

## Flagship 3 Coordinated Project 2019-2020

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### 2018-2020 TEC Contract for delivery by QuakeCoRE Flagship 3 Programme

#### Flagship 3:

This flagship will result in the development and validation of procedures to forecast the socio-economic impacts of building demolitions and retrofits that are legislated to occur within the coming decade. Improved assessment guidance will mitigate conservative seismic assessments that result in unnecessary demolition of existing buildings, including the country's built heritage, enabling economically-viable policy solutions. Proven cost-effective and architecturally-appropriate earthquake strengthening solutions will be developed and communicated to structural engineers nationwide so that results can be immediately implemented. Consideration will be given to the range of existing buildings posing a risk in New Zealand's cities, not just those classified as earthquake-prone by legislation. The key thrust areas are:

1. Development of validated methodologies for detailed assessment and improvement of earthquake-vulnerable buildings such as unreinforced masonry and reinforced concrete buildings. Where possible, validation may be achieved via field testing in buildings scheduled for demolition.
2. Development of methodologies for economic assessment of options for addressing earthquake-vulnerable buildings, namely: mitigation, demolition, or no action.
3. Understanding the development of policy and initiatives regarding earthquake-vulnerable buildings, including understanding societal involvement and expectations in such policy.

Thrust Areas	Key tasks/Deliverables	Start	Finish
FP3.1 Methodologies for earthquake-vulnerable buildings	1. Develop alternative methods for improved seismic assessment of existing buildings with focus on highest life safety risks	1/01/2016	31/12/2019
	2. Develop and test innovative retrofit solutions for earthquake-vulnerable buildings	1/01/2016	31/12/2019
FP3.2 Economics of earthquake vulnerable buildings	1. Assess impacts of earthquakes and earthquake-related policies on property and rental markets	1/01/2016	31/12/2019
	2. Assess the utility of different financial and economic tools for decision making related to existing buildings	1/01/2017	31/12/2020
	3. Investigate the role of insurance in the addressing earthquake-vulnerable buildings	1/01/2018	31/12/2020
FP3.3 Societal perceptions and Policy	1. Investigate public understanding of earthquake risk and mitigation options and their spatial and temporal variations	1/01/2017	31/12/2019
	2. Investigate the role of communities of practice in shaping earthquake prone building policy at a national to local level.	1/01/2017	31/12/2019
	3. Develop innovative methods for community participation in the development of policies and initiatives to address earthquake-vulnerable buildings	1/01/2018	31/12/2020

## FP3 Coordinated Project Plan – 2019-20

### Research Activities:

Understanding the risks and impacts of multi-story building failures and achieving viable solutions requires a multi-disciplinary approach. This project incorporates studies on the following interrelated objectives:

- Inventory and risk profile of Wellington CBD
- Vulnerability of concrete building components – nonductile columns and precast floors
- Modeling of existing concrete buildings to assess collapse risk
- Cordoning and associated impacts
- Prioritisation of demolitions or strengthening of earthquake-vulnerable commercial buildings
- Regulatory solutions for addressing earthquake-vulnerable commercial buildings

The Wellington focus provides contextual connection between the disciplines and provides connection with several additional complementary efforts.

### **Activity 1: Inventory and risk profile of Wellington CBD**

This activity seeks to:

- support and progress the ongoing development of the Wellington Building Inventory, a comprehensive, readily updateable, and centralized database containing select attributes and metadata representative of the existing building stock in the Wellington CBD. The building-level data contained within this Inventory, including both immutable and variable structural, non-structural, occupancy, insurance, and business continuity / downtime attributes, for the vulnerable multi-storey concrete commercial buildings within Wellington CBD will be fed into the objectives outlined below. Event-specific data from the Inventory will also be used, as available, to validate developed trends against observed values and explore interdependencies and downstream effects.
- conduct regional risk assessments to develop a high-resolution risk profile of the targeted subset

of structures within the project scope. Through the collaborative and multi-disciplinary approach outlined above, we expect to better understand the vulnerability of the Wellington building stock and the impact failures within this building stock will have on Wellington recovery.

### **Activity 2: Vulnerability of concrete building components – nonductile columns and precast floors**

This activity is co-funded by BRANZ for ReCast Floors: Retrofit of Precast Floors. It will contribute to the improved assessment of the seismic performance of buildings with precast concrete floors and provide guidance on potential mitigation options.

The focus for nonductile concrete columns study will analyse the test results on columns with high axial loads and low transverse reinforcement will be conducted. The study tackles a fundamental problem of directly accounting for variability of materials in identifying the likely failure mode of the column. It is hypothesised that for components where failure is controlled by the behaviour of concrete, there is a critical need to do multiple tests to assess the true variability of the component performance. This variability is not typically recognised in the development of fragility curves or deformation capacity limits as identical tests are not generally incorporated in test programmes. The research will include this variability in OpenSees analyses in order to estimate the impact on building collapse probability.

### **Activity 3: Modelling of existing concrete buildings to assess collapse risk**

This activity will seek to advance the state of the art in the numerical modelling and collapse risk estimation of existing structures. An existing reinforced concrete building in Wellington will be selected for a case study.

Activities include:

- Advanced three dimensional numerical models of the structure will be developed, accounting for phenomena such as nonlinear torsion and beam elongation.
- A series of simulated and non-simulated collapse modes will be analyzed to determine the collapse risk of the structure, accounting for the duration and response spectral shape of the ground motions.
- Comparison of collapse risk estimate to the anticipated average collapse risk of a newly designed structure determined in parallel benchmarking studies, to evaluate the %NBS of the structure.
- Comparison of the computed value to values of %NBS determined by other permissible simpler methods of analysis.
- Validation of created models. An instrumented building will be chosen or ambient vibration data will be recorded to help validate the created models. The estimated value of %NBS will be tracked as the model is refined using different types of recorded data. Availability of base rocking and rotation motion will also be critical to adequately capture torsional response.
- Assessment of sensitivity of each individual collapse mode and the collapse capacity of the structure in general to ground motion duration and response spectral shape will be assessed.

### **Activity 4: Cordoning and associated impacts**

The activity will produce a baseline for analysis of future post-earthquake cordoning and aligned QuakeCoRE research activities. It is focused on:

- learning lessons from both domestic and international cordoning experiences
- highlight the decision-making logic and motivation for cordoning in a post-earthquake city
- informing planning for a potential Wellington CBD cordon, and investigate the implications of cordoning following a future major earthquake.
- develop a cordon model for Wellington given a certain distribution of damage.
- identify issues and implications for long term recovery and policy development will be a primary output of the project, including the social and economic consequences of cordoning for businesses, residents and others in the affected area.

### **Activity 5: Prioritisation of demolitions or strengthening of earthquake-vulnerable commercial buildings**

Utilising the detailed building level data collected in Activity 1, this activity will:

- develop tools for prioritisation of RC EQ-vulnerable buildings.
- examine different incentive schemes that can allow for retrofits to happen. The 2017 Whanganui project has identified a set of incentives that may speed up the process of strengthening in the

smaller towns.

- identify a combination of incentives that is more appropriate for Wellington (or any other more urban cityscape).
- create a modelling framework for the role of each building in the local economy, an effort that will allow us to understand the benefits associated with strengthening (to the government, to the public, and to the owners).
- calculate how different incentive schemes change the associated benefits and costs to increase the likelihood of strengthening being prioritised and undertaken appropriately.

**Activity 6: Regulatory solutions for addressing earthquake-vulnerable commercial buildings**

This activity will provide:

- An understanding of risks and likely impact of the current regulatory environment for the multi-storey buildings in the Wellington region.
- Regulatory solutions for reducing risk and likely impact of a major event in the Wellington region.
- A regulatory framework for managing the loss of significant building stock in the post event environment.

For further details please contact the Flagship Leader