Project overview

Liquefaction hazard maps are typically developed from the identification of low lying quaternary aged alluvial deposits in geological maps, then further refining these areas using simplified CPT and SPT-based liquefaction triggering procedures on available CPT and borehole data. Recent studies of the 2010 to 2011 CES and 1987 Edgecumbe earthquakes have shown that the simplified liquefaction procedures over-estimate the predicted extent of liquefaction when compared to the observation records (i.e. van Ballegooy et al., 2015; Beyzaei et al., in review; Bastin et al., 2016), resulting in unnecessary restriction on land development and retrofitting of existing infrastructure to improve resilience, which may be cost prohibitive to many regions.

Liquefaction has been observed following upwards of 13 recent and historic earthquakes in New Zealand as shown in Figure 1 (Fairless & Berrill, 1984; Berrill et al., 1994; Christensen, 1995; Carr, 2004; Cubrinovski & Green, 2010; Hancox et al., 2013). Accounts from local residents and post-event reconnaissance mapping indicates that the distribution and extent of liquefaction was primarily limited to the highly susceptible sediments on alluvial plains, and generally proximal to modern and paleo-waterways (Christensen, 1995; Carr, 2004; Cubrinovski & Green, 2010; Hancox et al., 2013). The historical record of liquefaction provides important insights into the settings where liquefaction typically manifests, and thus the distribution of sediments susceptible to liquefaction. However, these historic records are currently distributed throughout technical reports, publications, local newspaper accounts and archives, and while some effort has been made to collate reports for individual earthquakes (i.e. Fairless & Berrill, 1984; Carr, 2004), no dataset outlining all historical cases of liquefaction in New Zealand is currently available. Collation of the extents of liquefaction from these historic earthquakes would enable the liquefaction predicted from the simplified methods (based on PGA contour estimates for the earthquakes and modelled depths to groundwater) to be compared, and areas of inconsistency to be identified.

Figure 1: Location of earthquakes for which there are comprehensive liquefaction observations from observational records, photo archives, published accounts and reports.

Detailed characterization of sites where liquefaction has historically manifested and also sites where it was predicted yet not observed, would allow the identification of ground conditions where the simplified methods are applicable and also where they are over-predicting the liquefaction. The detailed site characterisations will enable the potential reasons for these inconsistencies to be examined in depth. It is anticipated that collating historical records of liquefaction within New Zealand

and the subsequent study into the applicability of the simplified methods in various soil deposits would lead to a world-leading dataset facilitating many research projects, and assist in improving the liquefaction prediction tools.

Key objectives:

The key objectives of this research work are as follows:

1. Determine areas where liquefaction has previously occurred and also areas where liquefaction has not occurred in New Zealand from observational records, published accounts, and reports. Also, identify areas (soils) of interest that were subjected to high seismic demand, but did not liquefy.
2. Constrain the CSR above and below which no liquefaction was observed for various geologic units and geomorphic areas for the historical earthquakes by examining the extents and severity of liquefaction during recent and historic liquefaction-triggering earthquakes to identify and quantify whether some soil units have a higher liquefaction resistance compared to others (such as pumice soils and soils in swampy areas). This will be performed separately for various soil types of interest (e.g. clean sands, non-plastic sand –silt mixtures, low plasticity silty soils and 'special' soils, such as pumiceous soils, and importantly liquefaction triggering criteria will be tested for characteristic NZ site conditions and soils.
3. Identify the areas where the simplified SPT and CPT-based liquefaction analyses are either consistent with, or inconsistent with observations. Determine common subsurface sediment characteristics, geomorphic settings, and paleo-depositional settings where the liquefaction analyses performed either well or over-predicted observations.
4. Make use of field (V_P and V_S data) and laboratory (liquefaction) testing on soil samples to better characterize sites and cyclic behaviour of soils respectively, and on this basis provide an improved interpretation for prediction-observation discrepancies.

The aim of these four objectives will contribute towards the international research effort in improving the prediction accuracy of the simplified SPT and CPT-based liquefaction evaluation procedures.