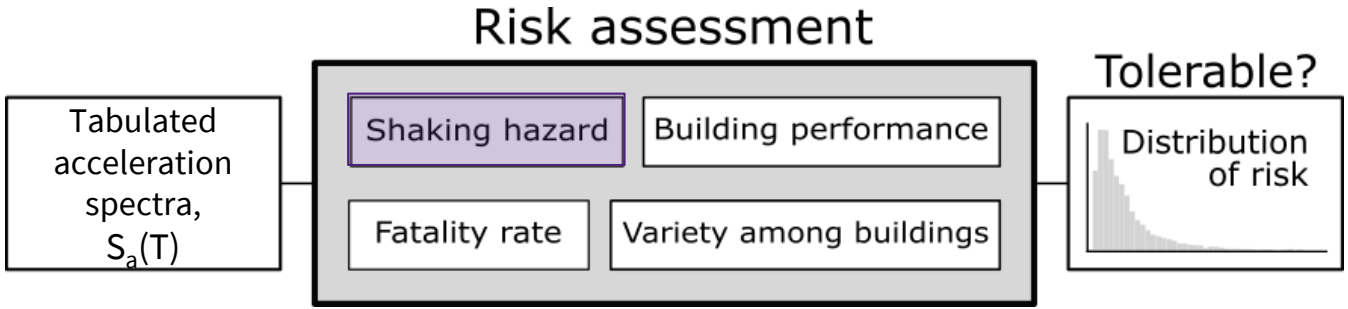
Metric: annual individual fatality risk, AIFR



- Risk distribution across all potential code-conforming buildings
  - Should roughly fall between 10^{-6} and 10^{-5}
  - Majority should be well below 10^{-5}

Risk assessment methodology

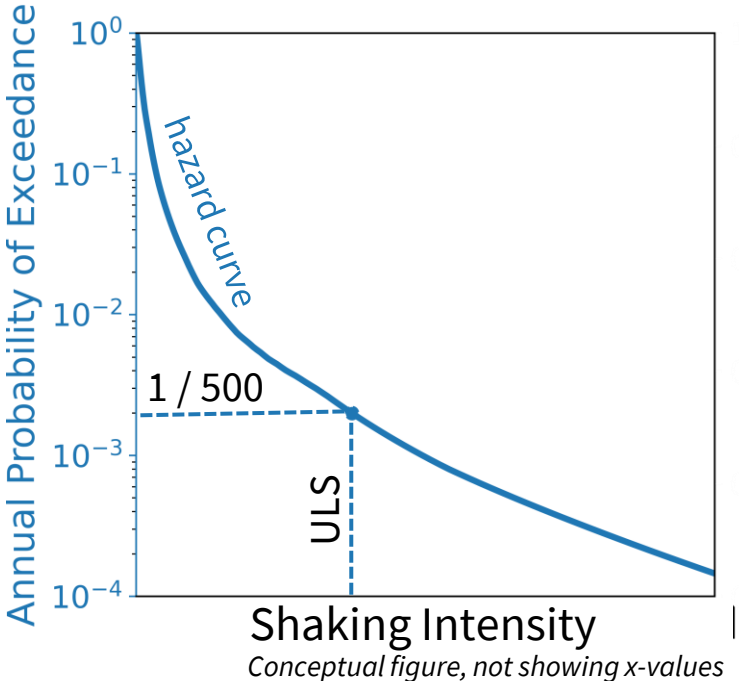
Quantifying the shaking hazard



Site's shaking hazard

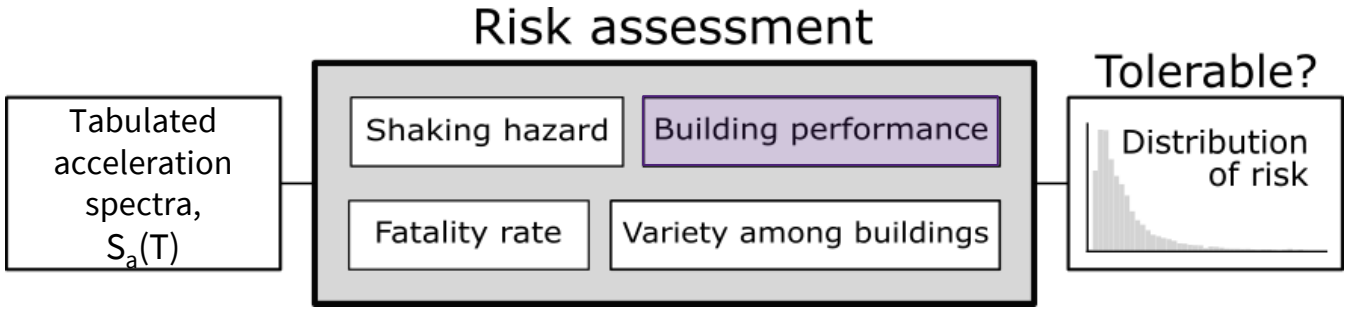
Provided by the NSHM

Probability of shaking for all intensities

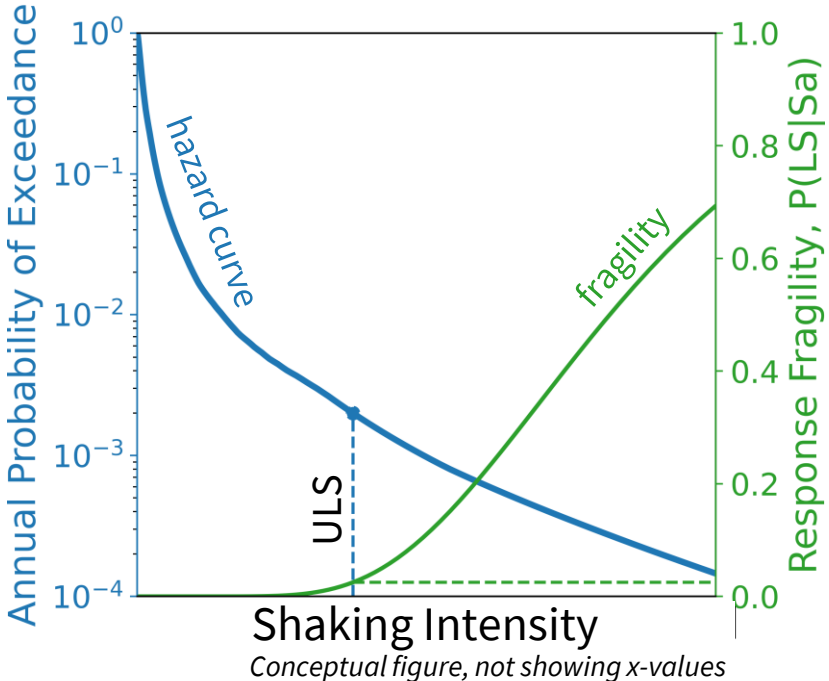


Conceptual figure, not showing x-values

Quantifying the building performance



Site's shaking hazard



Conceptual figure, not showing x-values

Probability of exceeding a limit state, LS

Fragility is linked to the design $S_a(T)$ (ULS)

Probability increases with intensity, steepness defined by uncertainty

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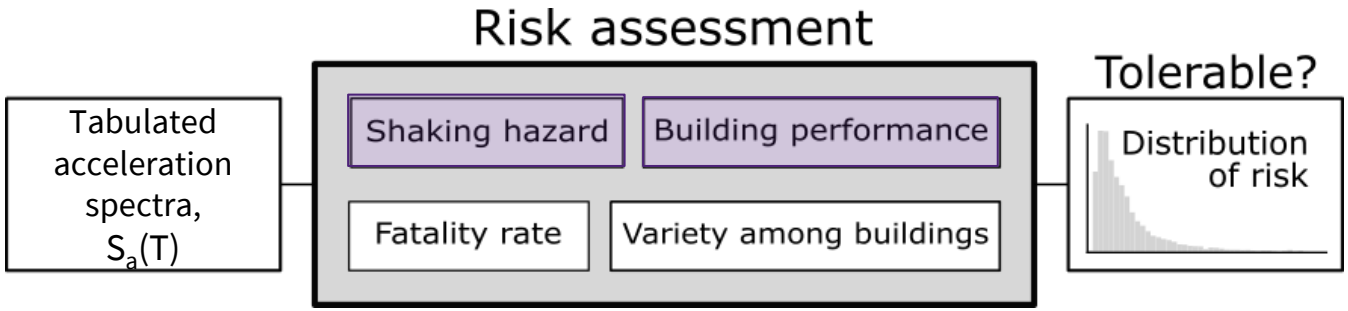
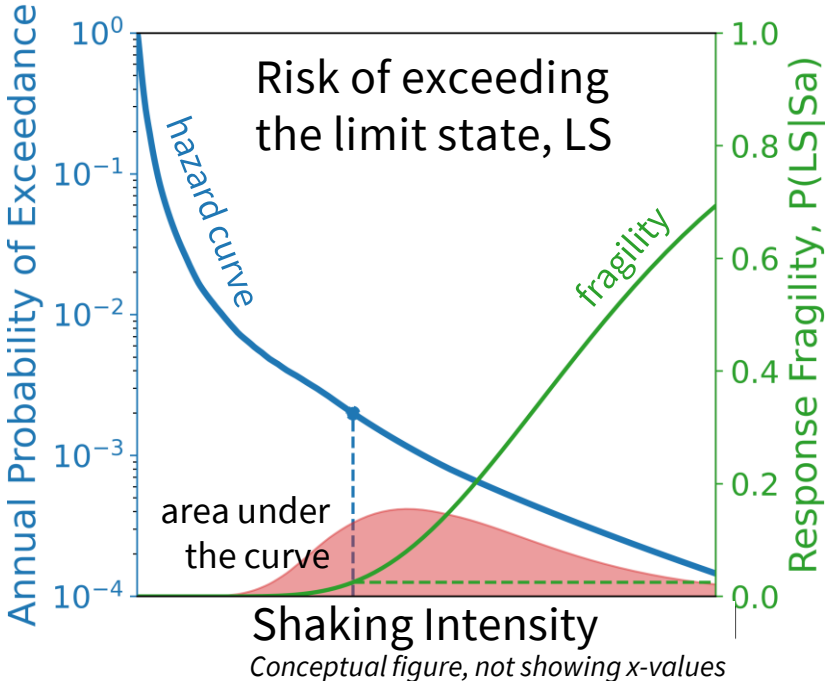
Risk calculation



Site's shaking hazard



Conceptual figure, not showing x-values

Probability of exceeding a limit state, LS

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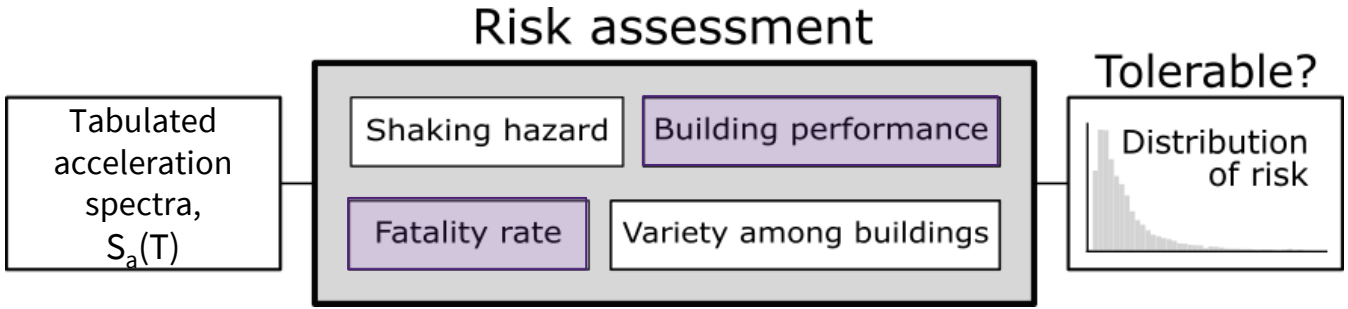
Linking fatalities to building performance



Majority of building-related deaths and serious injuries are caused by structural collapse (Horspool et al. 2020)

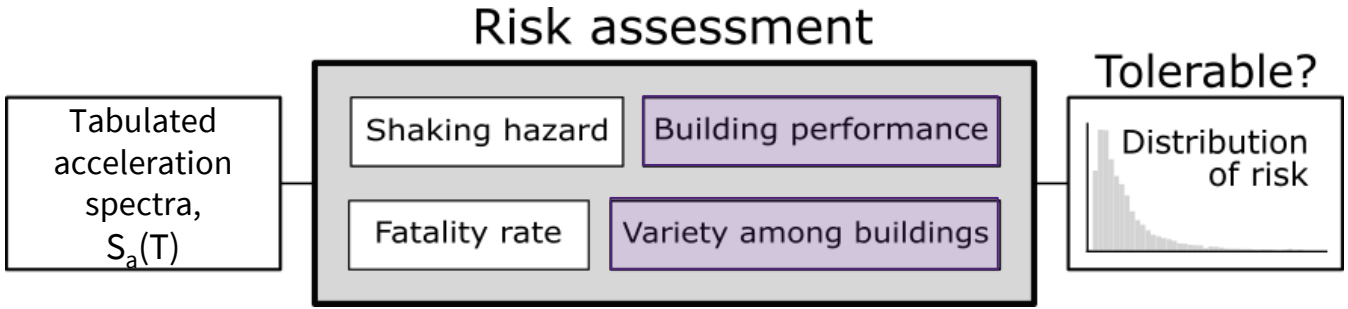
↳ building performance limit state = collapse

Rate of fatality given collapse

- Variable, depending on type of collapse
- Often taken as P(fatality|collapse)=10% (e.g. Silva et al. 2016, Horspool et al. 2023)

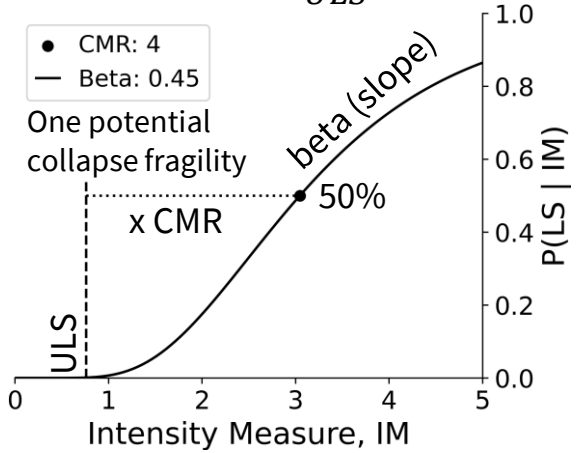
  ↳ annual collapse risk of 5×10^{-5} becomes AIFR of 5×10^{-6}

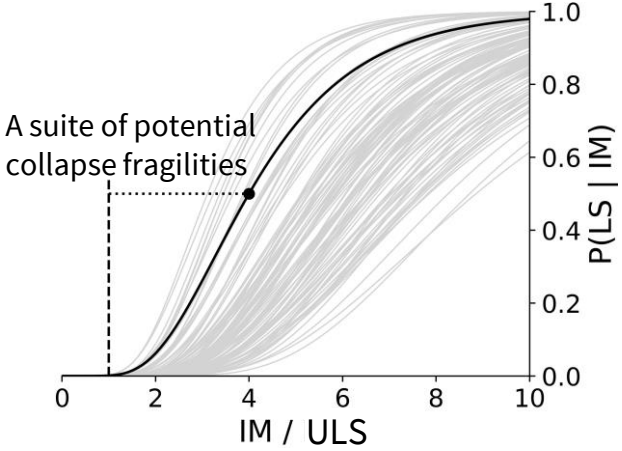
Including variability in building performance

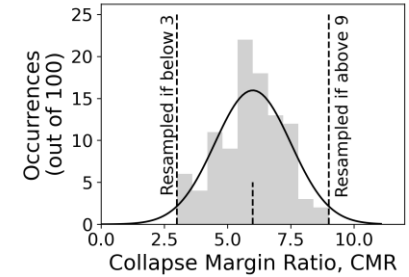


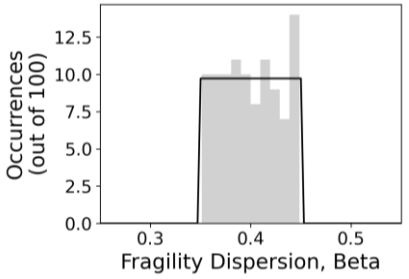
Collapse Margin Ratio,

$$\text{CMR} = \frac{IM_{P(C|IM)=50\%}}{ULS}$$









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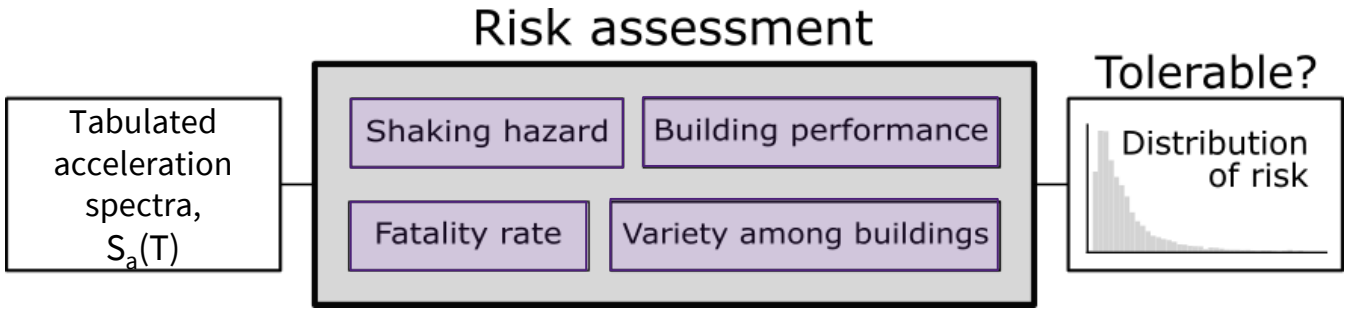
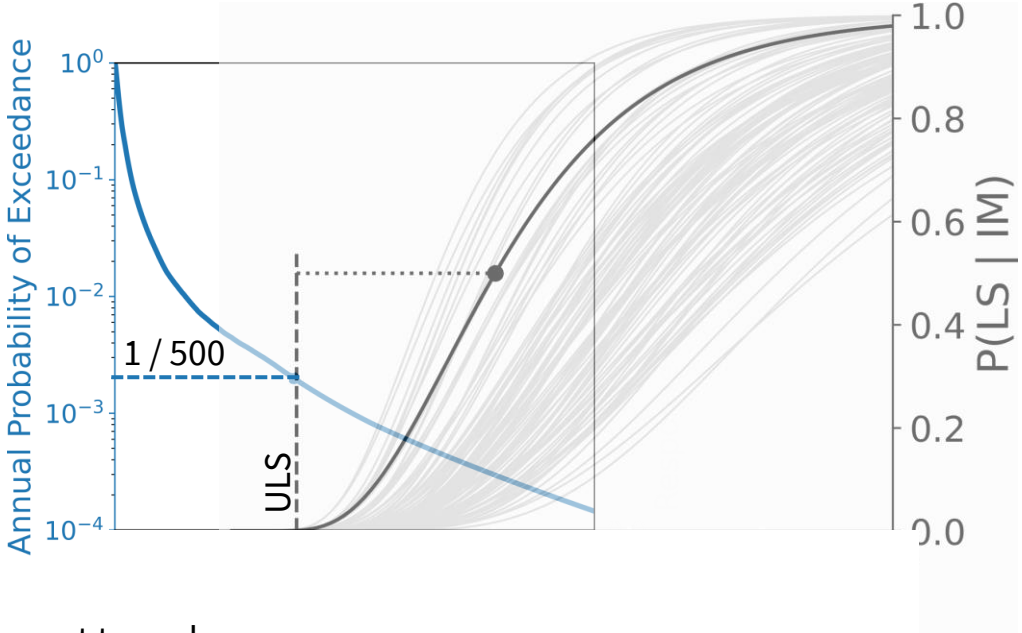
Computing fatality risk for all buildings





Each fragility produces a different risk value

Distribution of risk values can be plotted as a histogram

* Figures are not to scale

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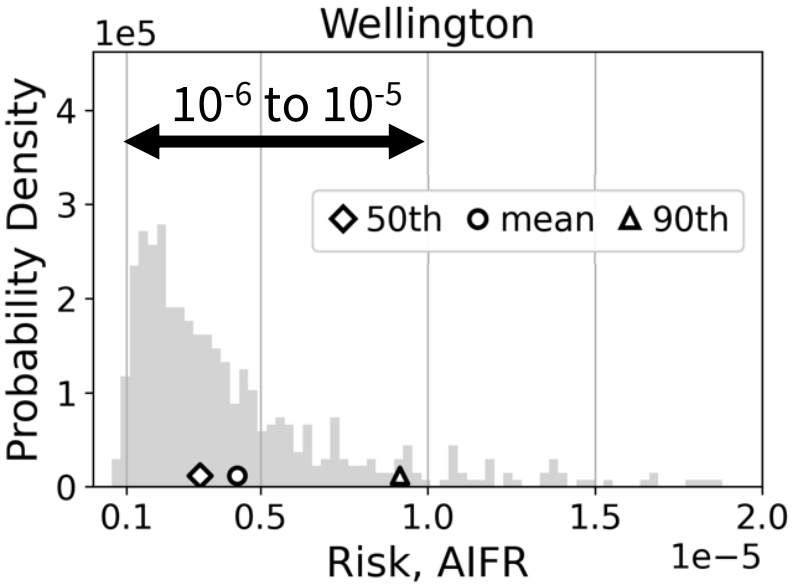
Fatality risk distribution

- Expected distribution of risk among code-conforming buildings
  - Less than 10% extends beyond $1x10^{-5}$
  - Majority is below $0.5x10^{-5}$

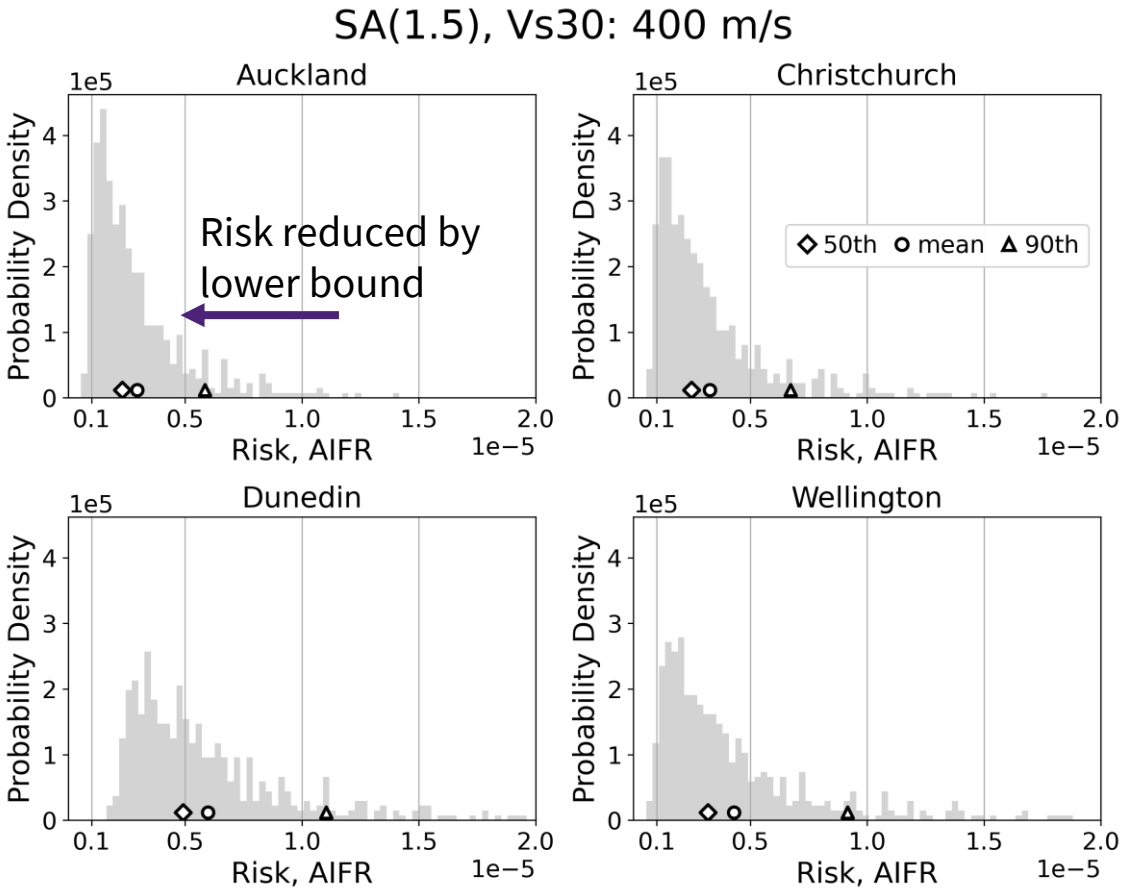


T = 1.5 seconds

V_{s30} = 400 m/s

S_a(T) for ULS: annual probability of exceedance of 1/500

Fatality risk by location



- T = 1.5 seconds
- Vs30 = 400 m/s
- $S_a(T)$: uniform hazard for an annual probability of exceedance of 1/500
- Auckland uses the APoE of 1/500 from the 90th percentile hazard (lower bound that controls in lower hazard)

Conclusion

- Risk is assessed/evaluated after the preliminary $S_a(T)$ development.
- Risk computation includes hazard, building collapse performance, and the likelihood of fatality given collapse
- Risk distribution considers a range of risk across code-conforming buildings
- Majority of risk associated with the ULS Sa(T) is within 10^{-6} to 10^{-5}