History of Seismic Design and Future Trends

Comment on Dr Dhakel's Presentation on Performance-based Earthquake Engineering
12 March, 2012

Richard Sharpe, Beca

Topics:

- Complementary views from a consulting engineer
- Some realities about design for earthquakes
- How certain are our design loads?
- Performance-based engineering – not new.
- Innovation in design for earthquakes
- Who is willing to pay for better resilience?

Some Realities

The Shaking on 22nd February

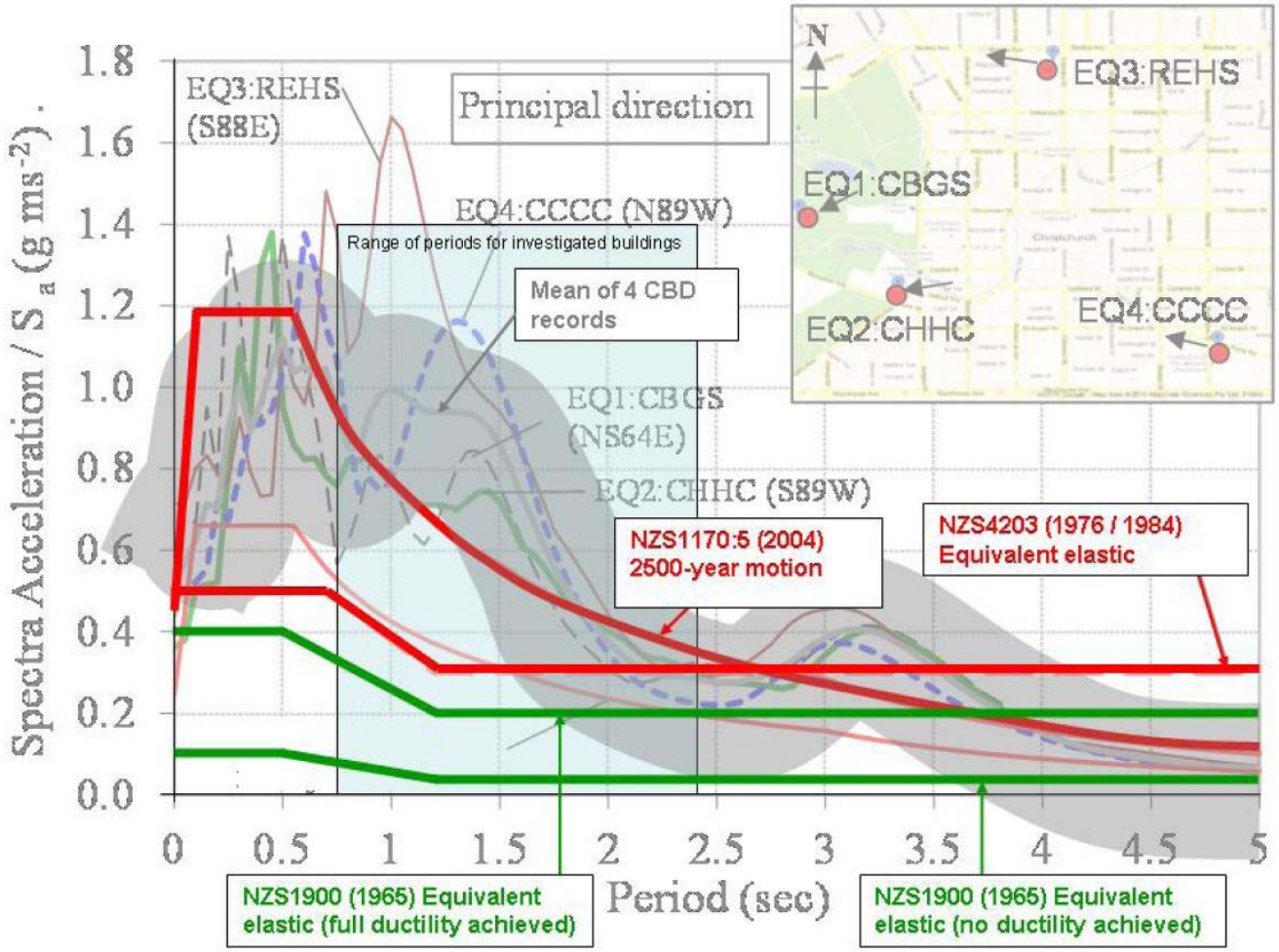
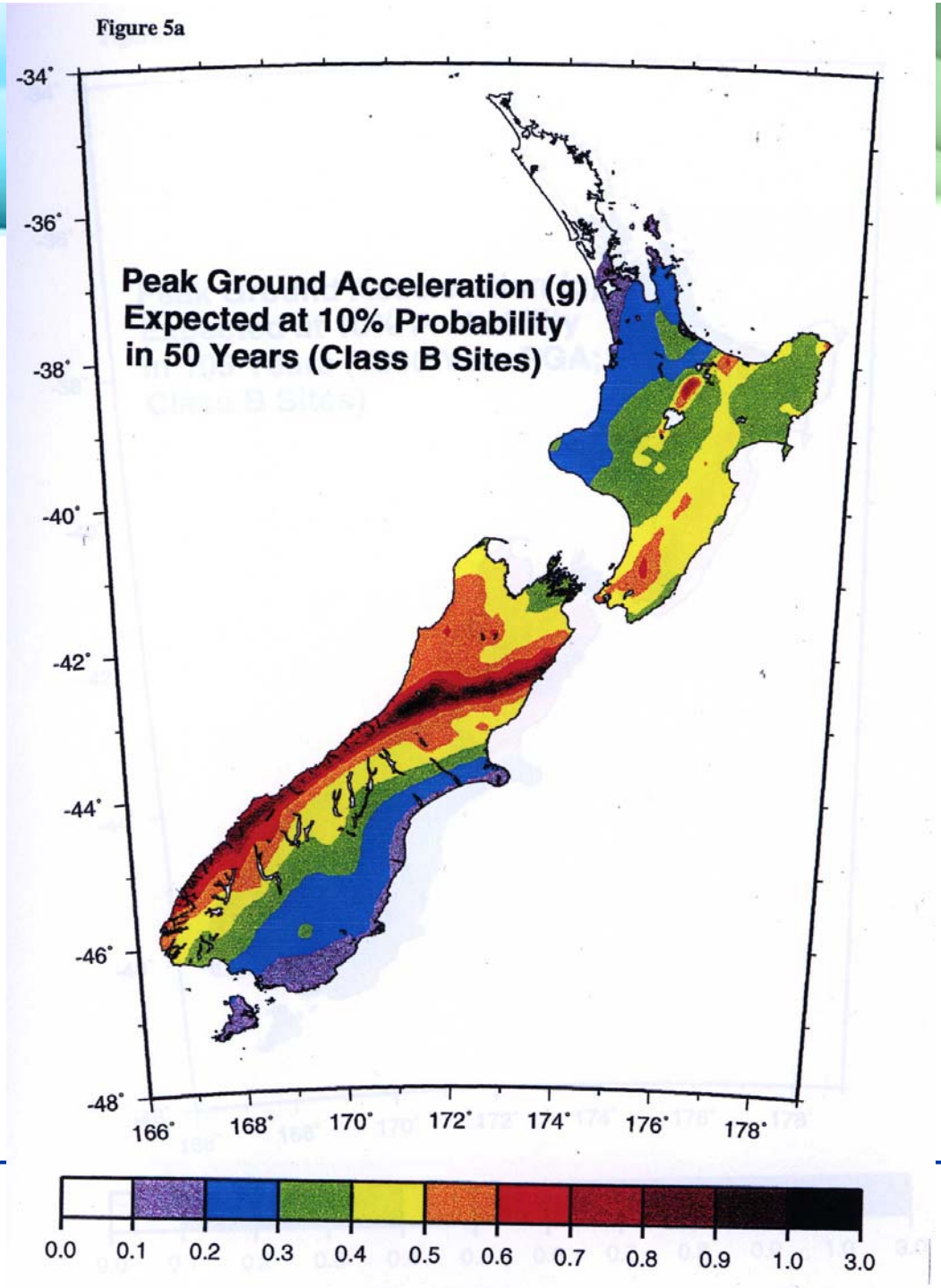
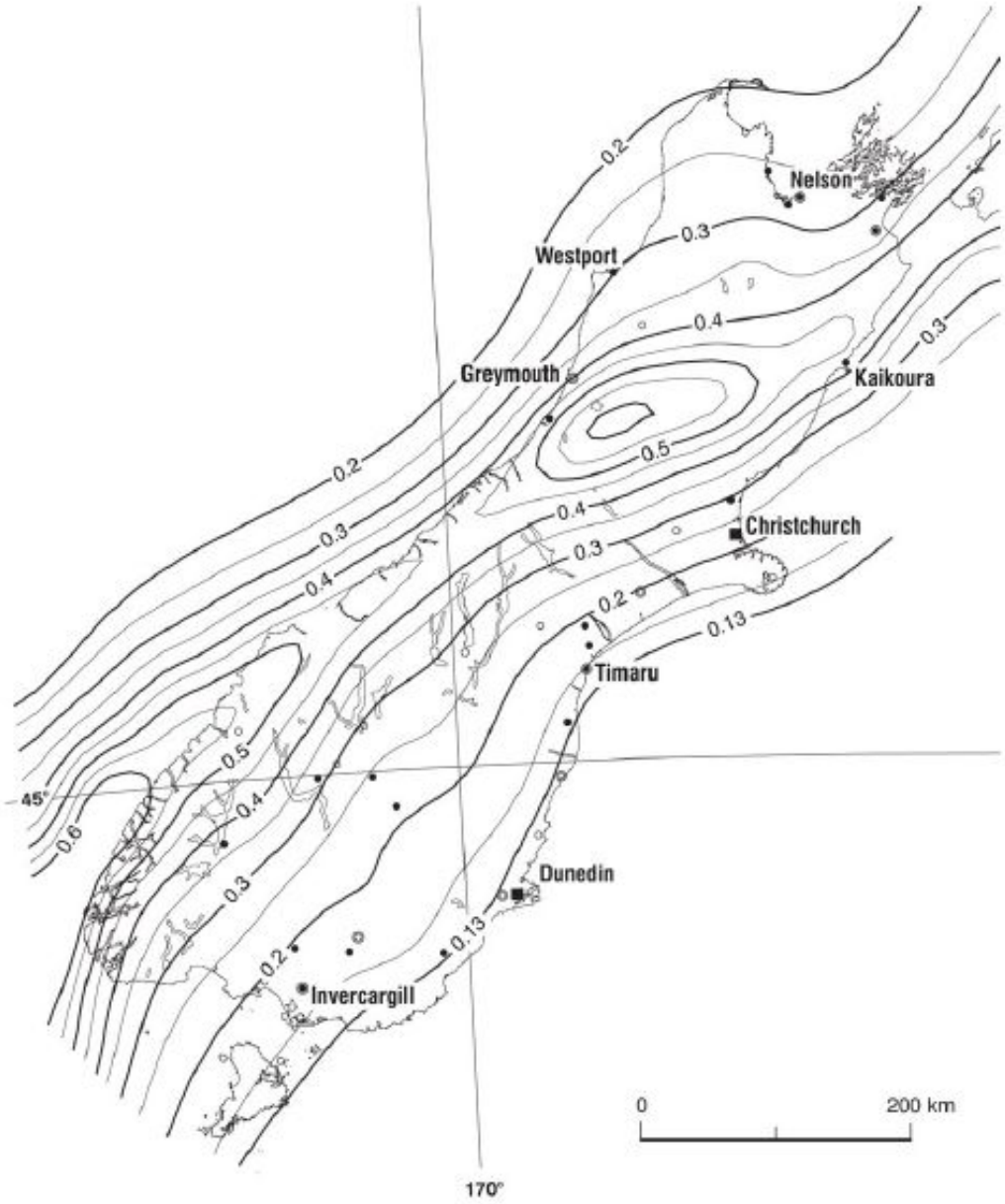


Figure 5a


Peak Ground Acceleration (g)
Expected at 10% Probability
in 50 Years (Class B Sites)
-34°
-36°
-38°
-40°
-42°
-44°
-46°
-48°
166°
168°
170°
172°
174°
176°
178°
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
3.0



NOTE: Circles and squares correspond to towns and cities.

FIGURE 3.4 HAZARD FACTOR, *Z*, FOR THE SOUTH ISLAND

Performance Requirements

- Implicit in NZ Building Code

Importance Levels

TABLE 3.1

CONSEQUENCES OF FAILURE FOR IMPORTANCE LEVELS

Consequences of failure	Description	Importance level	Comment
Low	**Low** consequence for loss of human life, *or* **small or moderate** economic, social or environmental consequences	1	Minor structures (failure not likely to endanger human life)
Ordinary	**Medium** consequence for loss of human life, *or* **considerable** economic, social or environmental consequences	2	Normal structures and structures not falling into other levels
High	**High** consequence for loss of human life, *or* **very great** economic, social or environmental consequences	3	Major structures (affecting crowds)
		4	Post-disaster structures (post disaster functions or dangerous activities)
Exceptional	Circumstances where reliability must be set on a case by case basis	5	Exceptional structures

Annual Probability of Exceedance

ANNUAL PROBABILITY OF EXCEEDANCE

Design working life	Importance level	Annual probability of exceedance for ultimate limit states			Annual probability of exceedance for serviceability limit states	
		Wind	Snow	Earthquake	SLS1	SLS2 Importance level 4 only
Construction equipment, e.g., props, scaffolding, braces and similar	2	1/100	1/50	1/100	1/25	
Less than 6 months	1	1/25	1/25	1/25	—	
	2	1/100	1/50	1/100	1/25	
	3	1/250	1/100	1/250	1/25	
	4	1/1000	1/250	1/1000	1/25	
5 years	1	1/25	1/25	1/25	—	—
	2	1/250	1/50	1/250	1/25	—
	3	1/500	1/100	1/500	1/25	—
	4	1/1000	1/250	1/1000	1/25	1/250
25 years	1	1/50	1/25	1/50	—	—
	2	1/250	1/50	1/250	1/25	—
	3	1/500	1/100	1/500	1/25	—
	4	1/1000	1/250	1/1000	1/25	1/250
50 years	1	1/100	1/50	1/100	—	—
	2	1/500	1/150	1/500	1/25	—
	3	1/1000	1/250	1/1000	1/25	—
	4	1/2500	1/500	1/2500	1/25	1/500
100 years or more	1	1/250	1/150	1/250	—	—
	2	1/1000	1/250	1/1000	1/25	—
	3	1/2500	1/500	1/2500	1/25	—
	4	*	*	*	1/25	*

* For importance level 4 structures with design working life of 100 years or more, the design events are determined by a hazard analysis but need to have probabilities less than or equal to those for importance level 3.

Examples of Required Performance

Transpower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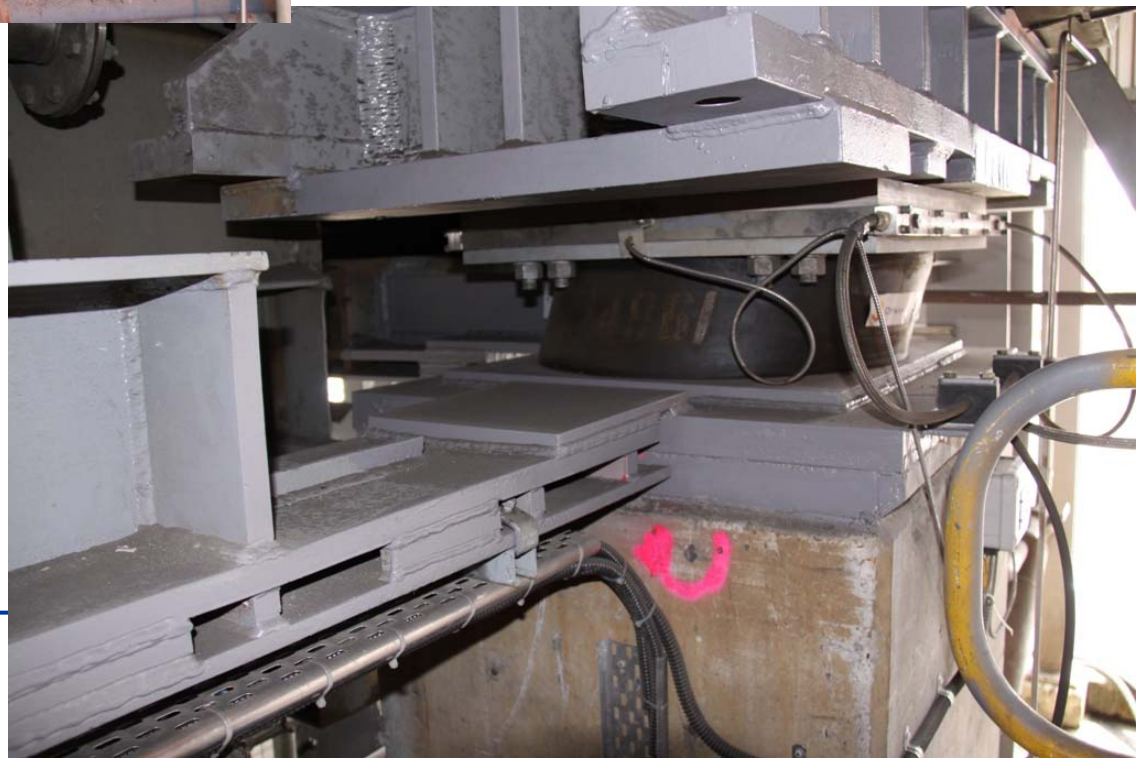
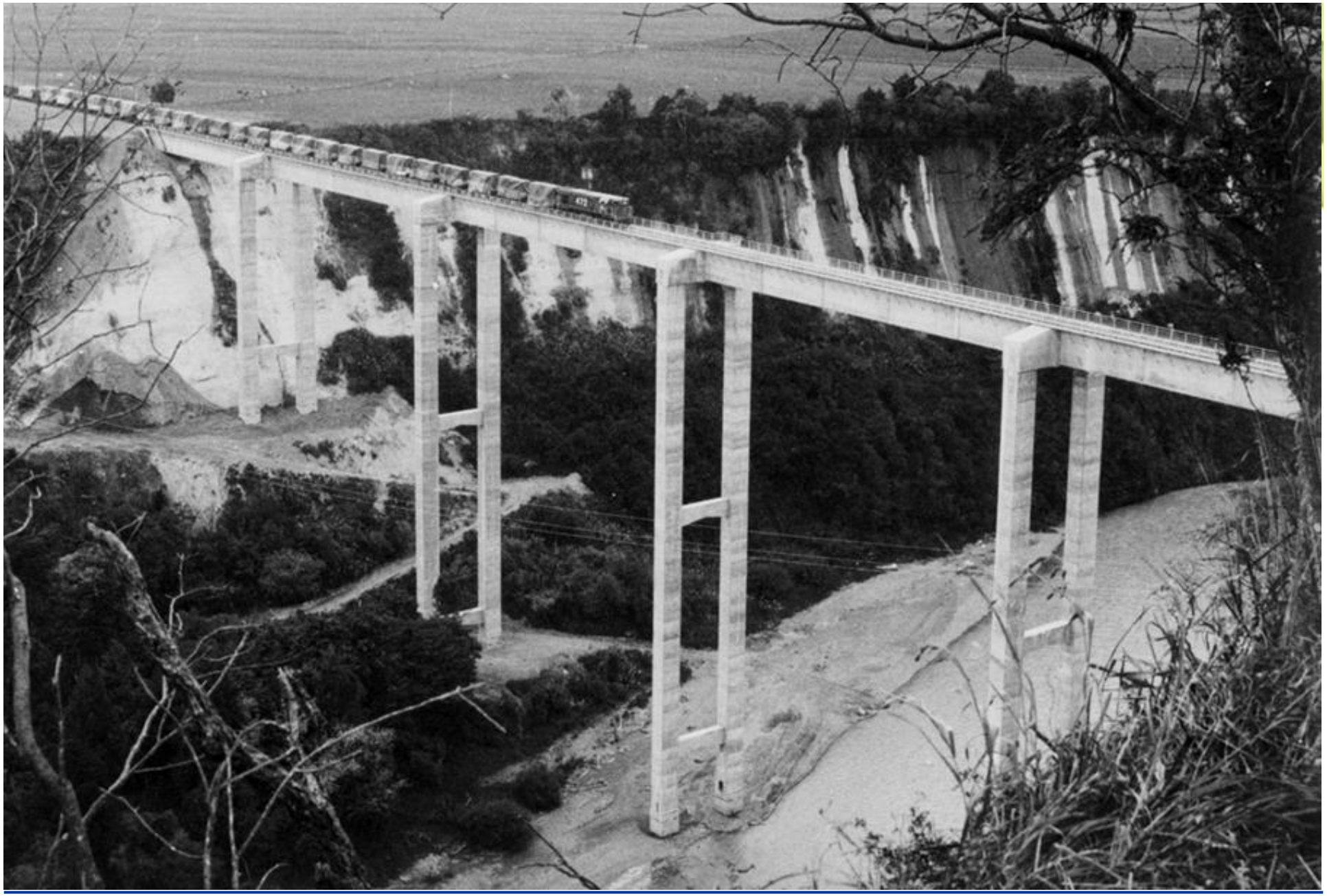
amec



Innovation – New Technologies


VICTORIA
UNIVERSITY
RAILWAY STATION



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ENG.SHA.0001.21


Pay and Display Parking
Pay at Machine
CAUTION TRUCKS


State Insurance
nova
AON


BUNNY ST
NO ENTRY
Except Vehicles on VUW business
30

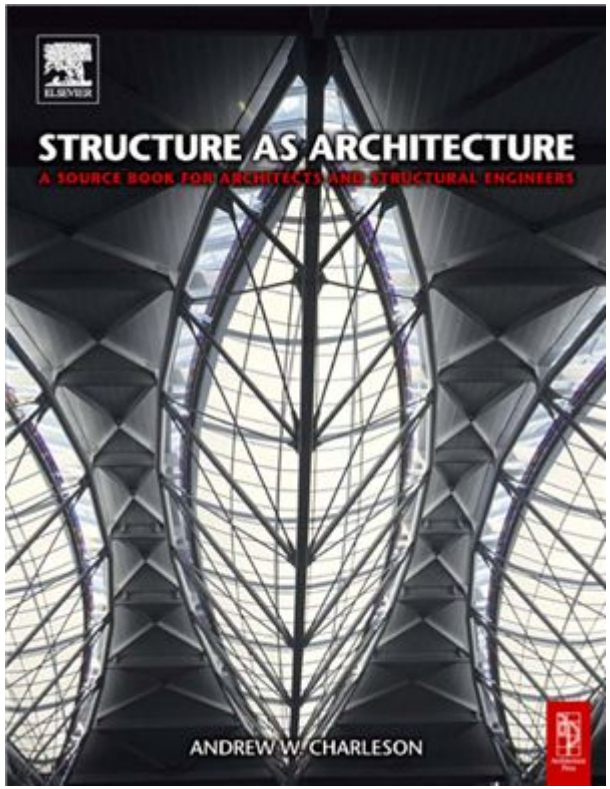
Base Isolation

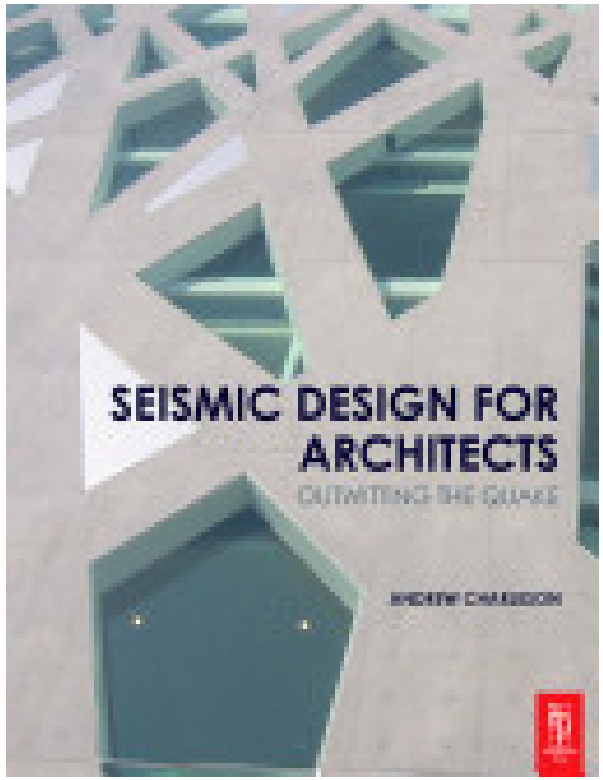

Hawkestone St
Karori


Christchurch Women's Hospital


SYBASE
NO ENTRY


Baldwins
HUNTER ST
WORKSHOP
WORKSHOP
HIGHER TASTE


STRUCTURE AS ARCHITECTURE
A SOURCE BOOK FOR ARCHITECTS AND STRUCTURAL ENGINEERS
ANDREW W. CHARLESON


SEISMIC DESIGN FOR ARCHITECTS

Buildings – you get what you pay for?


FUJITSU
FUJITSU
ANZ
JONES LANG LASALLE
FOR LEASE


bivouac outdoor

Fix, Fasten & Forget?

- In CBD and in residences, a lot of unnecessary disruption because of lack of “Fix, Fasten, Forget” to non-structural items.

Summary

- Getting the concepts right is more important that the design load level
- We don’t design earthquake-proof buildings
- We have embraced aspects of performance-based design for decades
- Damage-reduction technologies are developing rapidly, but base isolation is the best one for reduction of damage to contents.
- Institutional and industrial clients are ahead of commercial building ones.