Predicting the Consequences of Liquefaction on Residential Buildings

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The 2010 – 2016 Canterbury Earthquake Sequence (CES) affected the Canterbury region of New Zealand resulting in widespread ground surface differential settlement, mainly due to liquefaction ejecta, liquefaction related volumetric densification of soils, topographic relevelling and lateral spreading, causing extensive land, infrastructure and building damage. The liquefaction affected approximately 50,000 residential properties and damaged approximately 15,000 residential buildings beyond economic repair. The total economic losses from the CES were in the order of $40B, with approximately one third to one half of the economic losses being directly attributable to damage caused from differential ground surface settlement as a result of liquefaction. Extensive residential building damage data sets have been collected following the CES including deformation assessments of foundations for approximately 65,000 residential buildings in areas where liquefaction occurred. In addition, comprehensive floor level surveys have also been undertaken on approximately 2,500 buildings in areas where liquefaction occurred to measure the differential settlements and angular distortions.

Correlations between the foundation differential settlement and angular distortion of residential buildings and CPT-based liquefaction vulnerability parameters (such as LPI and LSN) have been developed from the CES data. These correlations can be used for predicting liquefaction-induced damage of residential buildings located on liquefaction susceptible soil deposits. These correlations work well at predicting damage on a portfolio basis but do not work so well when trying to predict the likely damage of an individual building. This is because there is a lot of scatter in the correlations mainly due to the difficulty in predicting the physical consequences of liquefaction (i.e. horizontal and vertical ground surface movements) and its effects on residential buildings. The first part of the presentation will examine these correlations and the reasons for the scatter.

The second part of the presentation examines the correlations between liquefaction related ground surface deformations derived from LiDAR surveys undertaken following the CES and the foundation differential settlement and angular distortion of residential buildings. These correlations have significantly less scatter compared to the correlations with the CPT-based liquefaction vulnerability parameters. Following an earthquake event, rapid assessment of liquefaction-induced horizontal movements from satellite imagery and vertical movements from airborne LiDAR surveys can provide the information to more accurately and rapidly estimate the liquefaction-induced damage to buildings on a portfolio basis. This information is useful for estimating metrics such as financial losses and the quantum of people that are likely to be displaced due to building damage. The rapid assessment of these metrics after a disaster is essential to inform the planning for an effective post-disaster recovery phase.