Smart Seismic Cities

Informing Pre-Earthquake Planning and Post-Event Response with Near Real-Time Impact Tools (NRITs)

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Research Objective

To develop a framework of near real-time impact tools including region-wide building inventories, non-linear numerical modeling, and monitoring **to inform pre-earthquake planning and post-event response.**

Introduction

The effectiveness of disaster planning and post-disaster response efforts is heavily reliant on the rapid availability of situational information, such as high-level estimations of extents of damage, loss of critical infrastructure functionality, and loss of life. The ability to quickly garner this information allows for the immediate accessibility of not only a pulse on the situation but a more detailed picture of the aftermath, thereby promoting a more organized, efficient, and confident response in the early hours following a disaster.

This project seeks to develop a framework of near real-time impact tools (NRITs), particularly consisting of a network of instrumented buildings and other monitoring sources feeding information to structural analysis software tethered to a city-wide inventory of structures in Wellington. The output of these tools will provide rapidly-accessible situational information, aiding in decision-making and resource allocation.

The current iteration is shown below. Note the feedback loops denoting validation and updating efforts.

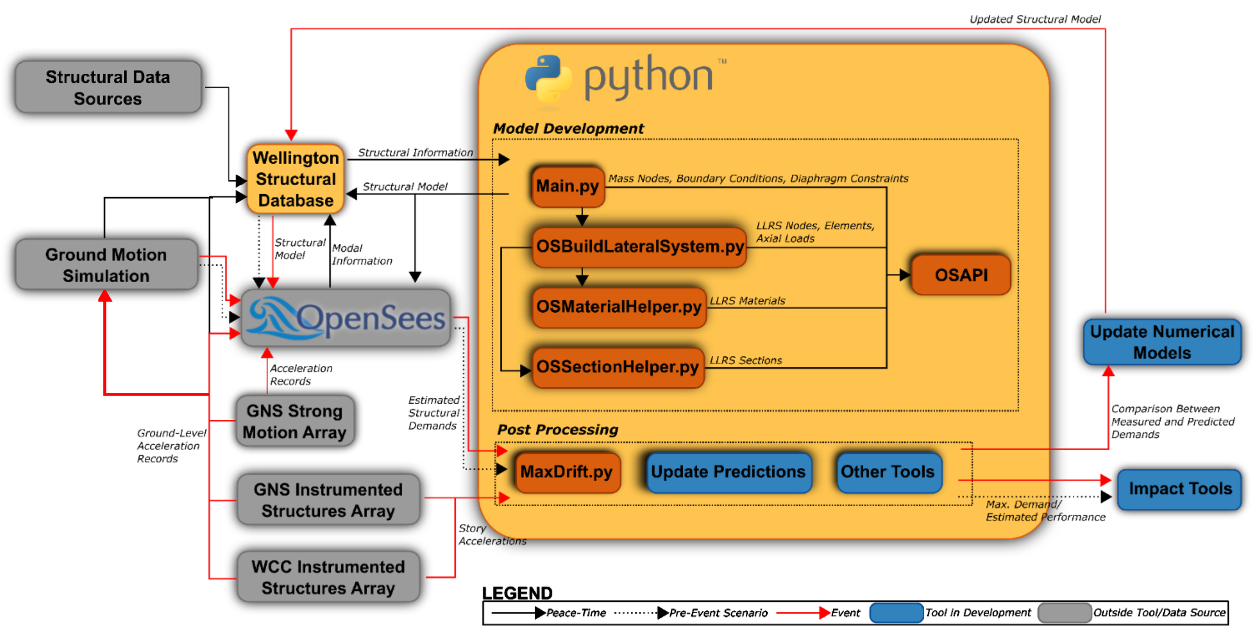

Figure 1: Current SSC Framework

Building Inventory

A detailed inventory of buildings built prior to 1980 of over 5 stories in the Wellington region is currently being constructed using information from a range of data sources. These sources are the existing instrumented structures, including drawings from the Wellington city council, pre-earthquake assessments, post-earthquake targeted damage assessments, some local special studies, and information from the existing RiskScape Building Exposure Database. The database is being developed using a technique to rapidly capture key characteristics of buildings from design plans that can be used to classify structural archetypes and identify deficiencies.

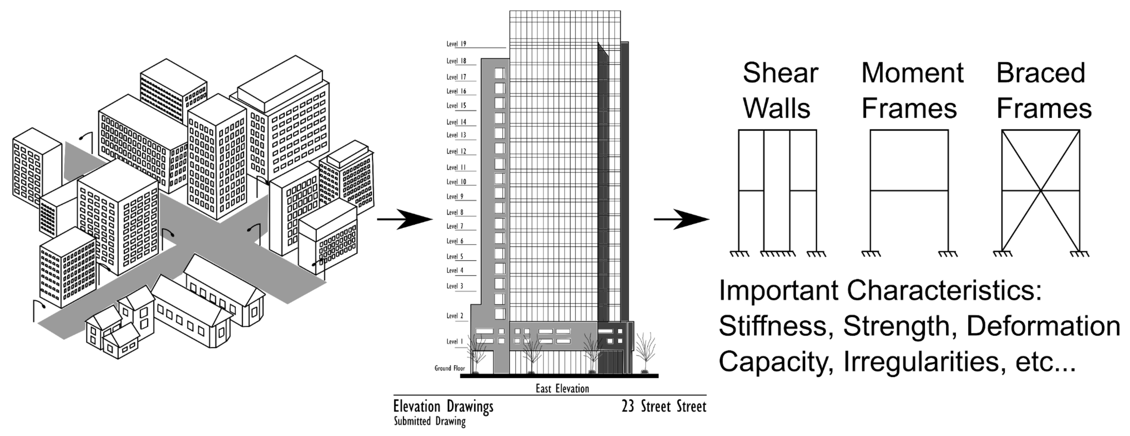

Figure 2: Building Locations and Acceleration Histories Recorded During the Kaikoura Earthquake

Numerical Models

Non-linear numerical models of varying complexity are developed corresponding to the data available for each building in the database. The more complete the dataset and the more confidence in the values contained therein, the more effort is put towards developing detailed models to suit. Models are expected to be validated to instrumented data, damage data, and other sources available.

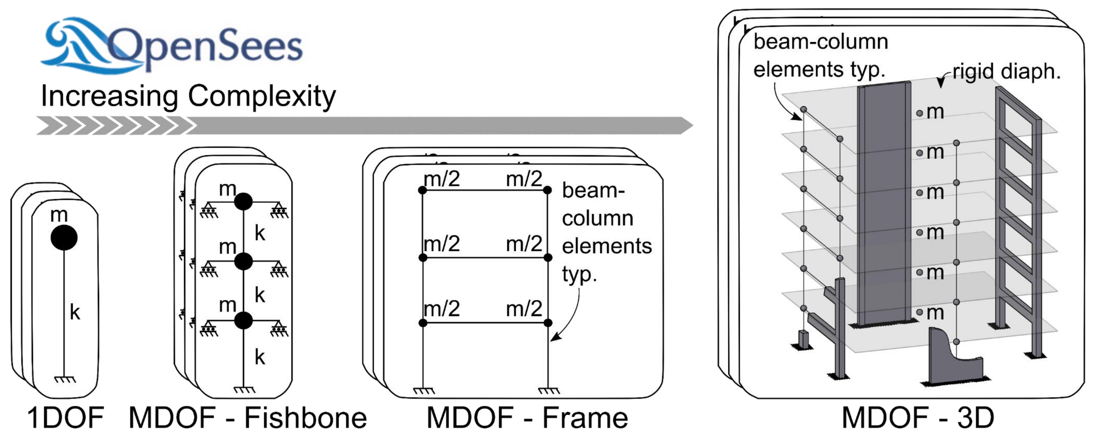

Figure 2: Numerical Models of Varying Complexity

Instrumentation Arrays

It is widely understood that further development of the site instrumentation network is desirable in order to better understand the dynamic characteristics of the Wellington waterfront.

Parallel to that, structural instrumentation of geographically and archetypically diverse 'indicator' buildings can be of considerable use for data collection and model validation.

An informed holistic approach to developing both networks is the hope of this project.

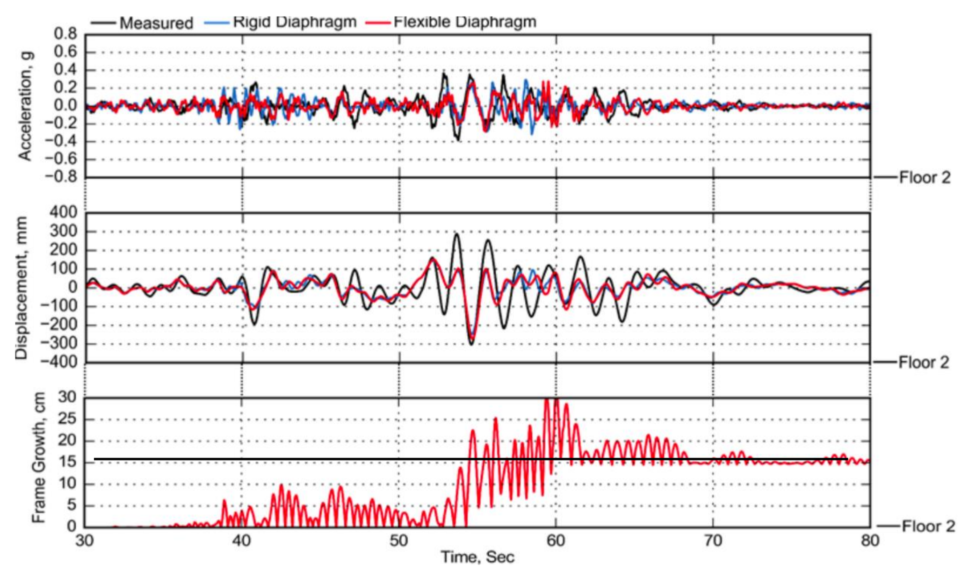

Figure 4: Model Validation using Structural Instrumentation

Target Output

The figure below showcases the intended output of the SSC framework, displaying a building-level impact map and allowing for extracting response priority based on expected levels of damage.

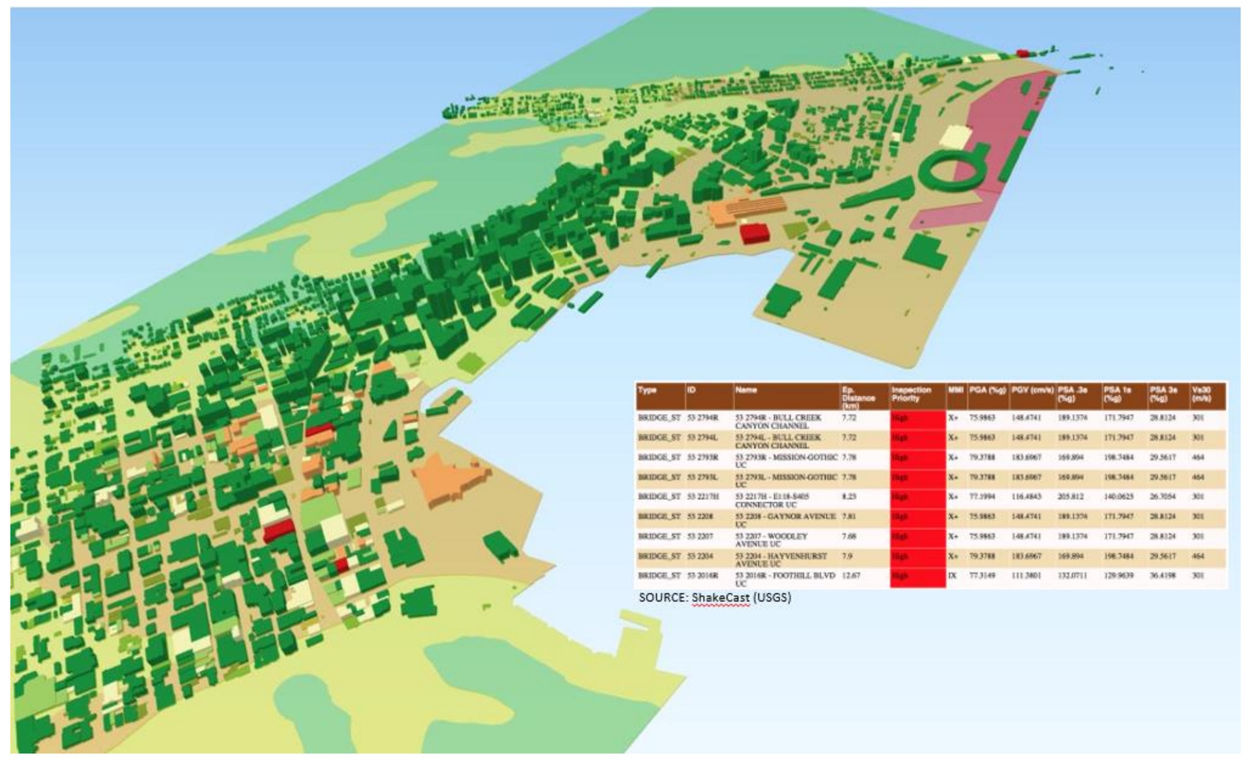

Figure 5: Target Output Impact Map and Building Response Priority (Note: For Illustrative Purposes Only)

Updating Impact Tools Output

Post-event, the measured response of instrumented buildings can be used to update the estimated numerical response of the buildings using a Bayesian approach. Due to tight turn-around time for situational data following an earthquake, execution and validation of this is expected to be heavily streamlined or automated.

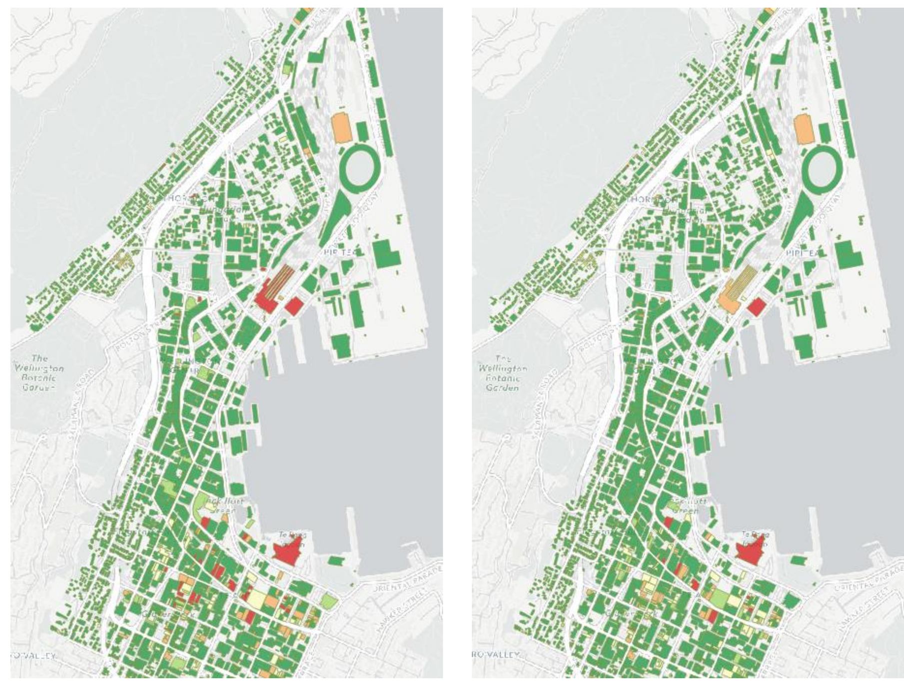

Figure 6: Prior (left) and Updated (right) Output (Note: For Illustrative Purposes Only)

In the proposed Bayesian framework, if we have a building (or class of buildings), M, and a probability distribution of predicted system responses, $p(D|\theta,M)$ that can be parameterised by n model parameters (θ), where D is the 'impact parameter', for example maximum interstory drift. Any observations of D can be used to update the predictions using Bayes' theorem:

$$p(\theta|D, M) = p(D|\theta,M)\ p(\theta|M)$$

Ongoing Work

- Further data collection and populating of Wellington Structural Database
- Classification of building stock and definition of structural archetypes
- Extensive data and model validation exercises
- Informing the proposed expansion of the existing instrumentation network to improve the robustness of the array and SSC network
- Collaboration with social scientists to understand how building- and city-level decisions will be made using data outputs

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