Earthquake-Flood Multihazard Impacts on Lifeline Systems and Communities

An International Collaborative Project

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TCLEE

NHRP
Natural Hazards Research Platform

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Project Scope

1) The purpose of is project to **investigate and document case studies** for the on-going 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 follow 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.

Example Multihazard Interaction
Christchurch, NZ

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 routs, 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

Project Motivation

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

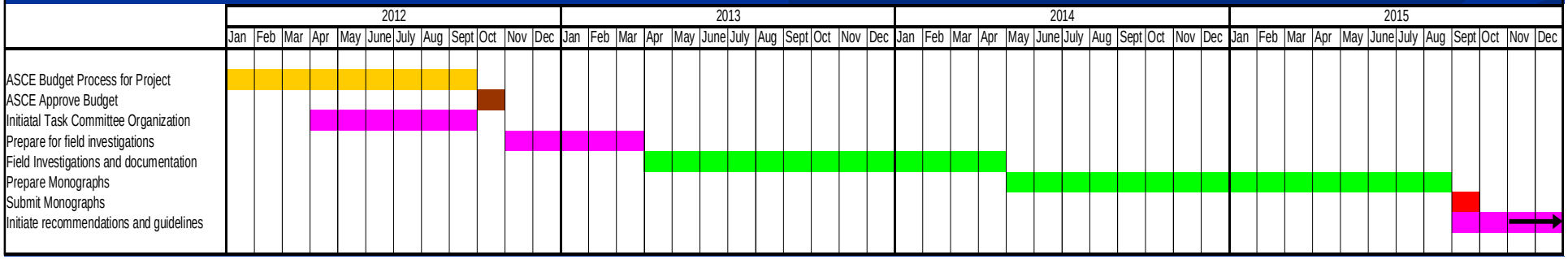
- United States/ASCE
  - TCLEE – Project Leader (Craig Davis)
  - Coasts, Oceans, Ports and Rivers Institute (COPRI)
- New Zealand
  - University of Canterbury (Dr. Sonia Giovinazzi – NZ Project Leaser)
  - New Zealand Costal Society (Dr. Deirdre Heart)
- Japan
  - Japan Society of Civil Engineers TCLEE
    - 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 provid co-funding the project (contributes to master scholarship)

Schedule (approximate)

- October 2013: Official project start in NZ
- October 2013 – May 2014: field investigations, data collection, documentation (NZ) (JP July 2013)
- 2nd-6th 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