FP4: Next-Generation Infrastructure: Low-damage and repairable solutions

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Flagship Summary

This flagship will seek a new design paradigm whereby reparability and damage-control is explicitly considered in the design process. This requires the development of new low-damage systems, quantification of the reparability (cost and time) of conventional systems, and design process methodologies for implementation. This flagship will also result in important changes to implementation standards; which provide the mainstream technology transfer mechanism given that all future designs must satisfy these standards. Significant economic benefits are also expected through both reductions in future earthquake losses and increased international competitiveness of New Zealand engineering consultants and marketing of new seismic protective devices.

The key thrust areas are:

1. Development of new technologies for buildings (structural and non-structural) to control damage in future events and enable rapid recovery.
2. Development of procedures to reliably assess and communicate the performance of new and conventional systems, including consideration of residual capacity of earthquake-damaged infrastructure and cost-effective repair techniques.
3. Integration of reparability performance objectives into implementation standards and alignment with insurance policies optimised for rapid recovery.

Thrust Areas	Key tasks/Deliverables	Start	Finish
FP4.1 New technologies for buildings	1. Develop low damage systems for buildings (with focus on whole-of-building performance) including guidance for their design and construction.	1/01 /2016	31/12 /2020
	2. Development of a risk-targeted design methodology for new systems.	1/01 /2018	31/12 /2020
FP4.2 Performance objectives and reparability of systems	1. Develop methodology for assessing residual capacity of building structures (generalised and material specific)	1/01 /2016	31/12 /2016
	2. Use of large-scale test results for validation of models to assess performance (including residual capacity and repair techniques)	1/01 /2018	31/12 /2020
	3. Develop improved means of considering reparability within the performance assessment of new and conventional buildings systems	1/01 /2018	31/12 /2020
	4. Develop alternative repair strategies for existing structures considering advanced performance measures	1/01 /2018	31/12 /2020
FP4.3 Implementation	1. Identify means (economic, regulatory, etc) to implementation of low-damage systems	1/01 /2016	31/12 /2020
	2. Propose alternative methods to assess performance (economic or other relevant reparability performance objectives) of traditional building solutions with that of low-damage systems	1/01 /2017	31/12 /2020

Opportunity

Earthquake resilience requires a built environment that not only protects citizens from death and injury, but also enables communities to return to the norms of everyday life soon after a major earthquake. In contrast, for example, current NZ and international building codes focus only on achieving “life safety” performance when a building is subjected to a major earthquake, and do not provide any assurance infrastructure will be repairable afterwards. After the Canterbury Earthquakes with approximately 70% of buildings in the CBD have been demolished, it is time for a new design paradigm whereby reparability or damage-control is explicitly considered in the design process. This requires both the development of new low damage systems and quantification of the reparability (cost and time) of conventional systems.

In Flagship 4, novel seismic protective systems including, among others, hybrid damping devices, damage-free rocking structural systems, and wide-scale ground improvement for liquefaction remediation will be investigated. This Flagship will also combine previously independent research efforts on low damage structural and non-structural components to consider the compatibility of the entire building system, with the goal of minimizing the overall losses (repair cost and downtime). Leveraging off the Christchurch-based SCIRT learning legacy program for underground infrastructure, the practical considerations of replacement of liquefaction-induced damage to pipe networks with high performance materials will be examined. Economic barriers to adoption of new low-damage systems will be considered and cost-effectiveness will be evaluated using a multi-criteria approach where seismic performance will be integrated with life-cycle cost analysis considering benefit estimation of the long-term reduction of direct and indirect losses from future earthquakes. Results from Seed Projects related to infrastructure durability and its effects on life-cycle seismic assessment will also be integrated into this Flagship. Using data from ongoing large-scale testing on concrete buildings, this Flagship will also provide models for residual capacity of damaged buildings - the critical missing link to considering the reparability of conventional building systems in the design of next-generation infrastructure.

Impact

Our goal is to inform the Christchurch rebuild with research excellence on the residual capacity of damaged buildings, underground infrastructure and new low-damage systems to be used in the construction of a truly earthquake resilient city. This Flagship will also result in immediate changes to implementation standards; which provide the mainstream technology transfer mechanism given that all future designs must satisfy these standards. Significant economic benefits are also expected through both reductions in future earthquake losses and increased international competitiveness of NZ engineering consultants and marketing of new seismic protective devices.

Projects

2017

- 16073 - Enhanced Seismic Resilience of Light Steel Frame Pallet Racking Systems (Clifton - UoA)
- **17096** - Large Friction Connection Performance and Reparability (MacRae - UoC)
- **17117** - Development and System-Level Implementation of Novel Damping Devices (Rodgers - UoC)
- **17137** - Usage of Seismic Loss Assessment to Motivate High Performance Building Solutions (Sullivan - UoC)
- **F4.1** - Exploration of Lower-Damage Modifications to Conventional Reinforced Concrete Walls (Henry - UoA)

2016

- 16015 - Design Procedure and Feasibility Analysis of Low-Damage Dissipative Rocking Precast Concrete Bridge Decks (Palermo- UoC)
- **16020** - Collaborative Framework for Large-Scale Structural Testing between New Zealand Research Institutions and Swinburne University of Technology (Hogan - UoA)
- 16046 - Residual Capacity of Repaired Reinforced Concrete Walls and Lower-Damage Modifications (Elwood - UoA)
- 16066 - Understand the Dynamic Characteristics of Post-Tensioned Multi-Storey Timber Buildings through Monitoring and Field Testing on Actual Implementations (Sarti - UoC)
- **16067** - Direction Dependent Dissipation (D3) Devices: Semi-Active Behaviour with the robustness of a passive device (Rodgers - UoC)
- **E6471** - Low Cycle Fracture Assessment and Earthquake Life of Structural Steel Elements (MacRae - UoC)

Related Effort

- **1** - Structural Reconnaissance to Kumamoto Earthquake
- **2** - Seismic Performance and Loss Assessment of New Zealand Code-Conforming Reinforced Concrete Frame System Archetypes

Case Study Buildings

Case study building layout templates for use in seismic loss assessment studies are being developed as part of **Project F4.3**. Building details, drawings, and models of various buildings designed for New Zealand conditions can be found on the project's wiki page.

Monthly Flagship 4 Meetings

If you would like to participate in the monthly web conference, please contact the flagship manager. You can attend the web conference through **ZOOM Video Link**.

Past meeting agendas and related presentations can be found **HERE**.

Workshops

System Interactions and Detailing of Low-Damage Buildings Workshop

QuakeCore held the 'System Interactions and Detailing of Low-Damage Buildings' workshop on the 26th of April 2017 in Wellington. Further details and presentations can be found on **HERE**.

Other Presentations

Requests for Proposals