

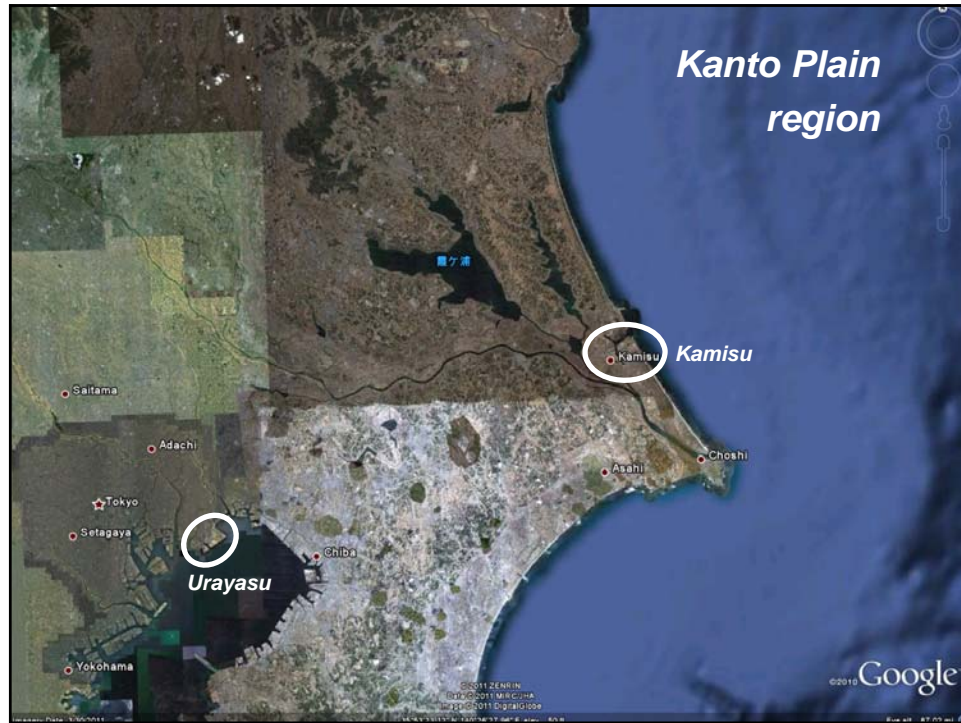
*EERI Annual Meeting and National Earthquake Conference
Memphis, Tennessee, April 10-13, 2012*

*Some
▲ Geotechnical lessons from the
2011 Great East Japan Earthquake &
2010-11 Christchurch earthquakes*

UC DAVIS
UNIVERSITY OF CALIFORNIA

*Ross W. Boulanger
Professor*

***Pervasive liquefaction hazards
(known &/or identifiable)***



Japan Times (4/8/2011): \$500 mil (US) to restore sewer, water, & roads in Urayasu City.

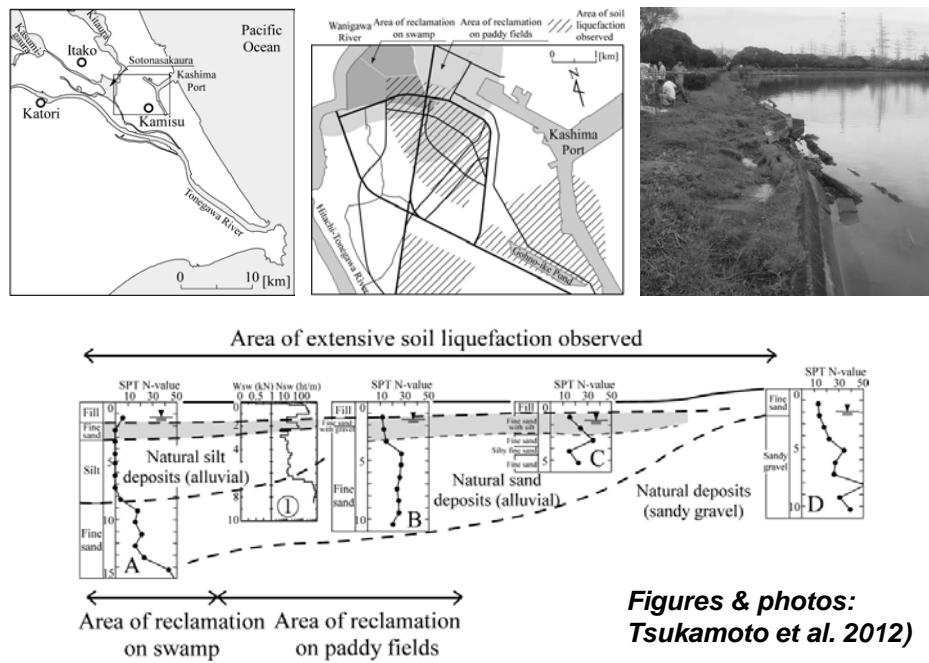


(photo Ishihara et al. 2012)

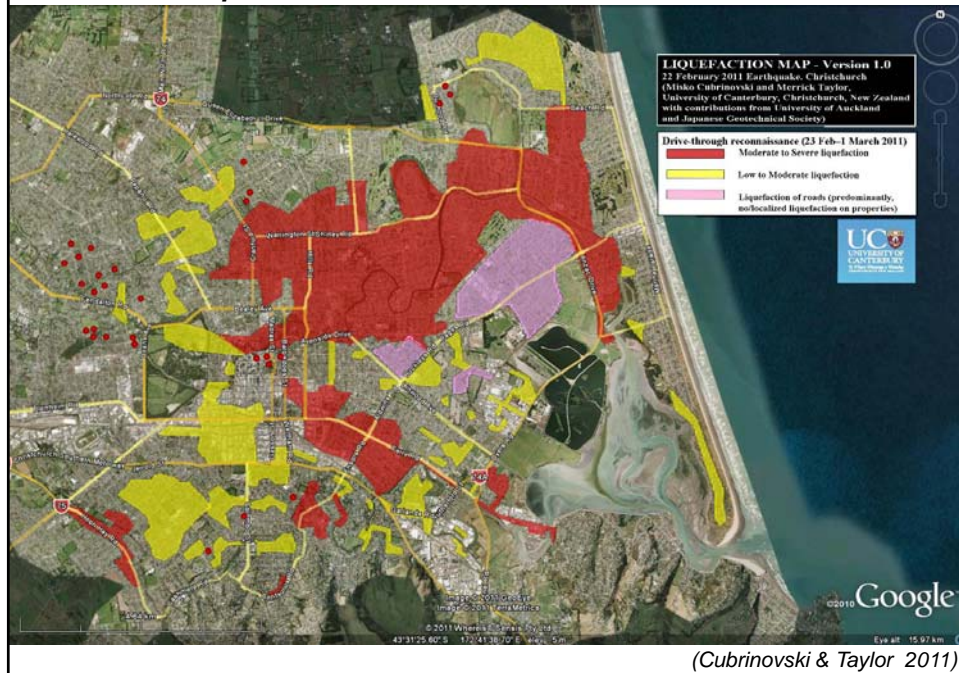


(photos by Urayasu City; Ishihara et al. 2012)

Kamisu City: Liquefaction in reclaimed fields, swamps & gravel pits

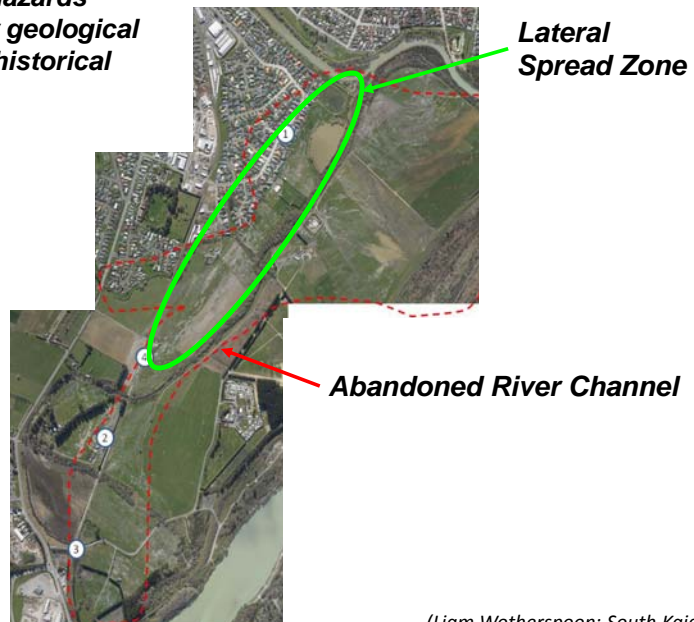


Christchurch liquefaction





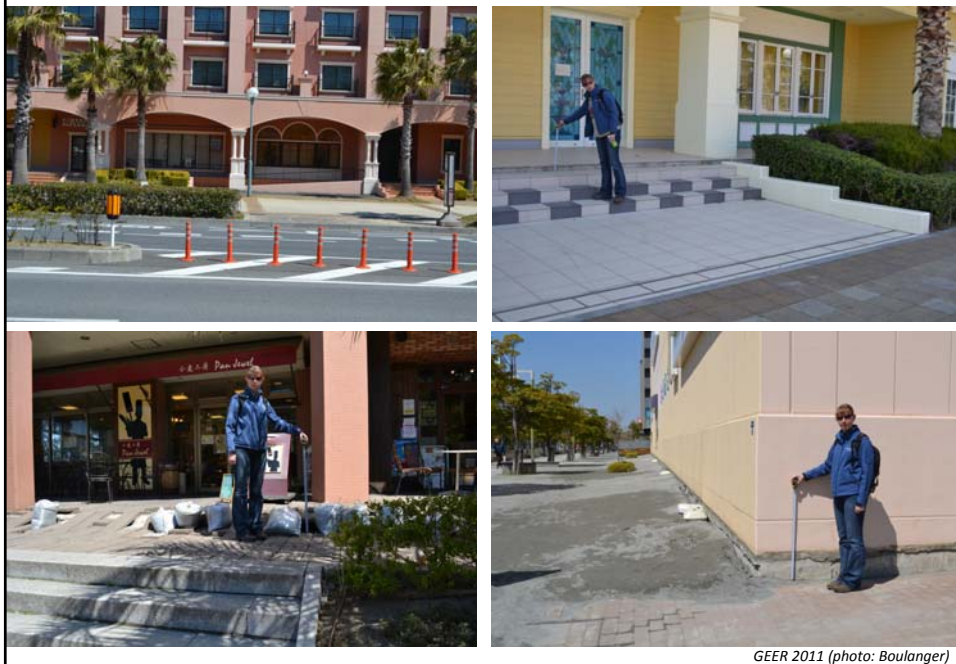
Repeated lesson:
Liquefaction hazards
identifiable by geological
features &/or historical
records



(Liam Wotherspoon: South Kaiapoi)

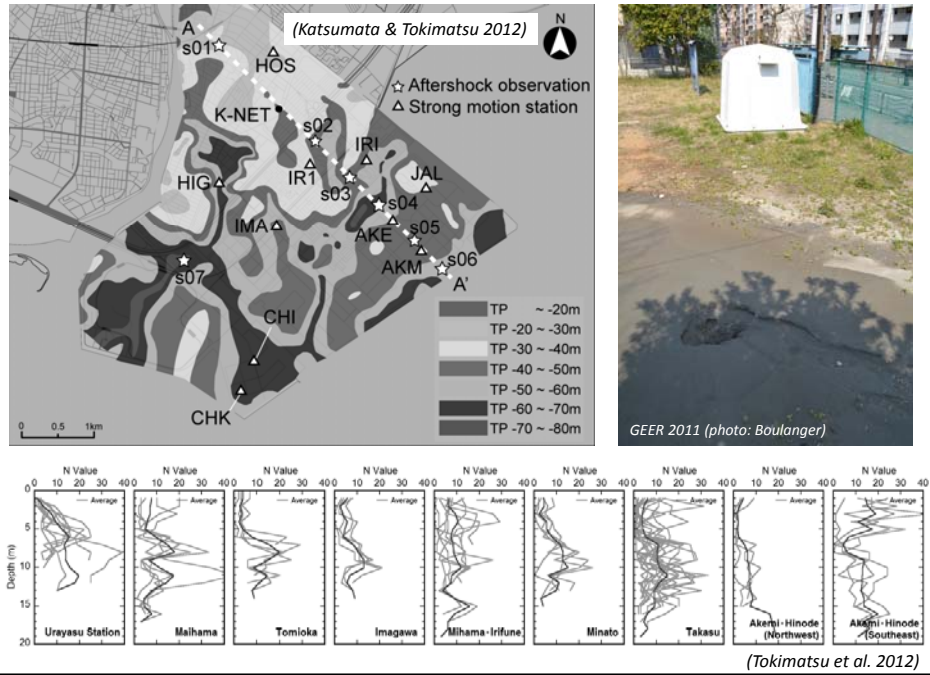
***Unique opportunities for advancing
PBEE methodologies:
Examples***

Liquefaction and buildings (Urayasu City)



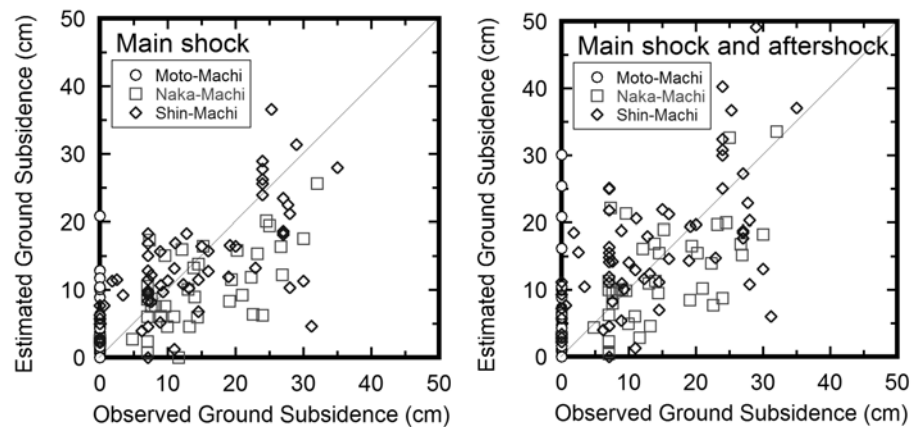


Motions & soil conditions well defined



How well do we predict liquefaction-induced ground settlements?

- Katsumata & Tokimatsu (2012) – AIJ procedures
- Other procedures? Bias & dispersion?



Effects on residential buildings (Urayasu City)



GEER 2011 (photo: Boulanger)

Effects on residential buildings (Kamisu City)



GEER 2011 (photo: Boulanger)



Effects on residential buildings in Christchurch area



(photos: Misko Cubrinovski & Mark Quigley)

Effects on residential buildings in Christchurch area



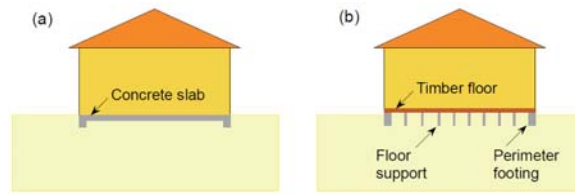
(photos: Misko Cubrinovski & Russell Green)

Typical slab-on-grade foundation (photo: Mick Pender)

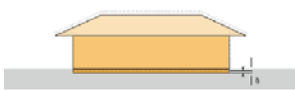


Cubrinovski (2012):

- Nearly 20,000 residential houses and properties damaged by liquefaction.
- Over 6,000 damaged beyond economical repair.



Uniform settlement



Tilt settlement



Lateral stretching



Hogging



Sagging or dishing



Racking/twisting



(Cubrinovski 2012)

Could we improve our foundation provisions?

Urayasu & Kamisu



Christchurch



Moss Landing, CA 1989



Liquefaction and utilities



(courtesy of Miyagi Prefectural Government)

Water treatment plant near Kashima City

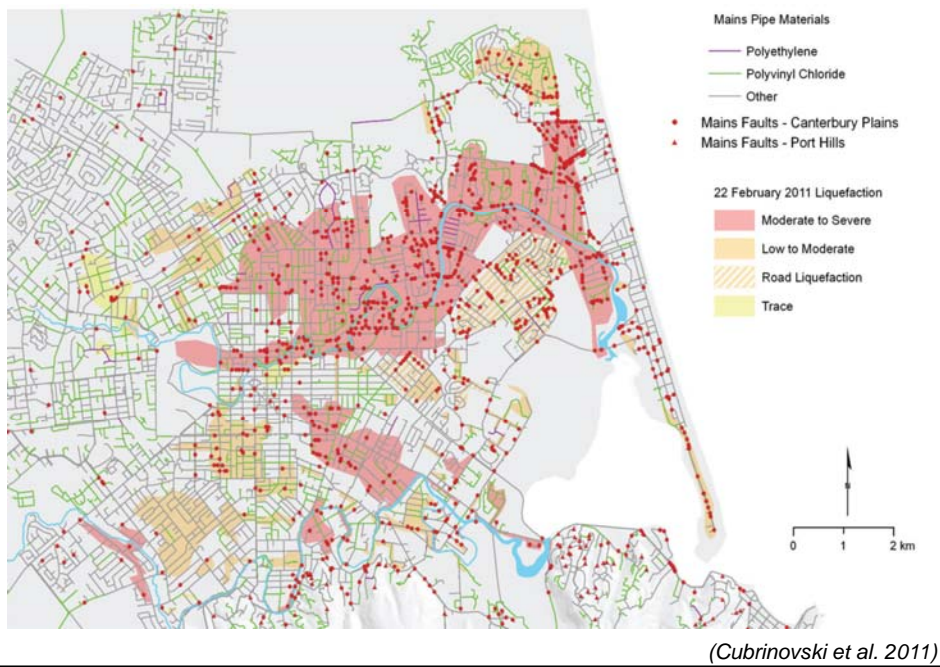


GEER 2011 (photo: Boulanger)



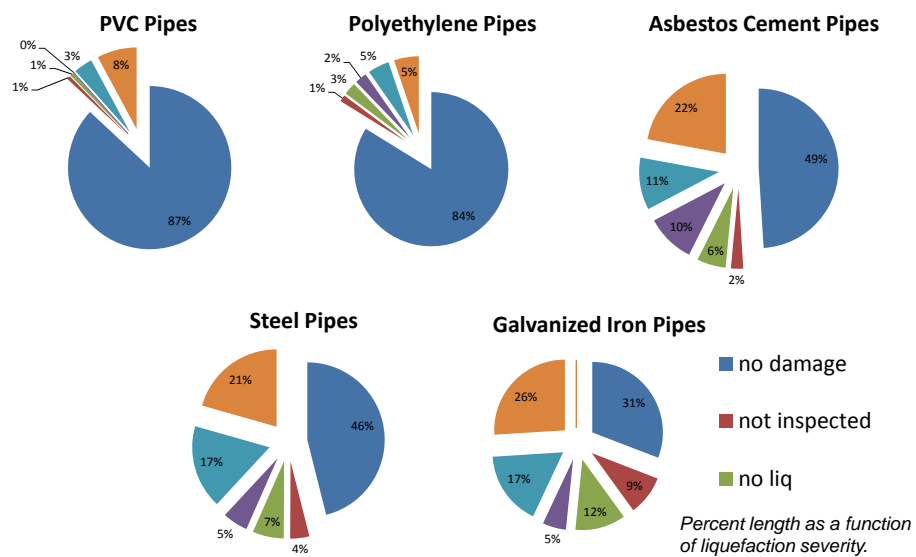


Potable water network in Christchurch

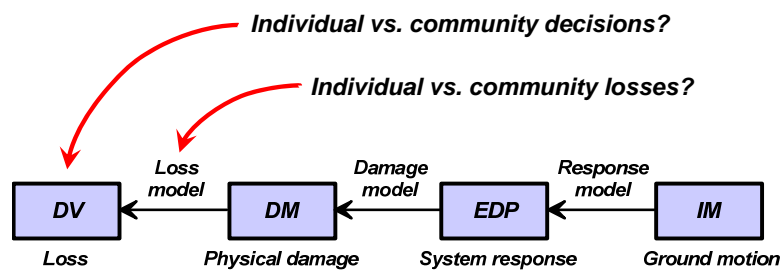


Damage to water mains in Christchurch

(data from Cubrinovski et al. 2011; Courtesy R. Green)



***Risks in decision making:
Individual versus community perspective***



$$\lambda(DV) = \iiint G(DV | DM) dG(DM | EDP) dG(EDP | IM) d\lambda(IM)$$

Concluding remarks

- **Pervasive liquefaction hazards**
 - Known or identifiable from geologic & historical records
 - Quality & quantity of data unprecedented, including extensive strong ground motion records in affected area
 - Archiving these data will be a lasting contribution.
- **Opportunity for advancing PBEE methods**
 - Quantify bias & dispersion in analysis methods by evaluation against large data sets rather than individual case histories
 - Example: Liquefaction-induced ground & building settlements
 - Example: Pipe performance, system fragilities, and recovery
 - Numerous other opportunities & unique lessons – Afternoon session
- **Risk from pervasive geotechnical hazards**
 - Revisit risks from community perspective in guiding building codes, land use planning, and other policies.
 - Risks from pervasive geotechnical hazards and rare events need to be better recognized by at-risk communities.

Acknowledgments

- **National Science Foundation for funding the reconnaissance activities from which these observations were drawn.**
- **The numerous colleagues in the US, New Zealand, and Japan who have generously shared information and ideas generated from these earthquakes.**

***EERI Annual Meeting and National Earthquake Conference
Memphis, Tennessee, April 10-13, 2012***

Questions?



***Ross W. Boulanger
Professor***