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Te Herenga Mātai Pūkaha

Near real-time building impact tool

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Max T. Stephens, Lecturer

QuakeCoRE
NZ Centre for Earthquake Resilience
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RESILIENCE TO NATURE'S CHALLENGES

Kia manawaroa – Ngā Ākina o Te Ao Tūroa

National SCIENCE Challenges

Earthquake Losses

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Recent events have resulted in large economic losses and disruption

Kaikōura Earthquake – M7.8 >200km from Wellington, New Zealand

10% of commercial space in CBD was closed, 20 demolitions

NEW ZEALAND (/NEWS/NATIONAL) / KAIKŌURA EARTHQUAKE (/NEWS/KAIKOURA-EARTHQUAKE)

New round of earthquake checks ordered for 80 Wellington buildings

8:10 am on 20 December 2016

Anne Gibson
Property editor of the NZ Herald

rter

Revealed: 16 Wellington blocks shut by quake

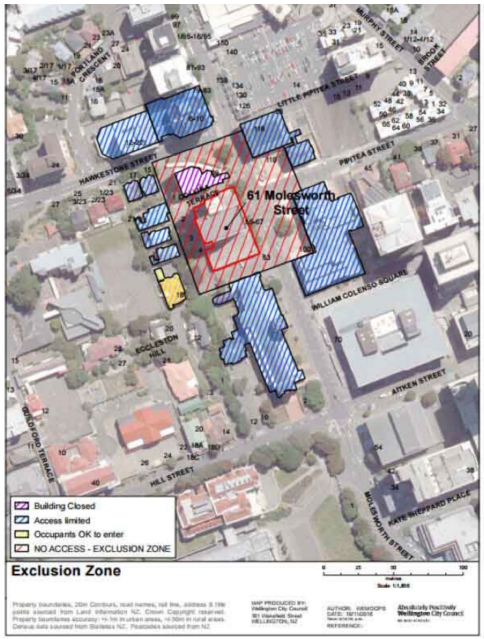
Wednesday, 07 December 2016

The New Zealand Herald

Wellington Reading Cinemas carpark building 'likely to collapse' in large aftershock

By Susan Strongman in Wellington, NZME

Cordons



Indicator building concept

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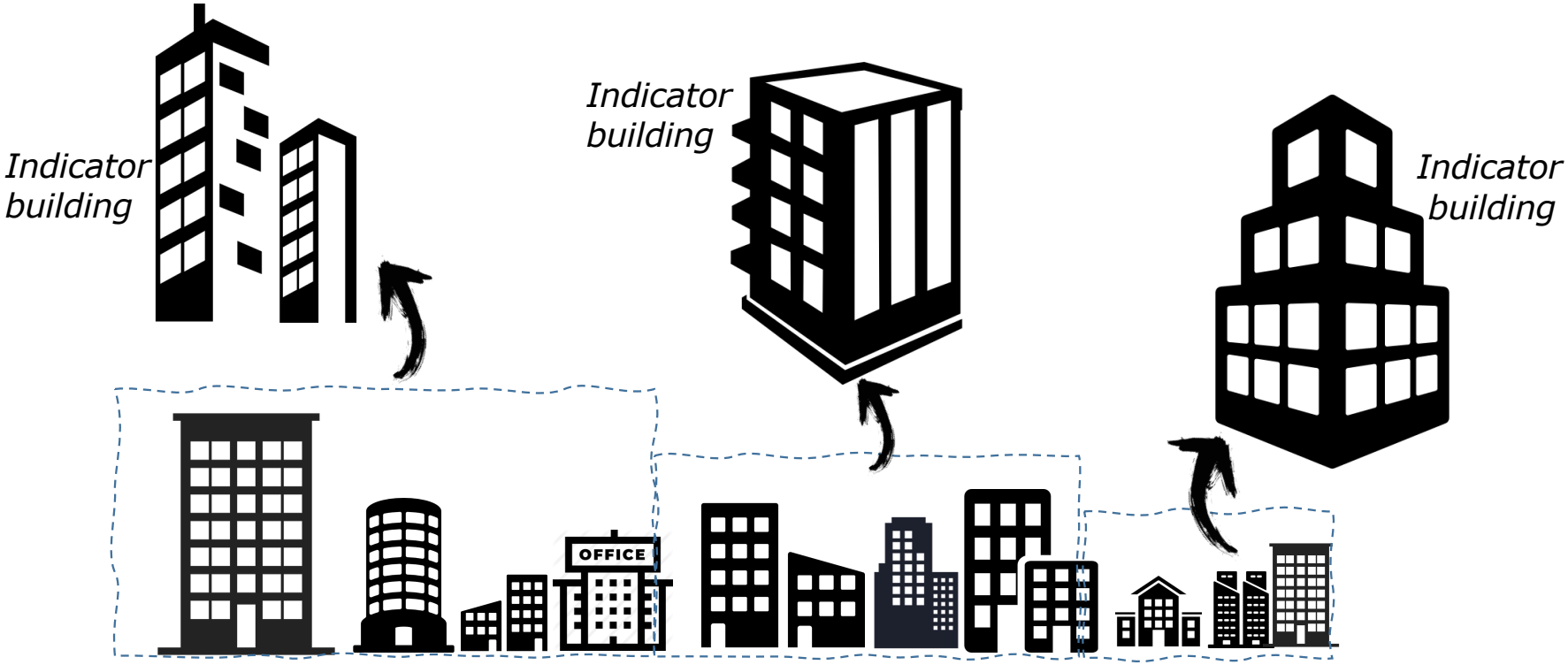
Typologically representative buildings that can be used to evaluate the response at a community scale



Workflow

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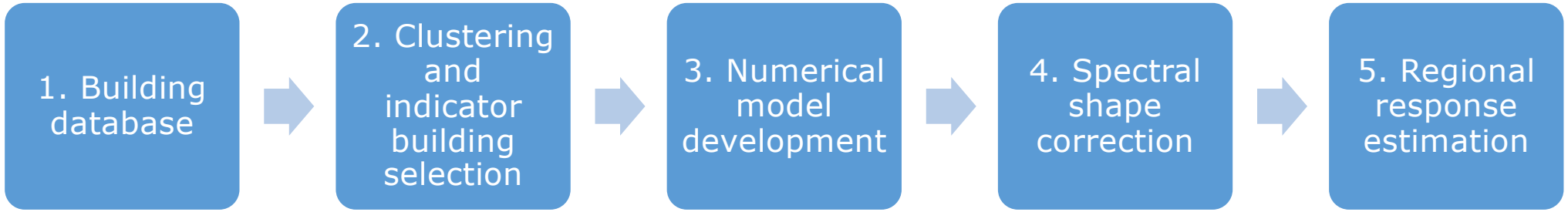

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Building database

Wellington Building Inventory

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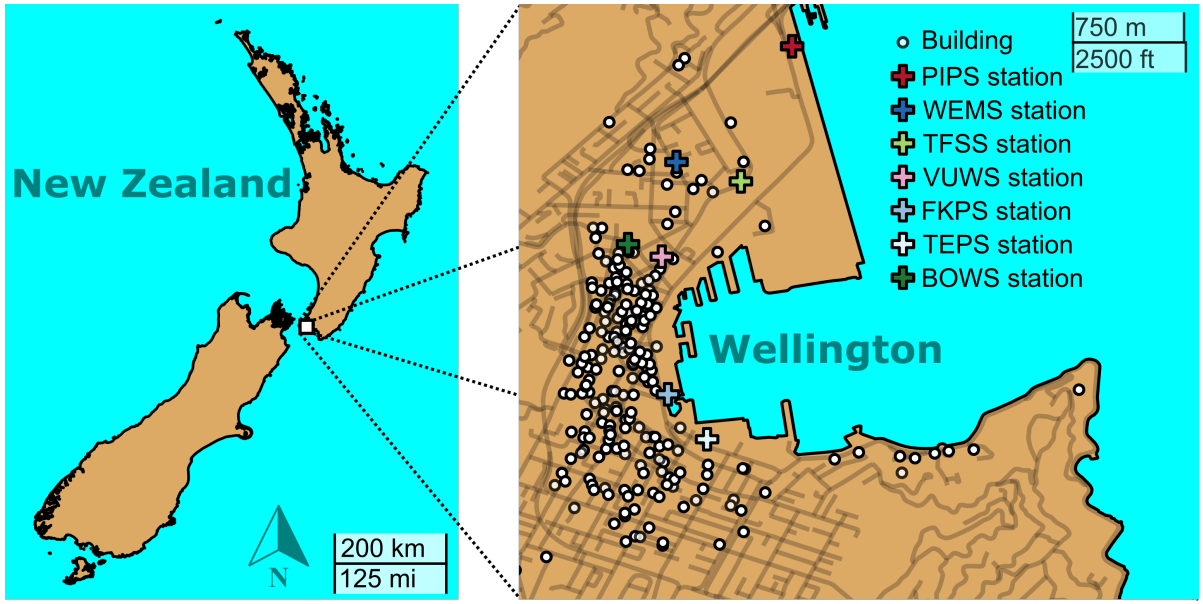
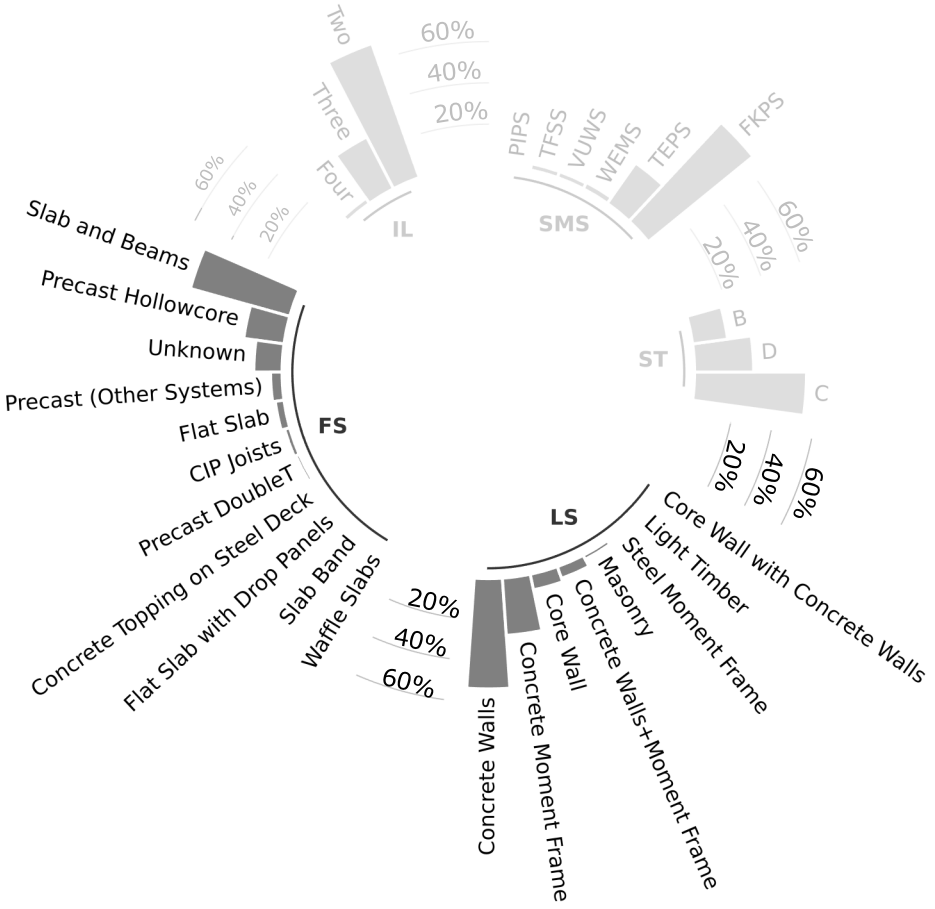
- ~800 five+ storey buildings in CBD
- Building information:
  - Structural parameters
  - Site characteristics (soil type, strong motion station)
  - Code of seismic design



Categorical Data

- Importance level (IL)
- Strong motion station (SMS)
- Soil type (ST)
- Lateral system (LS)
- Floor system (FS)

- **Note:** low proportion for some variables

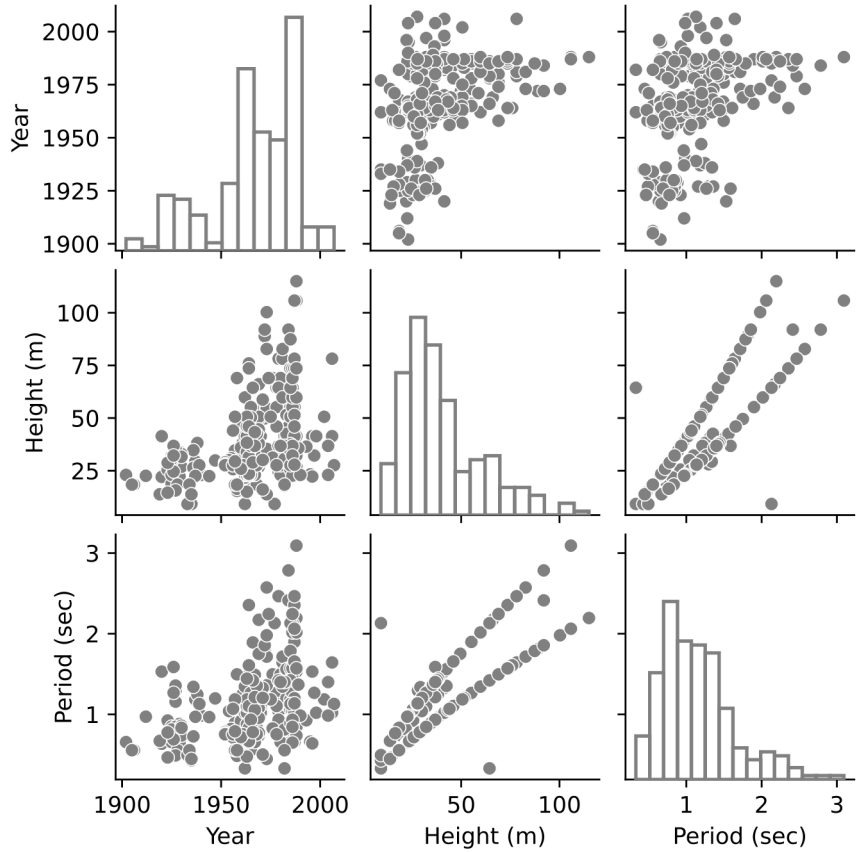


Numerical Data

- Year
- Height
- Period (code based)

Notes:

- Linear correlation between height and period
- No tall buildings before 1950



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Clustering and indicator building selection

Autoencoder Neural Network

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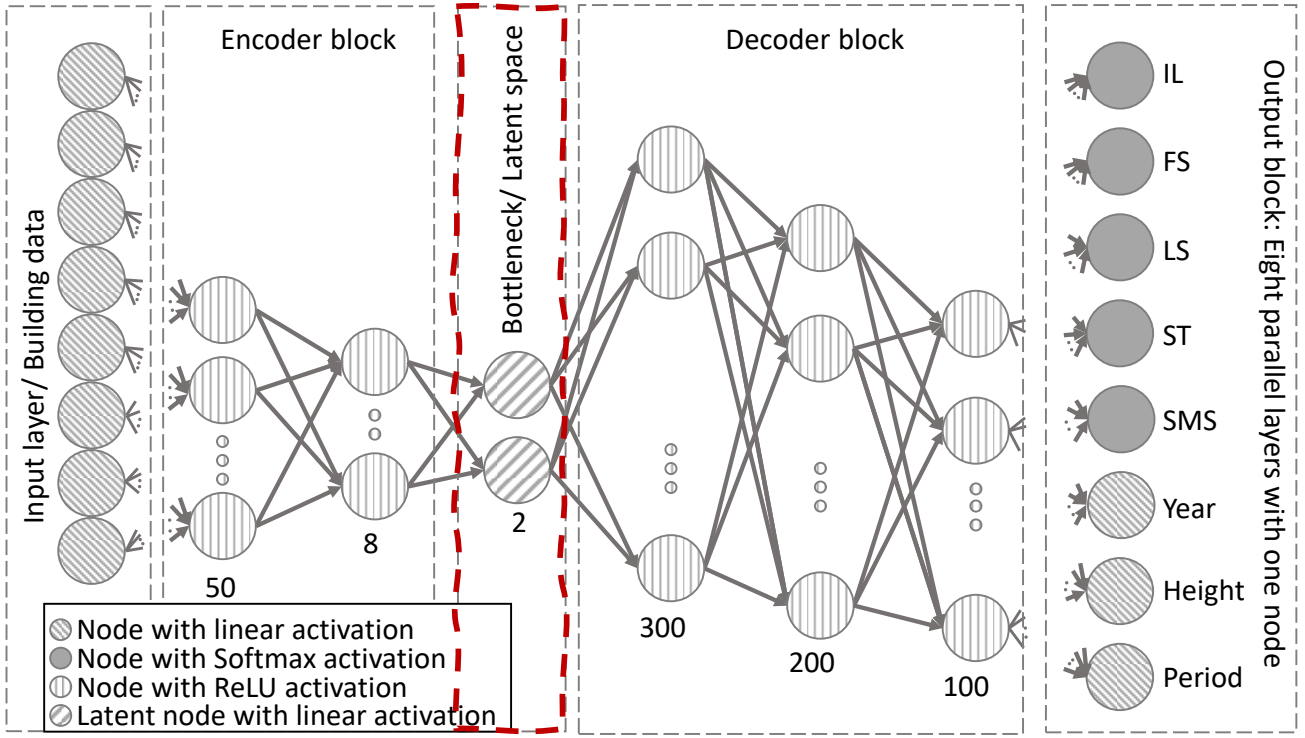
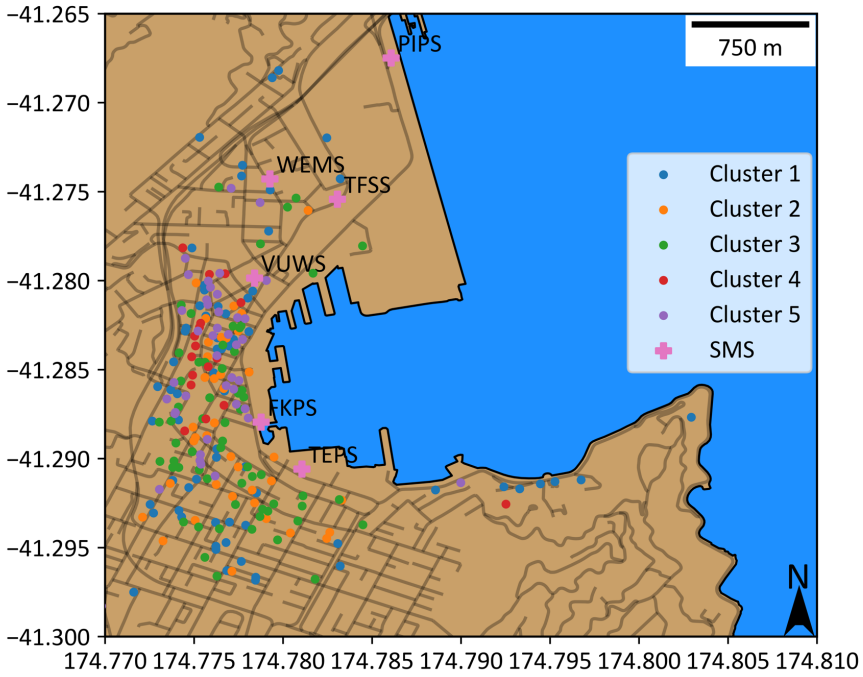
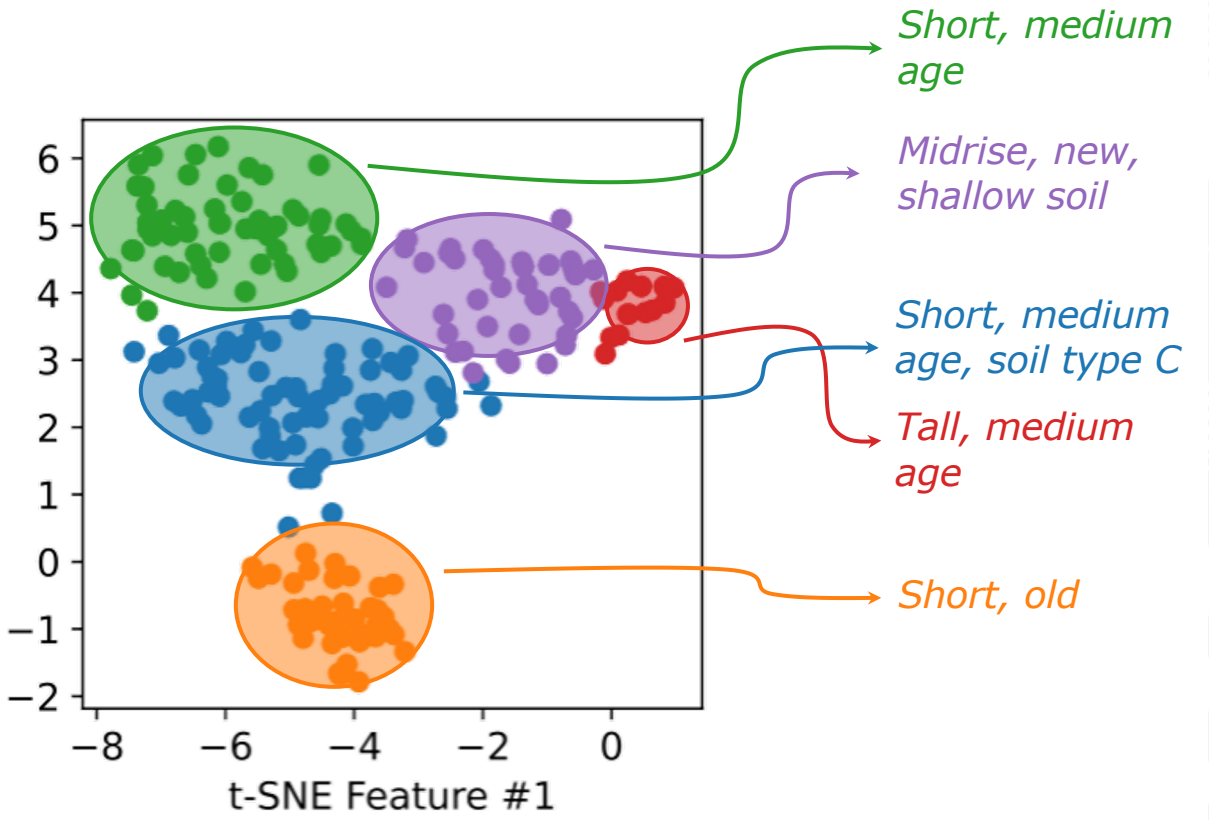
Extracts 2D numerical subspace from original database

- Preserves information in compressed numerical form in latent space



Clustering Results





Clustering Results

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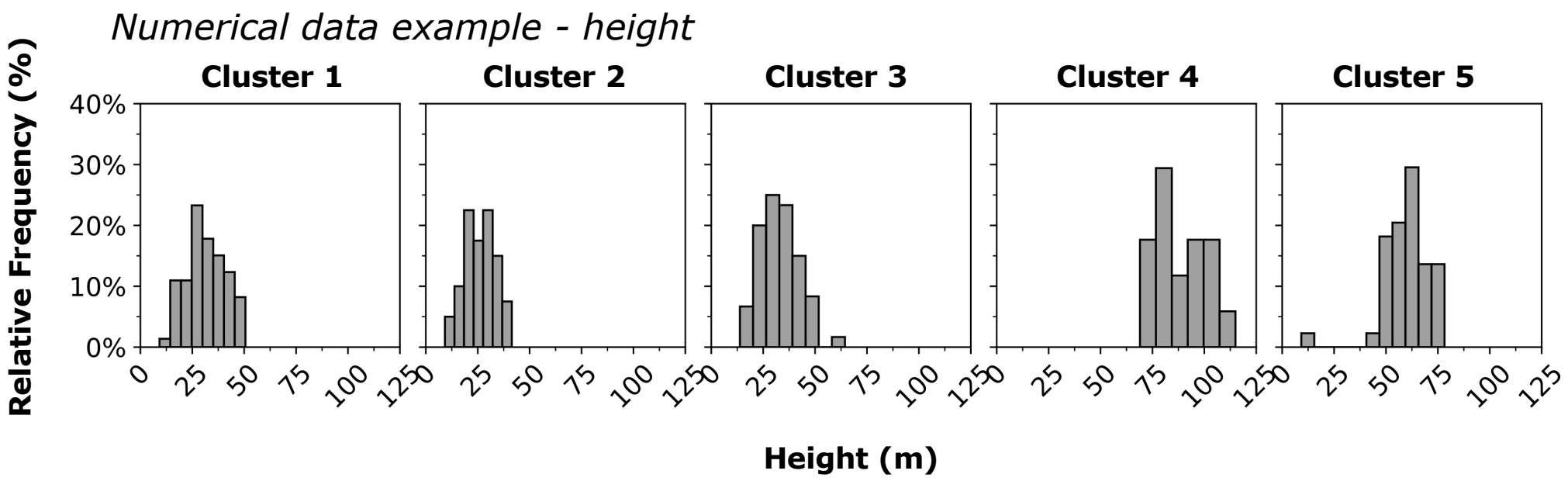
Looking at the clustering results from an ‘engineering’ perspective



Clustering Results

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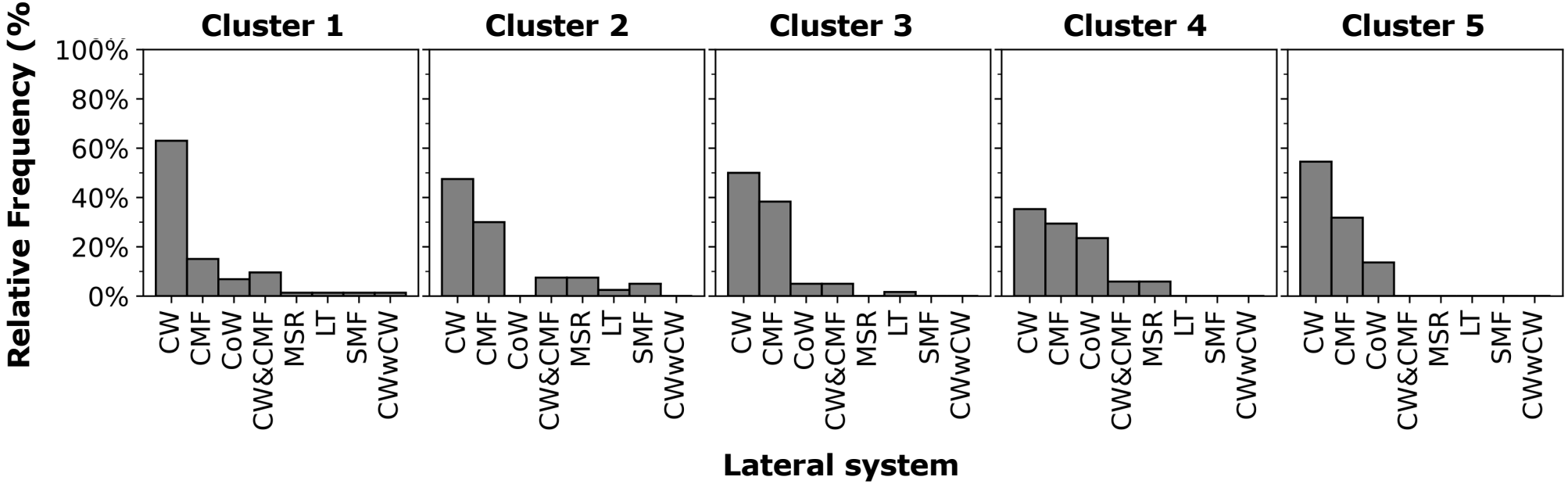
K-means on latent space most effective for both numerical and categorical data

Categorical data example – lateral system



Indicator Buildings

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Te Herenga Mātai Pūkaha

Dominant range and values					Representative buildings				C5 vulnerability category
Cluster	Year	Height (m)	LS	FS	Year	Height (m)	LS	FS	
1	[1962-1965]	[25-30]	CW (61%)	S&B (70%)	1963	32	CW&CMF	S&B	Prior to 1970s
2	[1926-1930]	[19-24] [29-34]	CW (44%) CMF (30%)	S&B (65%)	1926	23	CW	S&B	Prior to 1970s
					1927	28	CMF	S&B	Prior to 1970s
3	[1985-1988]	[28-34]	CW (50%) CMF (39%)	PH (40%)	1986	34	CMF	PH	Precast floors after 1980
					1986	32	CW	PH	Precast floors after 1980 Non-ductile columns 1982-85
4	[1982-1987]	[76-86]	CW (34%) CMF (30%) CoW (25%)	S&B (52%) PH (30%)	1972	88	CoW	PH	Precast floors after 1980
					1984	92	CMF	S&B	Non-ductile columns 1982-85
5	[1981-1987]	[59-65]	CW (53%) CMF (30%)	PH (36%) S&B (34%)	1981	56	CW	S&B	Shear walls in 1970s and 80s
					1985	64	CMF	PH	Precast floors after 1980

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Model development

Nonlinear models

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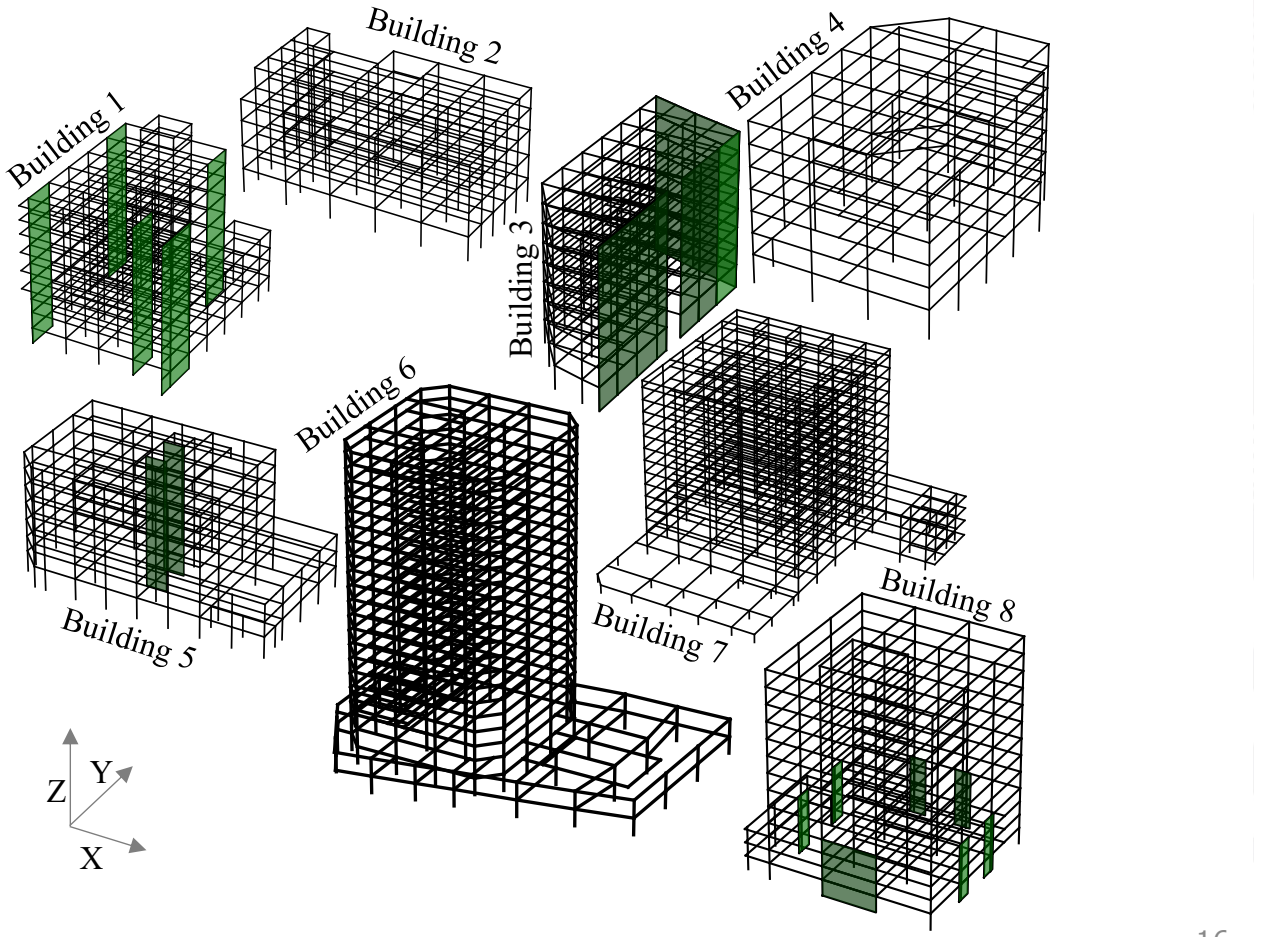
Indicator buildings modelled using macro approach



Supplementary models

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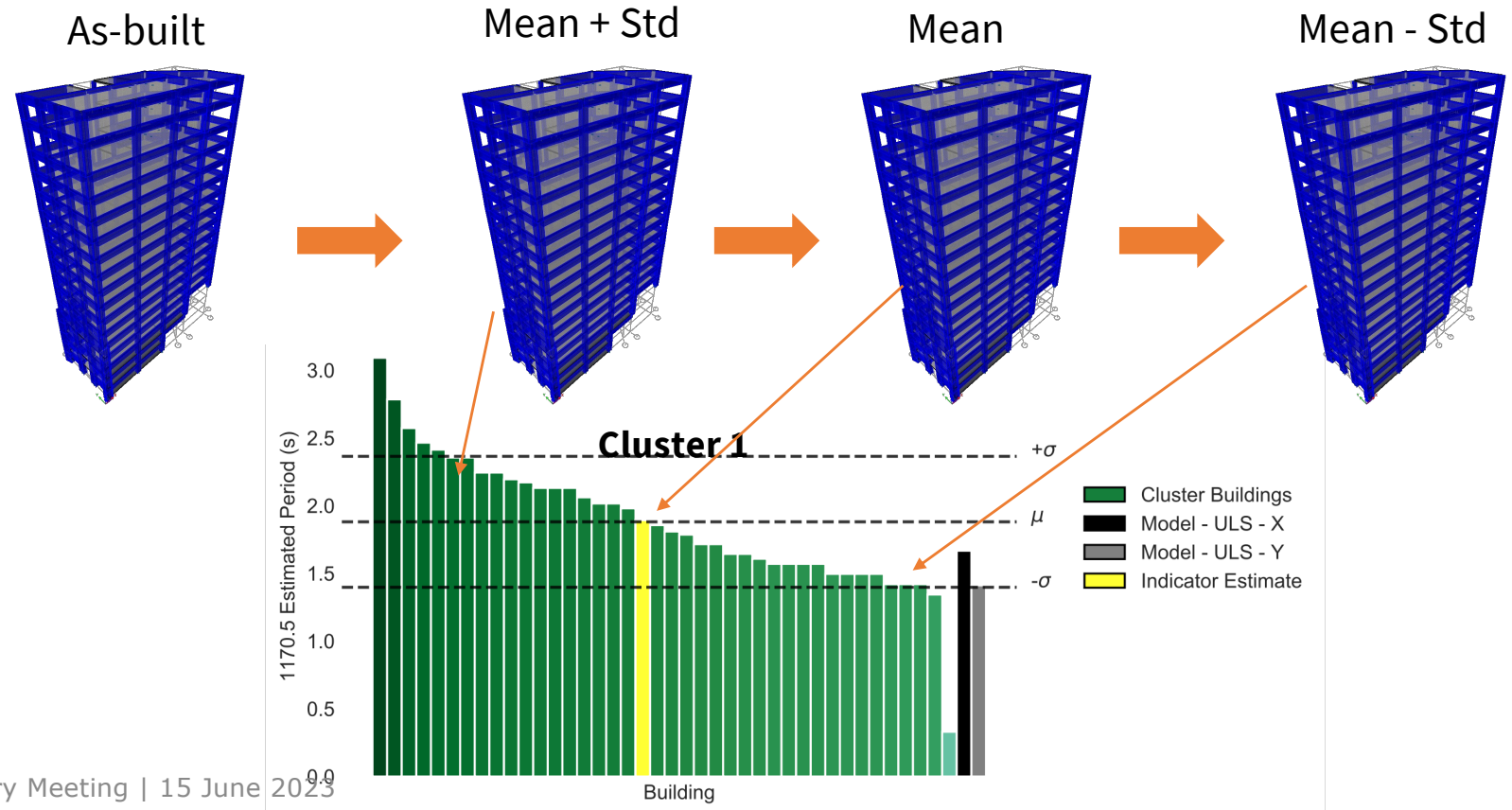
Four elastic models developed for each cluster



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Spectral shape correction

Spectral shape correction

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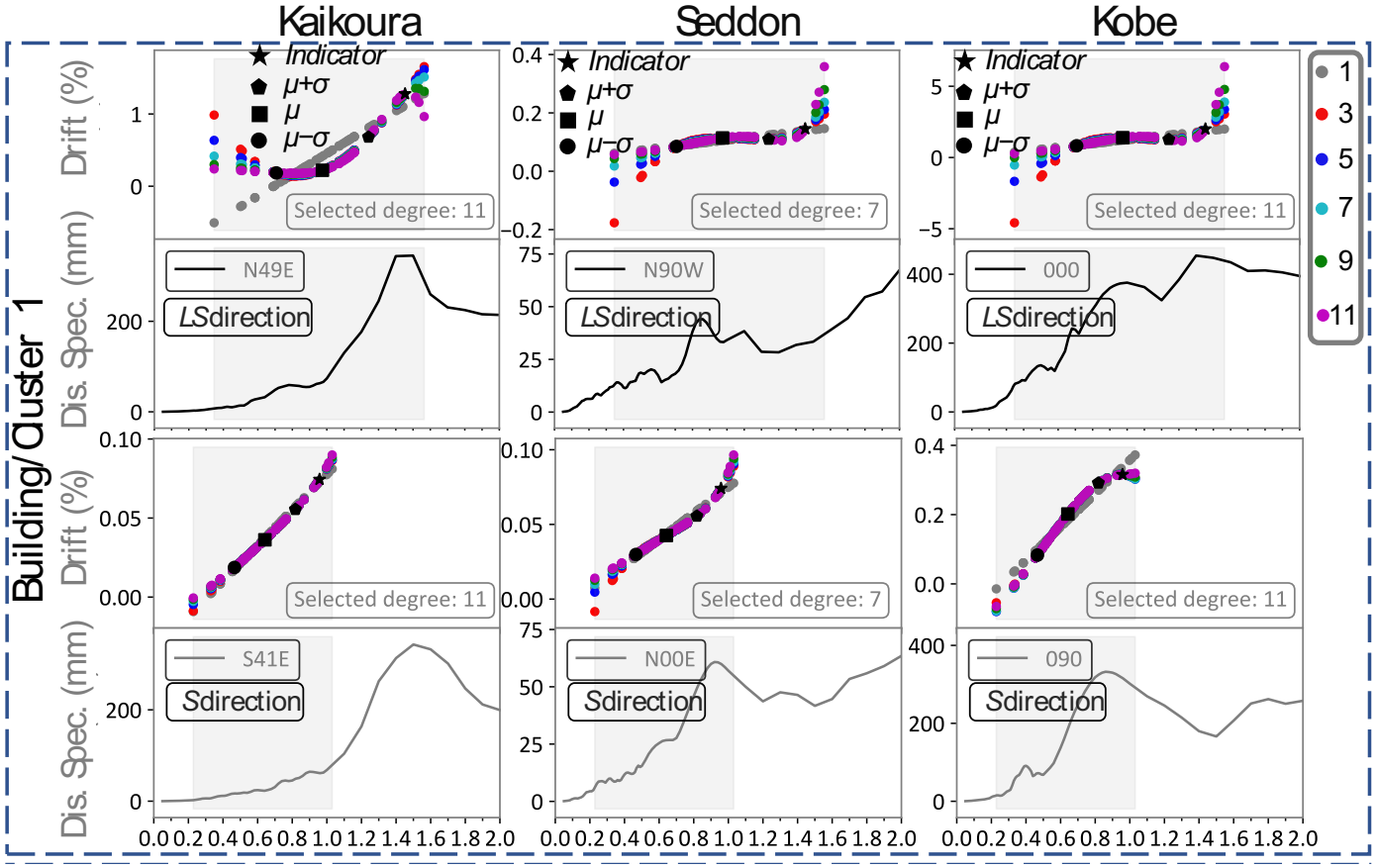
- Seismic demand varies based on period
- Variation is a function of building period
- Regression models investigated to generate correction



…this is a work in progress

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Regional response estimation

Drift estimation – shake city

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- Building level ‘shake maps’ can be developed
- Can be used for scenario planning or NRIT following event
- **Note**: Shake city is Wellington buildings assigned to footprints in fictional city

Kaikōura EQ

Kobe EQ

Validation (some level)

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Drift estimates compared to damaged observed following Kaikoura

Building Information				Damage Observation		Response and Damage Estimation		
Number	Stories	Year	Cluster	Observations	Damage cat.	Drift est., %	Damage State	Acceptable
I	12	1969	8	Closed for assessment	Local	1.33	Slight	Yes
II	10	1985	4	Undisclosed structural damage	Significantly	2.68	Moderate	Yes
III	17	2006	7	Cracking in stairwells	Local	1.62	None	Yes
IV	6	2007	4	Minor structural - extreme non-structural damage.	Significantly	1.54	Slight	No[1]
V	6	1989	4	No structural damage	Local	2.7	Moderate	No
VI	8	1979	7	Minor structural damage	Local	1.38	None	Yes
VII	8	2004	5	No structural damage	No identified	0.55	None	Yes
VIII	23	1987	6	Possible structural /Non-structural damage	Distributed	1.28	Moderate	Yes
IX	8	1954	1	Non-structural damage	No identified	0.55	None	Yes
X	11	1985	7	Cordon	No identified	0.62	None	Yes
XI	8	1986	5	Cordon	No identified	1.24	None	Yes
XII	15	1986	7	Cordon	No identified	1.54	None	Yes
XIII	7	1986	5	Possible structural /Non-structural damage	Local	1.84	Moderate	Yes
XIV	8	1986	5	Severe structural damage	Significantly	2.58	Moderate	Yes
XV	10	1987	4	Possible structural /Non-structural damage	Distributed	1.12	Slight	Yes
XVI	5	2004	4	Structural damage	Significantly	2.48	Moderate	Yes
XVII	3	1993	5	Cracking in stairwells	No identified	1.19	Slight	Yes

Ongoing work / research needs

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- Adding data to Wellington building database
- Spectral shape correction techniques
- Extending models to include SSI
- **We need to instrument more buildings!!!**

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Thank you

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