BUILDING PERFORMANCE

# Shaken, not stirred:
## *Seismic hazards in New Zealand and how we manage them*

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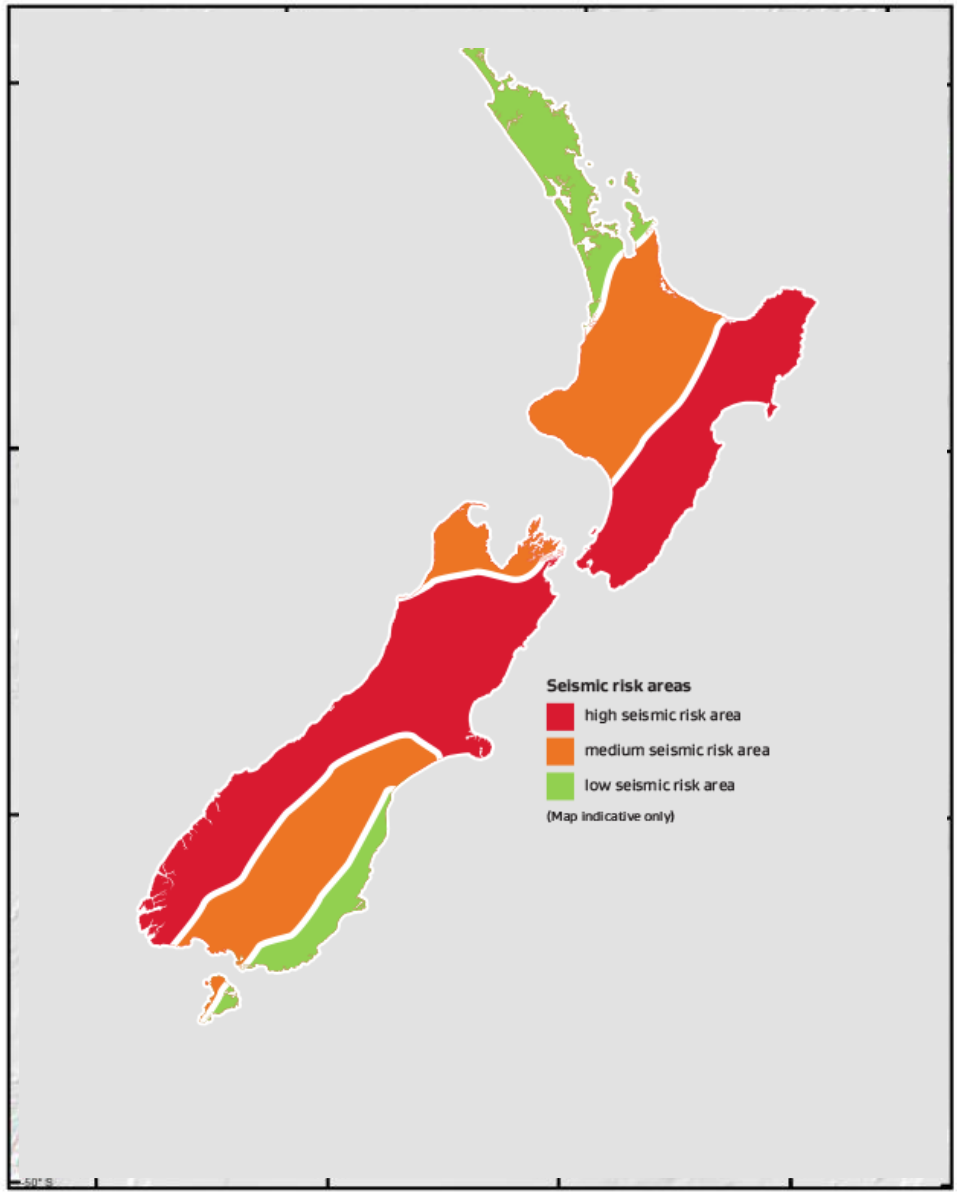
MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

New Zealand Government

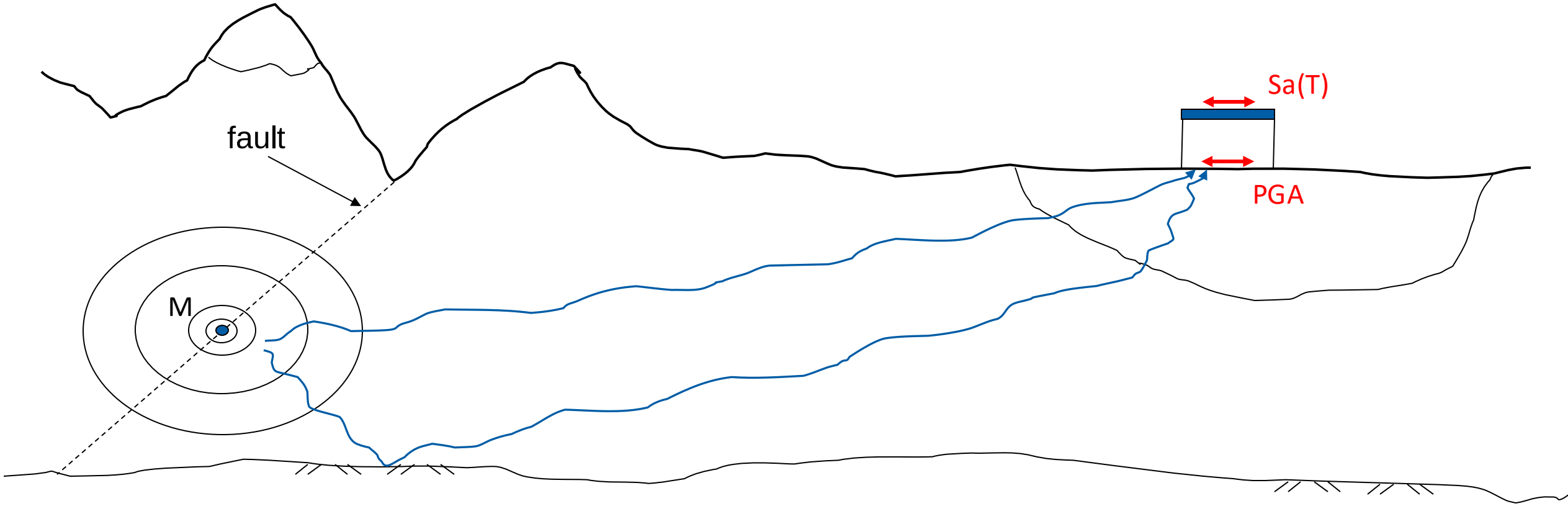
# The Shaky Isles

- We have lots of faults!
- Building Act Seismic Risk Areas:
  - ~~Low~~
  - Medium
  - High

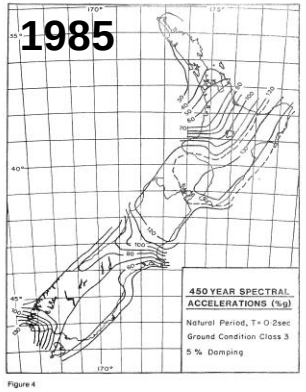
LOWER!

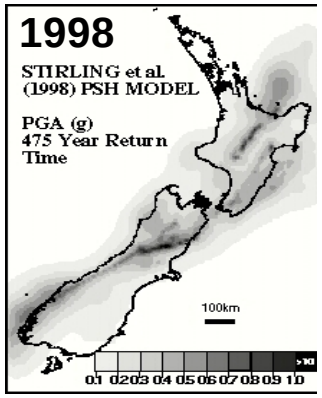



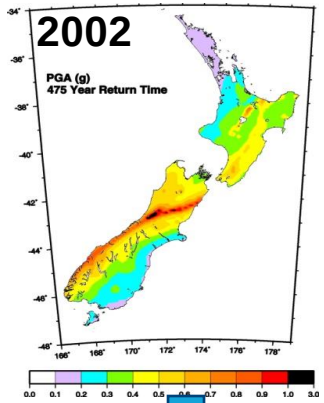
# The National Seismic Hazard Model (NSHM) produces forecasts of ground shaking

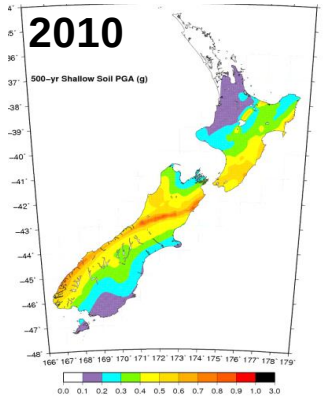


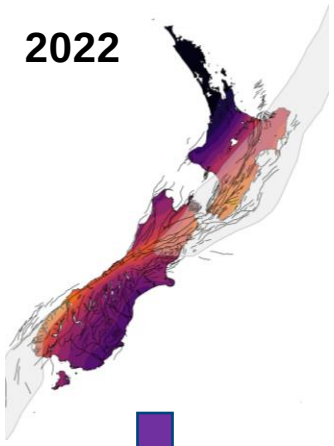
# A revision was long overdue




**NZS 1170.5:2004**

**Draft TS 1170.5:20XX**

**1998:** last major methodological revision

**2002:** minor update to rupture modelling

**2010:** data update for rupture modelling (method change for distributed seismicity)

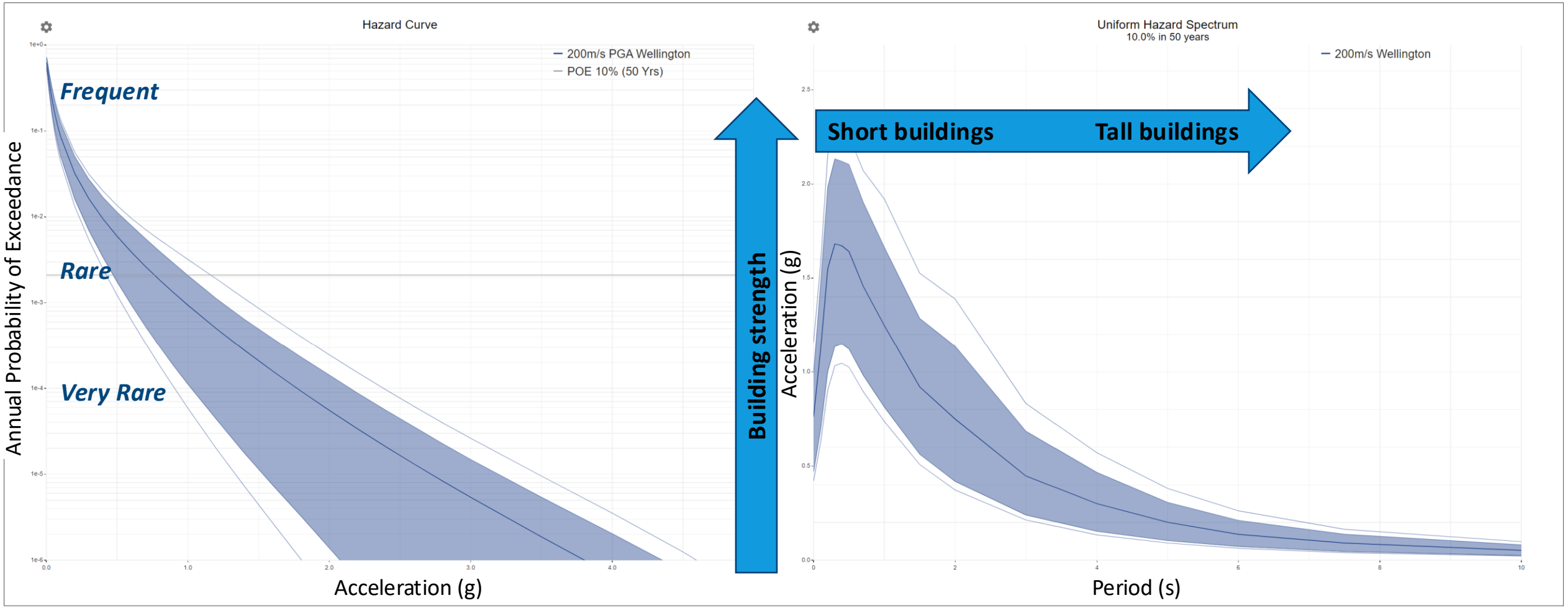
Significant changes in hazard were anticipated based on preliminary work done around the globe on New Zealand hazard

NSHM Site Hazard Hazard Maps Coming Features Resources Help

GNS SCIENCE TE PŪ AO

## Hazard Curves and Uniform Hazard Spectra

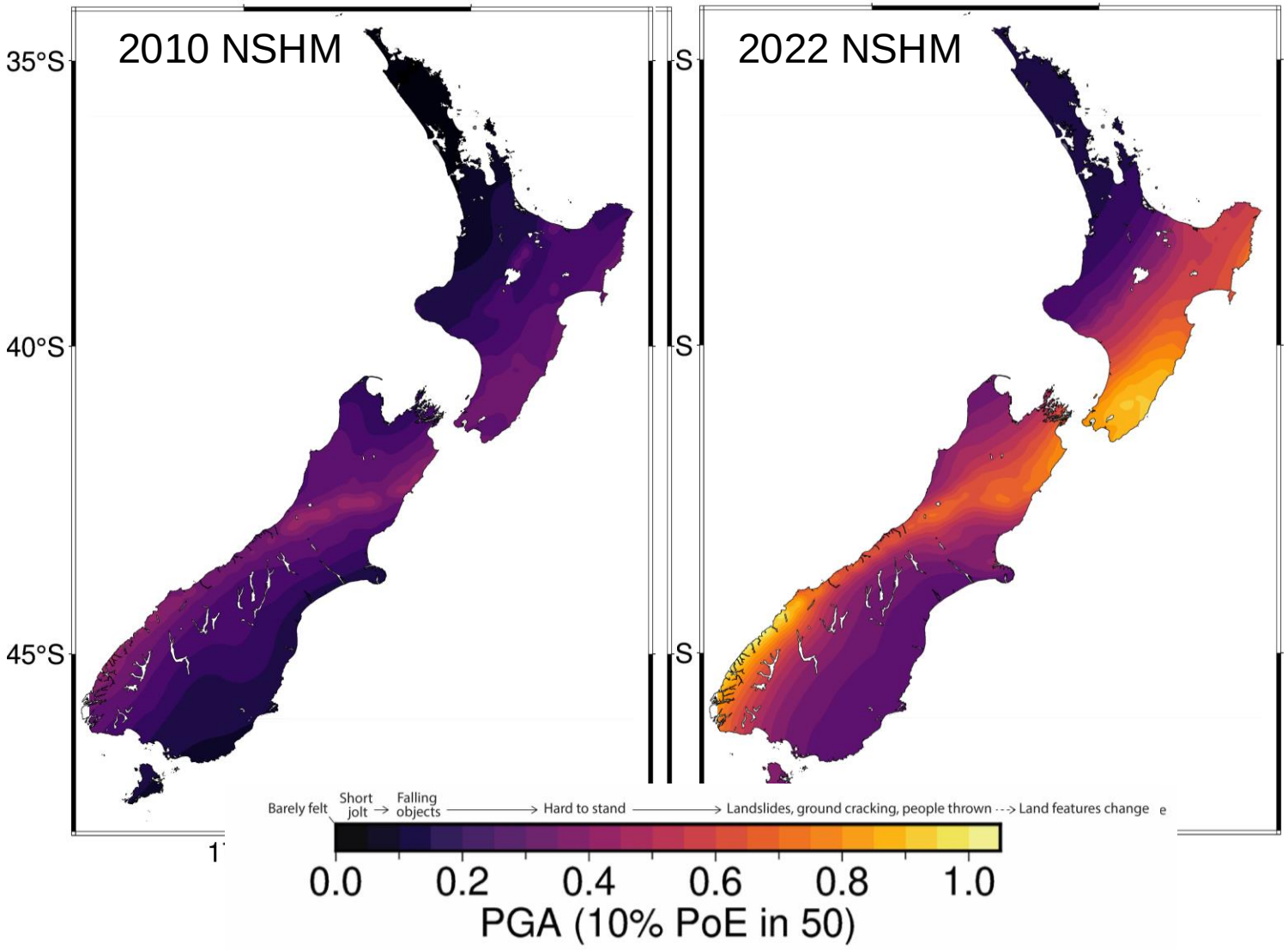
Locations: Wellington | Coordinates (lat, lon) | Vs30 (m/s): 200 | Spectral Period: PGA | Probability of Exceedance (50 Yrs): 10 % | SUBMIT




https://nshm.gns.cri.nz/

# Comparison of 2010 and 2022 PGA *Hazard* Maps

PGA: 10% Probability of Exceedance in 50 years

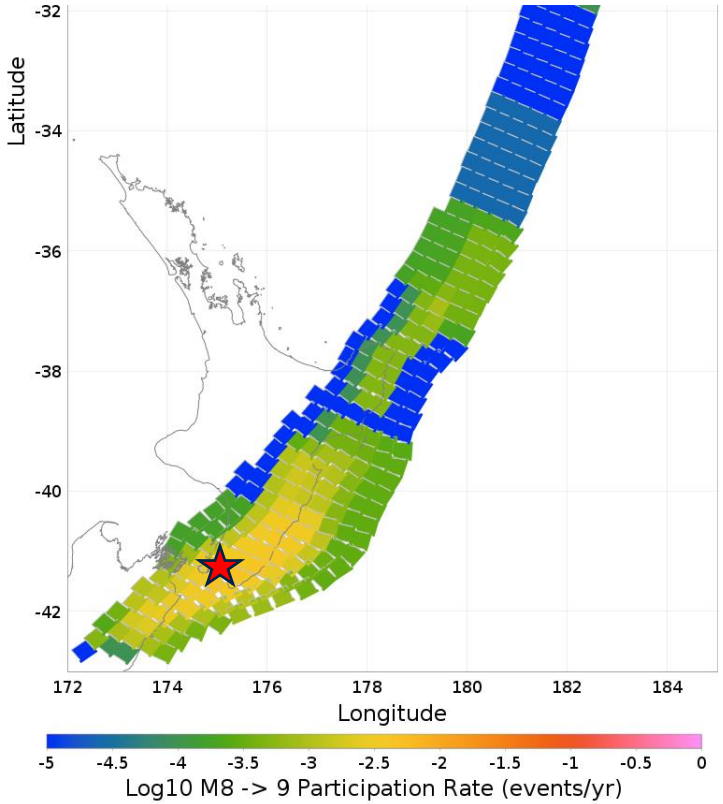



Across all hazard parameters a range from no increase to more than double is seen. **Average increase is about 50% or more.**

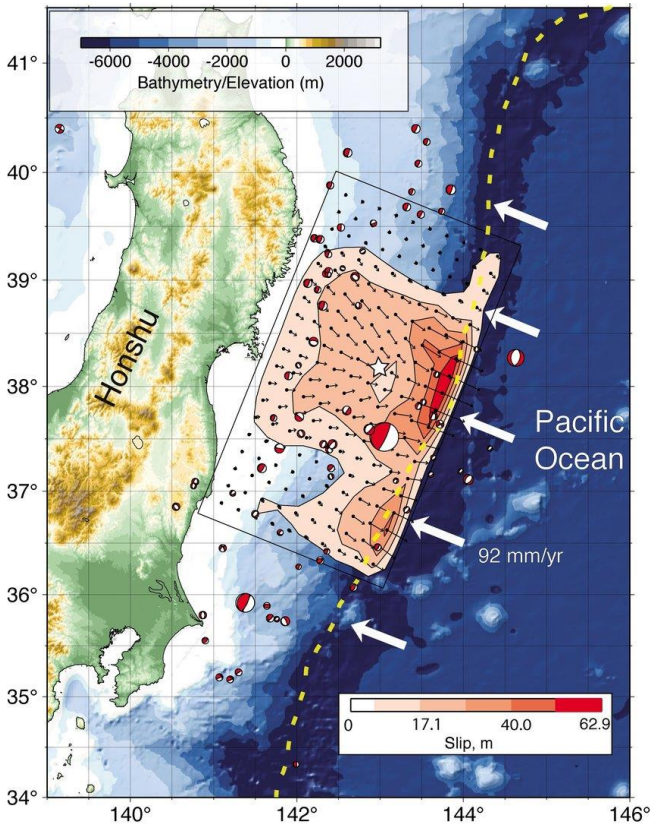
GNS, 2022

# Hikurangi Subduction Zone

## New Zealand




## Japan




*Lay et al 2011*

# NZS 1170.5:2004 being updated in two stages

- NZS1170.5:2004 is used to determine the seismic loads for design of new buildings.
- Stage 1: Minimum Viable Product
  *"immediate work required to enable the output of the NSHM … to be integrated into the existing framework, as soon as and in the simplest way possible"*

  **→ Draft TS 1170.5**

- Stage 2: Further updates to design and analysis provisions
  *"to develop a seismic design approach for buildings which provides better outcomes for society from our built environment in earthquakes, recognising cost and sustainability"*

# Draft TS 1170.5

- Released for public comment in Feb 2024
- 700+ public comments!
- All comments are being considered by TS Committee
- Premature to estimate a publication date for TS 1170.5
- Cost-Benefit Analysis is underway
- When published, TS1170.5 can be used via Alternative Solution.

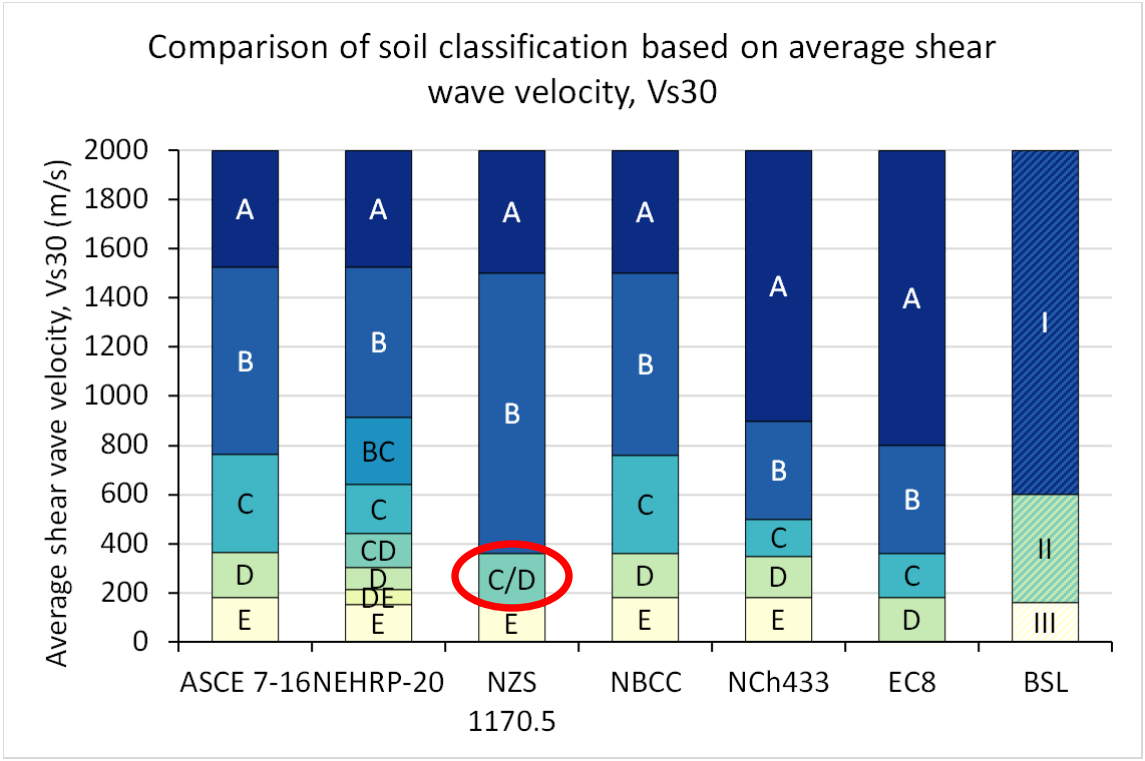
# Technical Specification (TS) 1170.5 Updates

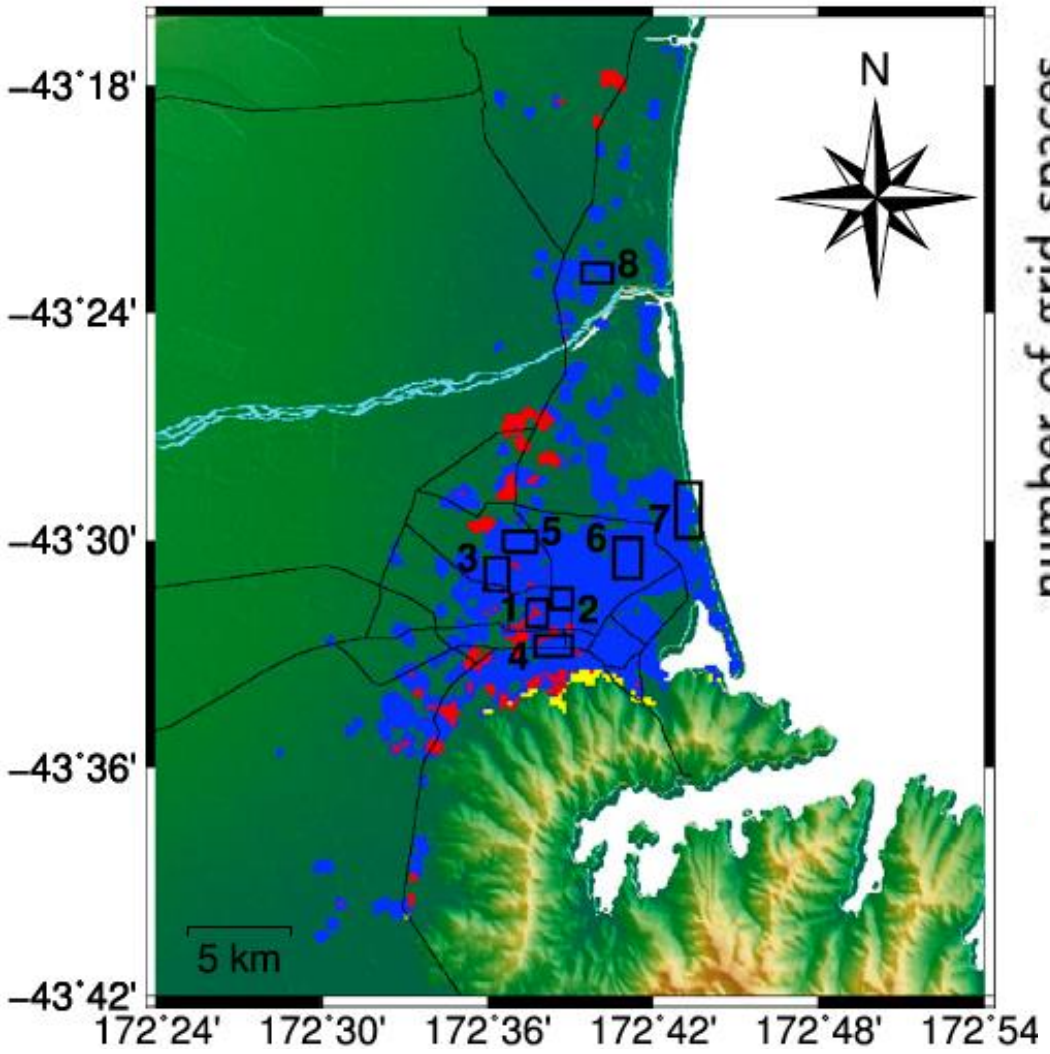
- Reflect new knowledge from NSHM
- Key components:
  - Elastic design spectrum:
    - **New site class definitions (based on $V_{s(30)}$)**
    - **New shape of elastic spectrum**
    - Estimation of fatality risk for new design spectra
  - Mitigate impacts of new spectra:
    - $k_\mu$ for short period structures
    - Rocking foundations provisions for simple structures
    - New Parts and Components provisions

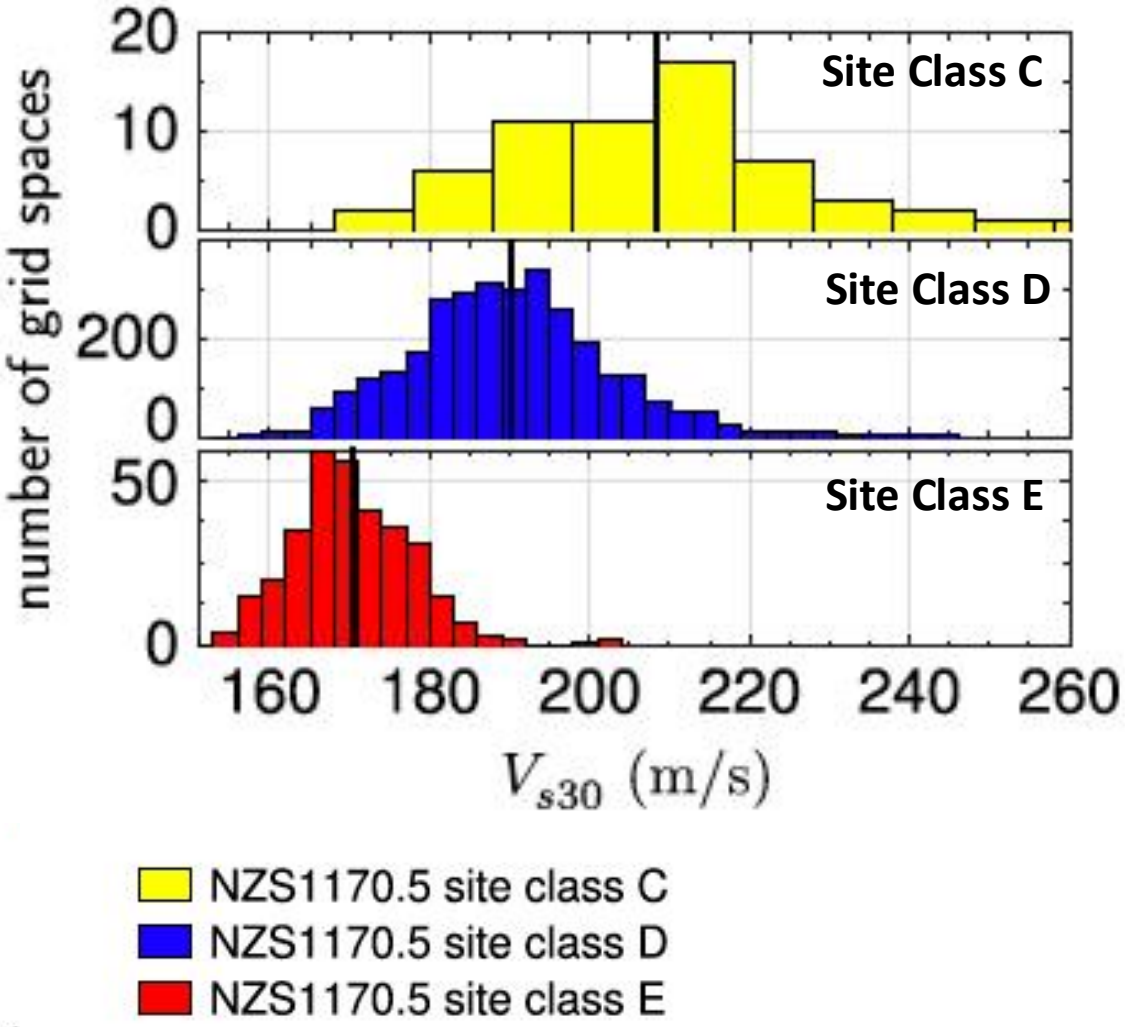
# Site Classification - $V_{s(30)}$

$$V_{s(30)} = \frac{\sum_{i=1}^{n} h_i}{\sum_{i=1}^{n} \frac{h_i}{V_{si}}}$$

- Used by international standards
- Only parameter used by NSHM to reflect site effects
  - Used in all Ground Motion Models
- Single measurable parameter **approximately** reflecting:
  - Initial soil stiffness
  - Site period (in some cases)
  - Macro differences in the site response characteristics






McGann et al., 2017

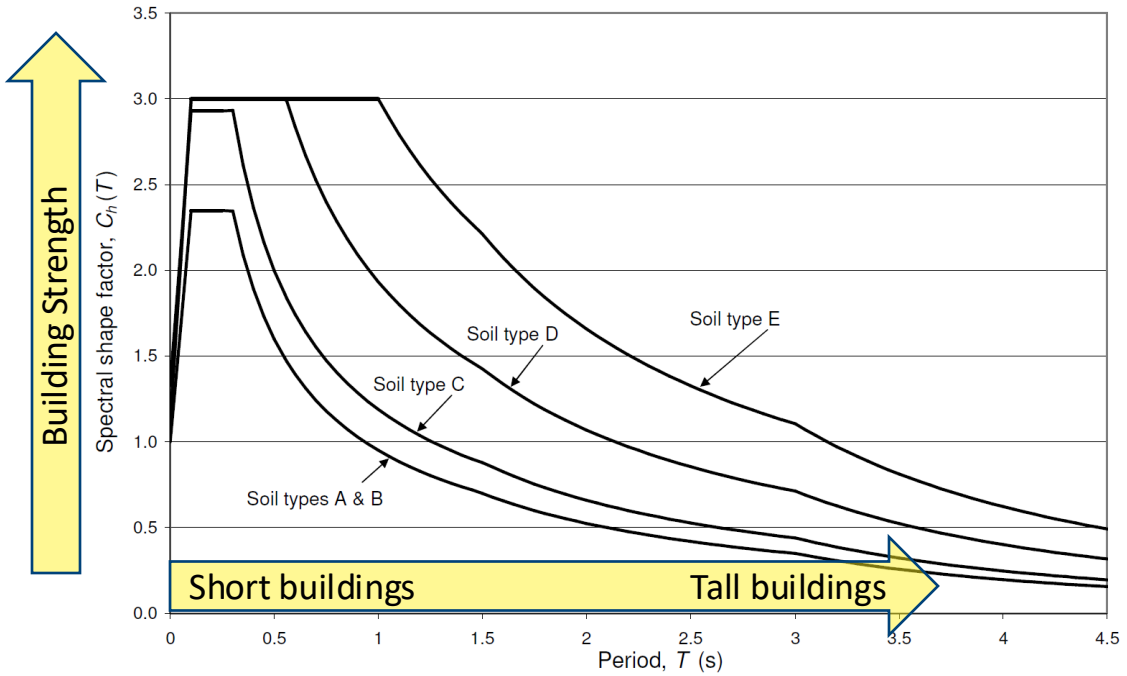
# Site Classification

$V_{s(30)}$ = time-averaged shear wave velocity from the ground surface to 30 m depth

| Site Class | Description | $V_{s(30)}$ range | Characteristic $V_{s(30)}$ value |
|---|---|---|---|
| I | Rock | $V_{s(30)} > 750$ m/s | 750 m/s |
| II | Very dense soil or soft rock | $450 < V_{s(30)} \leq 750$ m/s | 525 m/s |
| III | Stiff soil | $300 < V_{s(30)} \leq 450$ m/s | 375 m/s |
| IV | Moderately stiff soil | $250 < V_{s(30)} \leq 300$ m/s | 275 m/s |
| V | Soft or deep soil | $200 < V_{s(30)} \leq 250$ m/s | 225 m/s |
| VI | Very soft or deep soil | $150 < V_{s(30)} \leq 200$ m/s | 175 m/s |
| VII | Very soft or deep soil requiring site response analysis | $V_{s(30)} \leq 150$ m/s | - |

# Shape of spectrum

**NZS 1170.5:2004**

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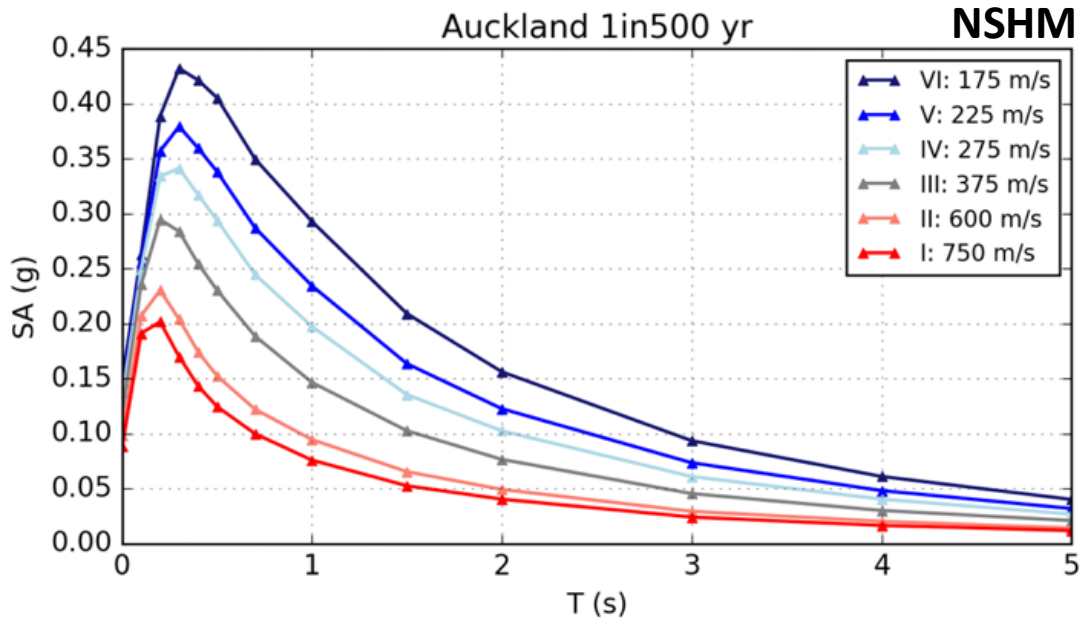
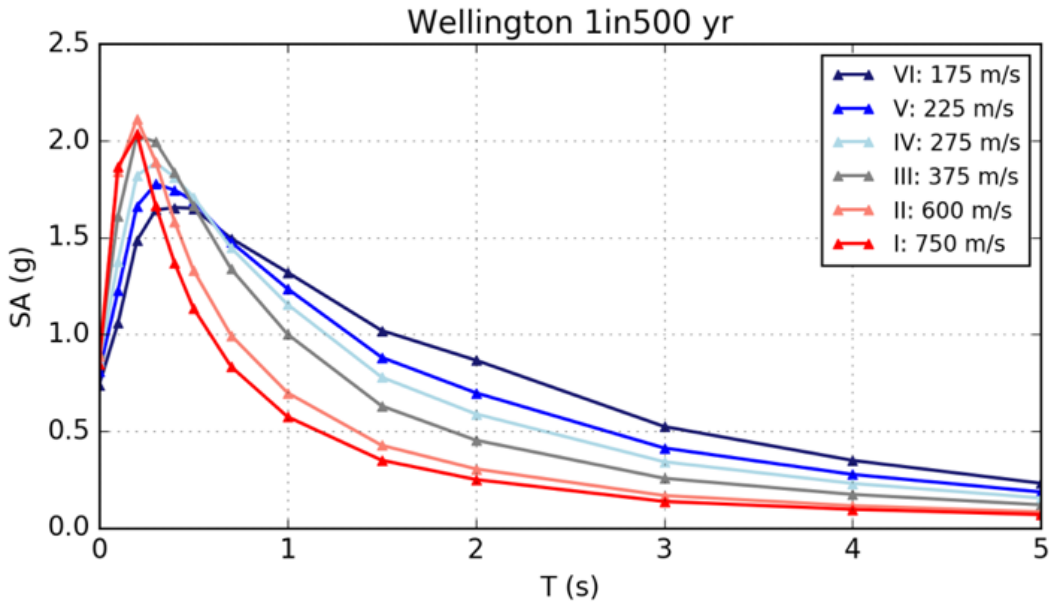
**NSHM**

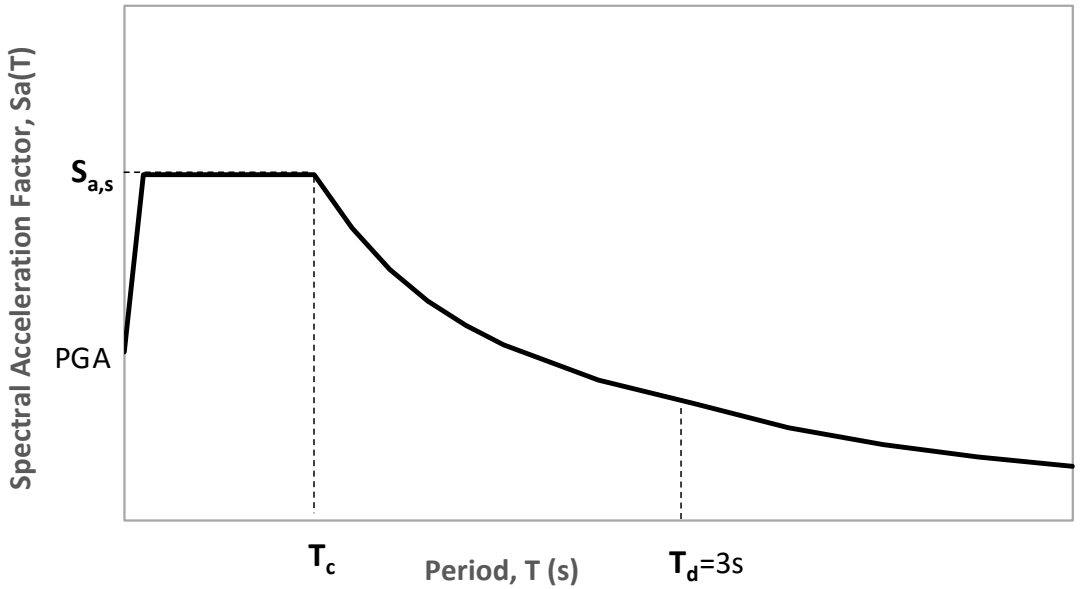


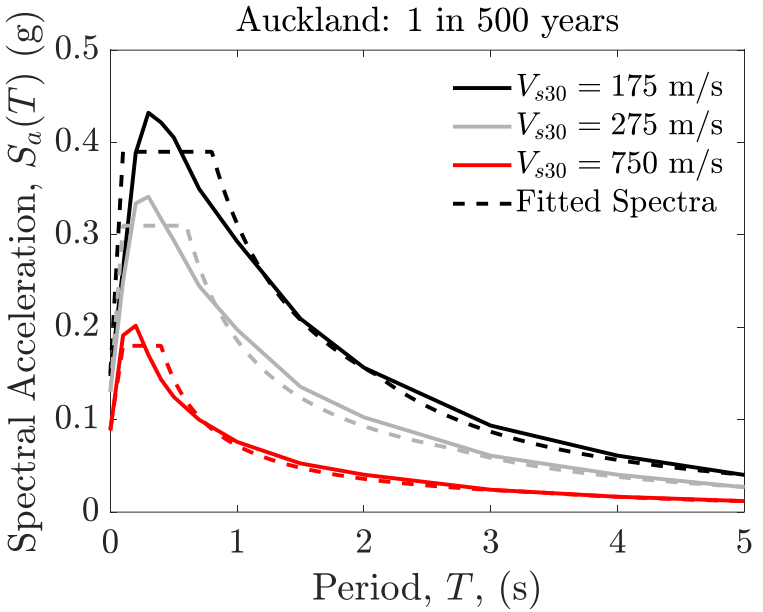



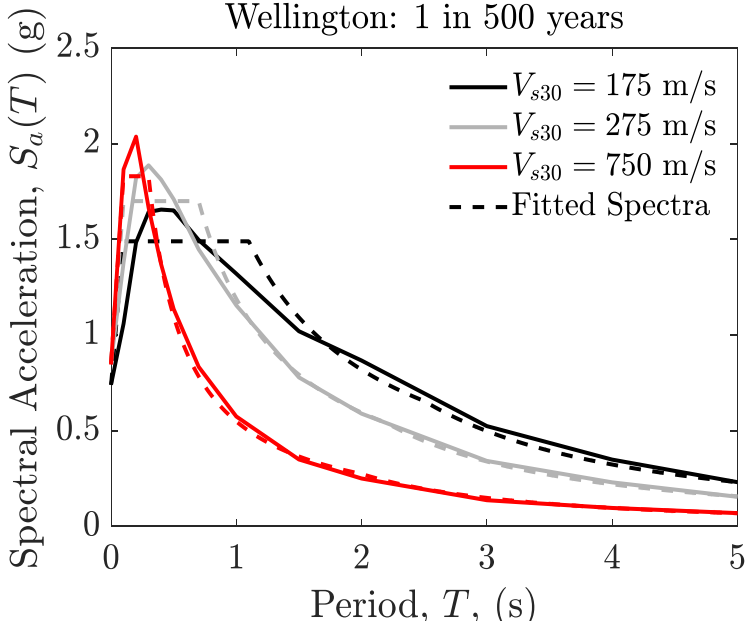
# Shape of Spectrum

Specified for each location, site class, and return period:

- PGA
- $S_{a,s}$
- $T_c$



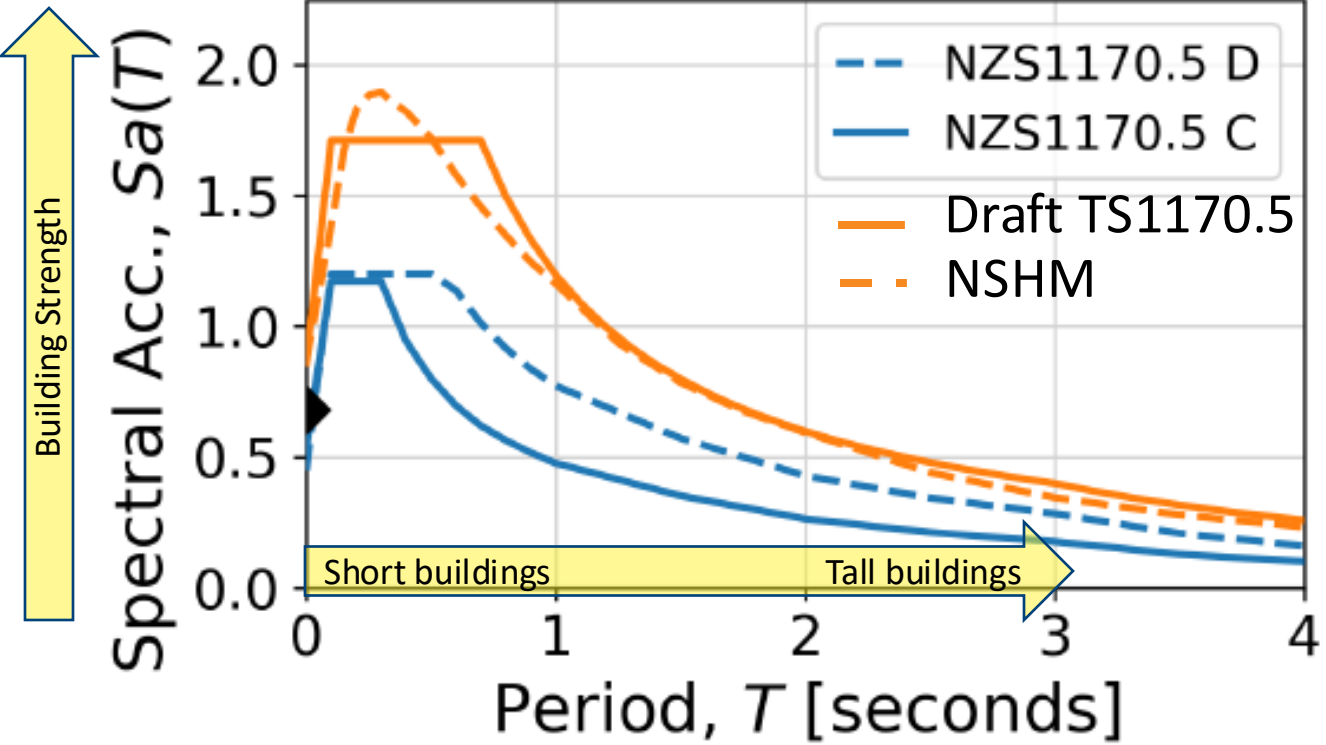



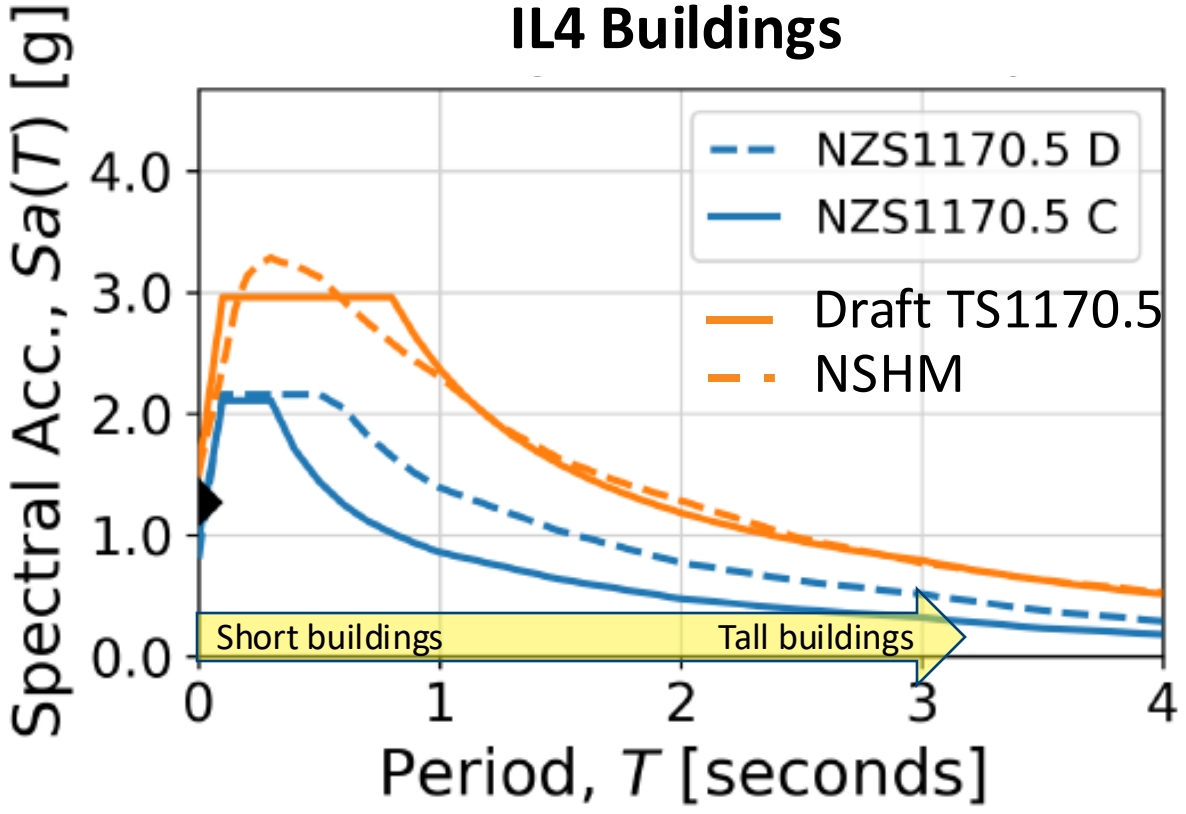

Sullivan et al, 2022

# Wellington Example Site ($V_{s(30)}$=275 m/s)

## 1/500 Annual Prob of Exceedance IL2 Buildings




## 1/2500 Annual Prob of Exceedance IL4 Buildings



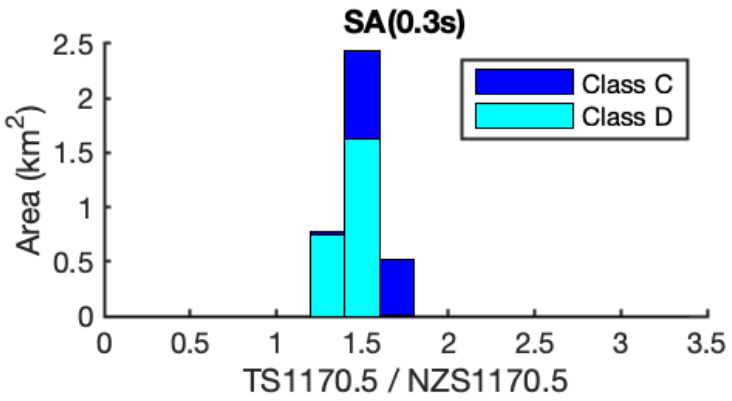
# Ratio of NZS1170.5:2004 to TS1170.5 for Wellington CBD

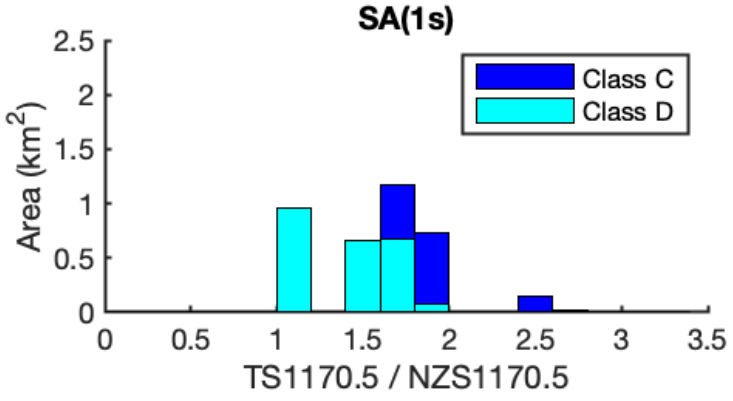
IL2 Buildings (1/500)

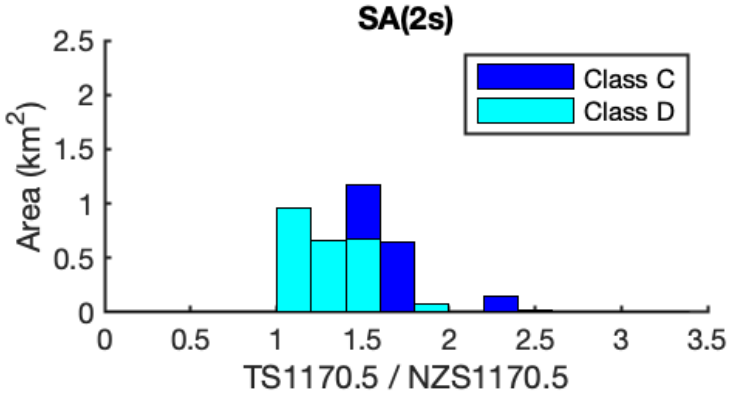

Short (1-2 storey) buildings

Midrise buildings

Highrise buildings

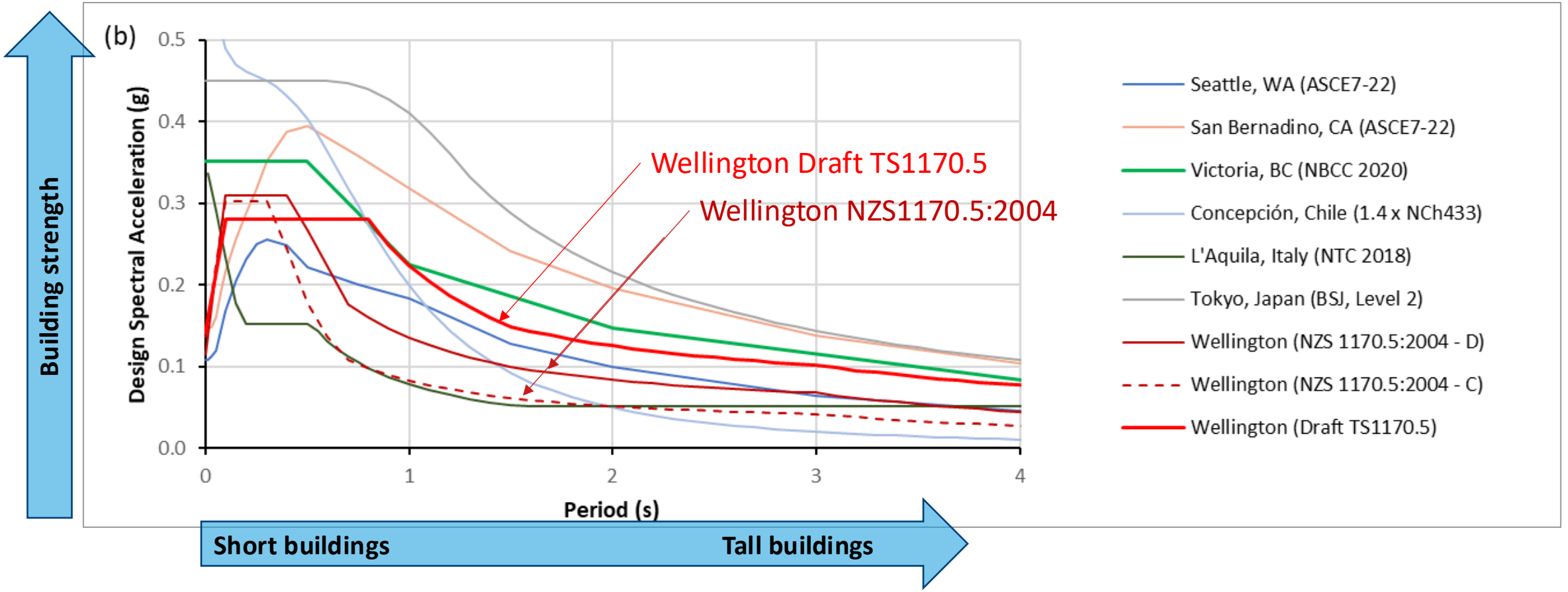


# International comparators

Example design forces for ductile concrete shear wall buildings on soft sites ($V_{s30}$=225 m/s)



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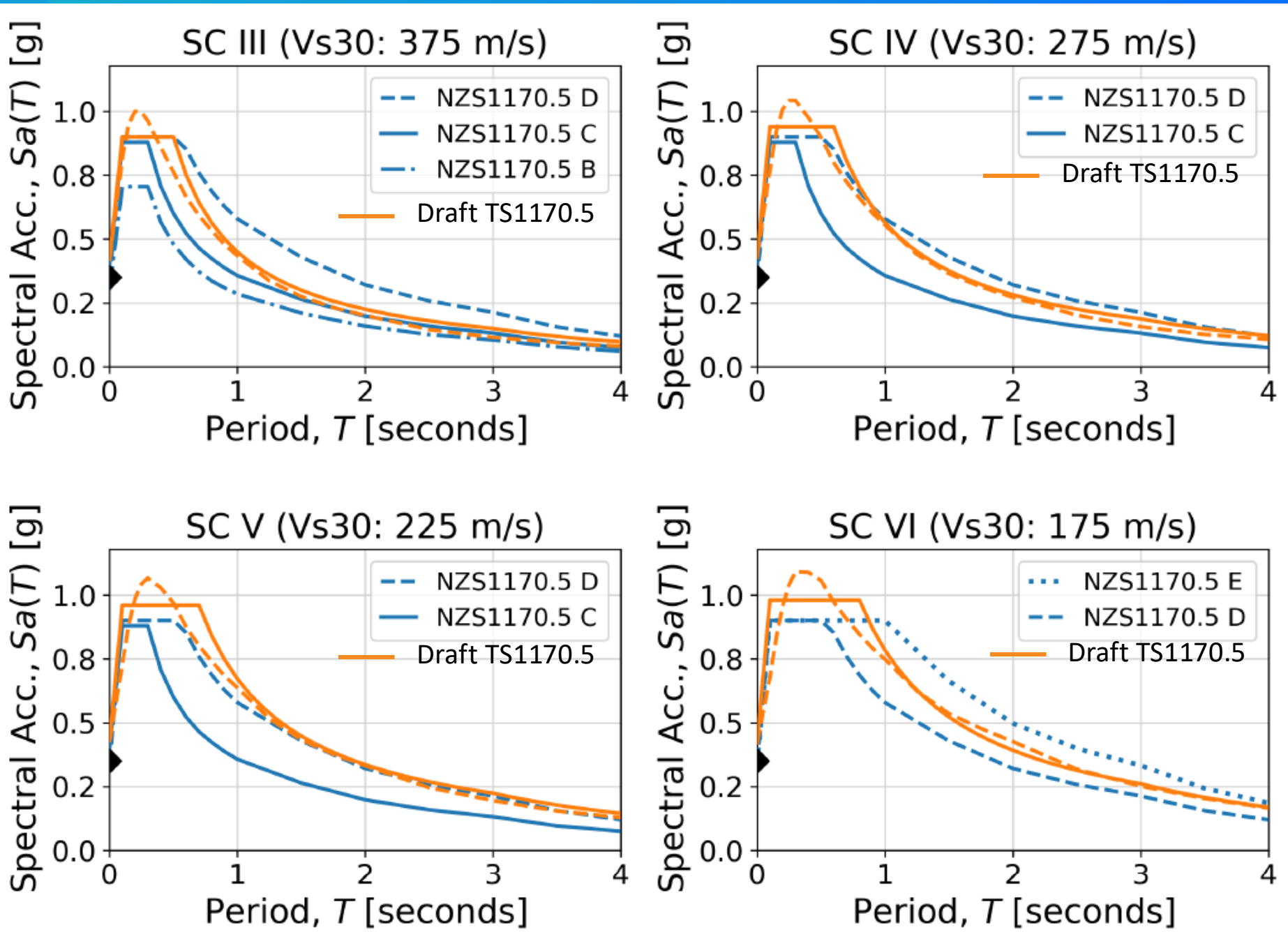
# Christchurch IL2 ULS



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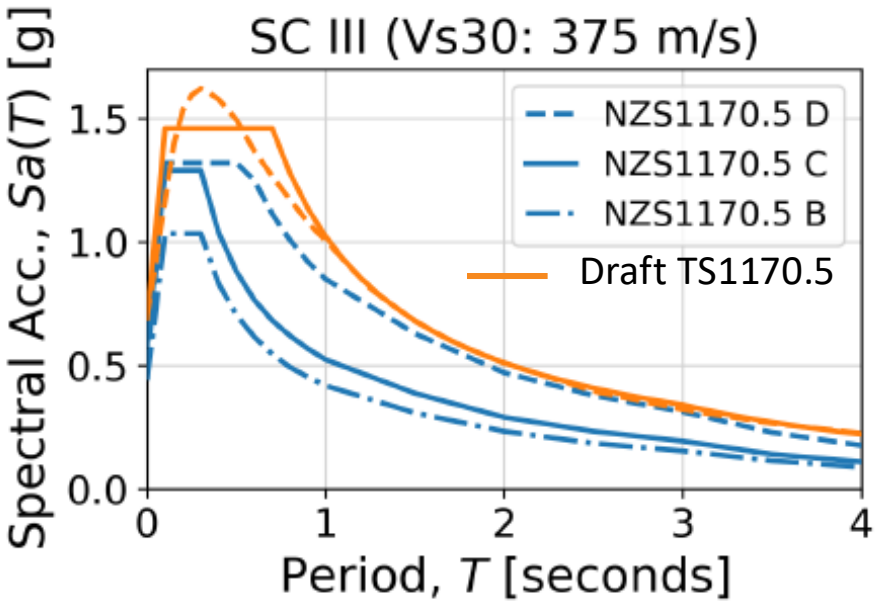
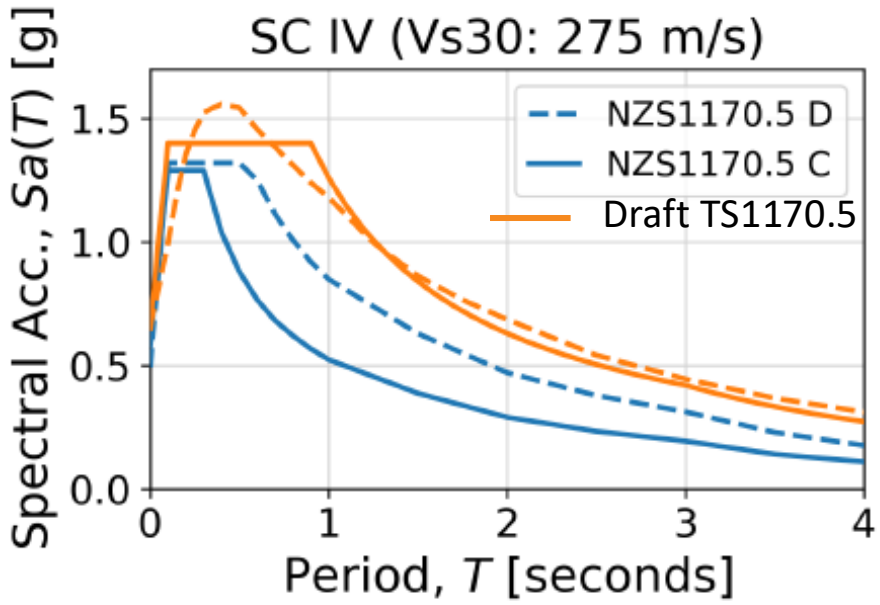
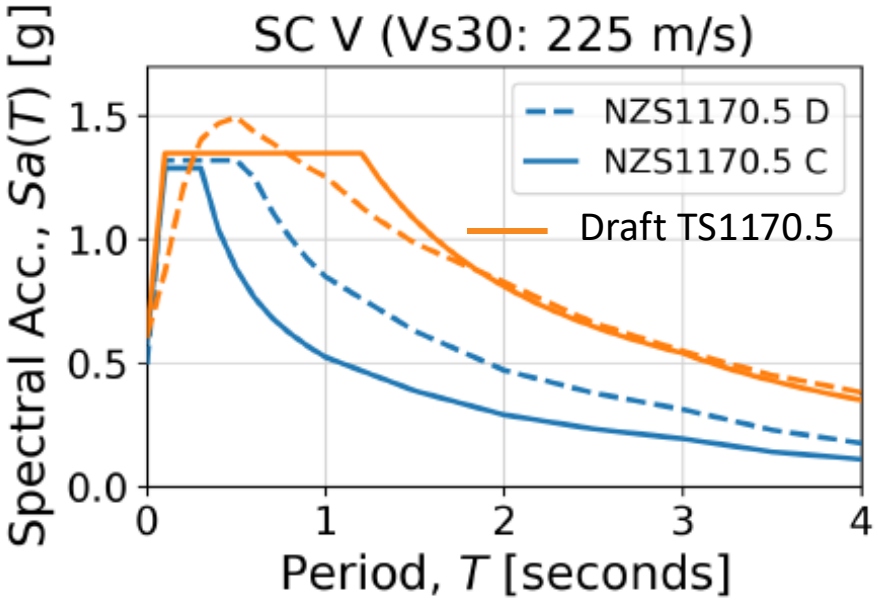
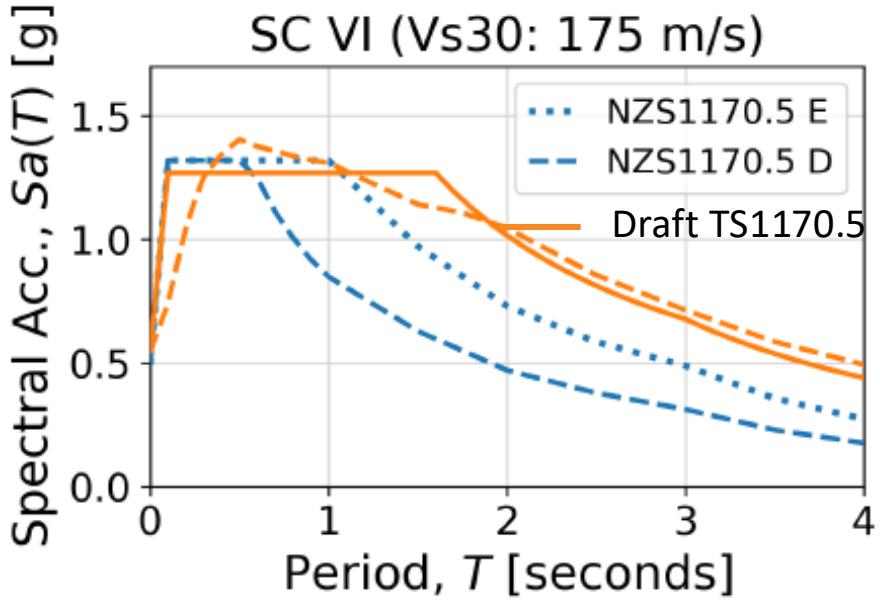
# Franz Joseph IL2 ULS



# NZS 1170.5 being updated in two stages

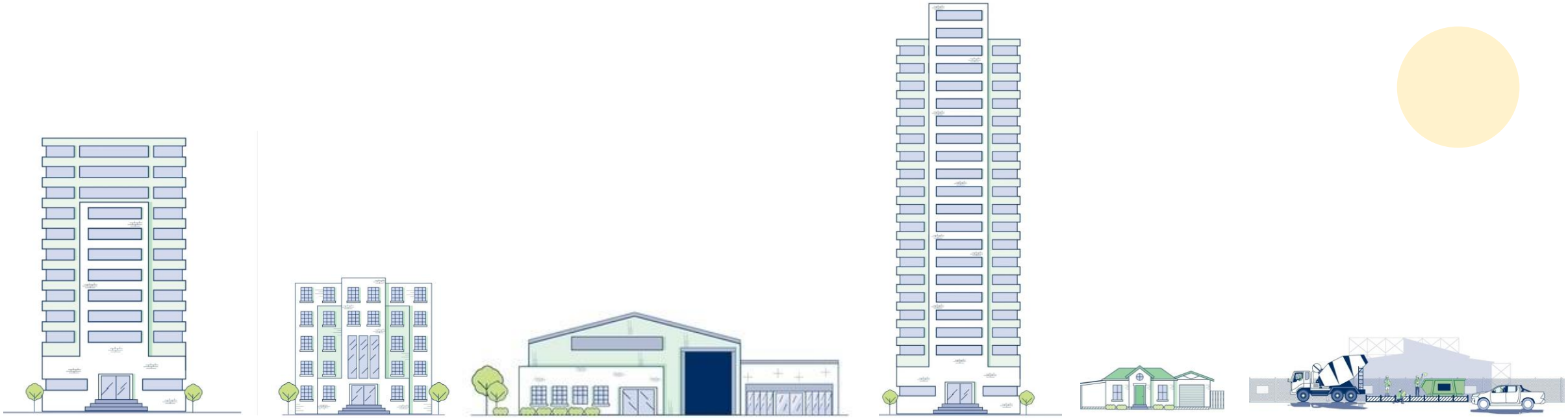
- NZS1170.5:2004 is used to determine the seismic loads for design of new buildings.
- Stage 1: Minimum Viable Product
  *"immediate work required to enable the output of the NSHM … to be integrated into the existing framework, as soon as and in the simplest way possible"*
  → **Draft TS 1170.5**

- **Stage 2: Further updates to design and analysis provisions**
  *"to develop a seismic design approach for buildings which provides better outcomes for society from our built environment in earthquakes, recognising cost and sustainability"*

# Key issues with current system being considered in Stage 2

- **Importance Level** structure confuses amenity and life safety performance objectives.
- **Design process** does not facilitate a focus on controlling damage in buildings.
- Critical role of **irregularities** in driving building damage is not fully recognised.
- **Analysis** provisions are out of date leading to uncertainty in estimated local demands and global response.
- Compliance framework does not adequately address **geotechnical considerations**.
- Inconsistent alignment between 1170.5 and **external standards**, including capacity design requirements.

# Seismic risk and the building regulatory system



<34%NBS life safety risk → 34-67%NBS and >67%NBS - economic, resilience, repair cost drivers → 100+%NBS

| Earthquake-prone buildings (pre-1976) | Existing buildings, mostly built after 1976 to previous performance standards | New and future buildings |
|---|---|---|
| *Seismic risk regulated through mandated upgrades* | *Seismic risk not regulated, but market forces drive building performance improvements* | *Seismic risk regulated through new standards cited in B1/VM1* |

# Existing building assessments

- For both earthquake-prone and non-earthquake-prone purposes:

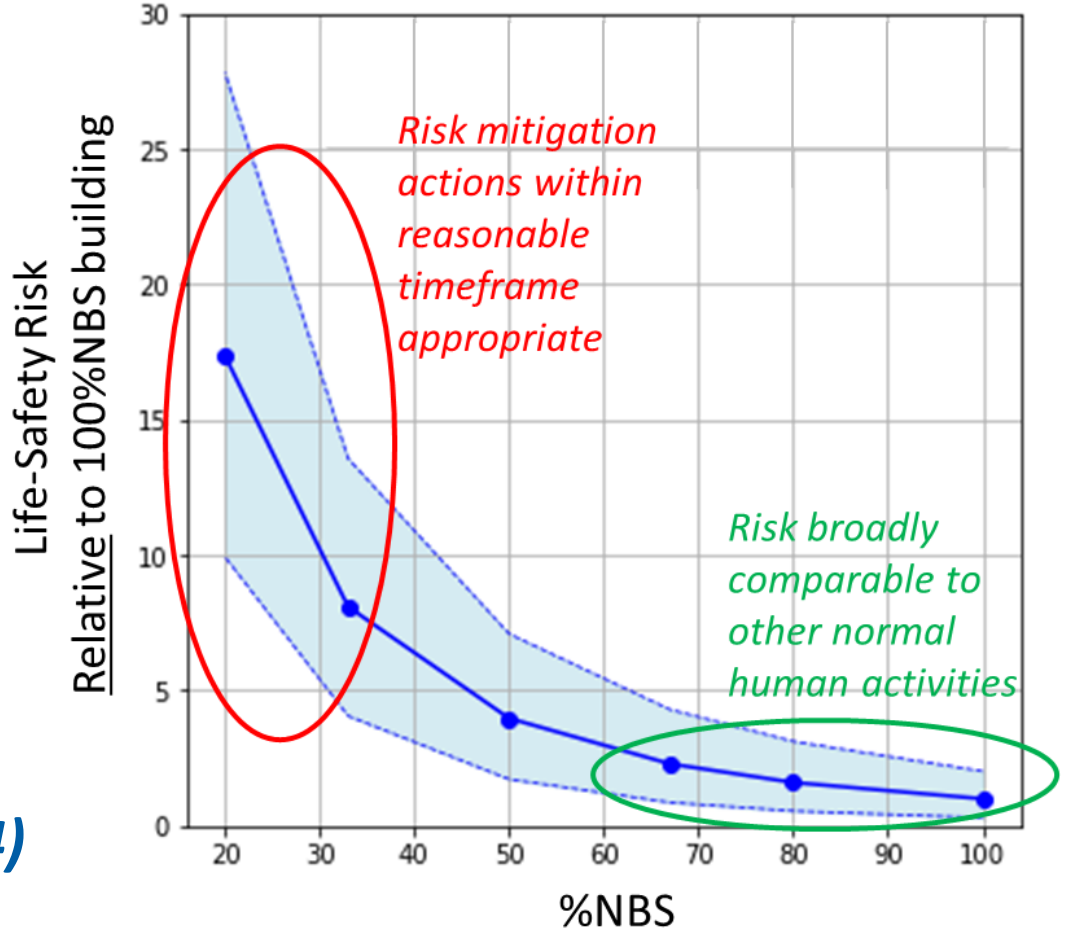
***Continue to use NZS1170.5:2004 and Geotech Module 1 (2016)***

  - Consistency of assessments between buildings and across time, supporting decision making related to asset and risk management.
  - Recommendation holds now and upon release of the new TS 1170.5.

# Guiding principles for seismic assessment

- Focus on identifying structural vulnerabilities and weaknesses
- Focus on the significant life-safety risks
- Turn energy to retrofit, where necessary
- Recognise benefits of relatively simple securing measures or mitigations, particularly at reducing risk from parts of buildings.

→ ***The existing framework (with NZS 1170.5:2004) can continue to be used for this purpose.***



# Key Takeaways

- **National Seismic Hazard Model (NSHM)** has improved out understanding of seismic hazards in New Zealand
    - Typically, higher seismic hazard than predicted by previous models
- **New Technical Specification (TS1170.5)** has been developed to help engineers consider implications of NSHM on design of new buildings
    - Expect to be published later this year
    - Further work ongoing in Stage 2
- For **%NBS**, continue to use NZS 1170.5:2004

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# Thank you!

*Questions?*