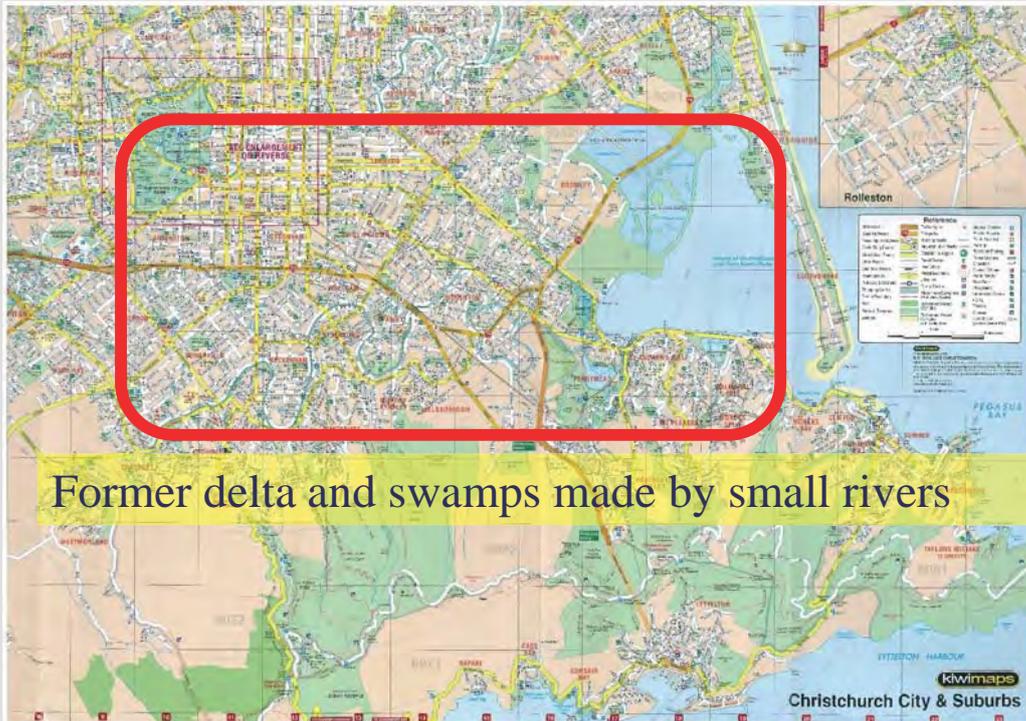


Christchurch, New Zealand Earthquake sequence in 2010-2011



クライストチャーチは、ニュージーランド第二の都市
南島の中心

人口は 37万人（国全体で469万人）
カンタベリー地震による被害額

被害 150億NZドル（約9,750億円）

復興費用 300億NZドル（約1兆9,500億円）は、
GDP約1,900億NZドル（12兆3,500億円）の15%以上。

http://www.clair.or.jp/j/forum/forum/pdf_261/05_kaigai.pdf
as per 20170818

Original soil condition in the present city center (Central Business District) of Christchurch (Black map of Christchurch in 19th Century)



The black map was removed from this file because of the copy-right issue.

There used to be many river channels and their meanderings.

Swamps along the Avon River (similar to low lands in Tokyo)



<https://teara.govt.nz/en/photograph/14283/christchurch-1860>

Also read http://www.nzine.co.nz/features/swamp_city1.html.

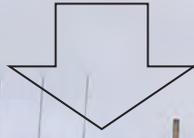
Situations after the 2011 Christchurch earthquake (Mw=6.1)



Situations after the 2011 Christchurch earthquake (Mw=6.1)



Going to be demolished,
as per March 2012, one
year after the disaster



Recent buildings were
sitting down on the
ground surface.

New technology: **rocking
foundation**

Minor tilting was fatal for
serviceability of buildings.



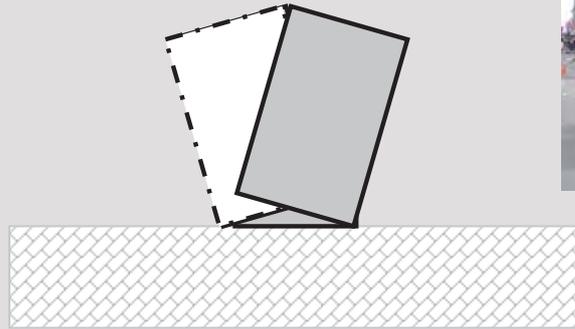
Slow reconstruction (20151104)



Missing new aseismic design
principle
Increased earthquake insurance
money



What is rocking foundation?



- Building is simply sitting at the surface of the ground.
- During strong shaking, building rocks back and forth.
- This motion absorbs the earthquake energy and reduces the dynamic response of the superstructure.
- In Christchurch, this idea worked well; no structural damage (and most probably no significant damage in non-structural members) in superstructures.
- What about the foundations?

Ideas on foundation of rocking foundation

- **Rigid or elastic ground** was the original idea: no plastic deformation remains after earthquakes (no tilting).
- Even in soft soil, rocking makes symmetric deformation on front and back sides → building sinks vertically only.
- Actually, buildings tilted in one direction: eccentricity during tilting.
- **Minor tilting was fatal to the serviceability of buildings.**
- Earthquake insurance money was sufficient to demolish those buildings.

: Lessons from experience

Situations after the 2011 Christchurch earthquake (Mw=6.1)

Low and wide building is preferred: no rocking risk.



Coseismic subsidence

Now sea (and river) water level is higher than before.

Seepage through the temporary river levee (March 2016)



Liquefaction occurred in both business district and residential land in former deltaic area.

Same sites got liquefied 3 times or more.



Post-earthquake situation in Christchurch

- Now insurance money is higher than before.
- How to design high-rise buildings in Christchurch?
- Low and long buildings (low aspect ratio) are preferred ← no rocking
- Liquefaction-prone residential areas are purchased by public and converted to an open area.



Grass cutting in former residential land



20120310

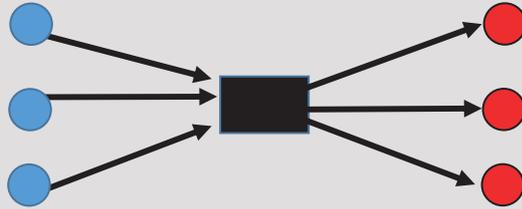


Lessons from other places

1999 Chi-chi earthquake in Taiwan (Magnitude $M_w=7.6$)

Node of trunk electric power lines was damaged

→ no power supply in huge area



Lessons from other places

2015 Nepal Gorkha earthquake; magnitude $M_w=7.8$

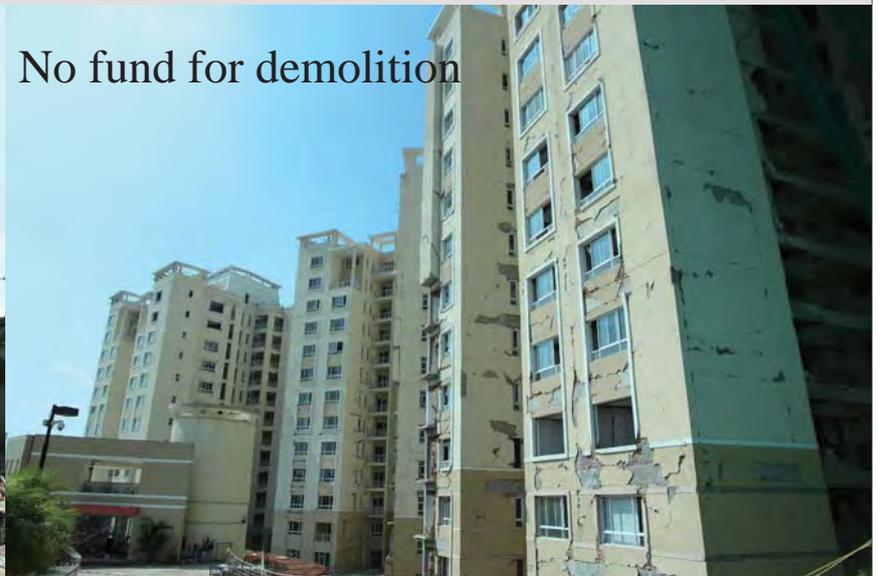
Poor performance of the public sector (politics)

Many foreign governments offered financial aids but the Nepal government could not develop a clear plan.

Virtually no progress of positive reconstruction/restoration



No fund for demolition



Overseas activities (Barpak, Nepal)



3 people with dinner, breakfast, beer and whisky → US 35 \$ per night

Overseas activities (Gujarat, India, 2001)

