Earthquake-Flood Multihazard Impacts on Lifeline Systems and Communities
An International Collaborative Project

Dr Craig Davis, Alex Tang, Dr Sonia Giovinazzi, Dr Deirdre Hart
1) The purpose of this project is to **investigate and document case studies** for the ongoing multihazard earthquake-flood interaction that is impacting lifelines systems and community-wide recovery in:

- the Greater Christchurch, New Zealand area following the 2010-2011 Canterbury earthquakes;
- the Tōhoku Japan region following the magnitude 9.0 Great East Japan Earthquake and Tsunami of March 11, 2011

2) Develop **recommendations and guidelines** for handling the post-earthquake flood and inundation risks.
Defining Earthquake-Flood Multihazard Interaction

**Multihazard Interaction**: the cascading effects of hazards and how one hazard can induce or change the risks associated with another hazard.

Damages resulting from an earthquake can increase the risk of flooding following the earthquake.

- **Earthquake-flood cascading effects**: flood control levee fails in earthquake and subsequent storms flood community.
Avon River in Christchurch. Arrows indicate impacts of liquefaction induced deformations on river capacity to convey storm water. The embankment settled, spread laterally into the river, and compression bulging uplifted the river bottom.

Potential impacts: Storm channel capacity, community flooding
Example Multihazard Interaction
Christchurch, NZ

Breakwater at the Lyttelton Port requiring fortifications

Potential impacts: Port inundation during storms
Example Multihazard Interaction
Christchurch, NZ

Liquefaction induced flooding

Potential impacts: Decreased functionality of road network, emergency response
Example Multihazard Interaction
Tohoku Region, Japan

Tidal flooding in Ishinomaki resulting from tectonic subsidence
Fill placed to protect land from daily tides in Ishinomaki

Potential impacts: Port inundation, transportation routes, surface drainage
Example Multihazard Interaction
Tohoku Region, Japan

Box conduit for storm water collection and conveyance that floated and distorted from liquefaction

Potential impacts: Storm water drainage
Defining Earthquake-Flood Multihazard Interaction

**Multihazard Interaction**: the cascading effects of hazards and how one hazard can induce or change the risks associated with another hazard.

Damages resulting from an earthquake can increase the risk of flooding following the earthquake.

- **Earthquake-tsunami cascading effects**: earthquake shaking damages a tsunami protection wall and a subsequent tsunami inundates community.

- **Earthquake-tsunami-flood cascading effects**: earthquake shaking cracks earthen levee, tsunami inundation erodes cracked levee, subsequent storm runoff fails levee and floods community.

- **Other cascading effects**: To be determined during project.
Example Multihazard Interaction
Tohoku Region, Japan

Collapsed tsunami protection barrier and gates at Minamisanriku

Potential impacts: Flood control, sea inundation at high tide
Recent earthquakes expose the significant need for investigating earthquake-flood and earthquake-tsunami-flood multihazard interaction

- Problem is not unique to Christchurch or Tohoku
- **No significant study or documentation presently exists**

Peter Connor,
NZTA
Canterbury Region
Manager
Participants, and Stakeholders
Engagement
International Organizational Structure

- **United States/ASCE**
  - TCLEE – Project Leader (Craig Davis)
  - Coasts, Oceans, Ports and Rivers Institute (COPRI)

- **New Zealand**
  - University of Canterbury (Dr. Sonia Giovinazzi – NZ Project Leader)
  - New Zealand Coastal Society (Dr. Deirdre Heart)

- **Japan**
  - Japan Society of Civil Engineers TCLEE
    - Professor Kazuo Konagai of the University of Tokyo
    - Professor Yasuko Kuwata of Kobe University
  - International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) Technical Committee 303 (TC303) on Floods
    - Professor Susumu Iai from Kyoto University DPRI
Project Status

- **US - Project supported with ASCE budget**
  - Project has strong support from TCLEE, COPRI
  - Minimal financial support
  - Requires collaboration in sharing data and financing with others

- **NZ - Project supported by NHRP (and GNS)**
  - Project has strong support from NELC, NZCS
  - Local Authorities, Ecan, Lifeline utilities, have expressed commitment and are co-funding the project (contributes to master scholarship)
  - UC Quake centre is supporting and provides co-funding to the project (contributes to master scholarship)
# Schedule (approximate)

- October 2013: Official project start in NZ
- 2\textsuperscript{nd}-6\textsuperscript{th} Decembe 2013 – Reconnaissance in Christchurch
- May 2014 – August 2015: Prepare monographs
- September/October 2014: submit monographs for publication (published in 2015)
- October 2015: Initiate work for guidelines
Methodology and expected outputs
Data Collection Topics

- Background flood risk (pre-earthquake)
- Mechanisms causing increased flood risk
- Increased flood related hazards
  - Post-earthquake flood-related impacts on lifeline systems
    - Earthquake/Flood impacted lifeline system affects on local communities

- Solutions to mitigate problems
Questionnaire

- Intended to create ideas and thoughts to allow local experts and experience direct the data collection process

- Multidisciplinary issues

- Need input from many different people, organizations, experiences
Discussion

- We are not problem solving at this point
  - However, if opportunity arises we will be pleased for this project to jointly improve real-time problems
- Project relies on local knowledge and international collaborators
Proposed Products

- 2 monographs published by ASCE
  - Develop case studies and data documentation for
    - Christchurch, NZ
    - Tohoku Region
  - Focus more on data documentation and less on analysis
- Recommendations and guidelines for engineering use