Response of Instrumented Buildings in Wellington in Kaikoura Earthquake

Presenter: Dr S.R. Uma

Team: GNS Science, QuakeCoRE

Acknowledgements

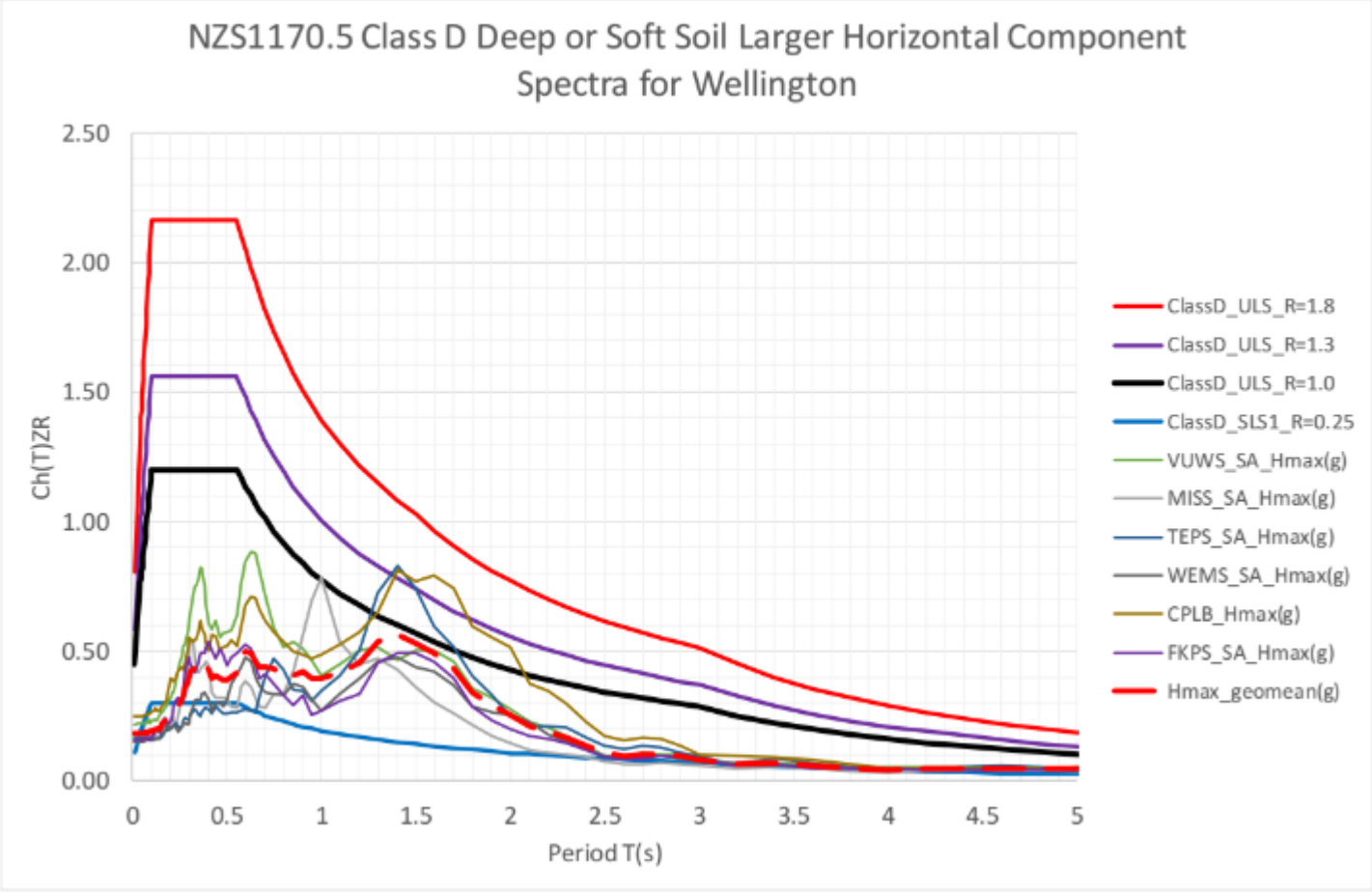
- **GNS Science**
  - GeoNet
  - Mostafa Nayyerloo
  - John Young
  - Graeme McVerry
  - And others..

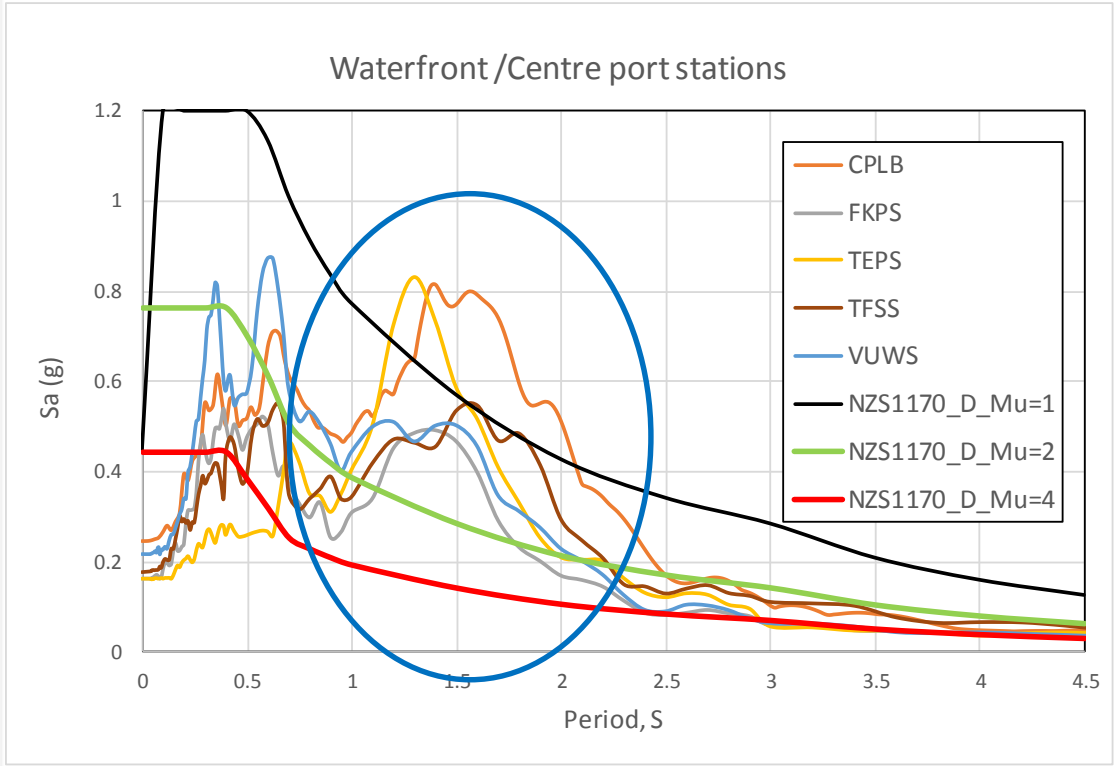
- **QuakeCoRE (University of Auckland; University of Canterbury)**
  - Quincy Ma
  - Liam Wotherspoon
  - Reagan Chandramohan
  - Brendon Bradley
  - Max Stephens
  - And others…

Disclaimer

The presentation slides show preliminary analyses and results. Further refinements and verification is required

Response spectra of Kaikoura earthquake





(McVerry et al. 2016)

Instrumented Buildings in Wellington

- GeoNet Building Instrumentation Programme (Permanent)

- Instrumentation by Auckland University (Temporary)

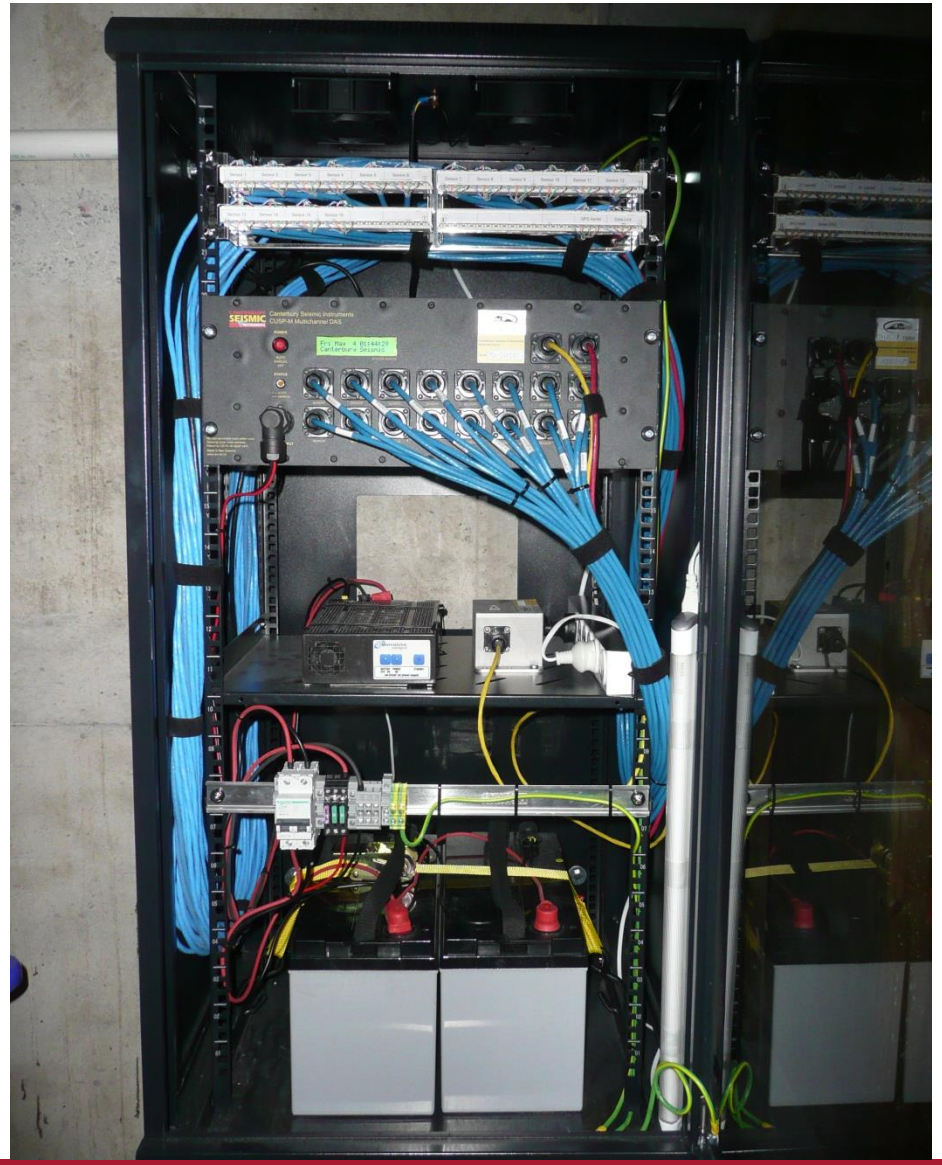
GeoNet buildings

Instrumentation scheme:

- ~16 sensors (triaxial)
- Data recorder
- GPS aerial unit
- Hard wired (cabled)

- BNZ Building, CentrePort Wellington
- Ministry of Business Innovation and Employment
- Wellington Regional Hospital, Newtown
- VUW Student Accommodation Building
- Majestic Centre, Willis St, Wellington
- GNS Science, Avalon
- Bridges: Thorndon Flyover

Instruments used



Temporary instruments

Instrumentation scheme:

- ~3 sensors (triaxial)
- Micro-Electro-Mechanical Sensors (MEMS)

"Rankine Brown Building"

"Tonkin and Taylor Office Building"

"Te Puni Kokiri Building"

"Old Public Trust Building"

"Spark Exchange Building 1"

"Spark Exchange Building 2"

"Old Government House"

"Customs House Building"

"Beca Building"

"William Clayton Building"

BNZ Building

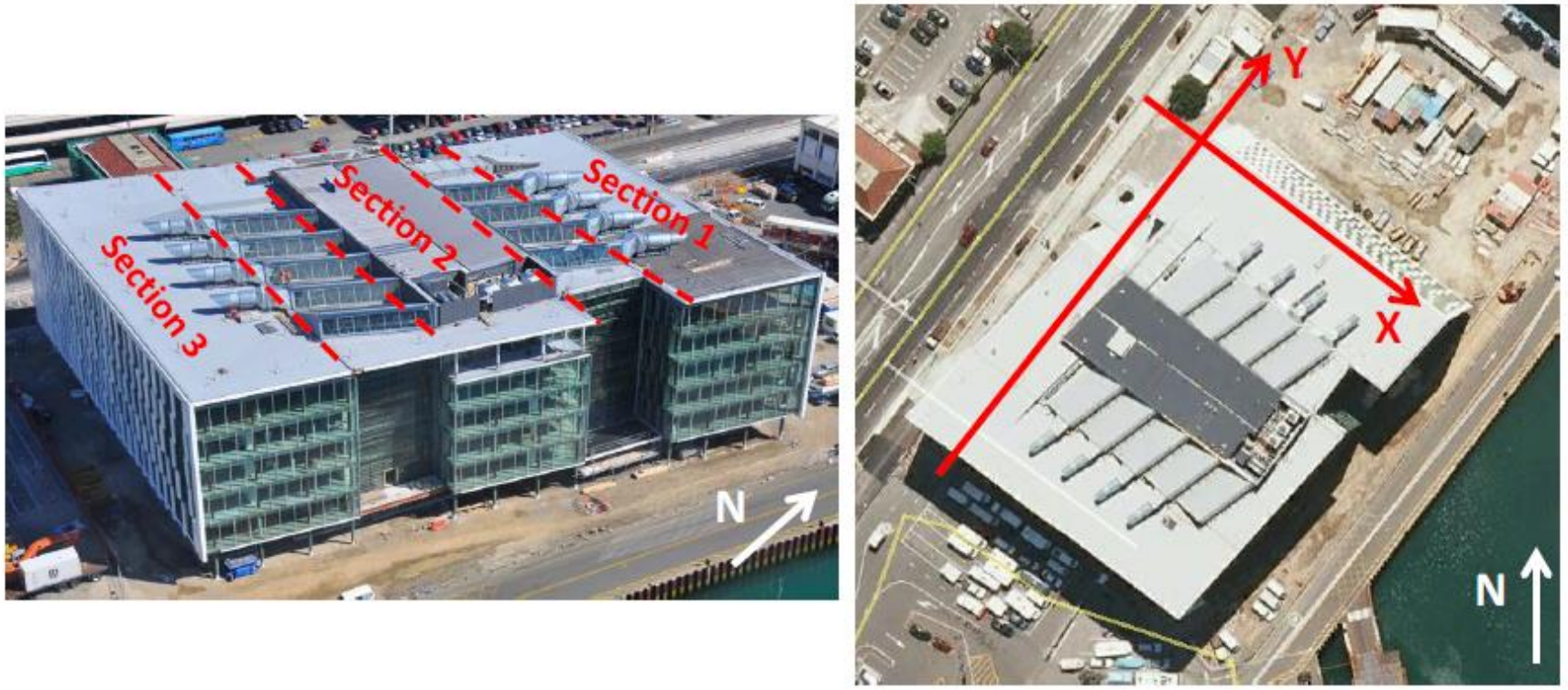
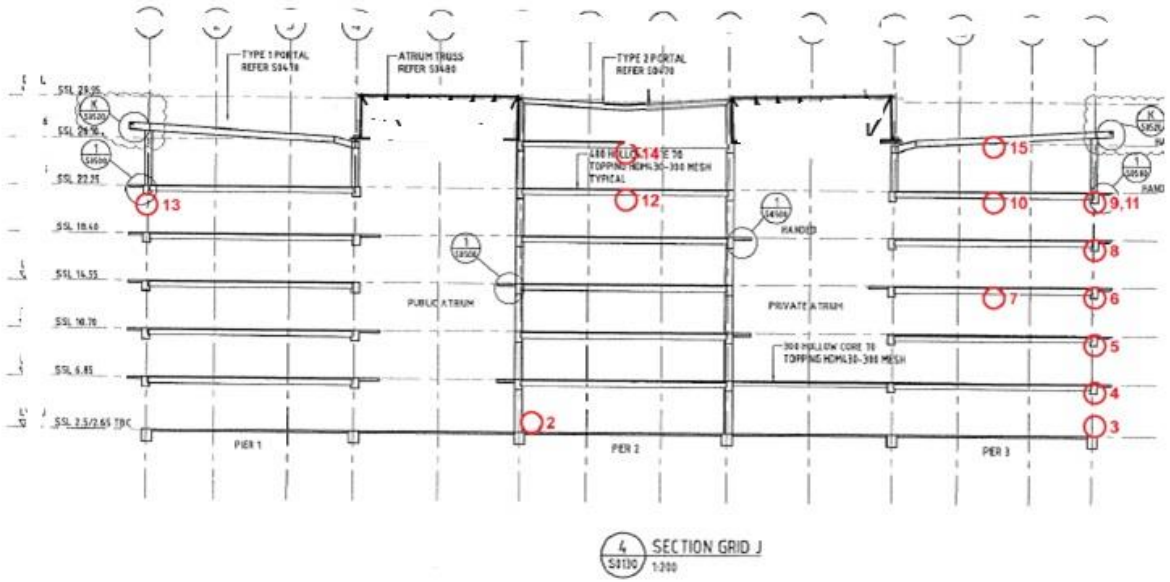


Figure 1. Aerial views of the CentrePort BNZ Building showing building sections and the coordinate system for instrumentation data. The building Y axis is 37° east of north.

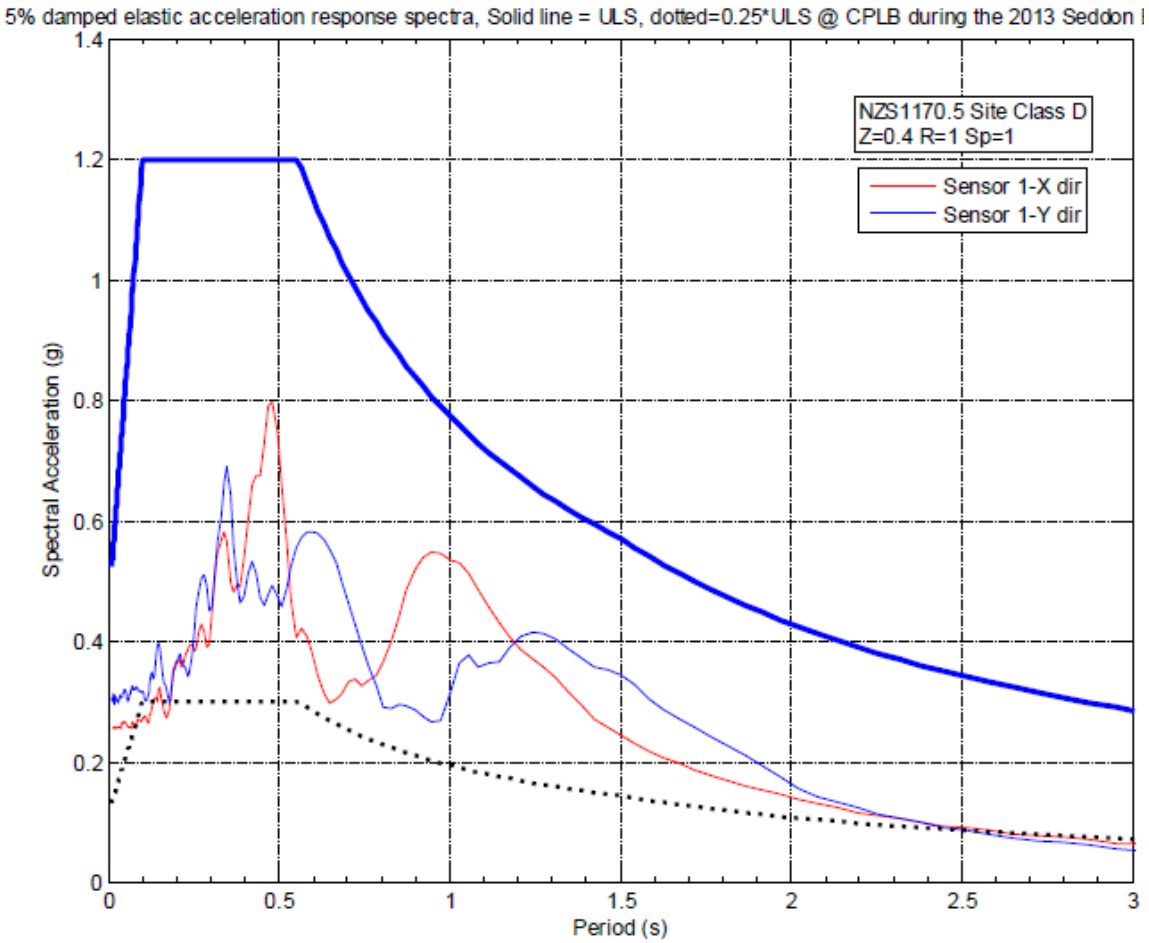
BNZ building sensor locations

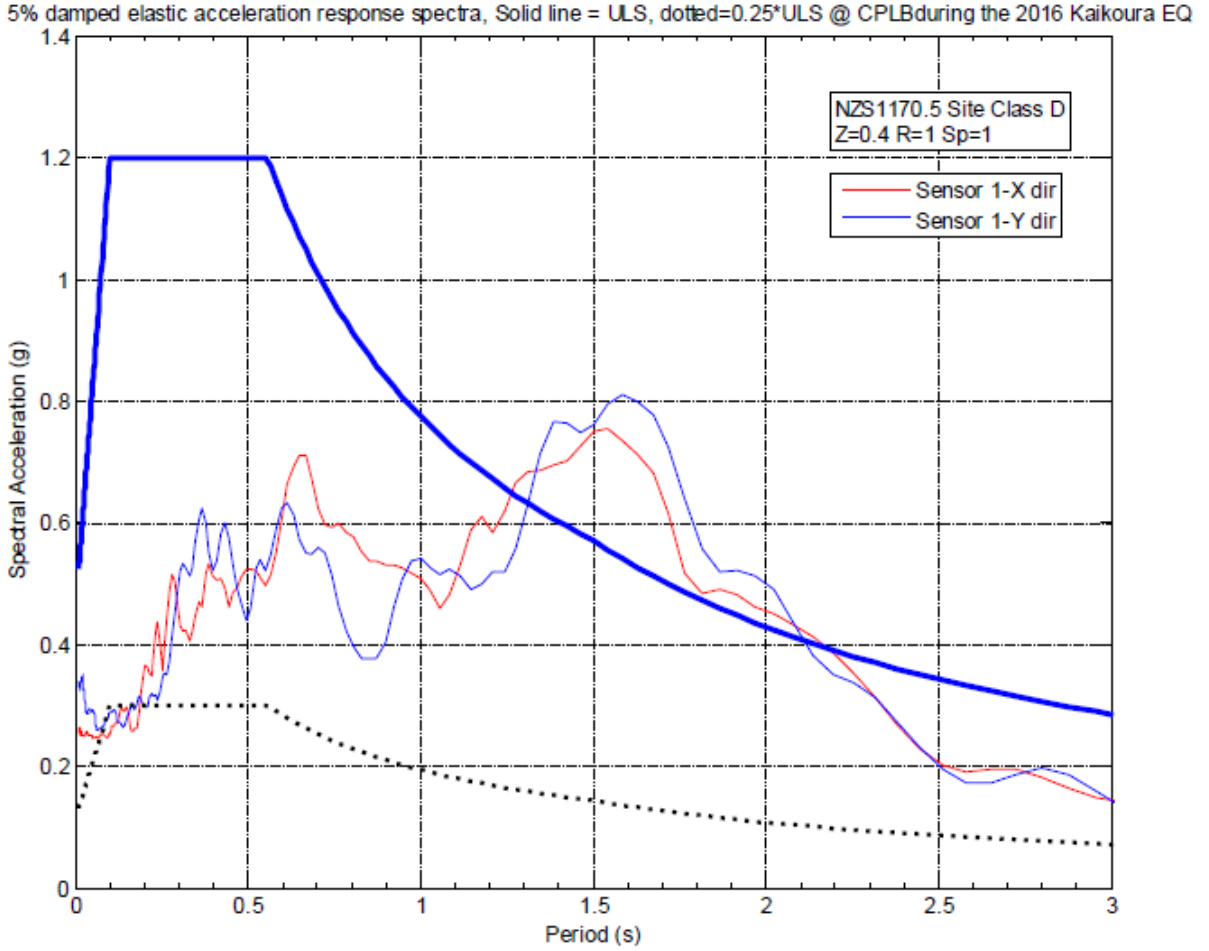


Seddon 2013 and Kaikoura 2016

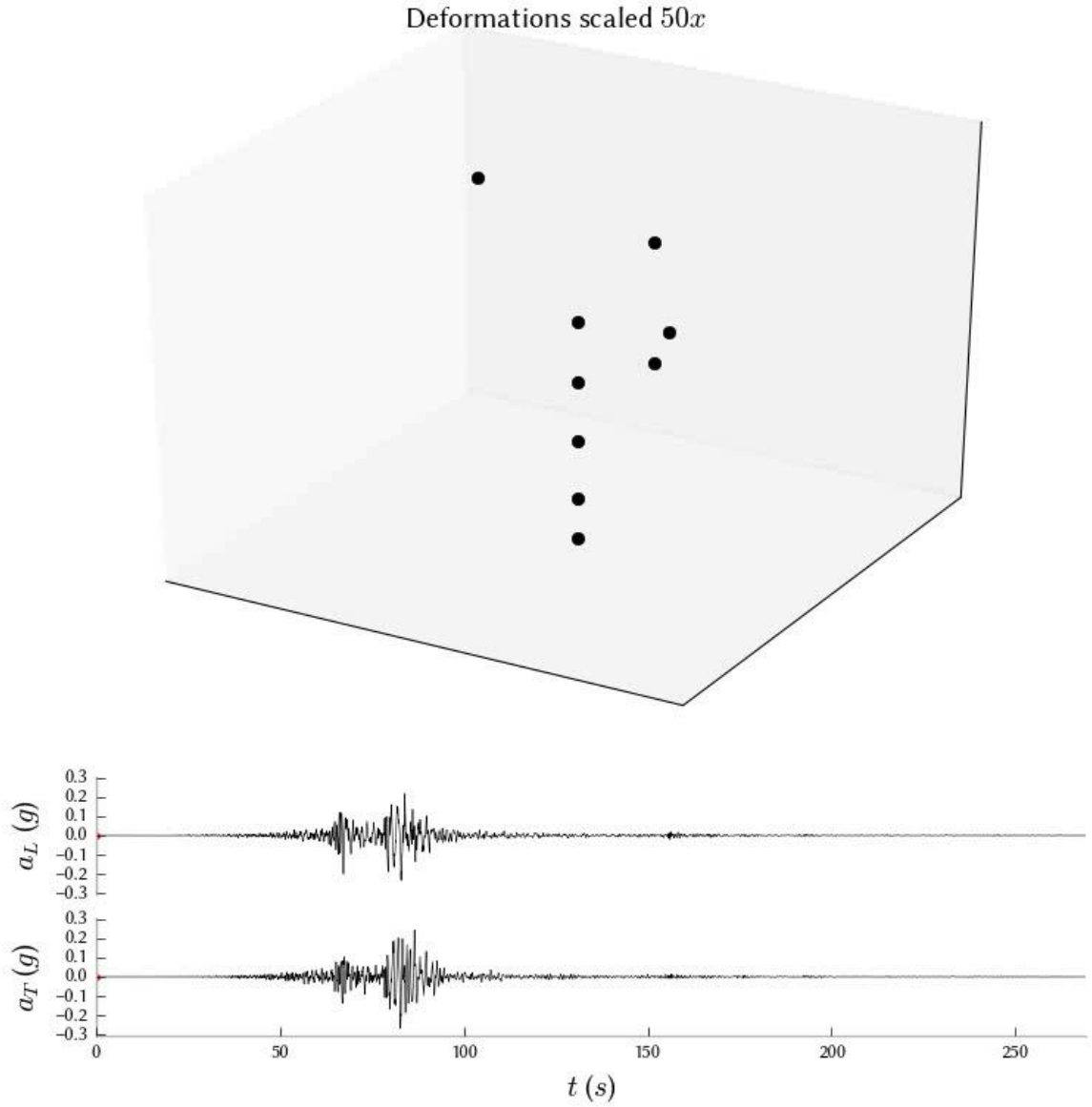
Earthquake Name	2013 Seddon Earthquake			2016 Kaikoura Earthquake		
GNS public ID	2013p543824			2016p85800		
Date of Event (NZ Time)	Sun, Jul 21 2013, 5:09:30 pm			Mon, Nov 14 2016, 12:02:56 am		
Time (UTC)	July 21 2013, 5:09:30			November 13 2016, 11:02:56		
Magnitude (M_w)	6.5			7.8		
Depth	16 km			15 km		
GPS co-ordinate of epicentre	-41.60, 174.32			-42.69, 173.02		
Distance to BNZ building	52.51 km			214.15 km		
	X	Y	Z	X	Y	Z
PGA at "free field sensor" (1)	0.26g	0.30g	0.06g	0.24g	0.33g	0.09g
Peak acceleration at 5th floor (9,11)	0.53g	0.53g	0.14g	1.02g	0.81g	0.30g
Significant duration ($D_{a,5-95}$)	8.9s	11.2s	17.1s	23.8s	25.4s	35.1s
Additional info available at	http://info.geonet.org.nz/display/quake/M+6.5%2C+Cook+Strait%2C+21+July+2013			http://www.eqclearinghouse.org/2016-11-13-kaikoura/		

Response spectra from Seddon and Kaikoura earthquakes

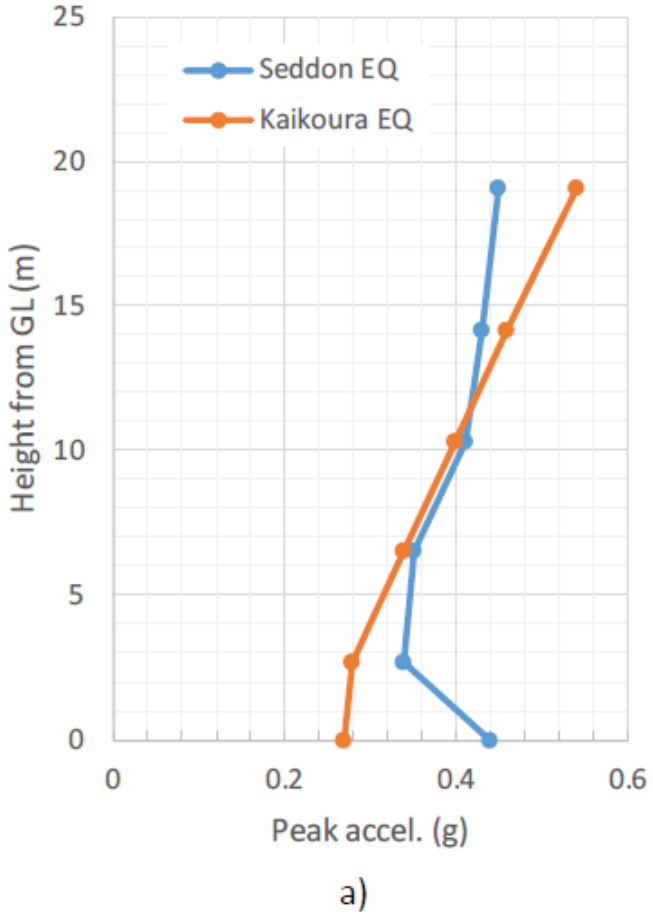


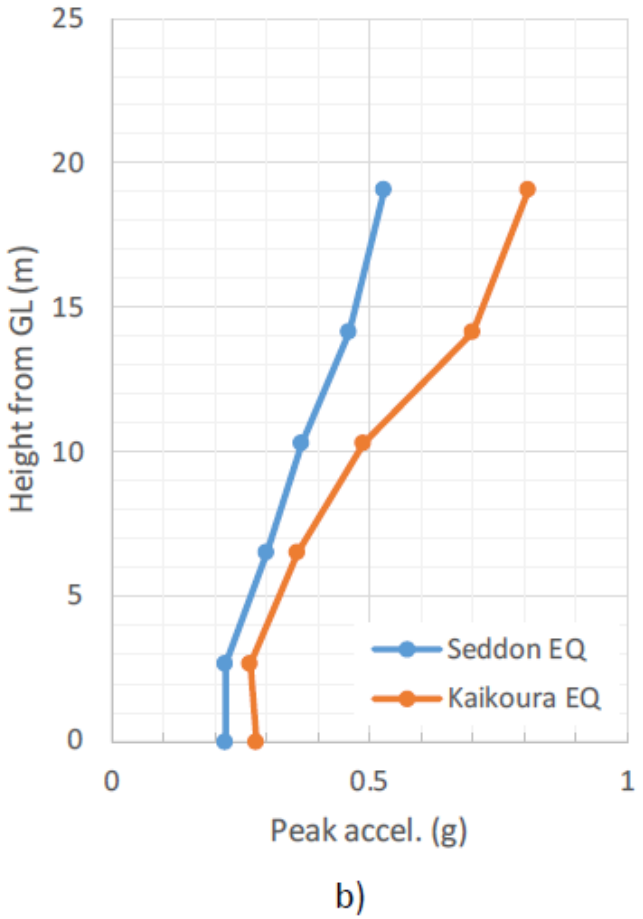


BNZ building



Peak floor accelerations

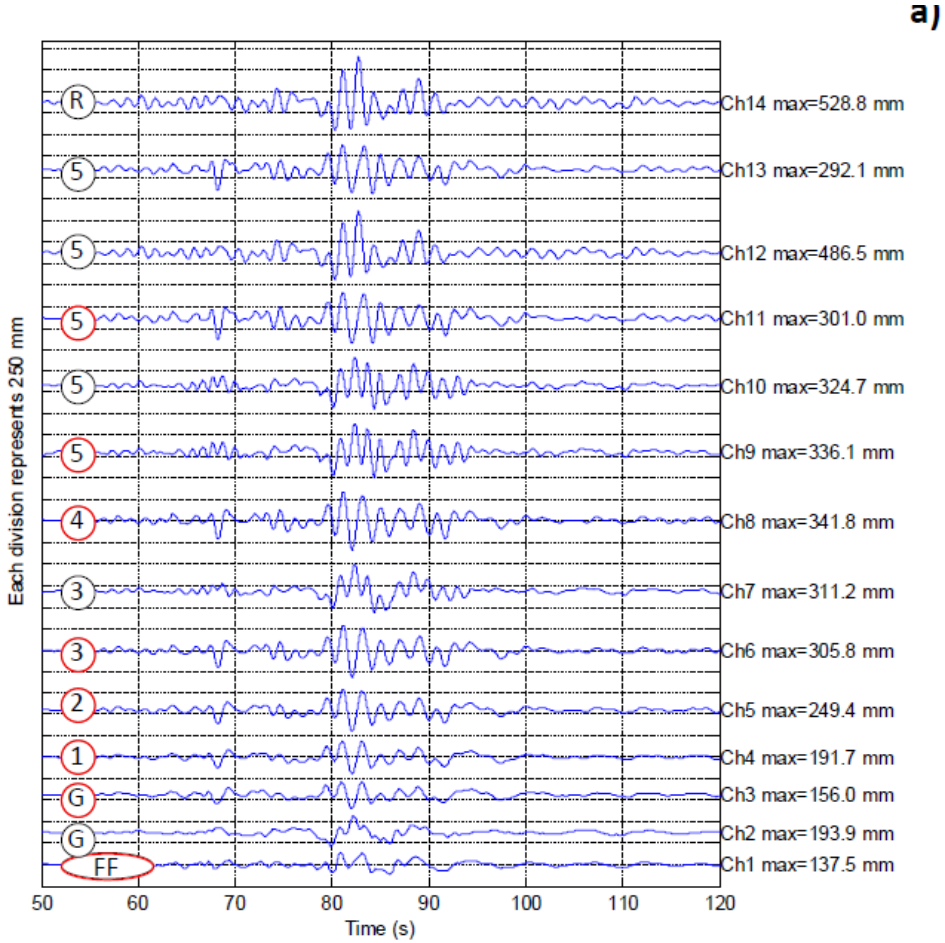




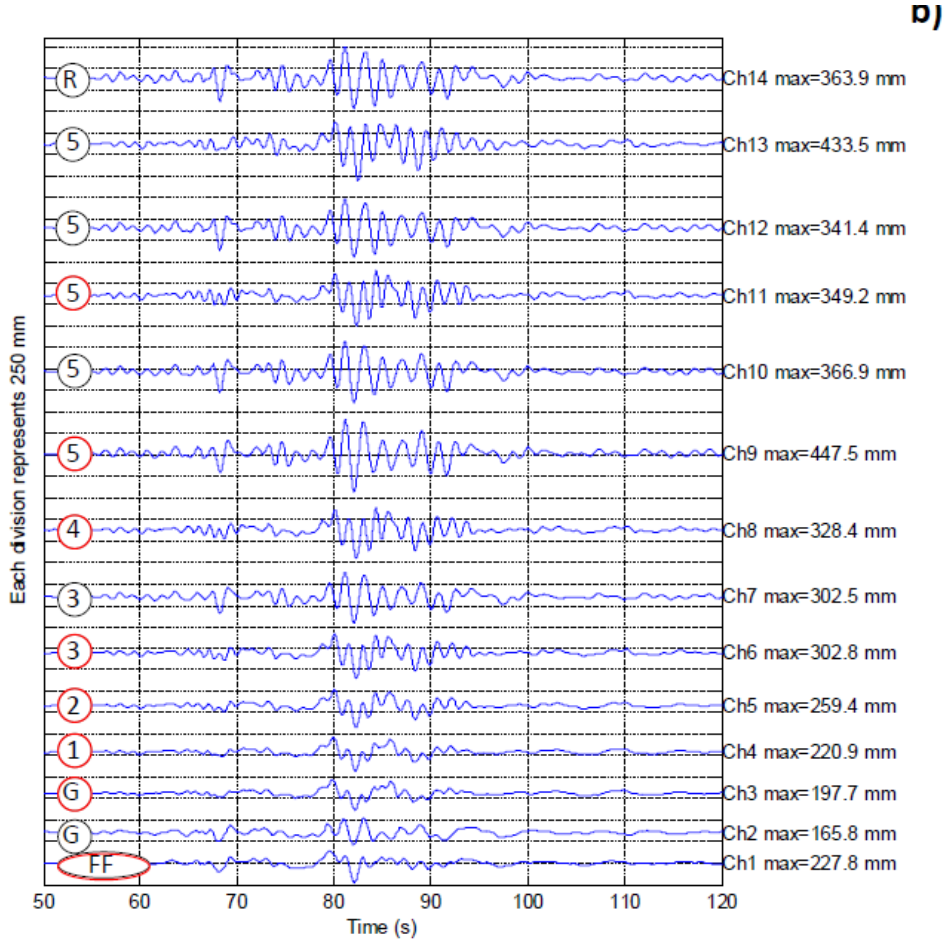
X - direction

Y - direction

Floor displacement history

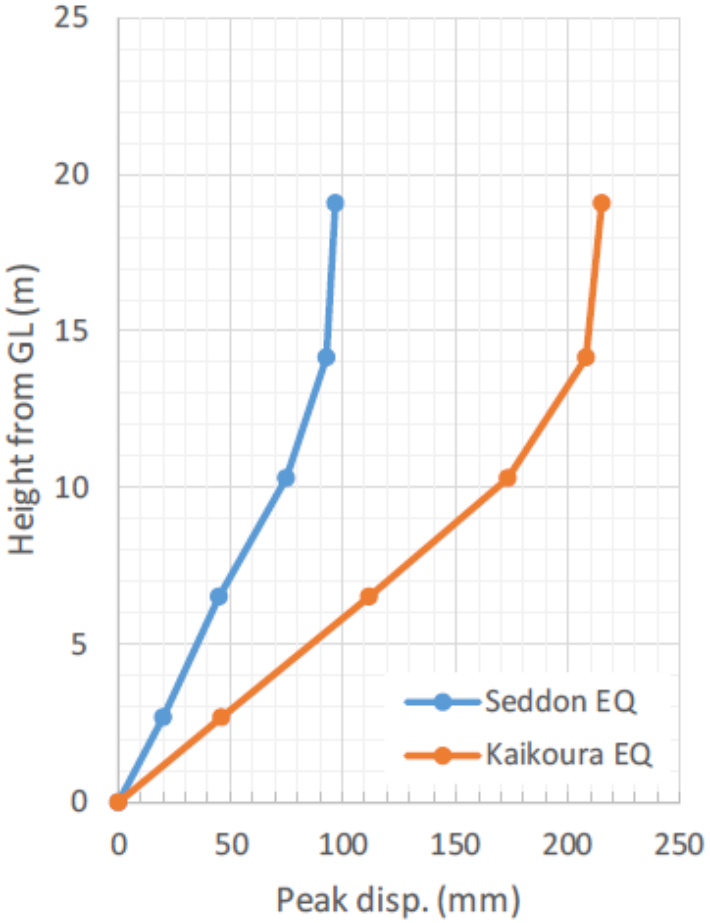


X - direction

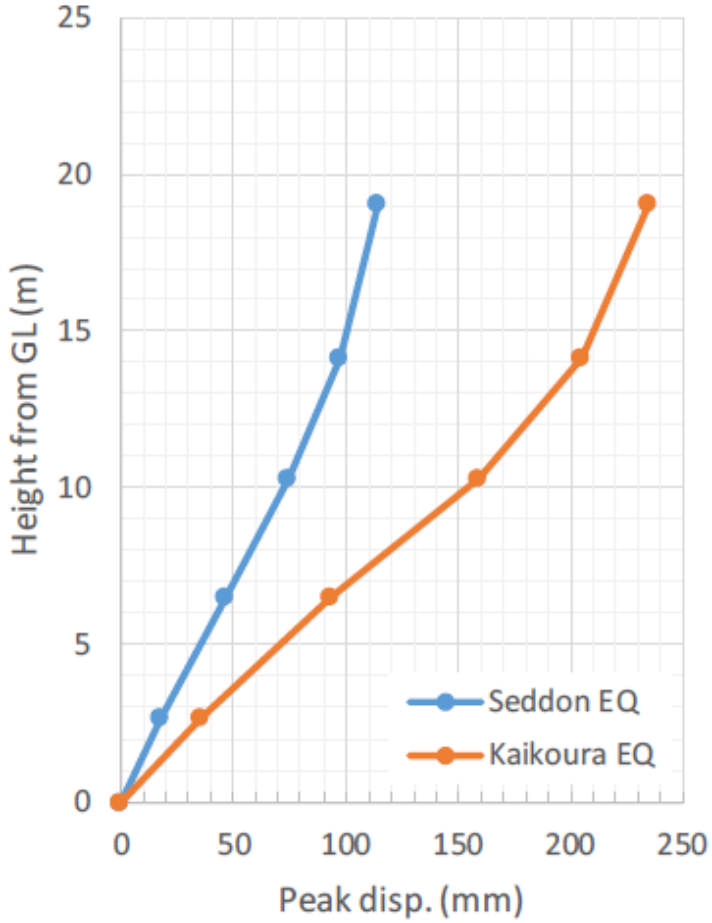


Y - direction

Peak floor displacements

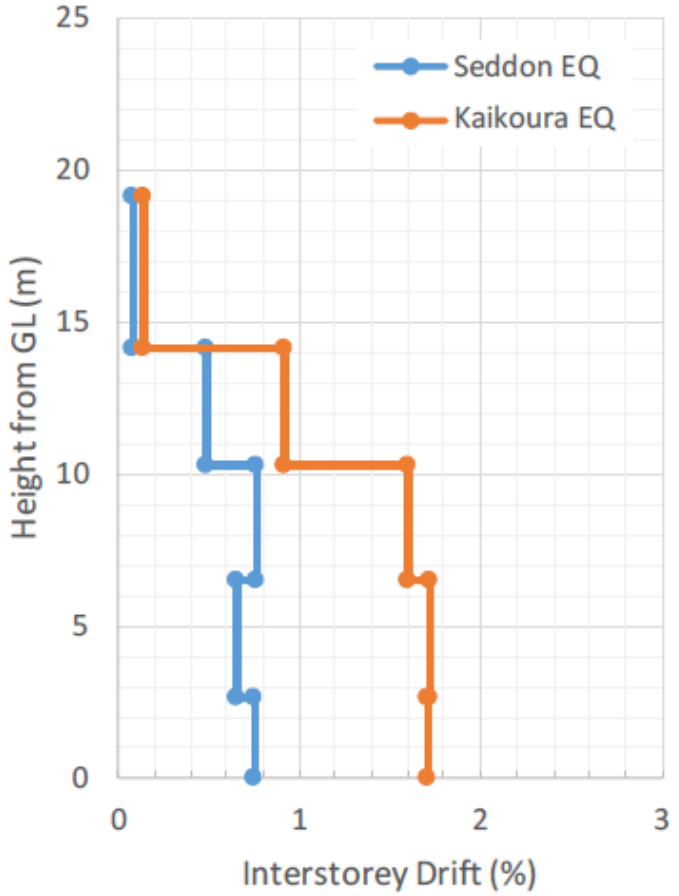


X - direction

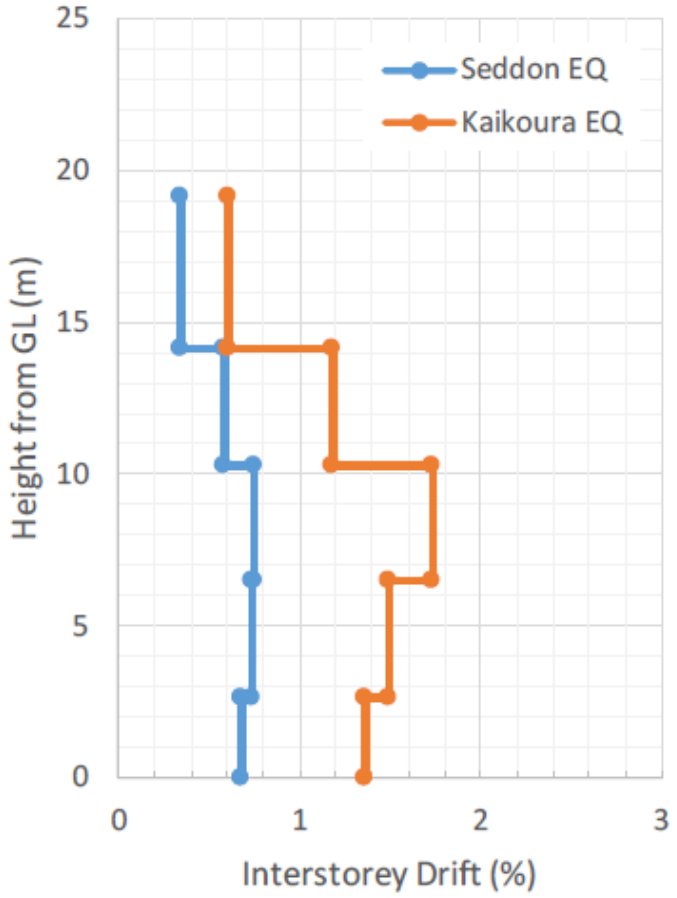


Y - direction

Inter-storey Drift Ratios



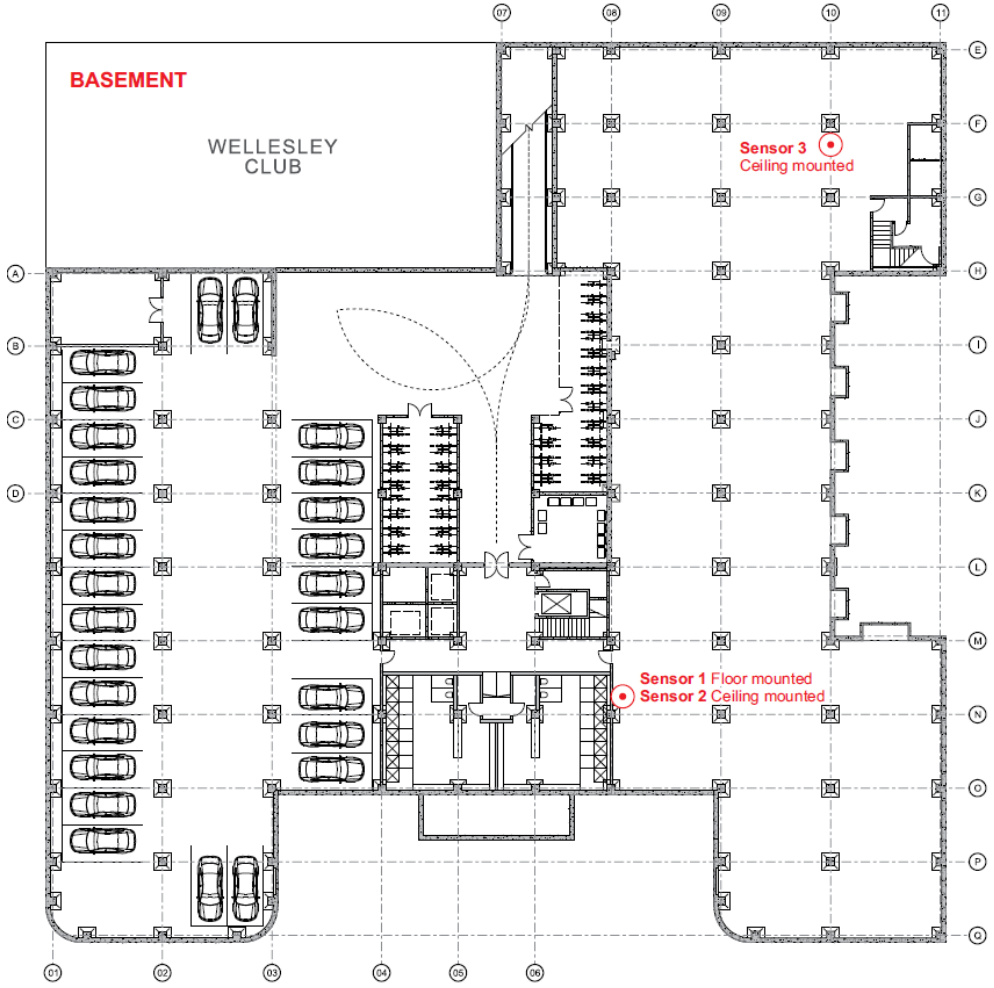
X - direction



Y - direction

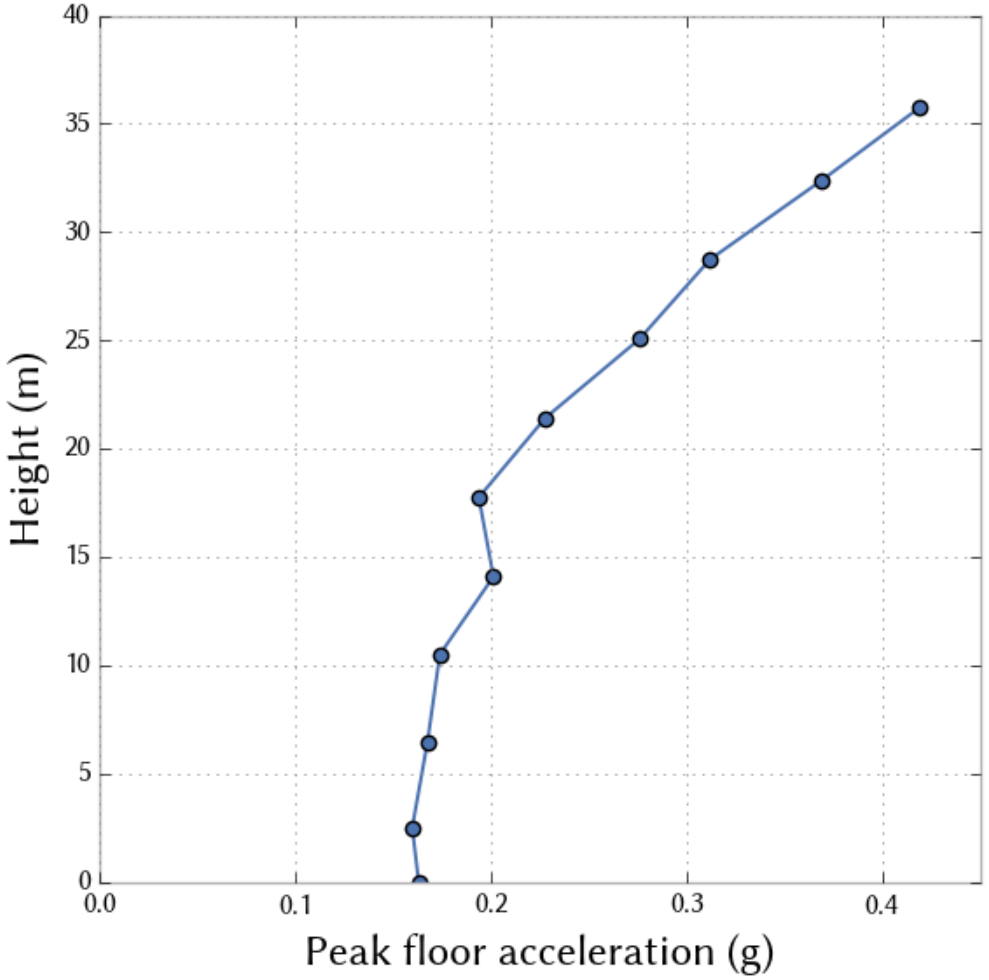
MBIE Building, Stout Street (8 storey building)

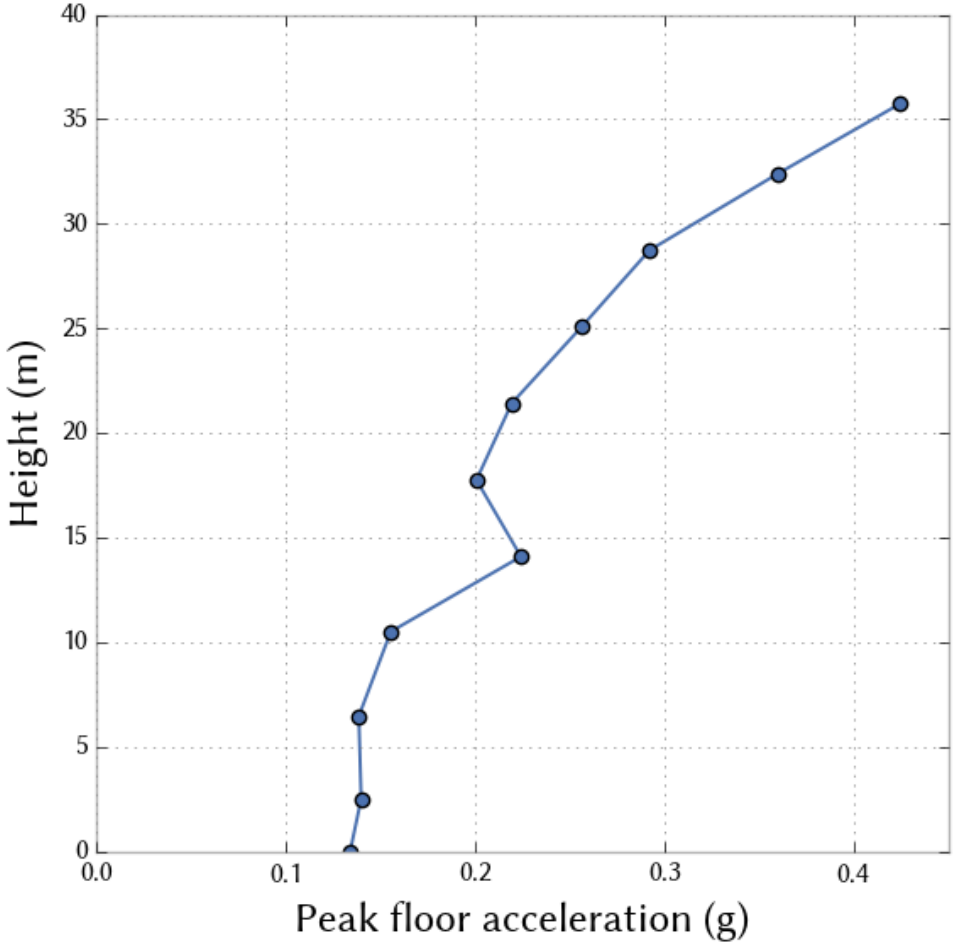
MBIE building, sensor locations



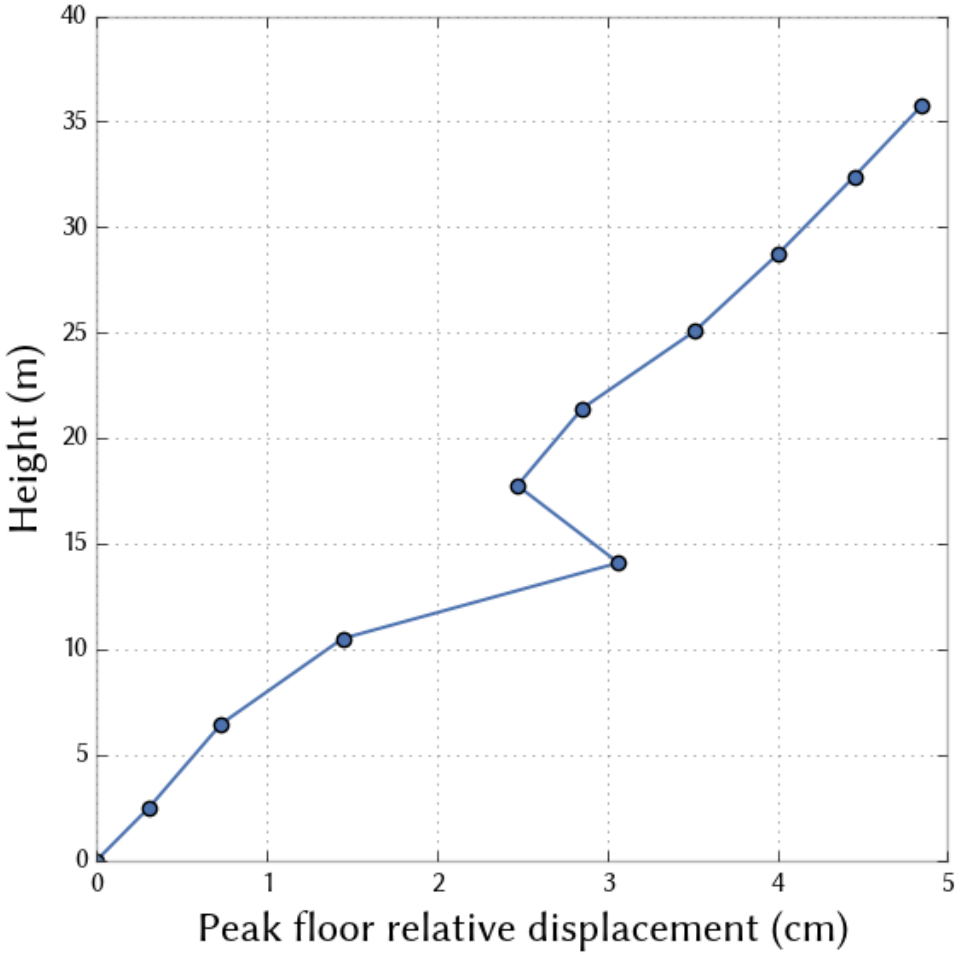
Sensor No	Level	Location	Height
1	Basement	N 08 - Floor	2.853
2	Basement	N 08 - Ceiling	0.353
3	Basement	F 10 - Ceiling	0.353
4	Ground	N 08 - Ceiling	-3.6
5	Level 1	N 08 - Ceiling	-7.644
6	Level 2	P 02 - Ceiling	-11.232
7	Level 3	N 08 - Ceiling	-14.897
8	Level 4	B02 - Ceiling	-18.56
9	Level 4	Q 02 - Ceiling	-18.56
10	Level 4	F 10 - Ceiling	-18.56
11	Level 4	P 10 - Ceiling	-18.56
12	Level 5	N 08 - Ceiling	-22.202
13	Level 6	N 08 - Ceiling	-25.882
14	Level 7	N 08 - Ceiling	-29.542
15	Level 8	N 08 - Ceiling	-32.881
16	Level 8	B02 - Ceiling	-32.681

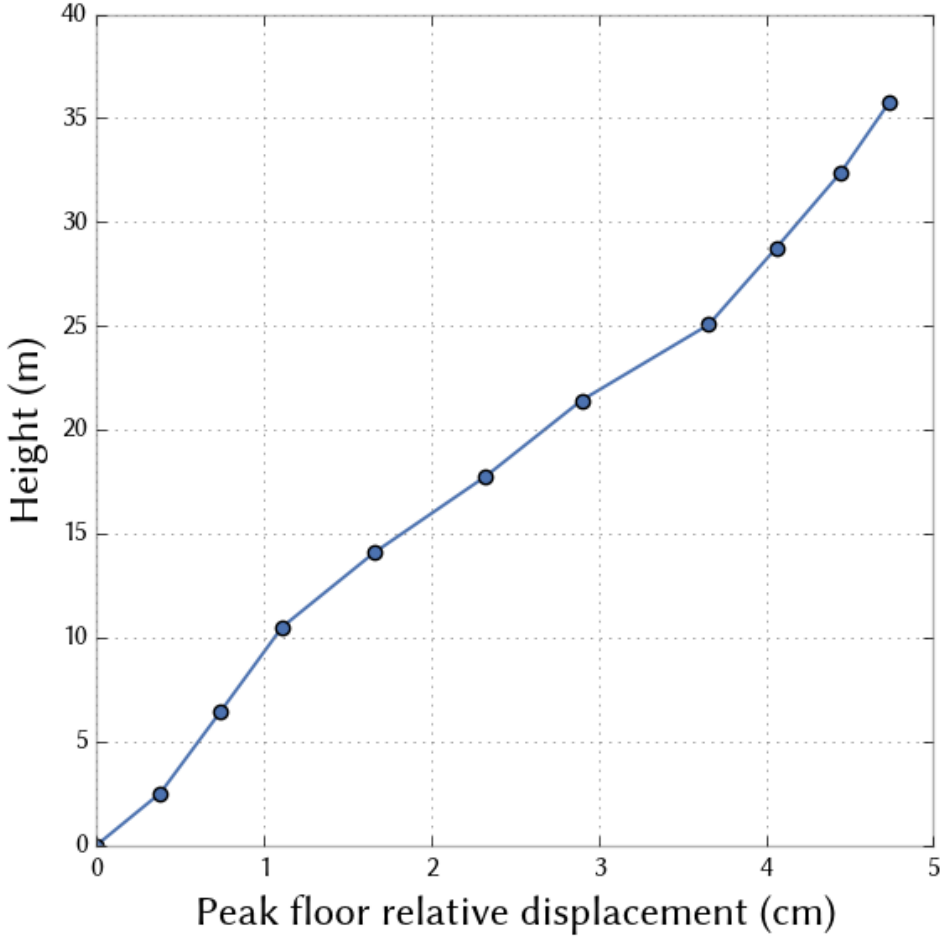
Peak floor accelerations



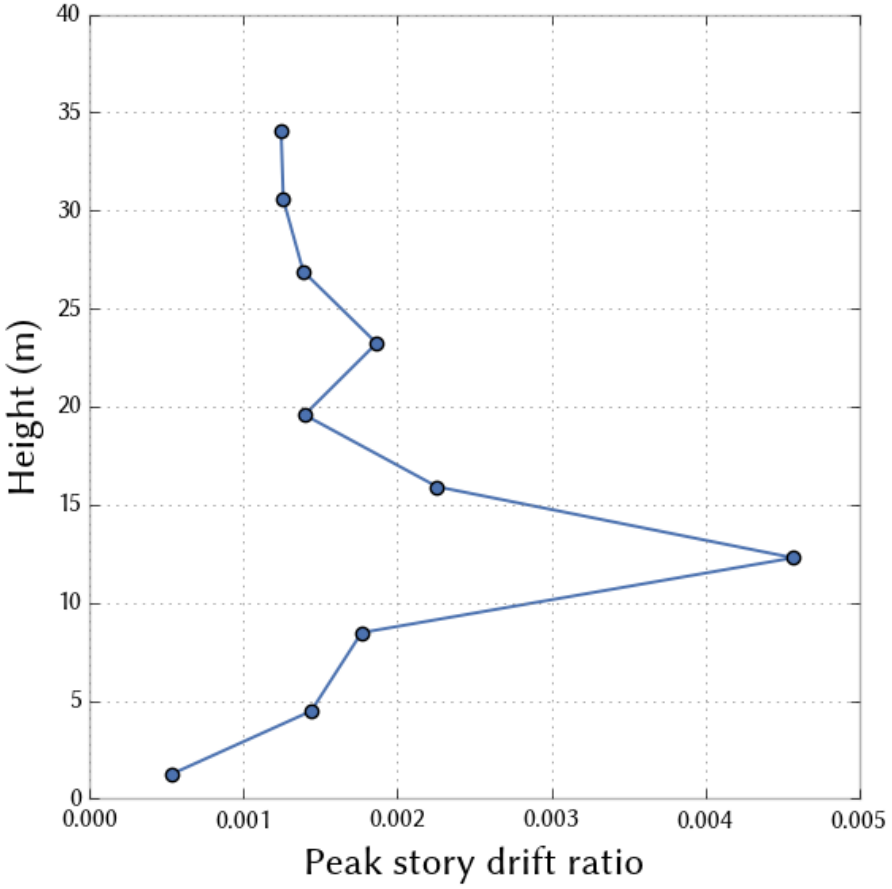


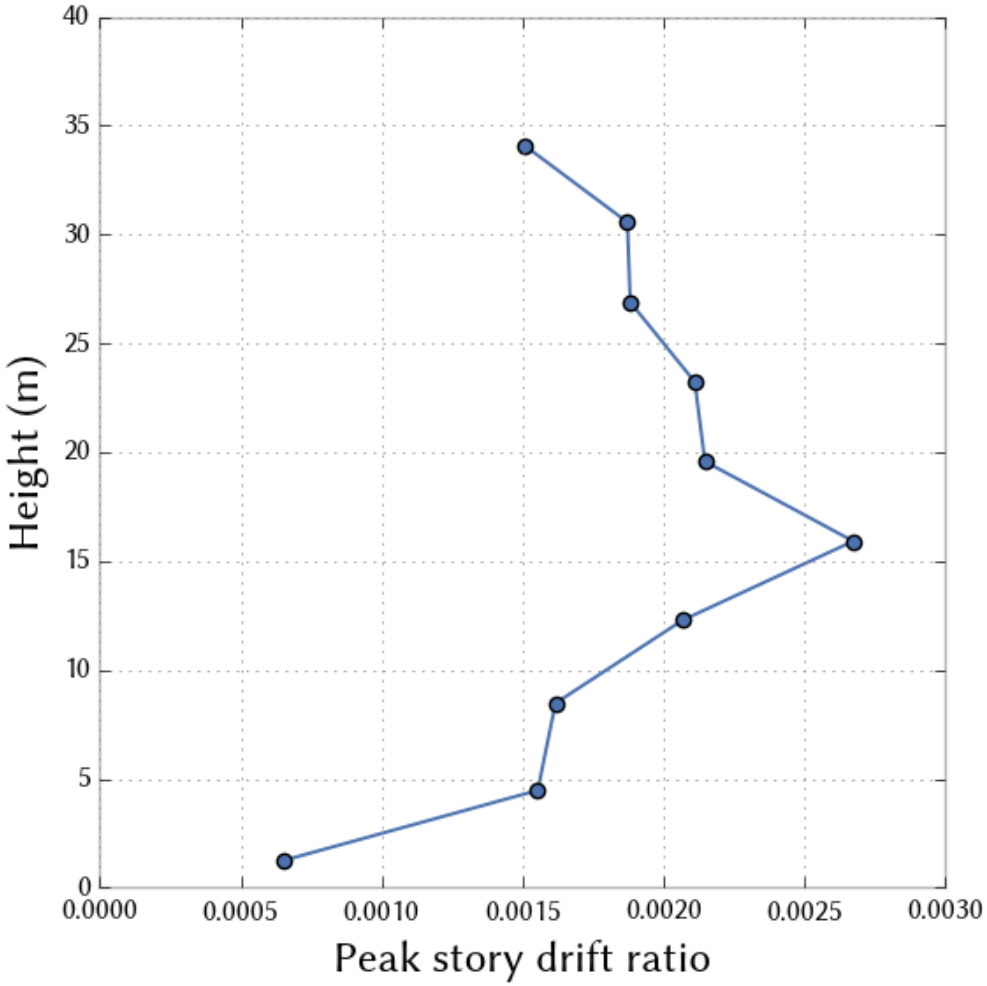
Peak floor displacements





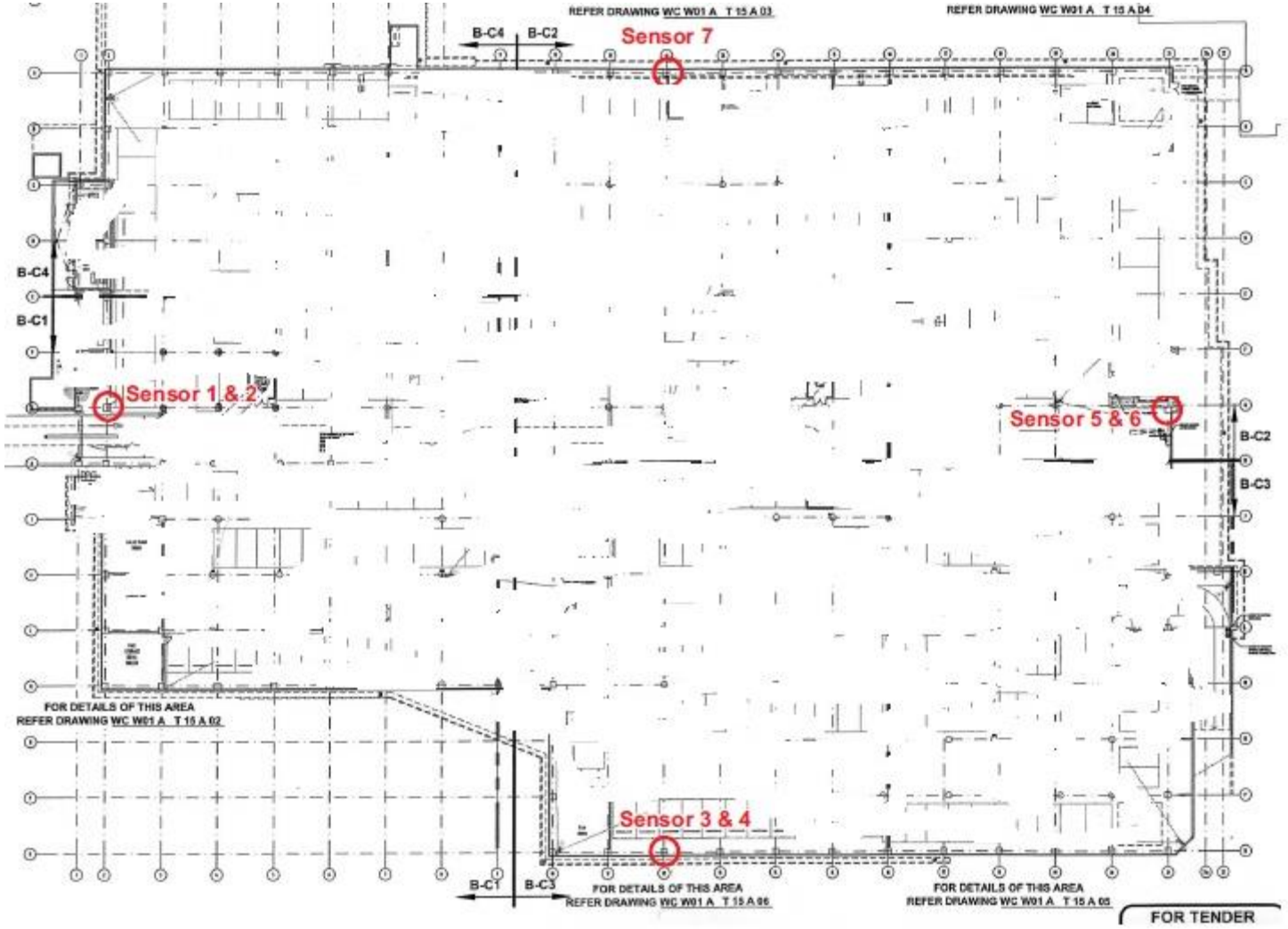
Inter-storey drift ratio





Wellington Hospital Building

Wellington Hospital, sensor locations



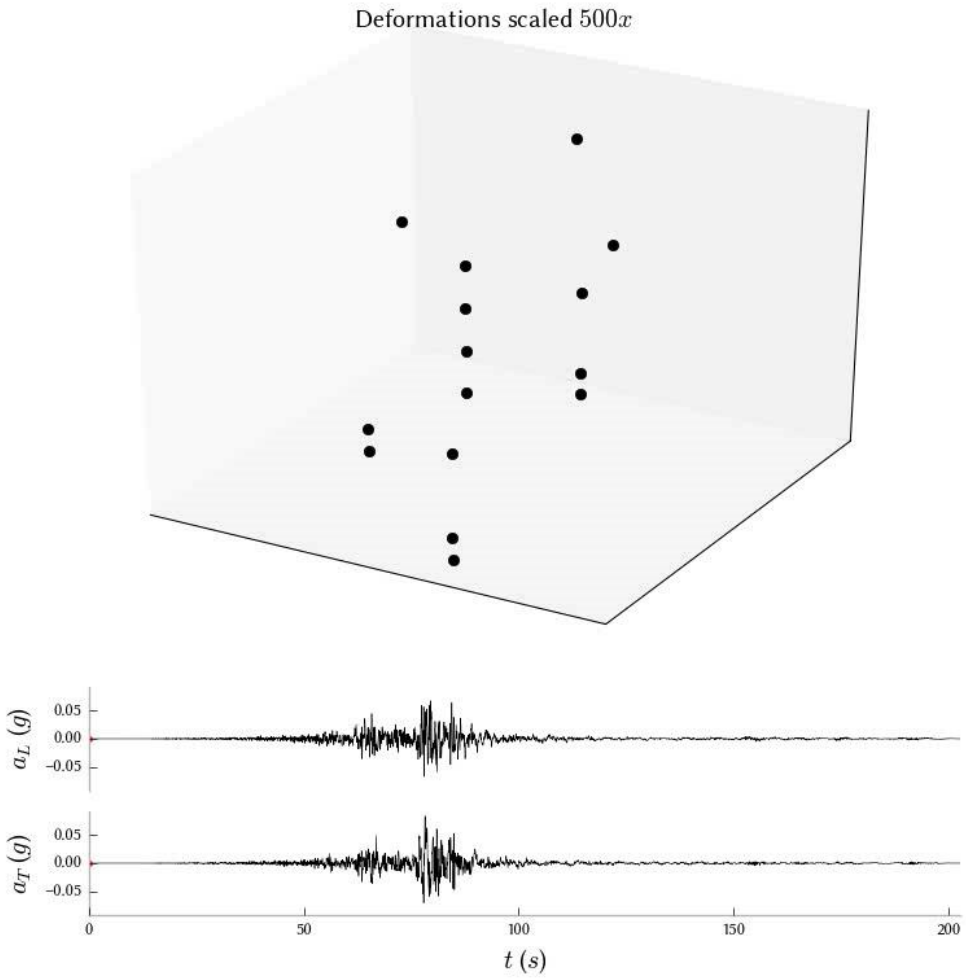
Sensor	Building Level	Grid Reference - Location
1	A	G2 - Bottom of Column
2	A	G2 - Top of Column
3	A	R11 - Bottom of Column
4	A	R11 - Top of Column
5	A	G21 - Bottom of Column
6	A	G21 - Top of Column
7	A	A11 - Top of Column
8	C	G2 - On column in ceiling space
9	C	G21 - On column in ceiling space
10	D	G19 - On column in ceiling space
11	E	G19 - On column in ceiling space
12	F	G19 - On column in ceiling space
13	G	G19 - On column in ceiling space
14	G	B15 - On column in ceiling space
15	G	G3 - On column in ceiling space
16	G	L15 - On column in ceiling space

Isolation devices used

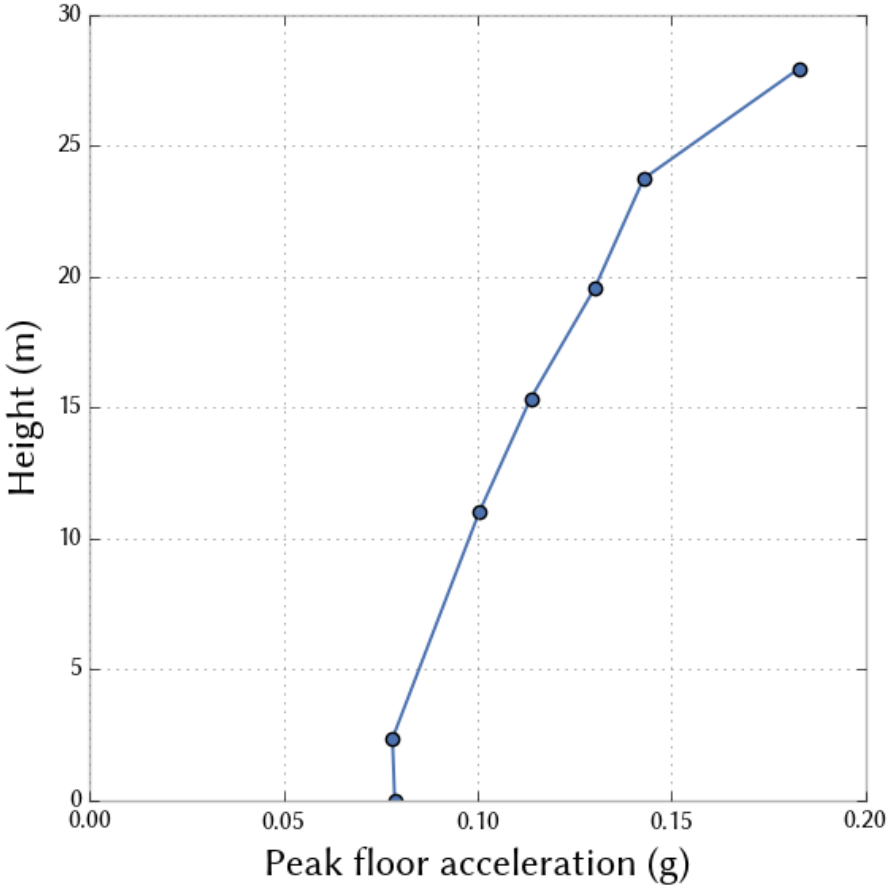
Lead rubber bearing

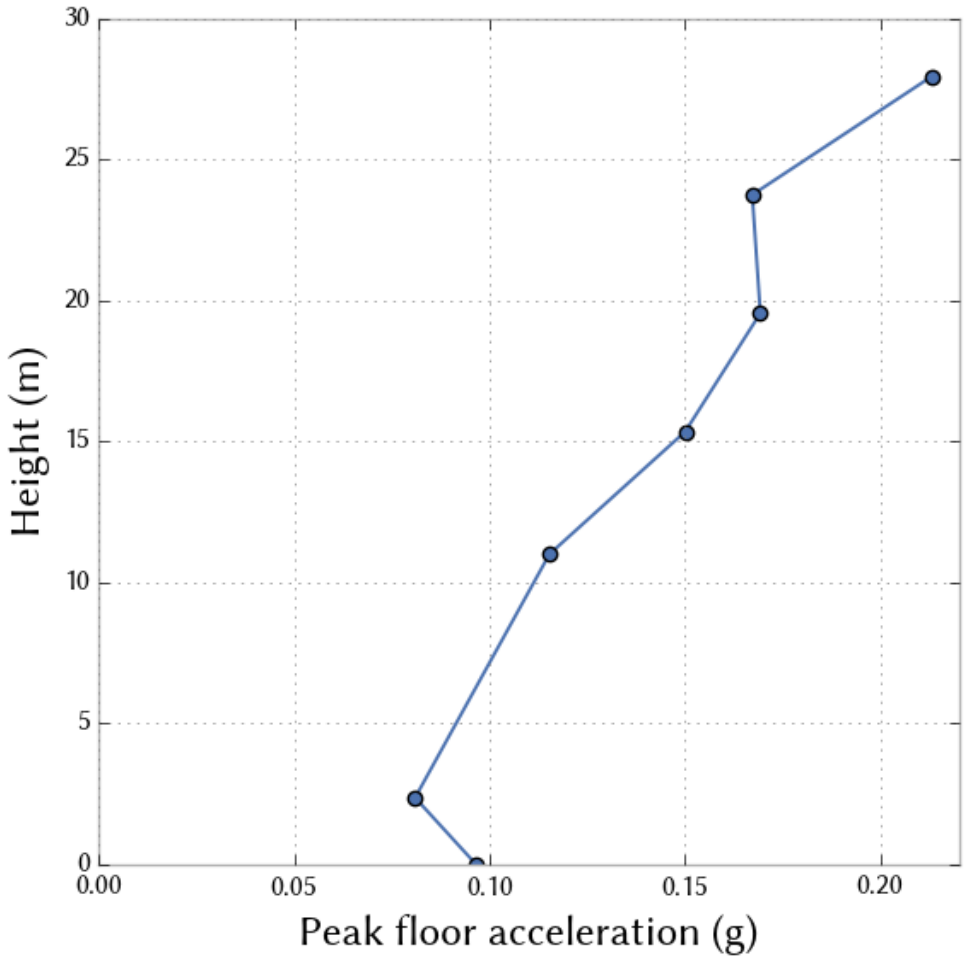
Ro Glider bearing

Animation

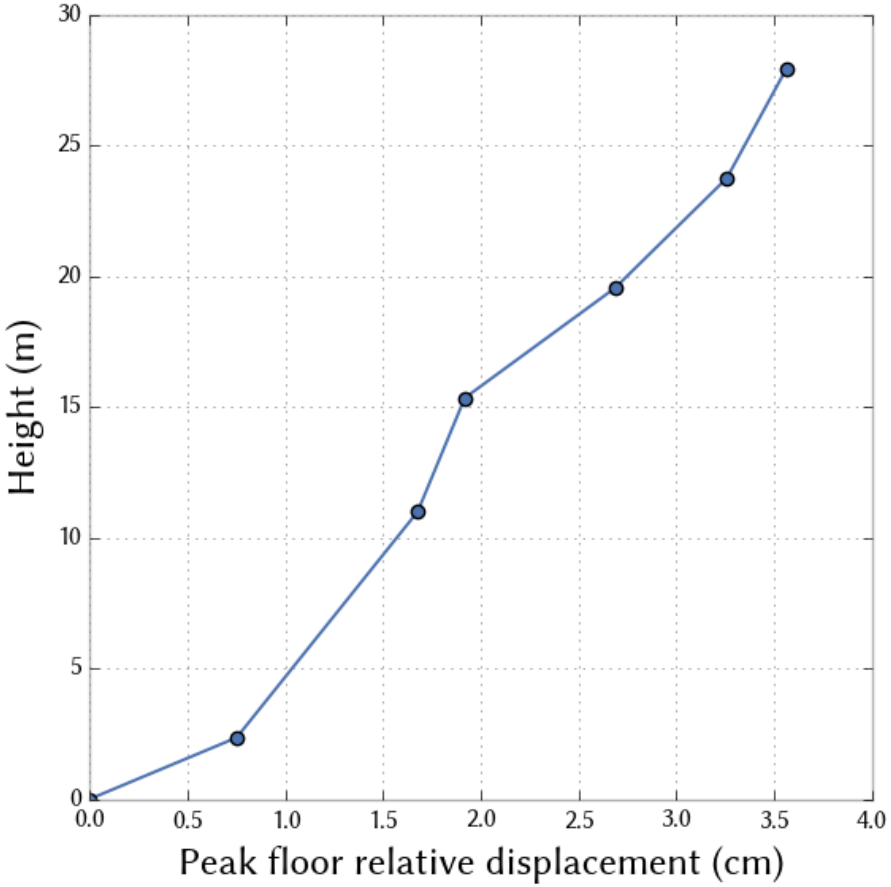

Deformations scaled $500x$
a_L (g)
0.05
0.00
−0.05
a_T (g)
0.05
0.00
−0.05
0
50
100
150
200
t (s)

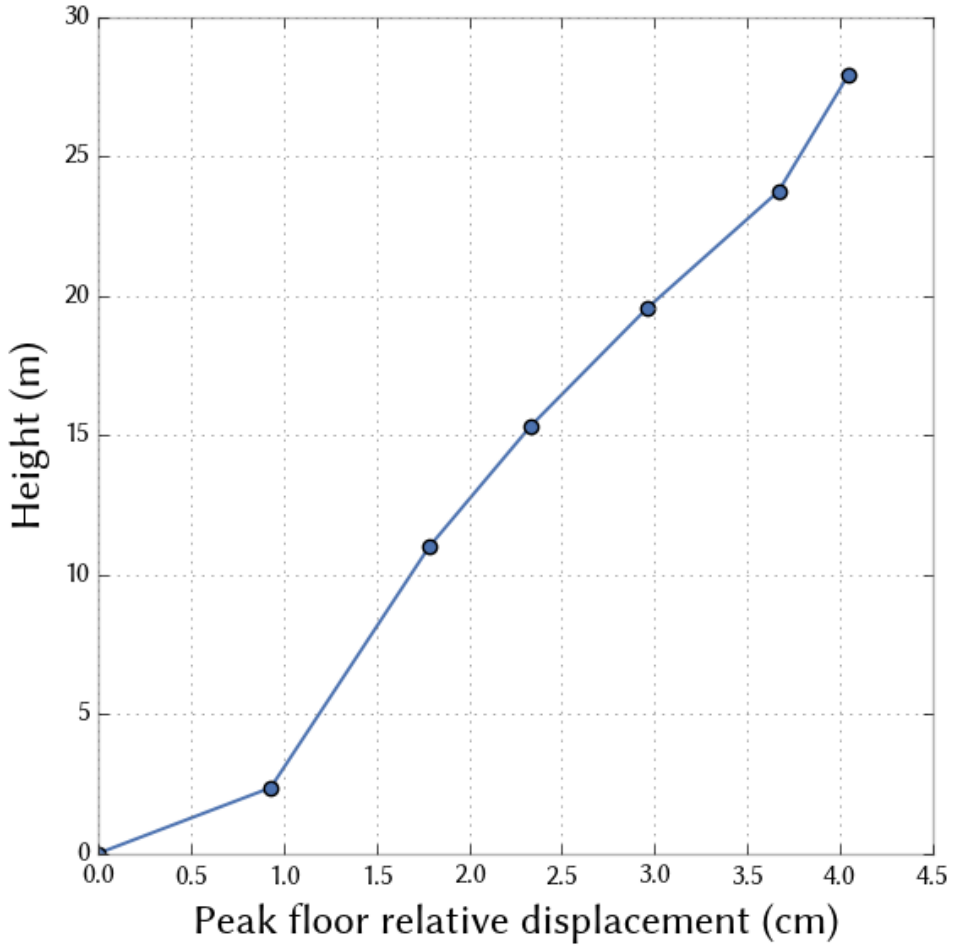
Peak floor acceleration



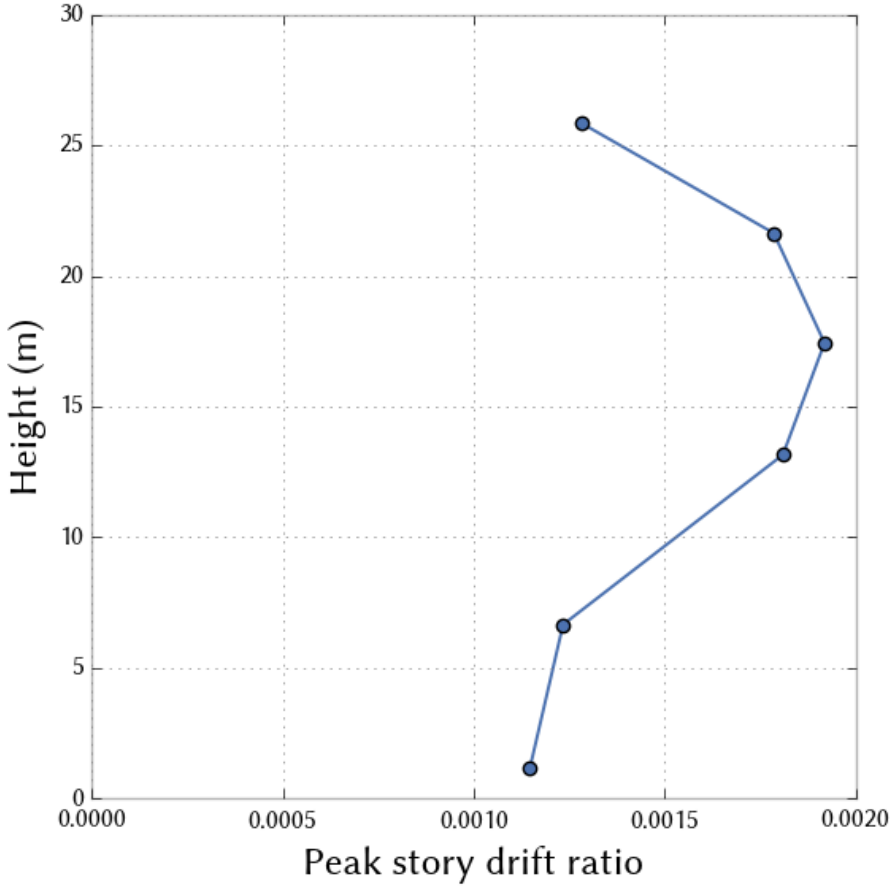


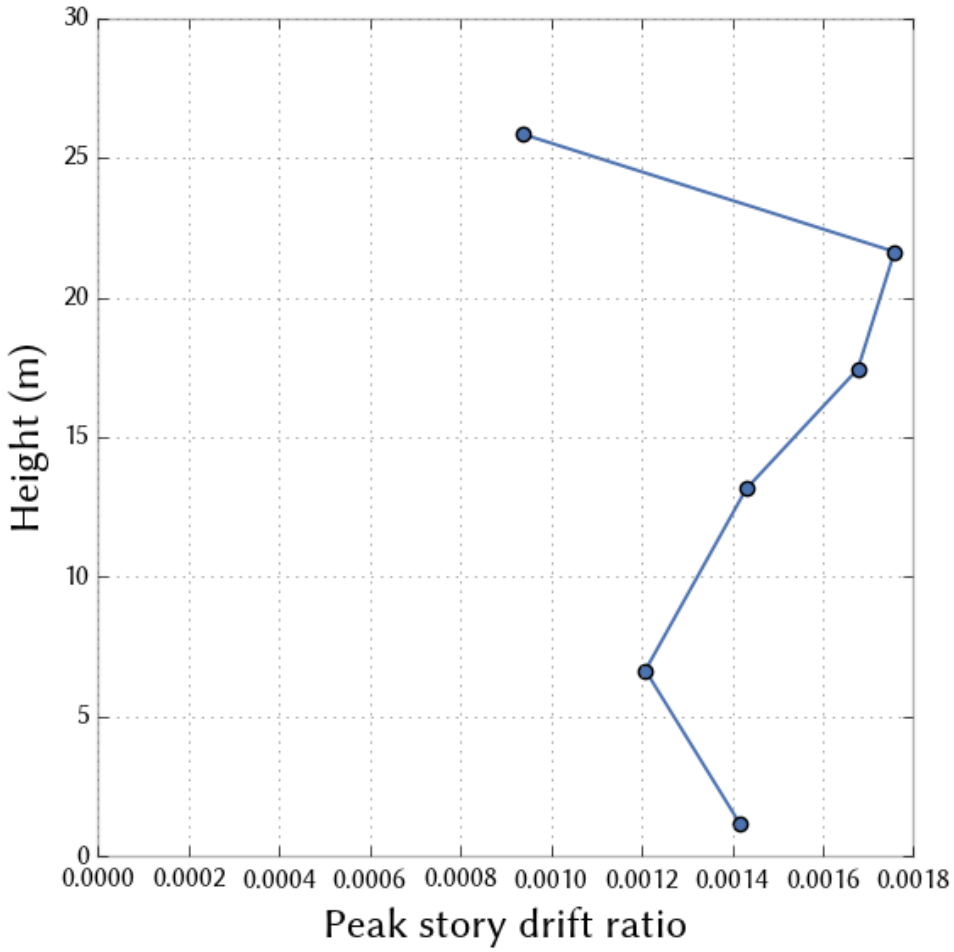
Peak floor relative displacement





Peak inter-storey drifts





Acquiring data

- Approach info@geonet.org.nz
- Terms and conditions - accept
- Triggered data / Continuous waveform data available

Thank you for your attention!

Questions?

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