Residential Building Fragility due to Liquefaction Induced Ground Surface Movement

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SUMMARY

The 2010-2011 Canterbury Earthquake Sequence (CES) caused regional tectonic subsidence and uplift. The CES also triggered widespread liquefaction causing ground surface subsidence and localized lateral spreading, consequently resulting in 16,000 residential houses with more than 50 mm of differential settlement over the building footprint and approximately 15,000 being damaged beyond economic repair and needing to be rebuilt. Aerial light detection and ranging (LiDAR) surveys were used to quantify the ground surface deformations over the CES. By subtracting the estimated vertical tectonic movements (between pre- and post-CES surveys), the subsidence attributable to liquefaction was estimated. The results correlated well with areas observed to be affected by liquefaction. Horizontal ground surface movements were also estimated using sub-pixel correlation of pairs of LiDAR data sets. By subtracting the estimated horizontal tectonic movements, the localised lateral spreading horizontal movements were estimated. The results correlated reasonably well with the mapped lateral spreading observations and ground based survey horizontal movements. Independently, horizontal movements were also estimated from optical image correlation of satellite images taken pre- and post-CES. The results from the optical satellite image correlation correlate even better with the mapped lateral spreading observations and ground based survey horizontal movements compared to the movement estimates using the sub-pixel correlation of pairs LiDAR data sets. This paper explores the correlations between the measured vertical and horizontal liquefaction-induced ground surface movements to the observed residential building foundation deformation over the residential building portfolio in Canterbury. These correlations are then used to develop fragility functions for damage assessment purposes, catastrophe loss modelling purposes as well as helping to focus the displacement range over which predicted CPT-based empirical estimation methods should be calibrated (fine-tuned).
