

The Christchurch (New Zealand) Earthquake, 4 September 2010

A Reconnaissance Field Trip Report

The Christchurch Earthquake 4 September 2010 (4:35 am NZST)

Prof. Dr. Ing. Stefano Pampanin

Department of Civil and Natural Resources Engineering
University of Canterbury, Christchurch, New Zealand



Prof. Dr. Ing. Stefano Pampanin

Department of Civil and Natural Resources Engineering - University of Canterbury, Christchurch, New Zealand

How many “Lessons” do we still **NEED**?

1999 —————→ 2009



Izmit-Kocaeli, 1999

(photo courtesy: EERC Library, Berkeley)



L'Aquila, 2009

(photo courtesy: Anna Brignola)

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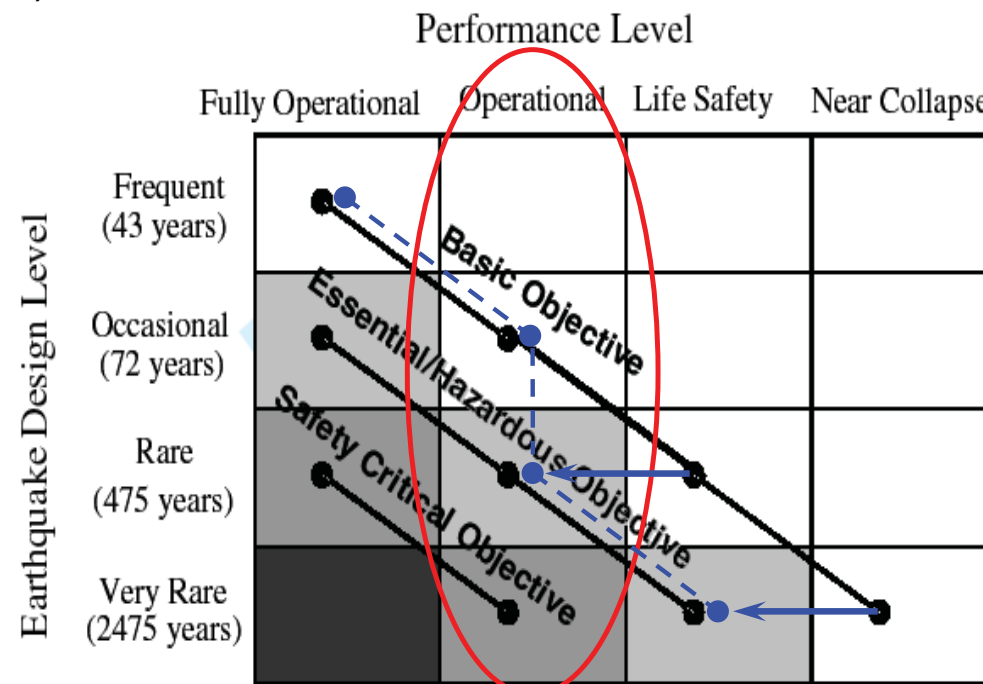
The real challenge of Performance-Based Design & Retrofit



Higher expectations of modern society (“the three **D**s”):

No victims nor collapse (**D**eaths)

- Minimum level of damage or direct costs (**D**amage = **D**ollars)
- Minimum business interruption and recovering (indirect) costs (**D**owntime)



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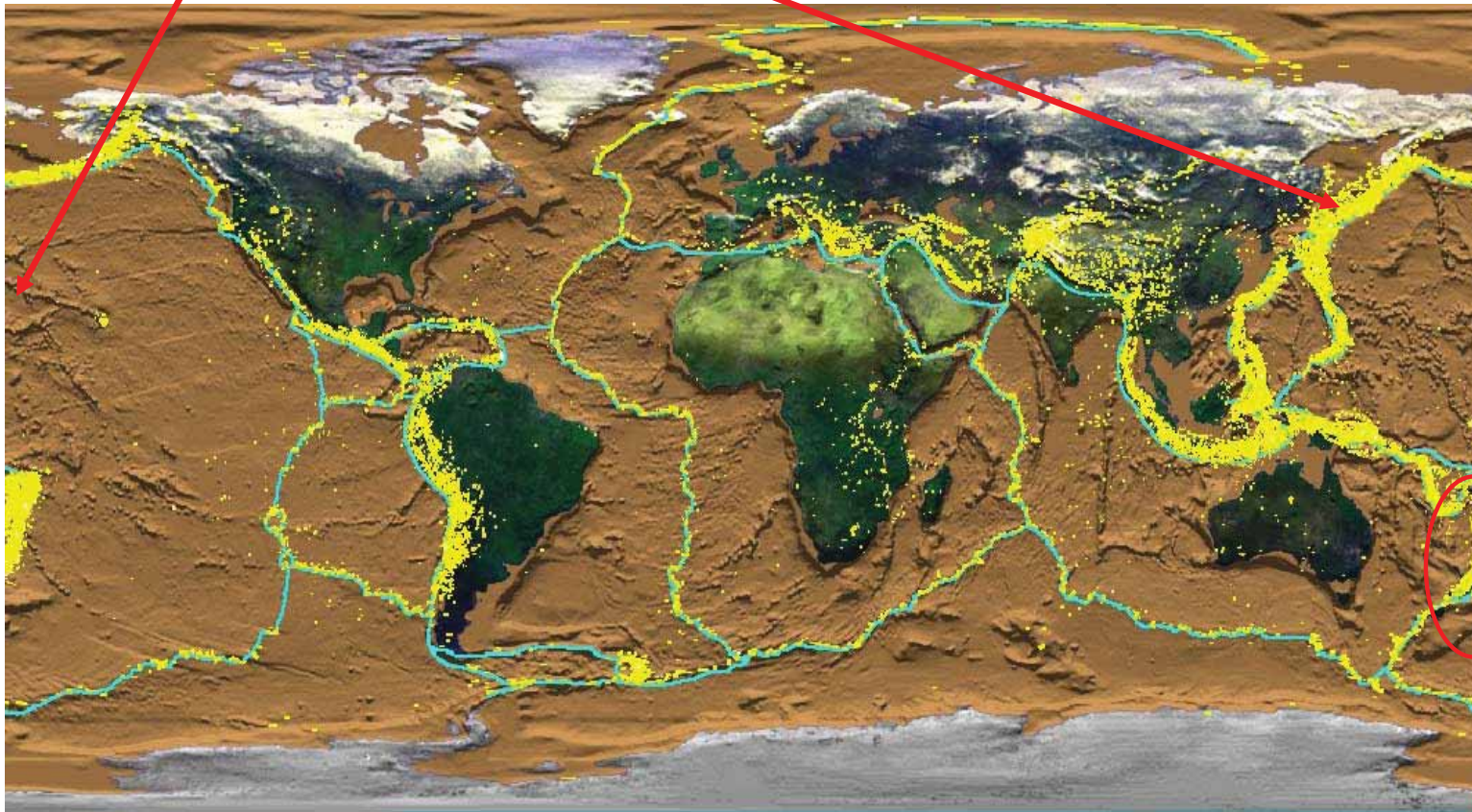
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Pacific ring
of fire

New Zealand

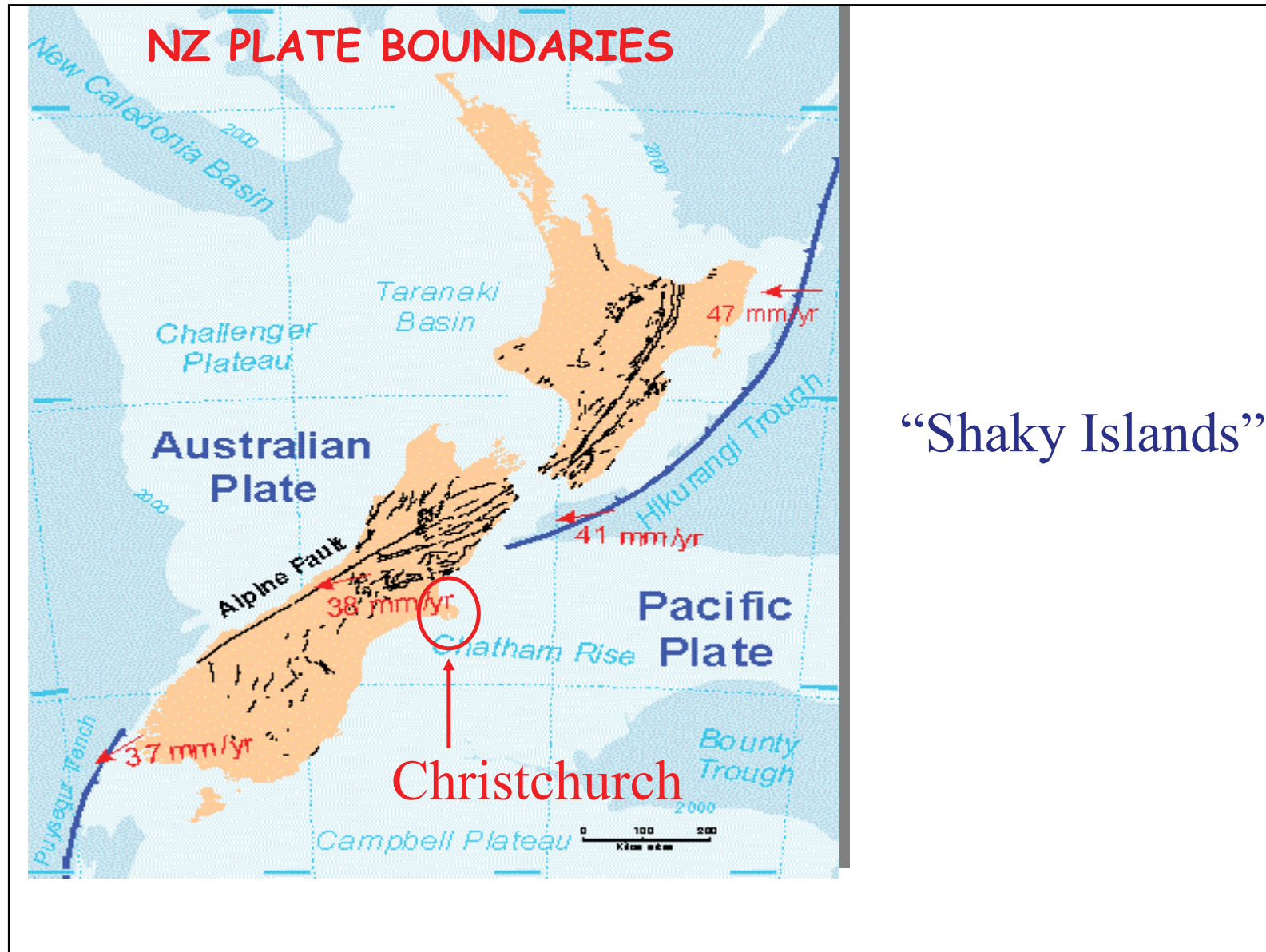


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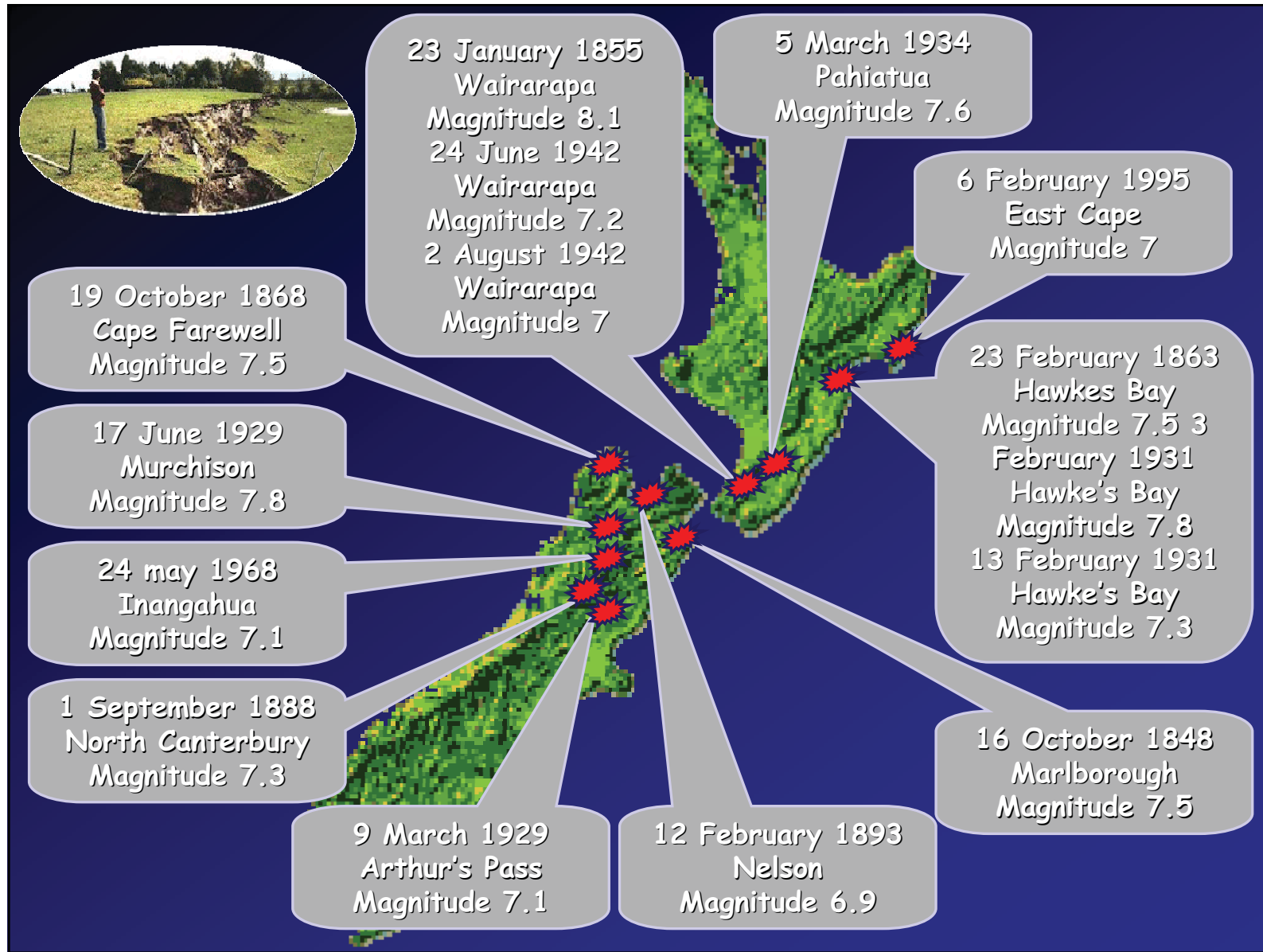


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Canterbury Plains and Banks Peninsula



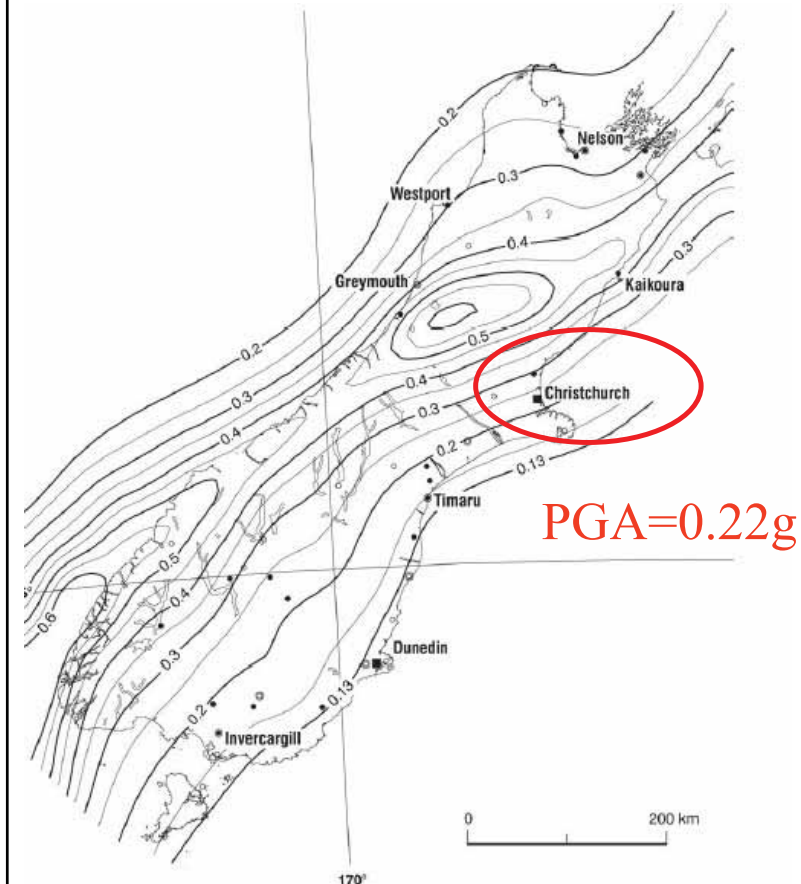
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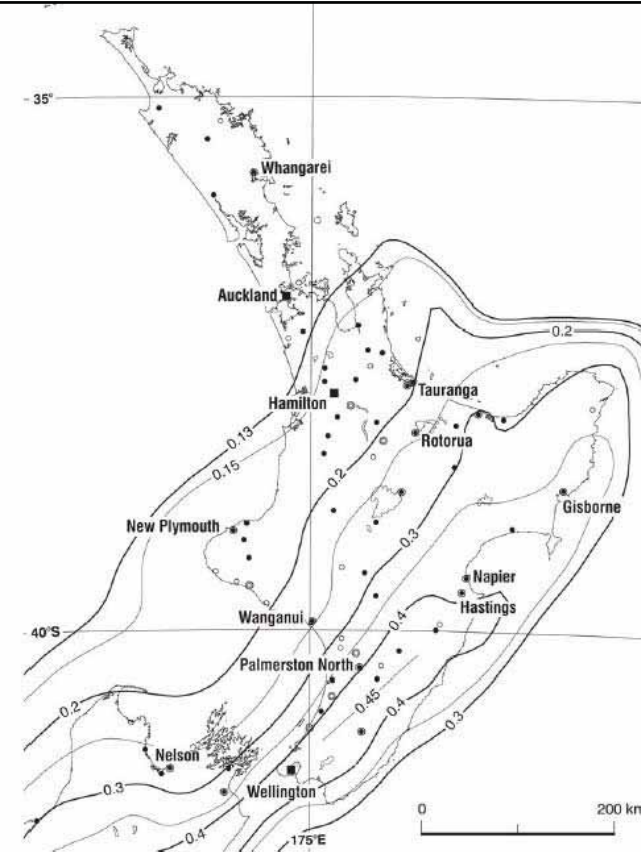
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Hazard factors Z (NZS1170.5 Loading Standard)



NOTE: Circles and squares correspond to towns and cities.

FIGURE 3.4 HAZARD FACTOR, Z, FOR THE SOUTH ISLAND



NOTE: Circles and squares correspond to towns and cities.

FIGURE 3.3 HAZARD FACTOR, Z, FOR THE NORTH ISLAND

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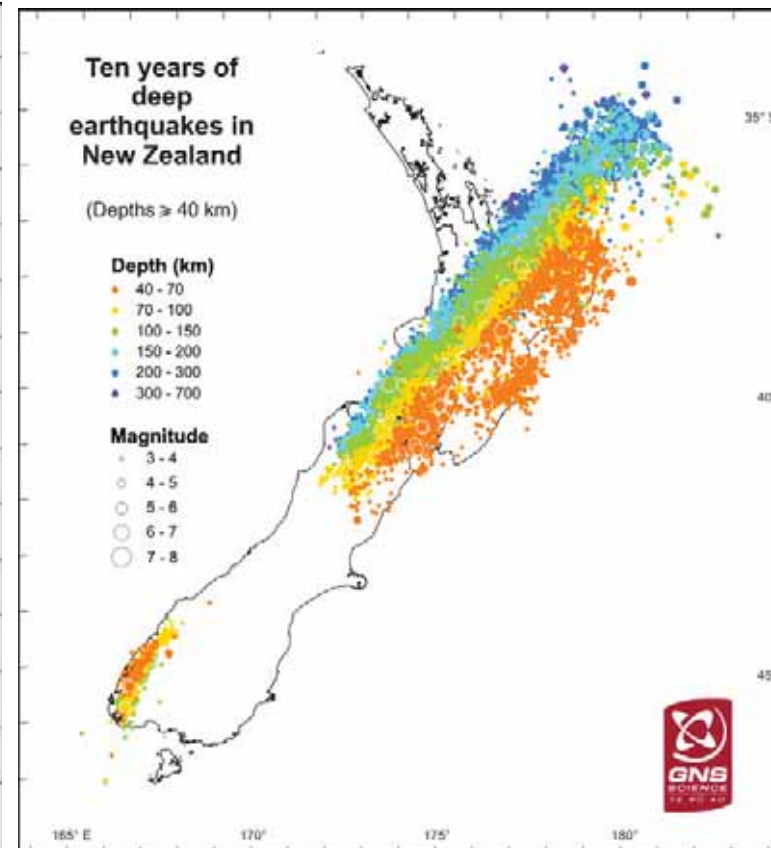
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2000-2010 Earthquakes in NZ

Shallow <40km



Deep >40km



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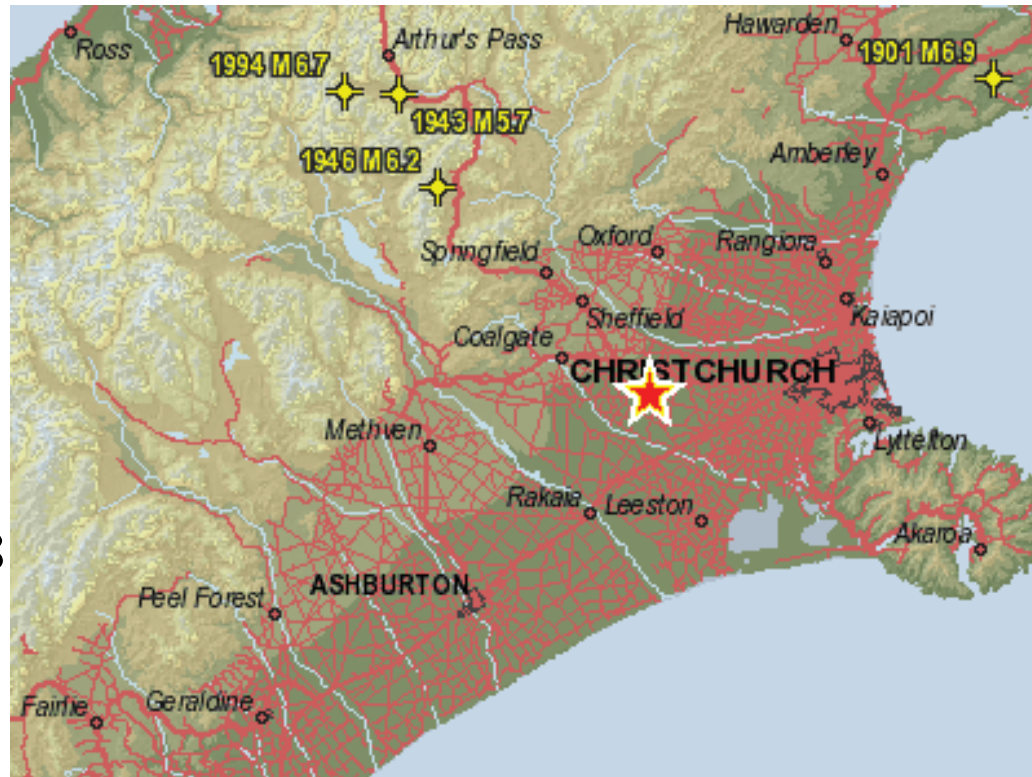
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The Main Shock

Saturday, September 4 2010 at **4:35 am** (NZST),
(UTS Sept 3, 4.35pm)

- **Magnitude $M_w=7.1$**
- **Focal Depth: 10 km**
- Location: 43.55°S ,
 172.18°E
- **30-40 km west of
Christchurch CBD**
- 10 Km from Darfield
- Max Intensity $\text{MMI}=8$



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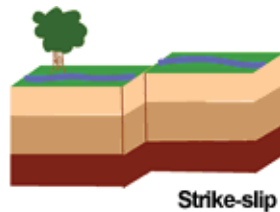
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Earthquake Losses

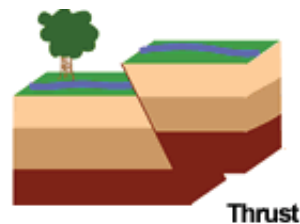
- **Victims: NONE**
- Injuries: 2 severe
- 2700 homes uninhabitable
- 3000 no weather proof
- 51 building in the Chch CBD assessed as unsafe
- 22 buildings in Kaipoi assessed as unsafe
- Approx. 250+ people in welfare centres plus dislocated people
- Thousands of properties damaged
 - **(60,000+ EQC insurance claims)**
- Estimated Damage Cost: **4+ Billion NZ\$**

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- Main Shock and several aftershocks: Strike Slip Mechanism



- Closed to the hillside and two Aftershock: Reverse Fault Mechanism

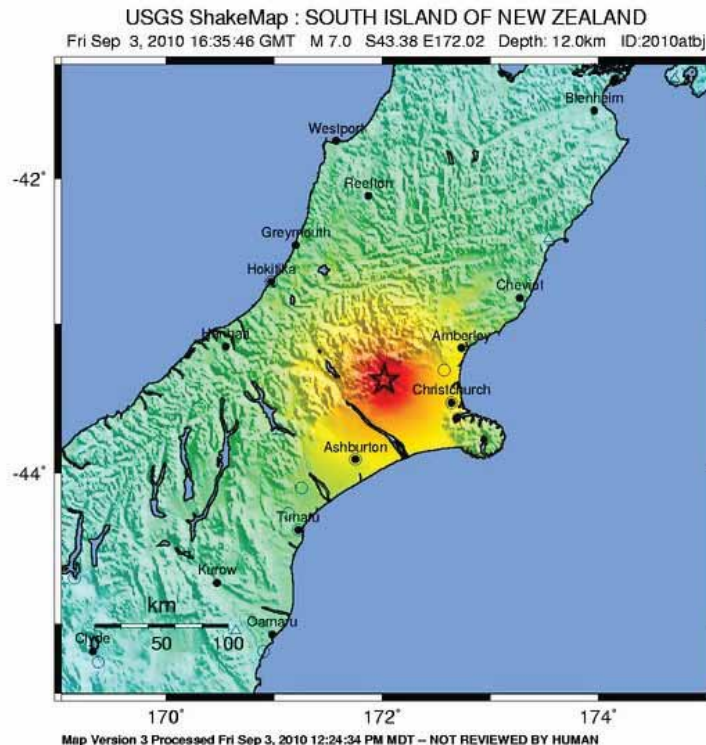
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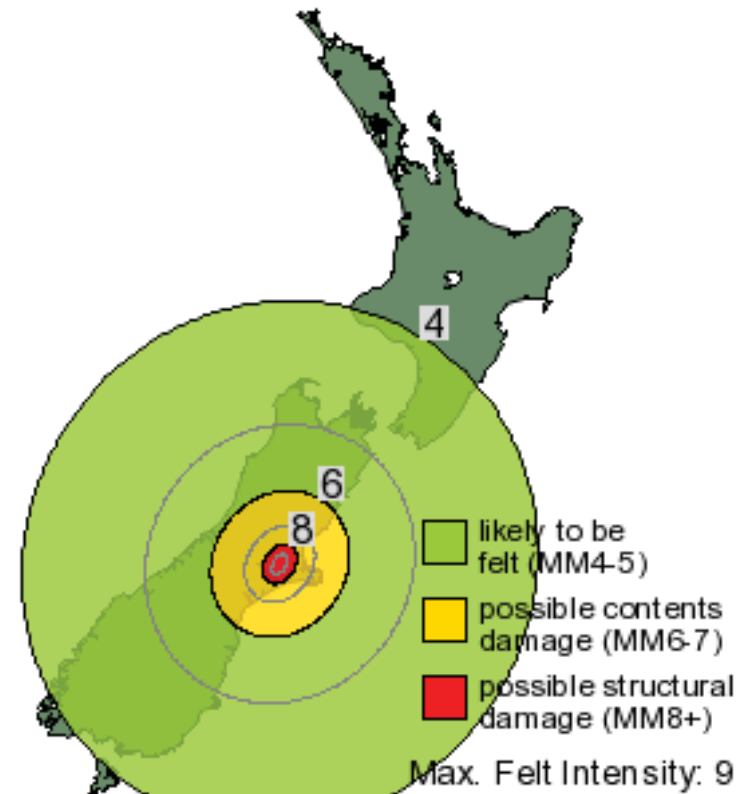
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Real-time Predicted Shake-Maps



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC. (%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL. (cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+



Geonet- GNS NZ

@ 9.55pm Italian time

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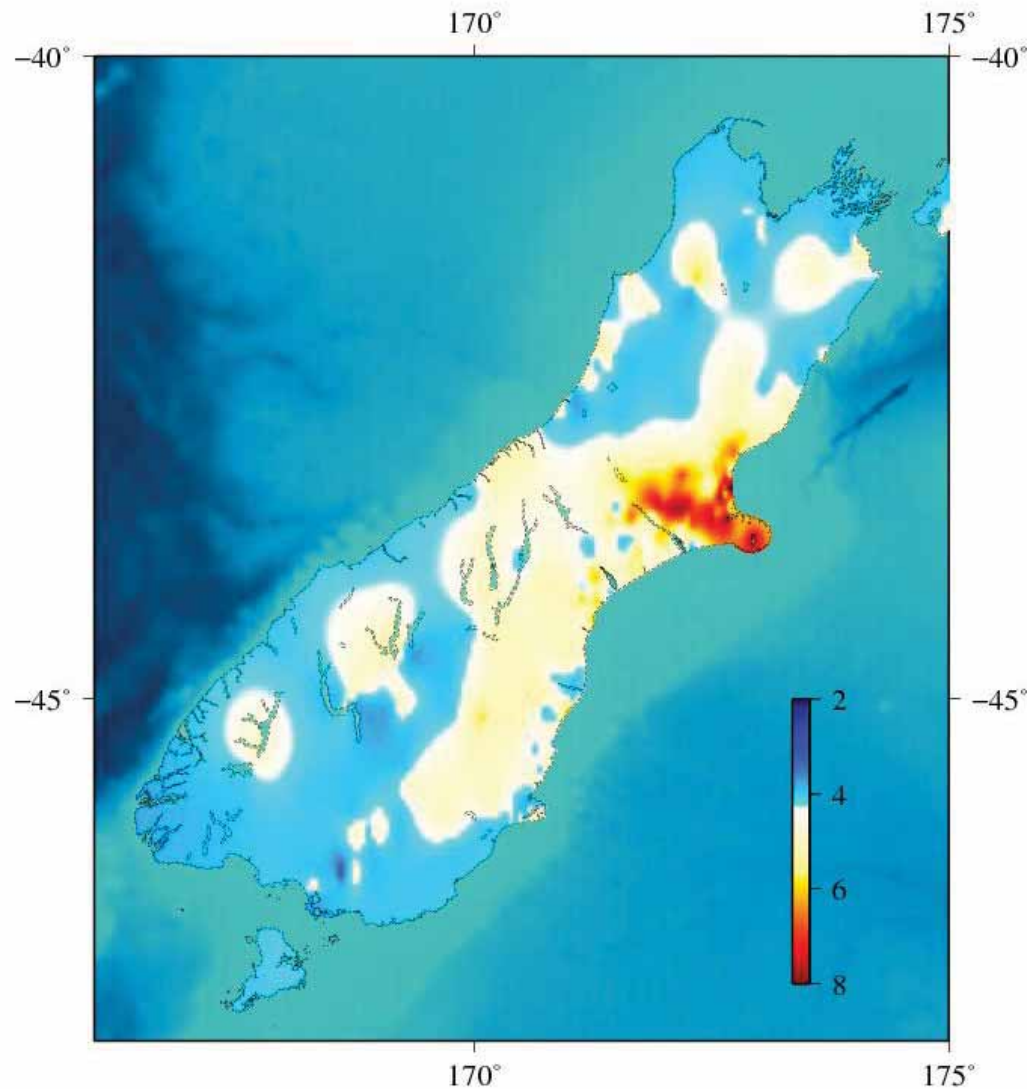
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ShakeMap
(felt by people)

up to MMI 8

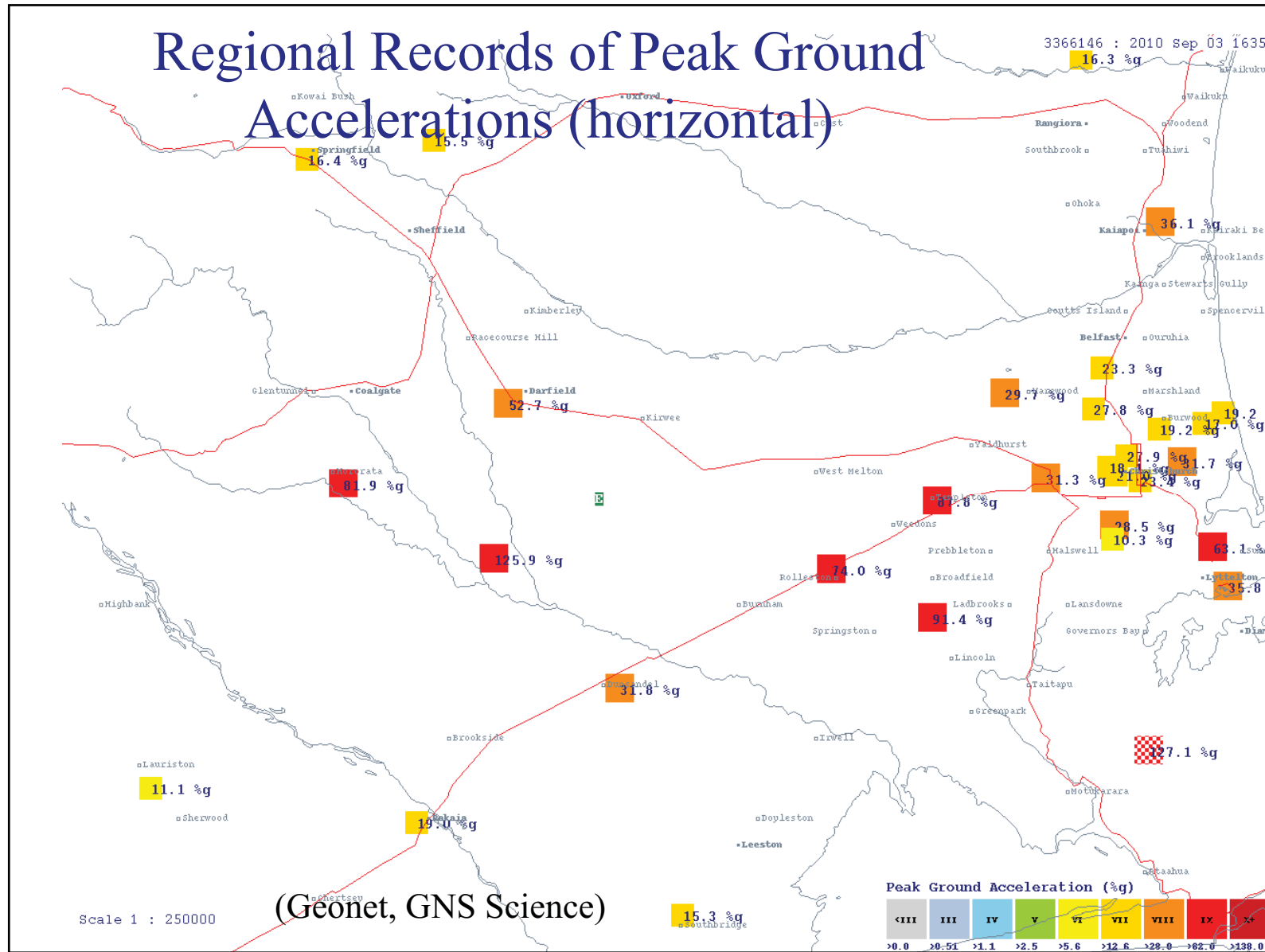


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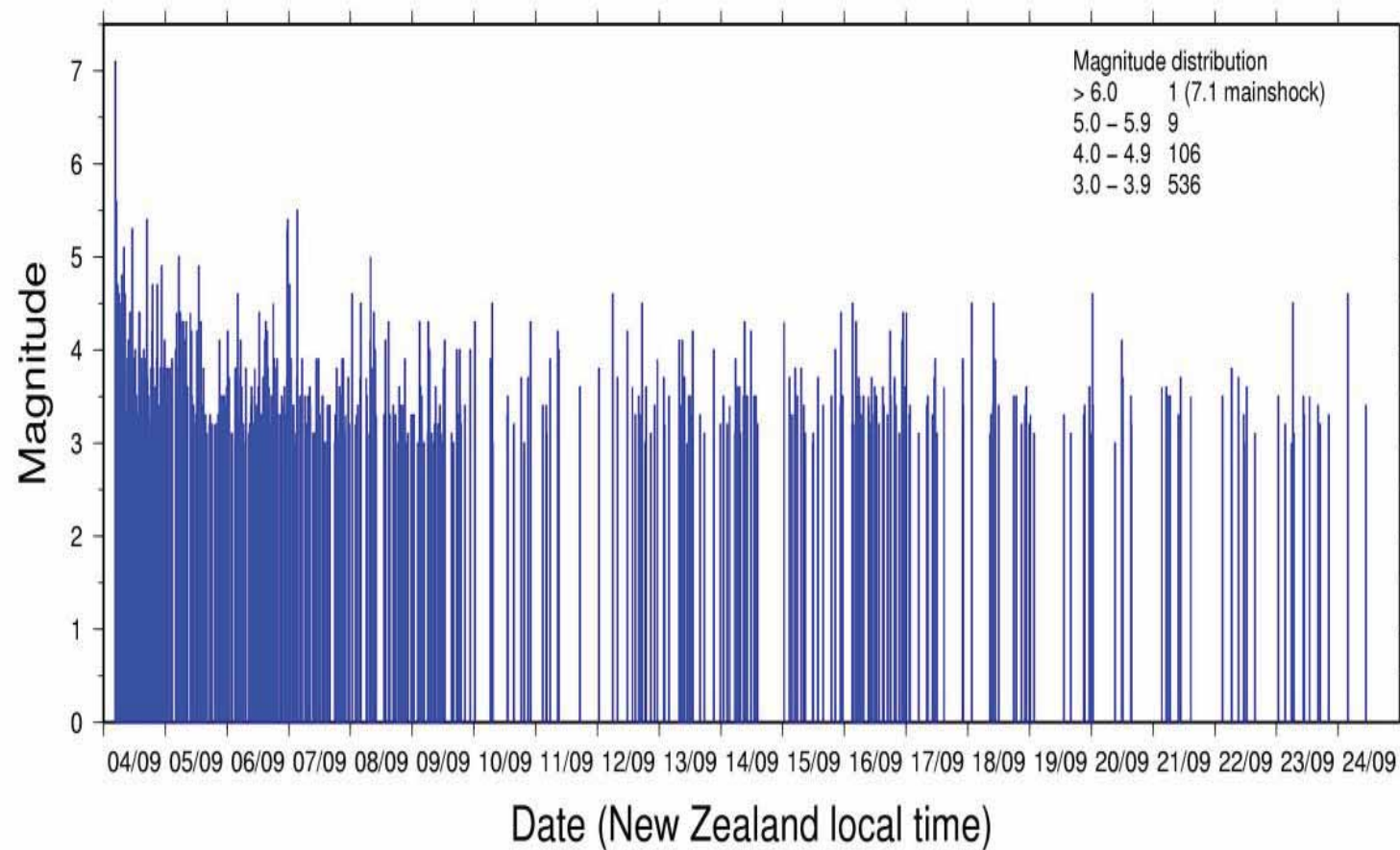
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Aftershocks



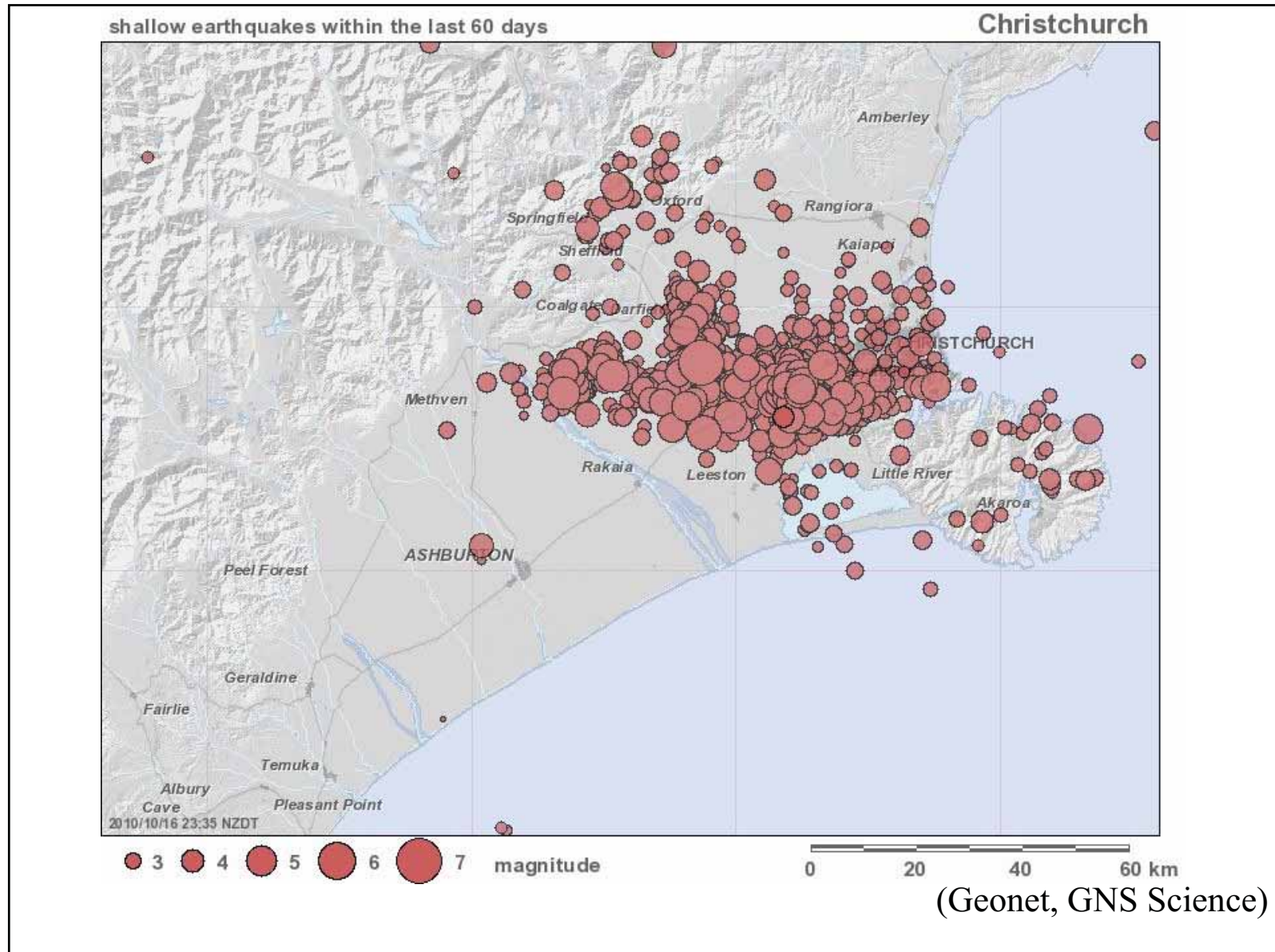
(Geonet, GNS Science)

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Aftershock (4.0+) forecast

Dates	Expected number of aftershocks of magnitude 4.0-4.9	Observed	Expected number of aftershocks of magnitude 5.0 and above	Observed
Sep 4	43 - 73	34	2 - 12	4
Sep 5	11 - 29	18	0 - 5	1
Sep 6 - Sep 12	28 - 53	35	1 - 9	4
Sep 13 - Sep 19	8 - 23	17	0 - 5	0
Sep 20 - Sep 26	4 - 16	9	0 - 3	0
Sep 27 - Oct 3	2 - 13	3	0 - 3	0
Oct 4 - Oct 15	4 - 15	9	0 - 3	2
4 week forecast		Average		Average
Oct 4 - Oct 31	10 - 26	17	0 - 5	2

(Geonet, GNS Science)

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Canterbury Earthquake - first flyover of fault trace



Right lateral offset of up to 4 metres
in centre of trace

(Source: YouTube, GNS Science)

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Canterbury Earthquake - first flyover of fault trace



**Fault trace passes beneath two
farm buildings and close to others**

(Source: YouTube, GNS Science)

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Flight early
view

(Source: The PRESS)



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Railway

(Source: The PRESS)



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Flooding in New Brighton

(Source: The PRESS)



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Outdoor Sportive Facilities



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(photo courtesy: Greg MacRae)

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Kaiapoi Fire Station



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Repaired and re-damaged
by aftershock



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Pedestrian bridges



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Christchurch city aerial view 1965



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Christchurch CBD nowadays



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Variety of Building stock
(architectural style, structural
systems, material and age)



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Christchurch CBD

Centre Building
District

(Source: The PRESS)



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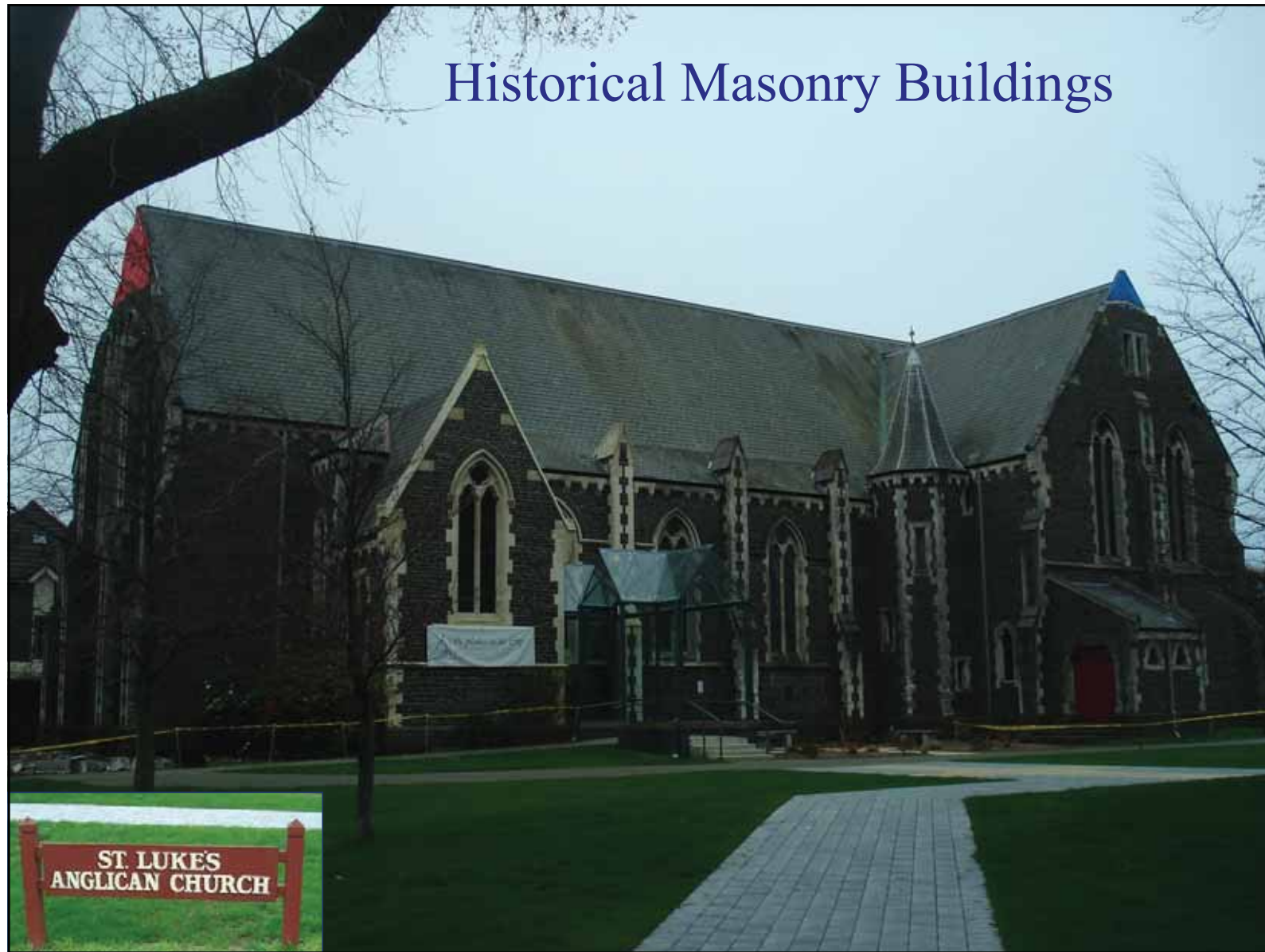


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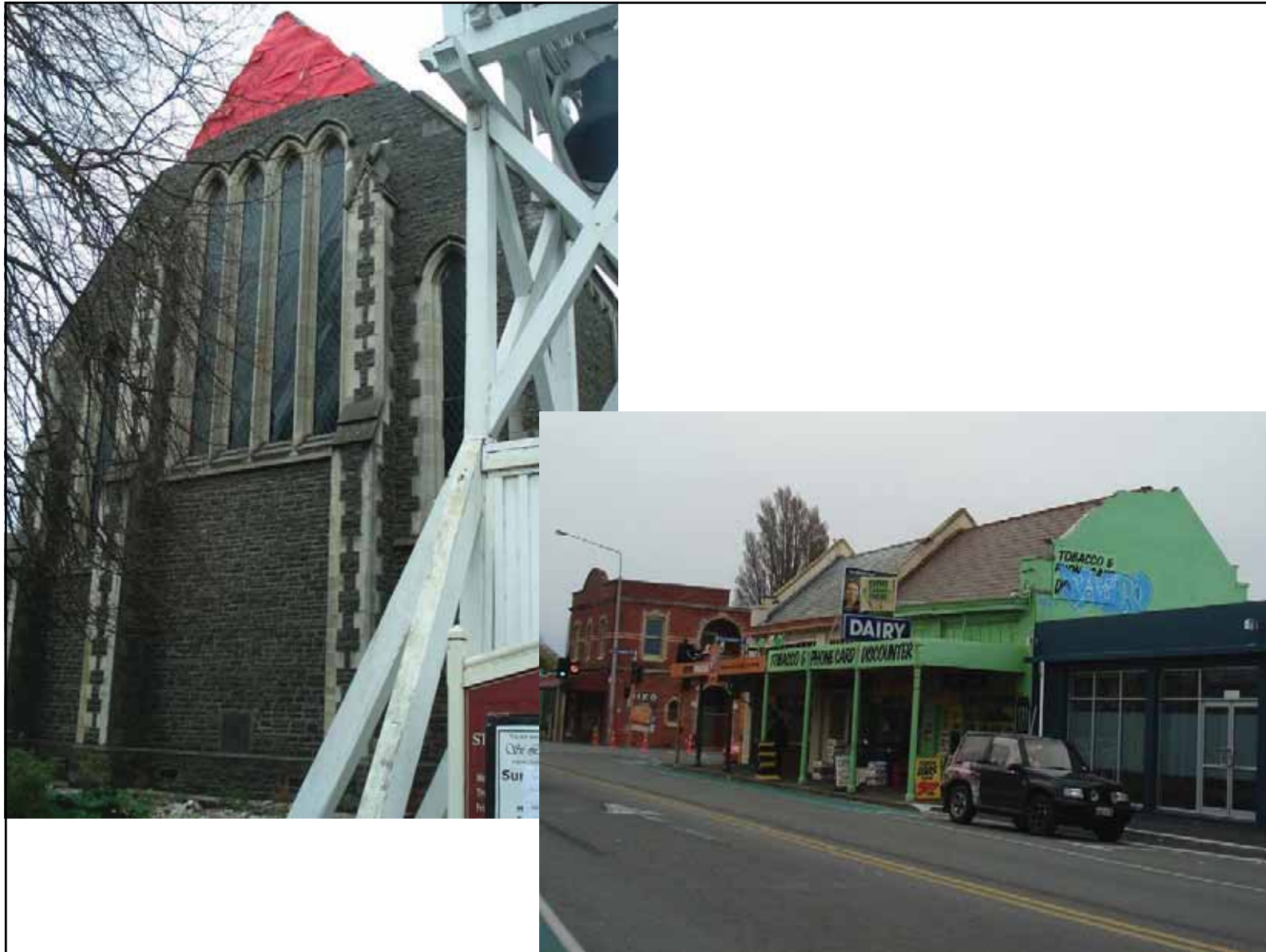


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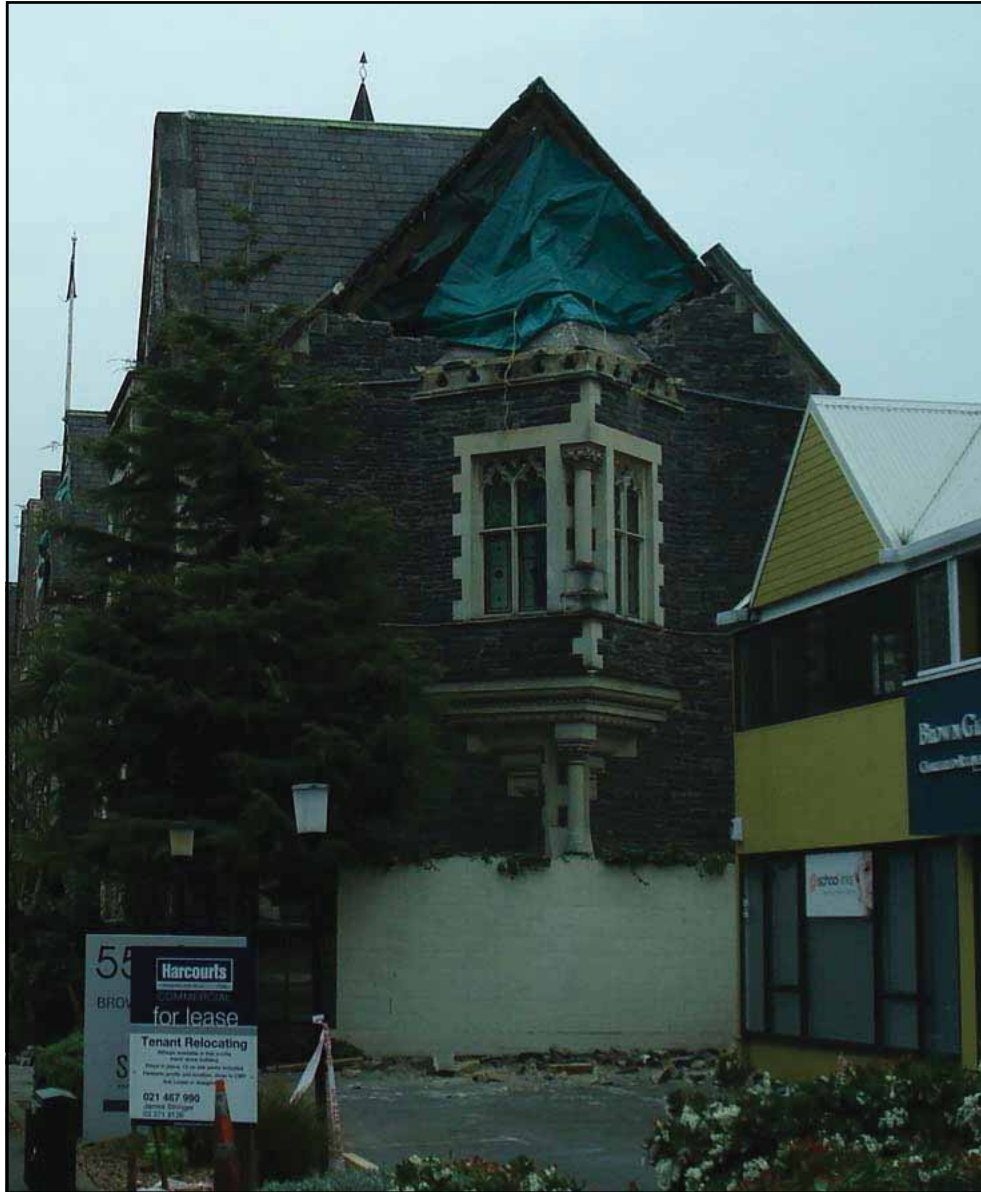


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Lyttleton Theatre - Tie-back of the facade

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Former UoC ME student Euving Au involved in the strengthening



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Reinforced-Concrete pre-1970s Buildings

St Elmo Courts



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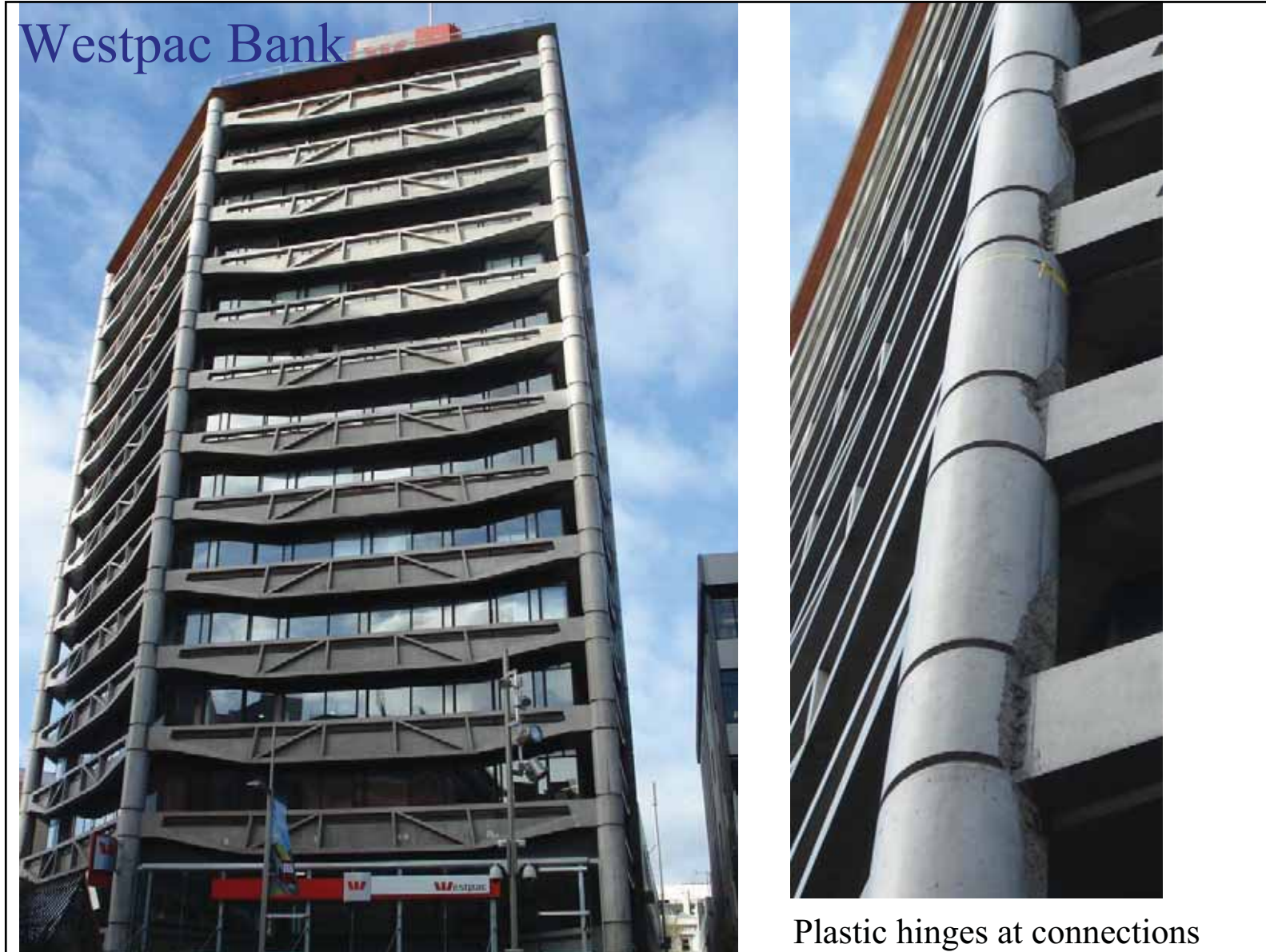
**Inside
St Elmo Courts**

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Plastic hinges at connections

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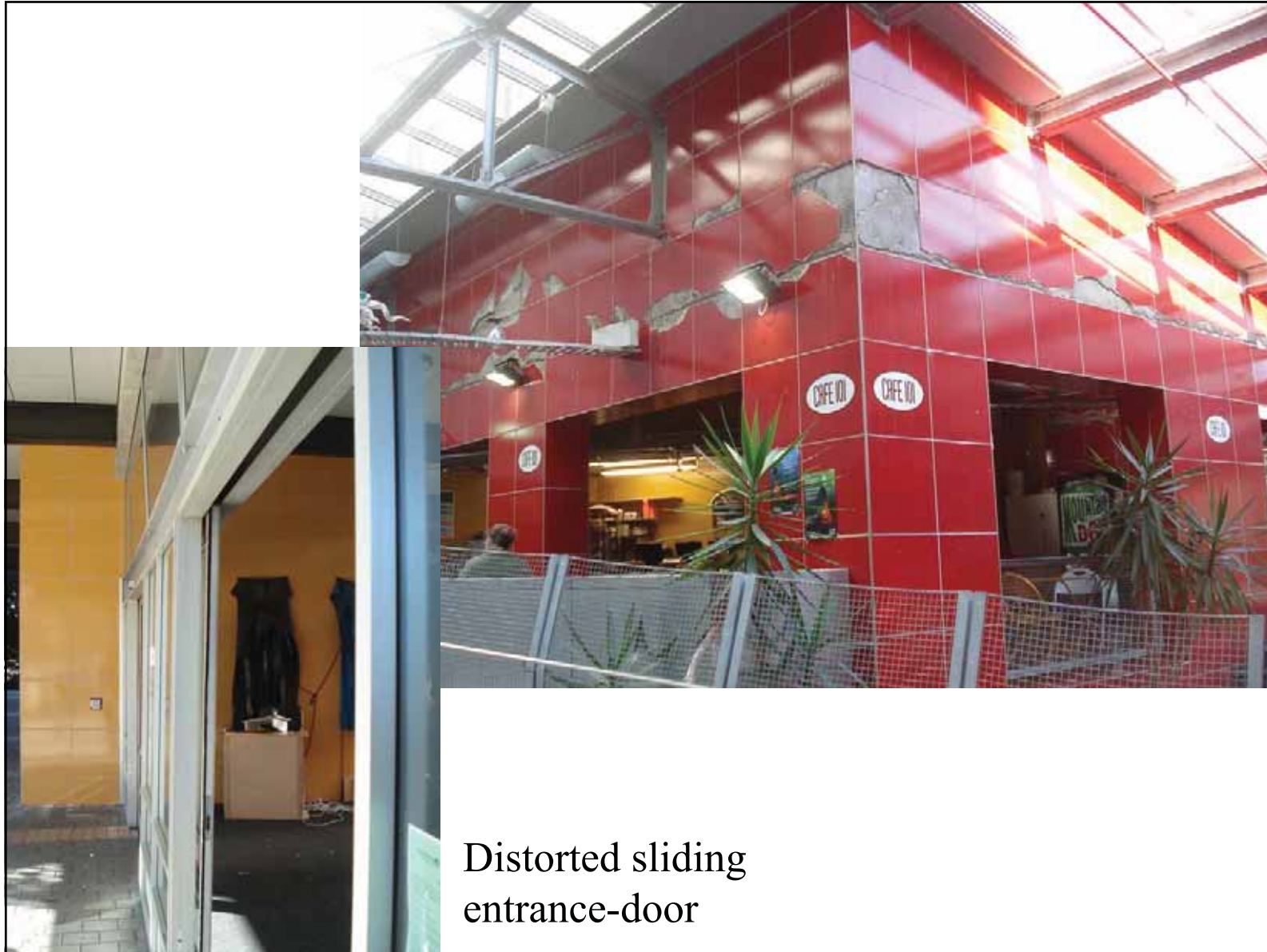


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Hollowcore Units

Shear Damage



Spalling of concrete edge support

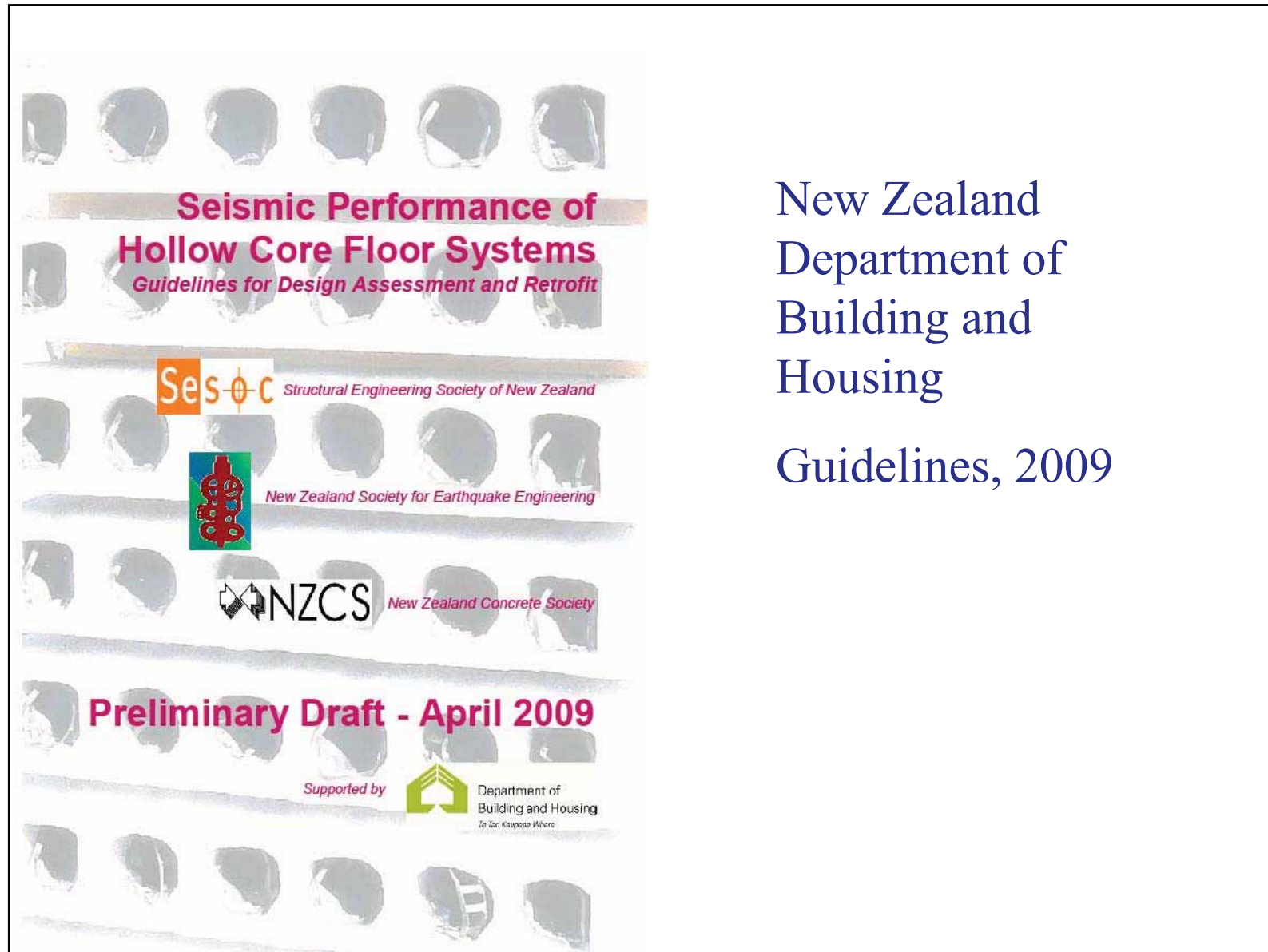


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New Zealand
Department of
Building and
Housing

Guidelines, 2009

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Shear Failure of Columns under bidirectional loading

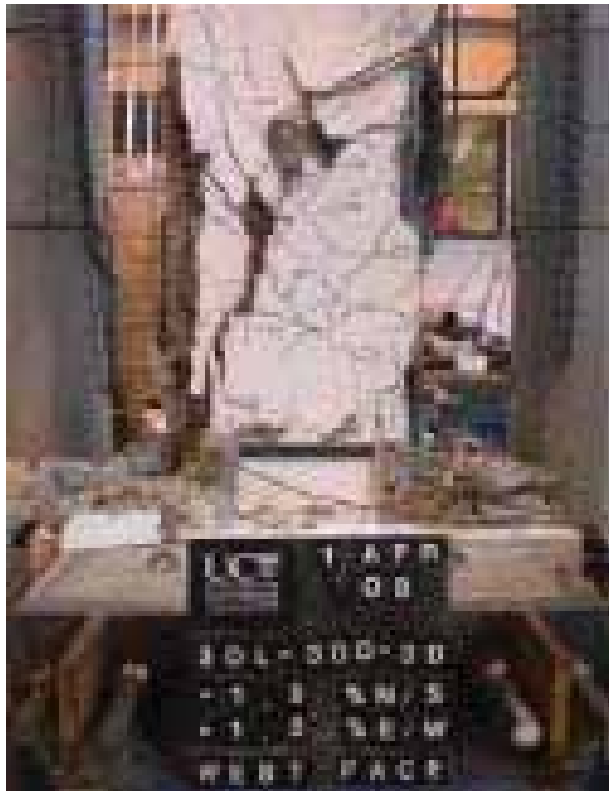


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Laboratory Testing vs. Real Earthquake Testing

UoCanterbury



Boys, Bull, Pampanin, (2008)



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Non-Structural Elements Damage

(Façade, Glazing/windows, infills, Partitions, Ceilings, Contents)

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A Reconnaissance Field Trip Report

UoCanterbury meeting room



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Department of Civil and Natural Resources Engineering - University of Canterbury, Christchurch, New Zealand

The Christchurch (New Zealand) Earthquake, 4 September 2010

A Reconnaissance Field Trip Report



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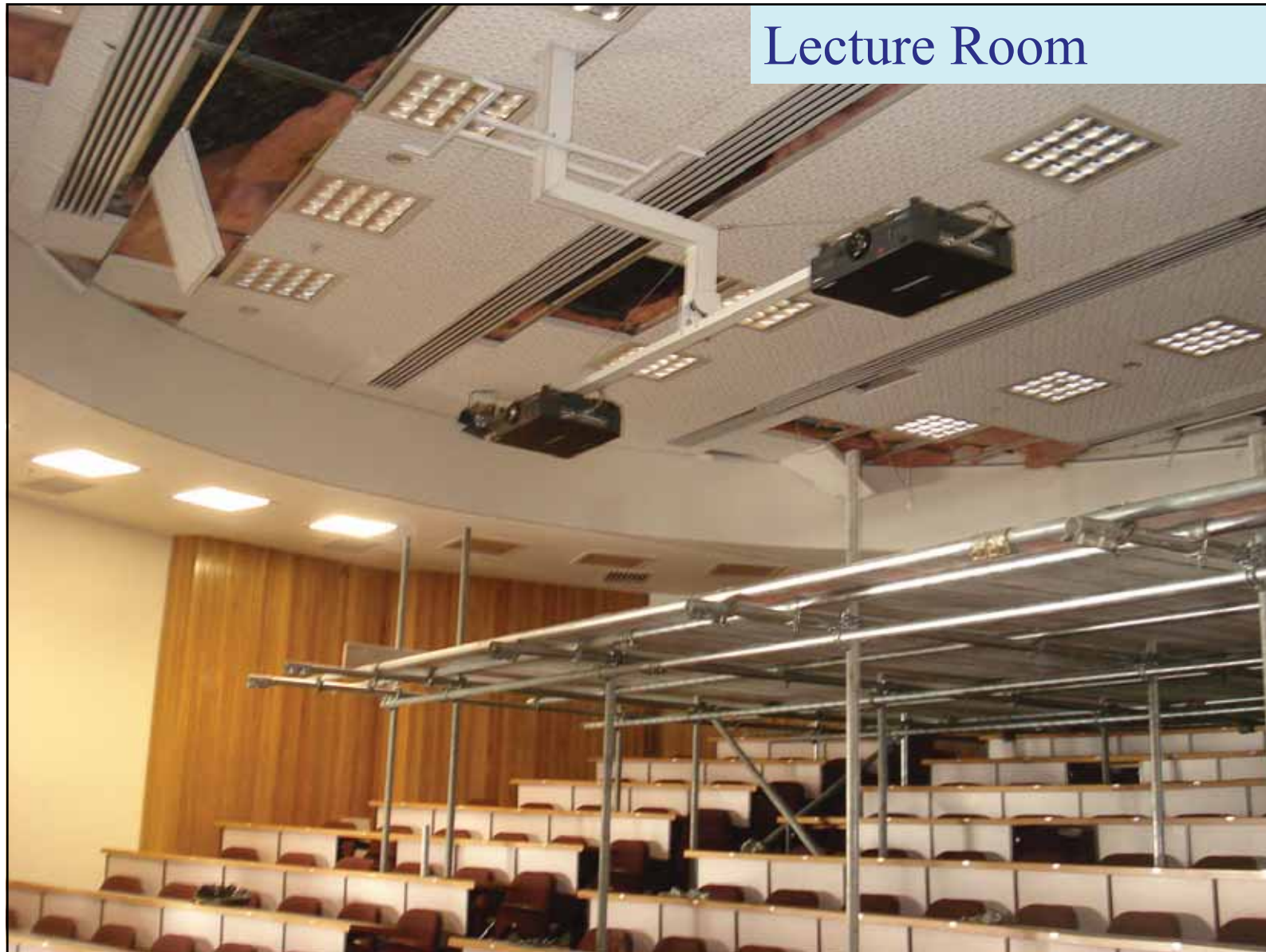


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Refurbishing Lecture Rooms (two weeks after)



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Facades/windows



UoC non-structural elements group



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Racking Systems

(Uma, GNS Science)



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University of Canterbury Library Damage



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Library Damage

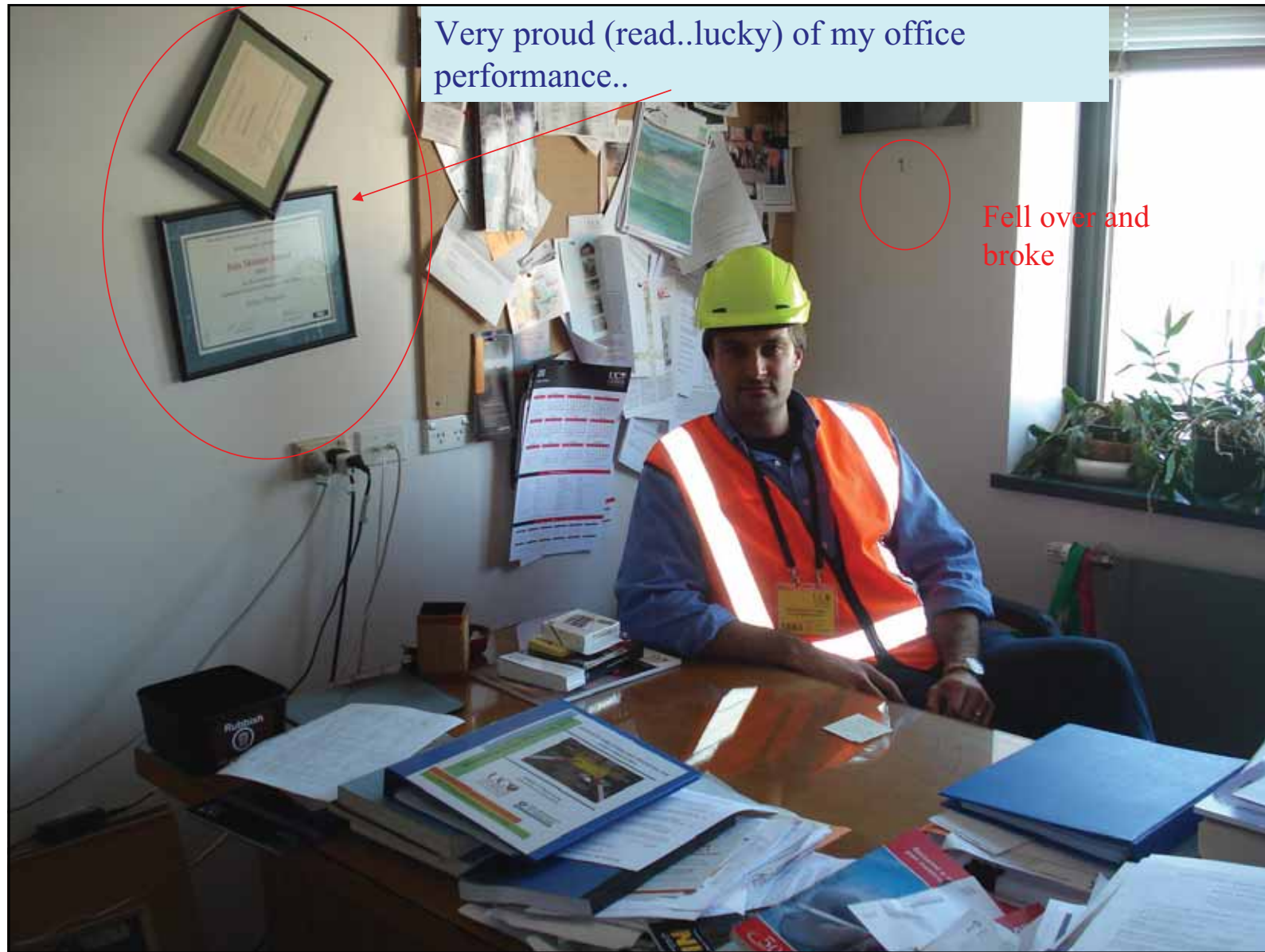


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Supermarkets and Storage Units



(Uma, GNS Science)

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Pipelines

Water-Sewage

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Stefano Pampanin

UoC PhD Candidate
Patricio Quintana
(Chile)

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Water Storage-Tank



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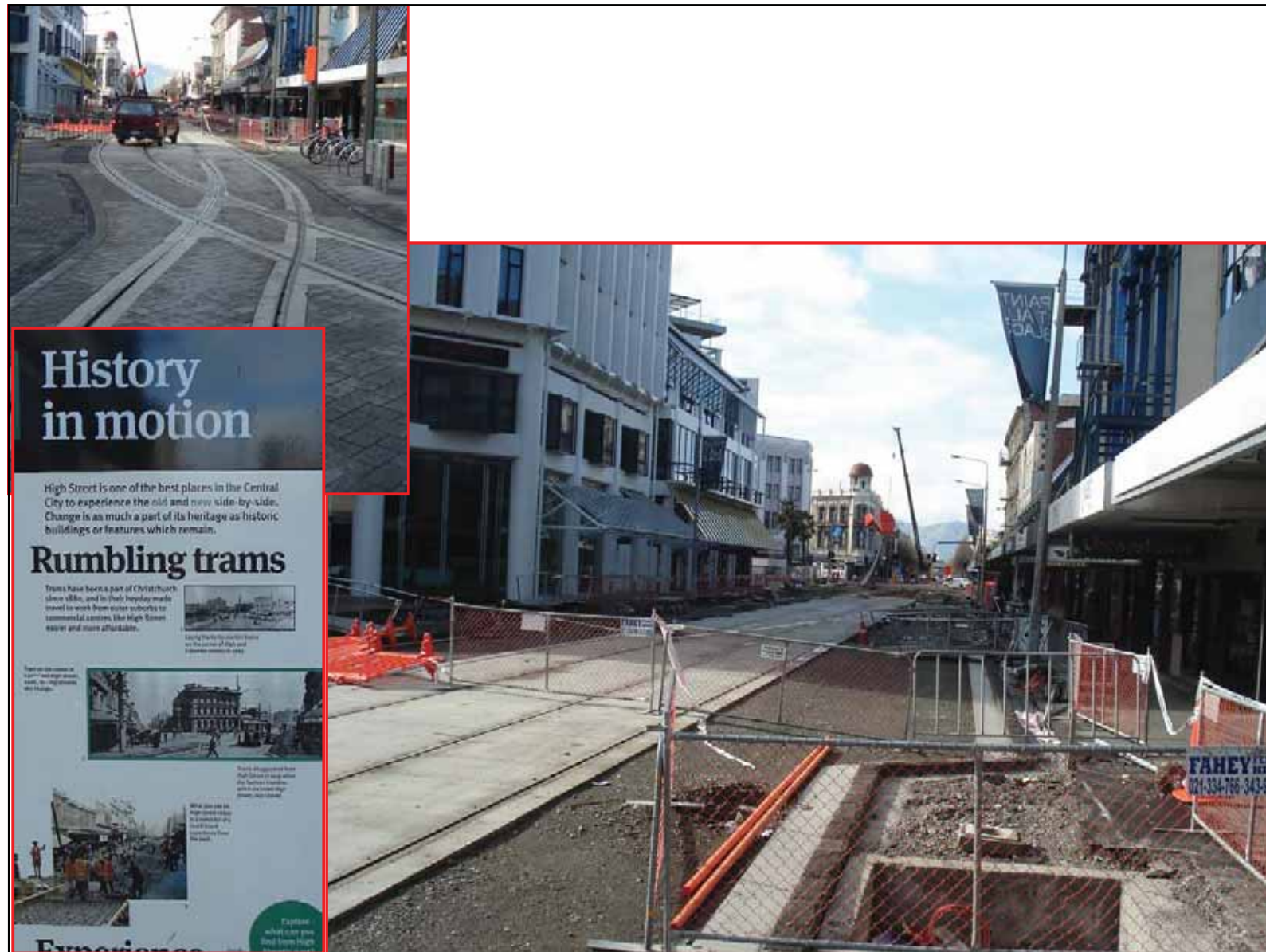
Repairing of Centre-City Tram Rail-tracks

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Replacements of pipelines in the Centre-City

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Liquefaction jets in many private backyard gardens



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Floating of buried pipes on the beach



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Electrical poles (timber and concrete)



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Gas Station



P. Quintana

S. Pampanin

S. Tasligedik

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Lyttleton Harbour Port Facilities

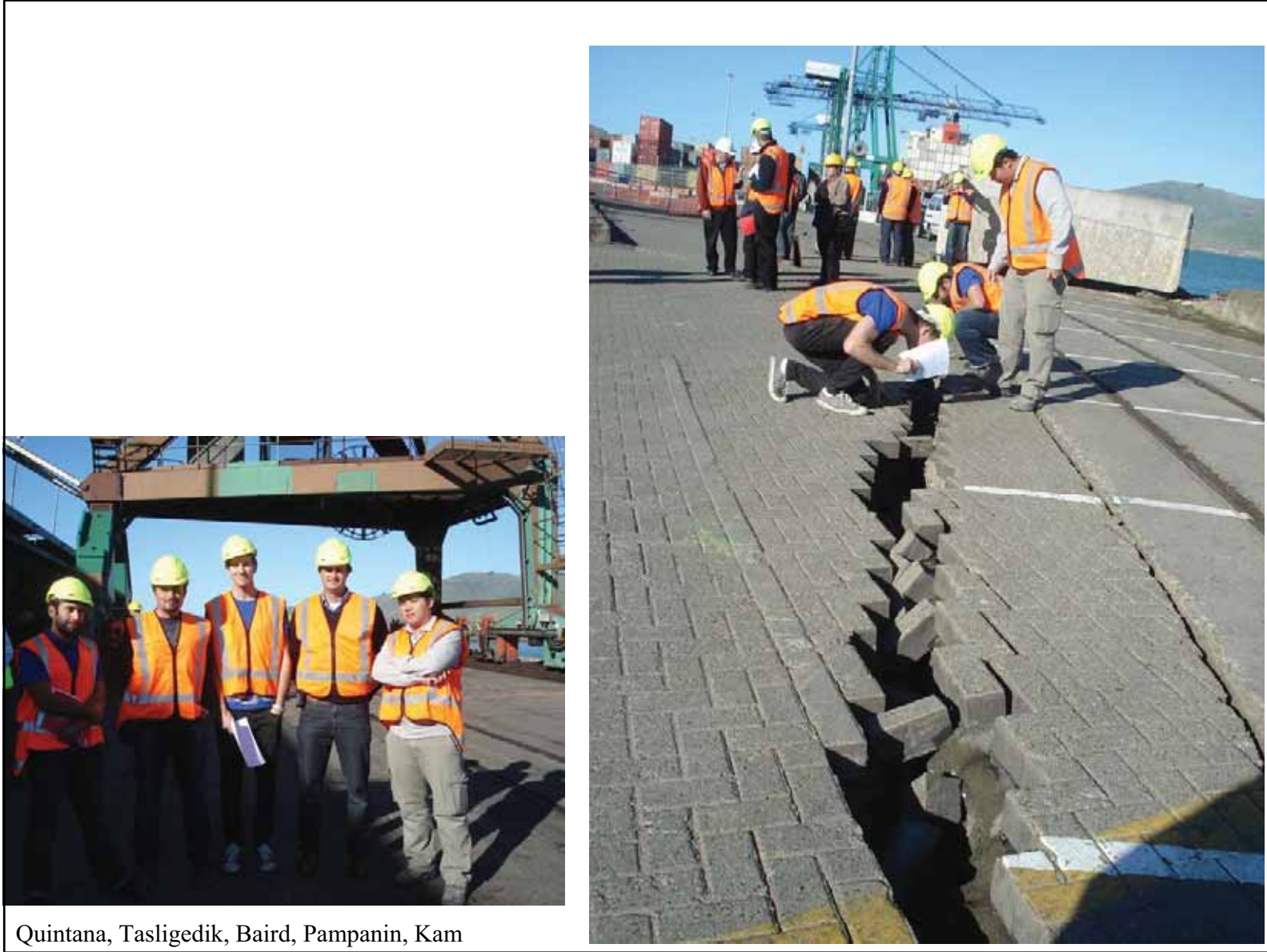


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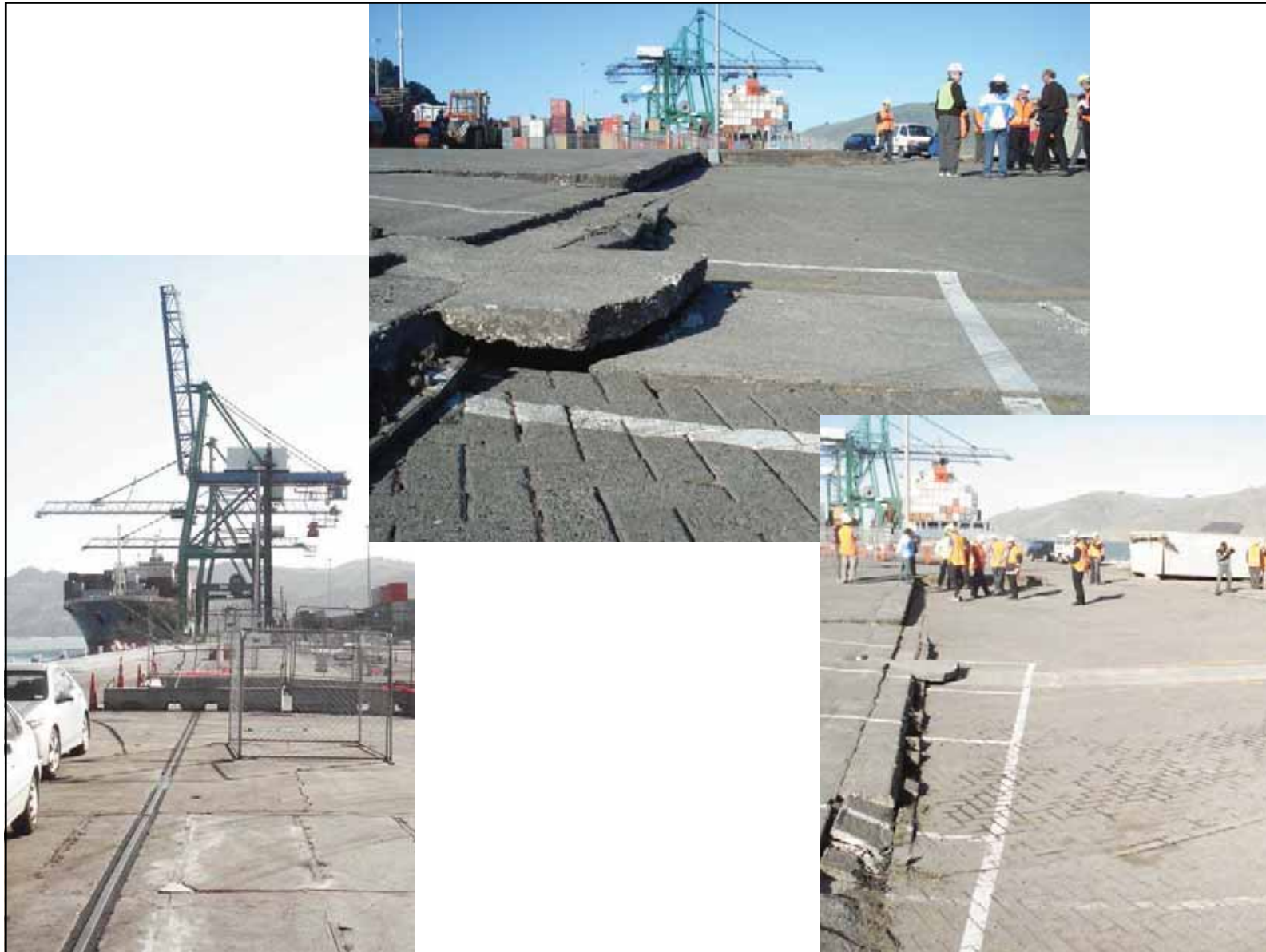
Quintana, Tasligedik, Baird, Pampanin, Kam

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With the EERI team

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COMUNICATION

**internally (scientists/engineers) and
externally
(media,public,policians,decision-makers)**

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NZ Society of Earthquake Engineering
ClearingHouse Group



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Christchurch-City Council

Meeting with engineers re
new policy on Repair and
Retrofit requirements

Open Public Presentation

by Christchurch Mayor Bob Parker
re Heritage Building Policy



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CCC- Recovery Office Public Information



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**Past Implementations
of Retrofit/Strengthening
or appropriate Seismic Design
made a major difference**

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Retrofit/Strengthening using Post-tensioning



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Chains

(bars or tendons)



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Retrofitted building at
University of Canterbury

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Simple and cheap
non-engineered
urgent
“strengthening”

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NZ FRST-Funded Project “Retrofit Solutions” (2004-2010)



www.retrofitsolutions.org.nz

Pre 1970 Concrete
Buildings

Seismic Assessment

Seismic Retrofit Solutions

FRP

Metallic Haunch

Post-Tensioned
Rocking-Dissipative Walls

Selective Weakening

Seismic Risk Analysis
and
Retrofit Strategies
at Territorial Scale

Damage Scenario

(Principal Investigator-
Stefano Pampanin)

Prof. Dr. Ing. Stefano Pampanin

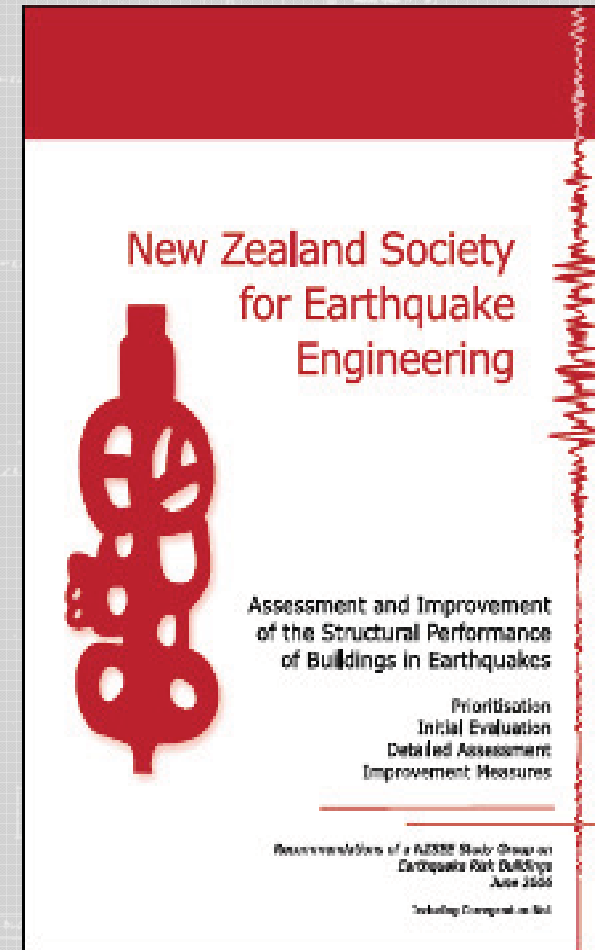
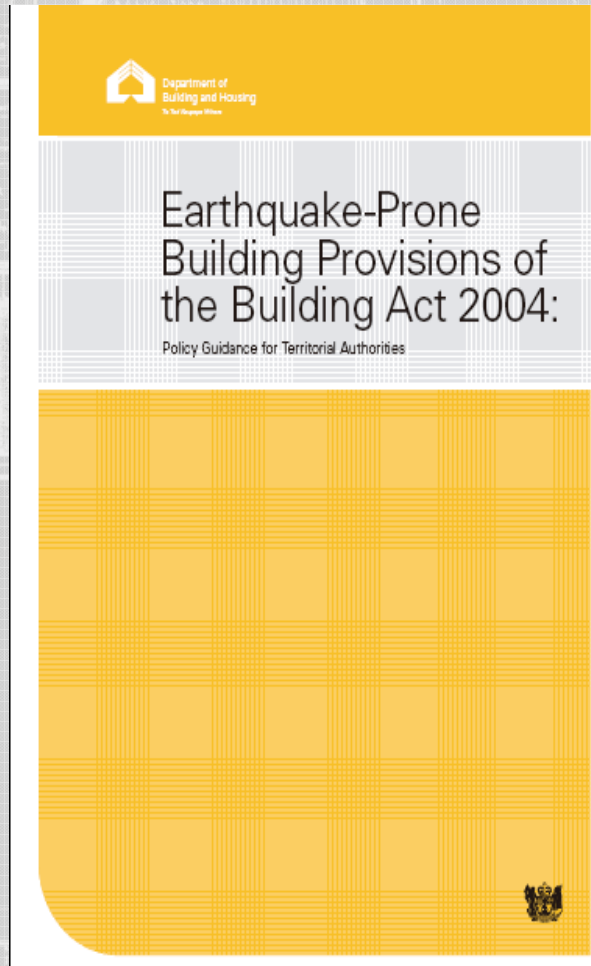
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Amendments to the current (2006) NZSEE Assessment Guidelines

+ Retrofit Solutions Handbook (under preparation)

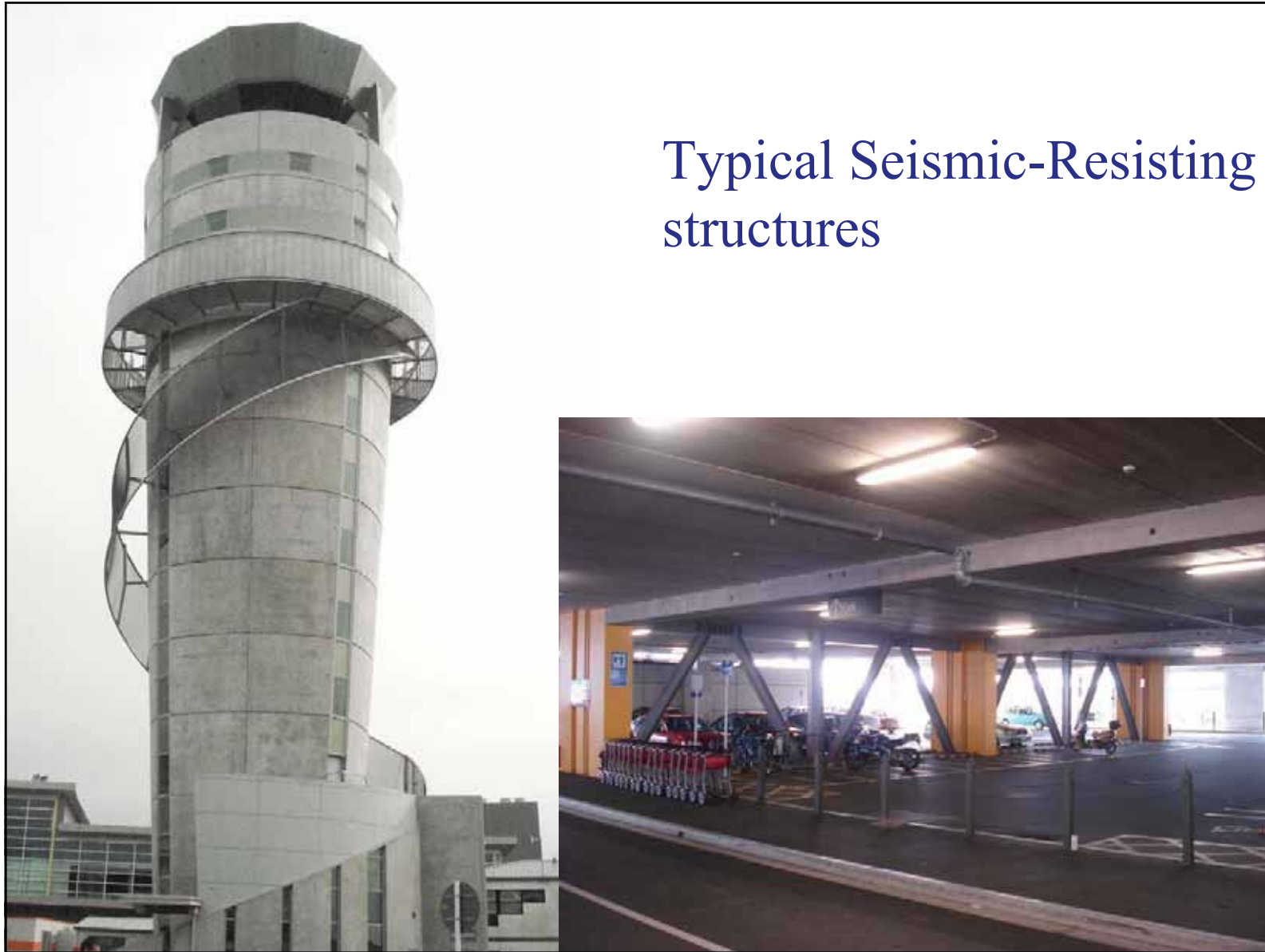


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Christchurch's Women Hospital (Base Isolated Structure)



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Slider



Steel Laminated Lead
Rubber Bearing

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Permanent Displacement of
the rubber bearing isolator

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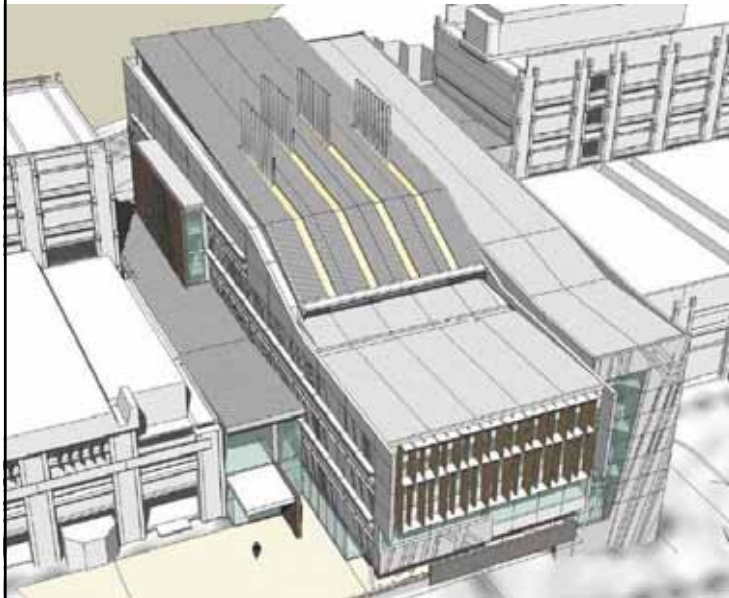
“Isolation Detailing” to allow relative displacements between soil and isolated superstructures



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Emerging damage-free precast concrete systems: PRESSS-technology



NZ's first PRESSS-Building

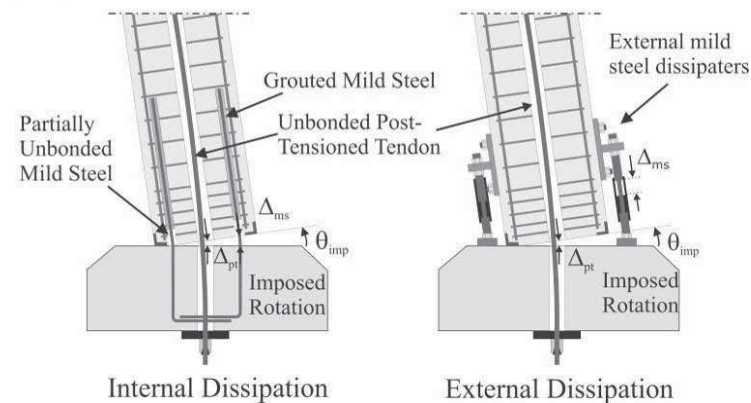
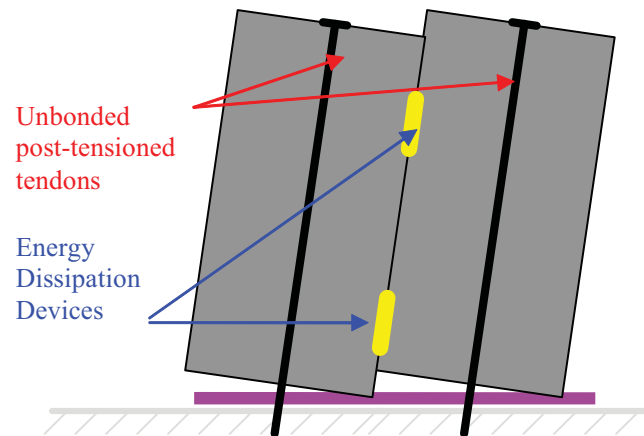
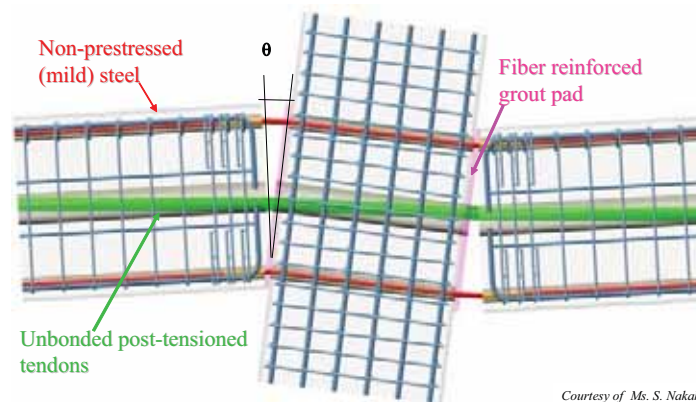
Victoria University Wellington (Cattanach and Pampanin , 2008)

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New Generation of Damage-Resisting systems

- **Jointed Ductile** DRY connections assembled by post-tensioning techniques



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PRESSS Ltd.



Dunning
Thornton
consultants



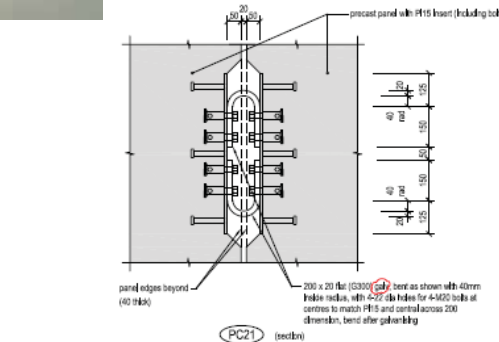
21st Century Precast: the Detailing of NZ's First Multi-storey PRESSS Building

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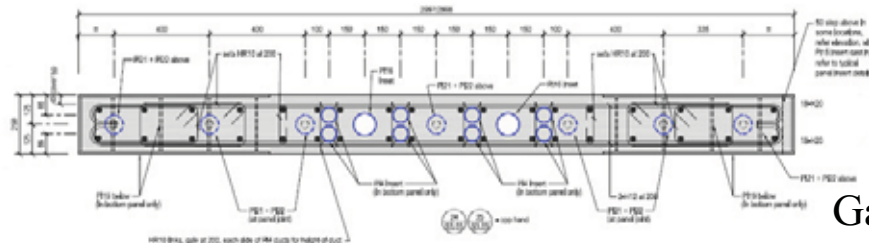
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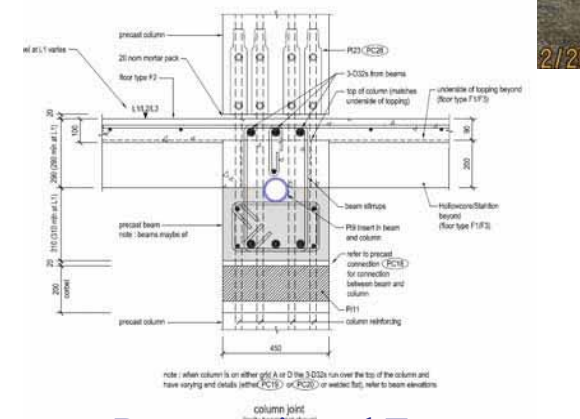
NZ's second PRESSS-Building (Southern Cross Hospitals, Christchurch)



Post-tensioned Coupled Walls



PRESSS Ltd. **structex** **UC**
UNIVERSITY OF



Post-tensioned Frames

Gardiner, Haverland and Pampanin, 2009

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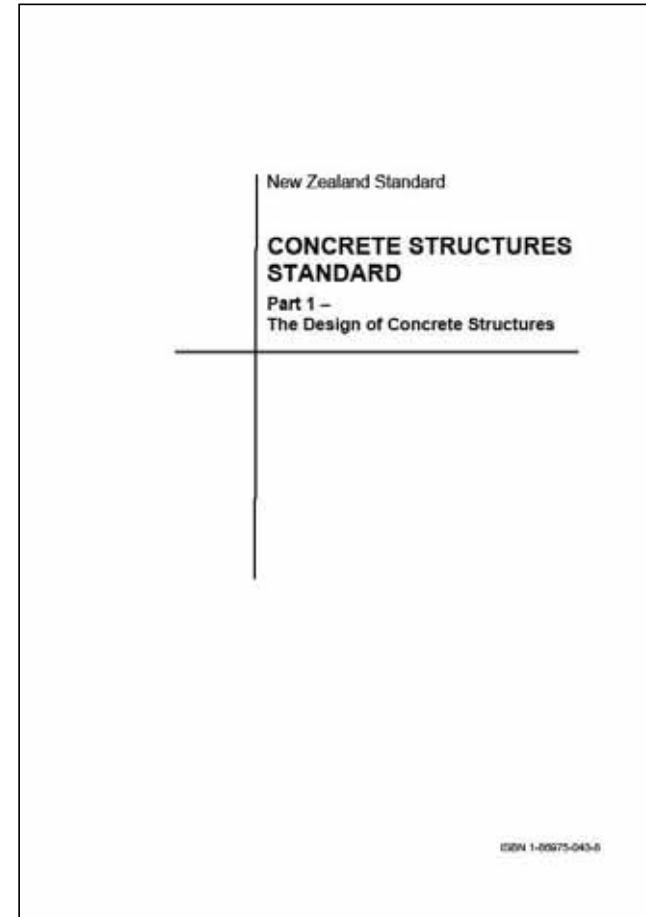
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Code Design Provisions and Guidelines



fib Bulletin n. 27, 2003
(Chairmen: *Profs. B. Park & Watanabe*)



NZS3101:2006 Concrete Standard

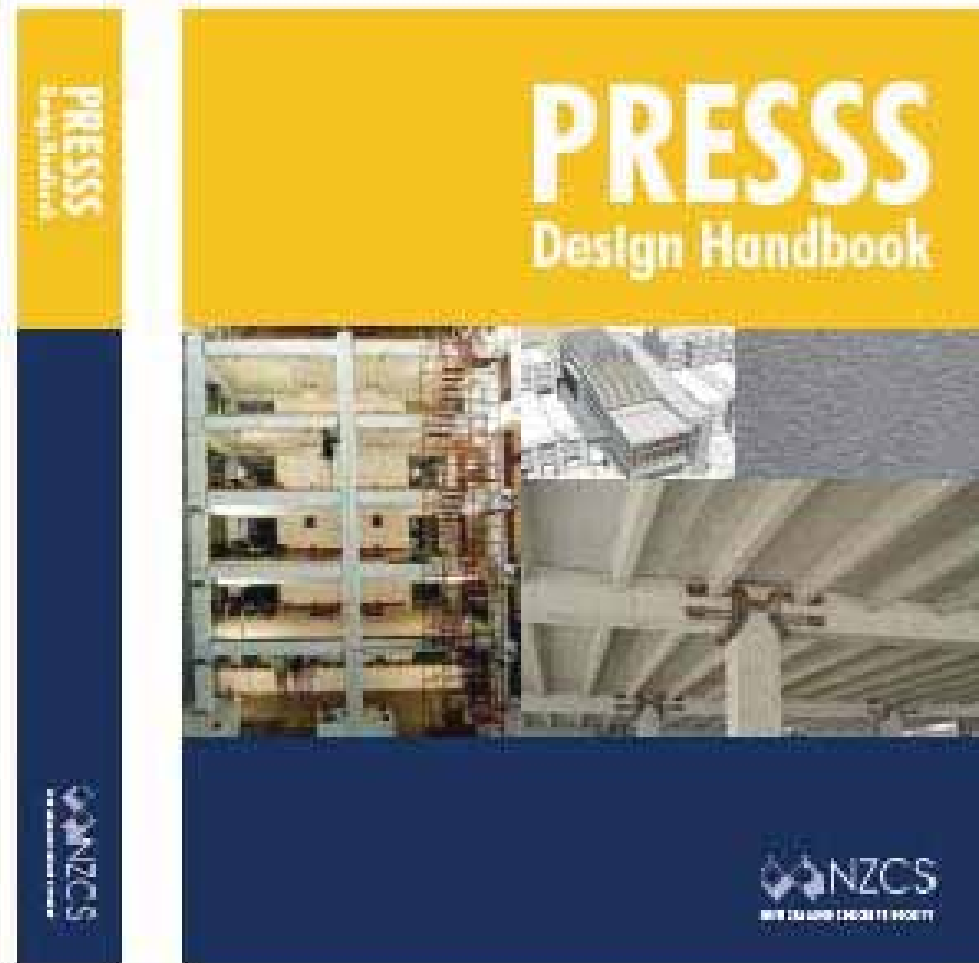
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PRESSS Design Handbook, 2010



Theory, Design Examples
(5-storey building), Charts,
CD Software “Hybrid”



NZ Concrete Society (www.concretesociety.org.nz)

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Thanks for your attention,

Grazie per la cortese attenzione

Kia Ora” from *downunder* New Zealand



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