Holistic Evaluation of Resilient Structures: The Environmental Performance of Beyond New Zealand Building Code Structures.

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1 Introduction

Designing a structure for higher-than-code seismic performance can result in significant economic and environmental benefits. This higher performance can be achieved using the principles of Performance-Based Design, where engineers design structures to minimize the probabilistic lifecycle seismic impacts on a building.

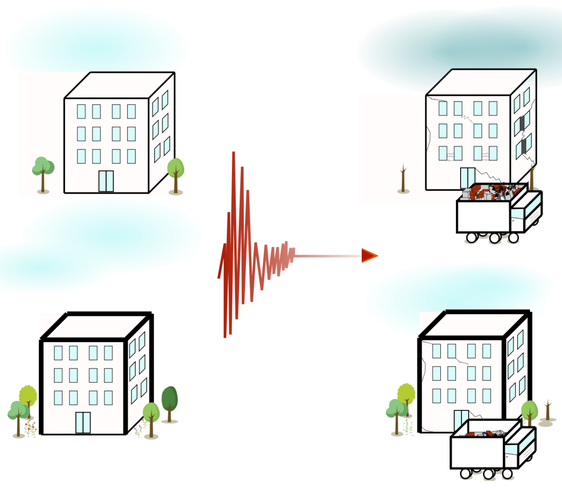


Figure 1: Design a structure for higher seismic performance

2 Framework For Estimating Environmental Impacts of Demolitions Following Earthquakes

Figure 2 summarises a comprehensive framework for calculating the environmental impacts associated with demolishing a building. The framework is broken into three distinct modules which incorporate embodied carbon and energy in the building materials, the processes used in the construction of the building, and transport and waste management after demolition.

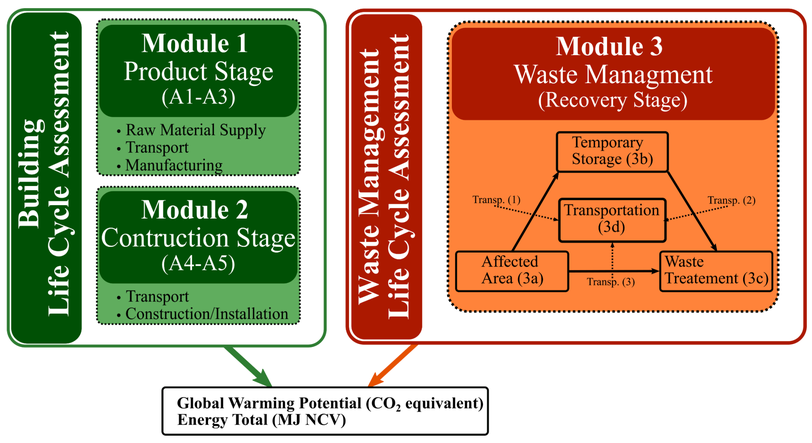


Figure 2: Framework for Calculating Environmental Impacts of Building Demolition

3 Post-Earthquake Demolition in Christchurch, New Zealand: a case-study towards incorporating environmental impacts in demolition decisions

To highlight the importance of incorporating environmental considerations in demolition decision making following earthquakes, a preliminary case-study was conducted to provide a quantitative evaluation of the environmental impacts of building demolitions in Christchurch following the Canterbury earthquakes.

Research Objective

This research is focused on providing policy makers and stakeholders with evidence-based environmental incentives for designing structures in New Zealand for higher seismic performance.

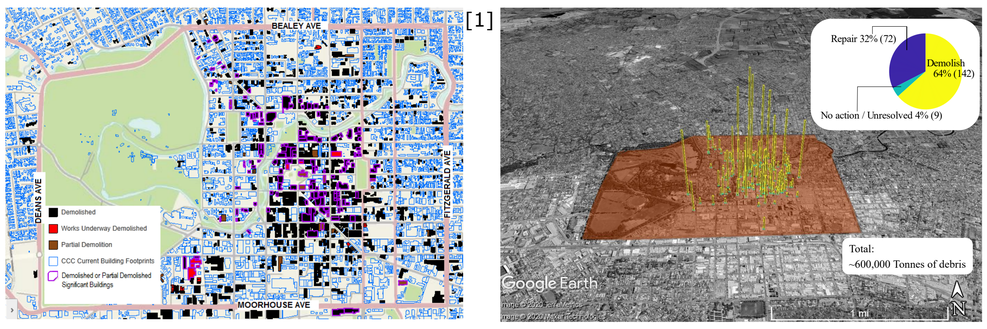


Figure 3: Overview of Buildings Demolitions in Christchurch CBD

4 Methodology for Case Study

A building data set consisting of 142 demolished concrete buildings was used to quantify the embodied carbon and energy. A reduced building data set was used to develop a material take off model to estimate quantity of material across the entire data set. This material information was used with the environmental data from BRANZ to estimate the embodied carbon and energy.

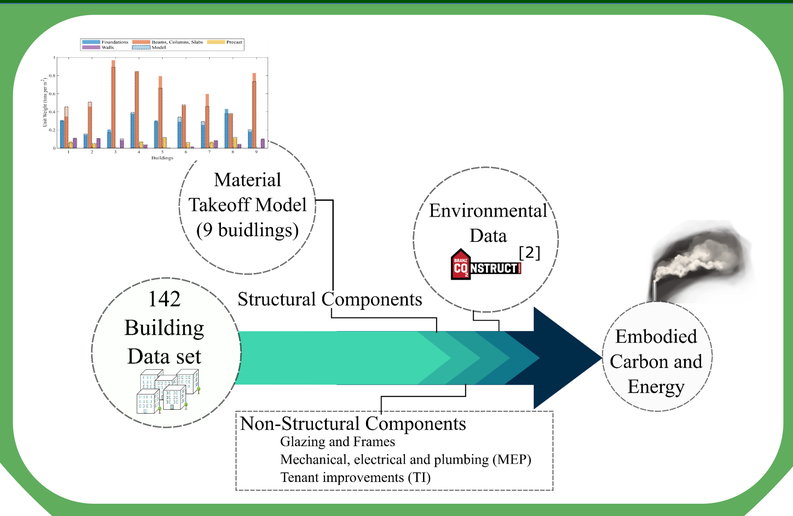
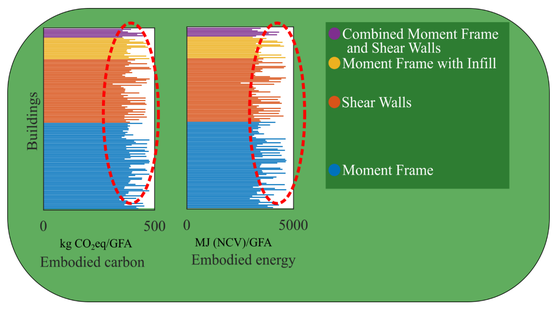


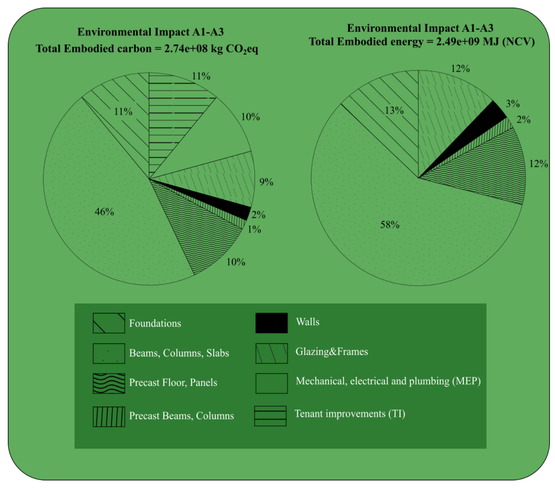
Figure 4: Methodology for Calculating Embodied Carbon and Energy

5 Results

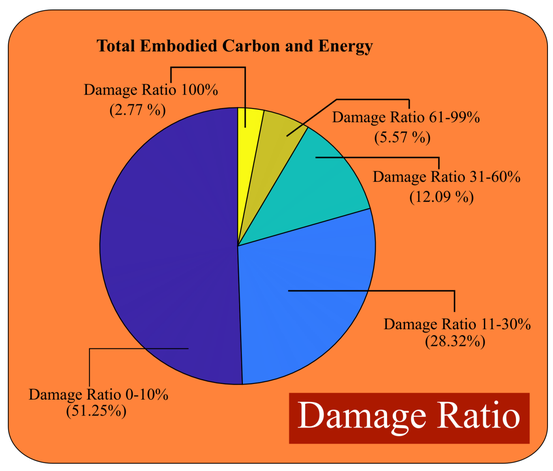
The embodied carbon and energy of the 142 demolished buildings were calculated assuming a like-for-like replacement of materials in buildings that were demolished.



(a) Normalised by Gross Floor Area



(b) Contribution of the Different Material Categories



(c) Based on Damage Ratio

Figure 5: Embodied Carbon and Energy from 142 Demolished Buildings

6 Conclusions/Future Work

- The total embodied carbon across the demolished building is approximately equal to the annual CO_2 emissions of purchased electricity in 360,000 average homes in New Zealand.
- Ongoing work is focused developing an environmental impact framework that incorporates all the complex factors (e.g. construction methodologies, repair methodologies, demolition methodologies, and waste management) that contribute to the environmental impacts of building repair and demolition following earthquakes.

References:
[1] Marquis, F., Kim, J.J., Elwood, K.J., Chang, S.E., 2017. Understanding post-earthquake decisions on multi-storey concrete buildings in Christchurch, New Zealand. Bull. Earthq. Eng. 15, 731–758. https://doi.org/10.1007/s10518-015-9772-8
[2] BRANZ, 2019. Whole-building whole-of-life framework [WWW Document]. BRANZ CO2NSTRUCT. URL https://www.branz.co.nz/environment-zero-carbon-research/framework/branz-co2nstruct/

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