Terrestrial Laser Scanning Deformation Analyses of Blast-Induced Liquefaction Settlements

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SUMMARY

Liquefaction resulted in significant damages across the city of Christchurch, New Zealand during the Canterbury Earthquake Sequence. Approximately 50,000 residential homes were affected by liquefaction-induced ground failure including settlement and lateral spreading, particularly in the area nearby the Avon River. The New Zealand Earthquake Commission (EQC) funded a study to evaluate the performance of ground improvement techniques to improve the resilience of new or rebuilt houses. Several test beds with varying ground improvement strategies were constructed in a location along the Avon River in the "red zone" that has previously experienced severe liquefaction during the earthquakes. For the tests, liquefaction was induced via explosives in the ground to generate ground shaking. Detailed terrestrial laser scan surveys were completed before and after each blast test to record the deformation magnitudes and patterns of settlements from the liquefaction. Additionally, these surveys also helped identify and locate sand boils. Appropriate setup locations were chosen that minimized data gaps from obstructions. To minimize systematic errors, scans and total station surveys were completed from nearly the same locations for the before and after surveys at various locations across the site. For these surveys, many temporary control points were established to provide a high amount of redundancy. Many black and white checkerboard targets were scattered across the scene and linked back to the stable control points in both the before and after surveys using a total station. The surveying and data processing strategy that was implemented proved successful in generating digital elevation models (DEMs) and resulting settlement raster maps with 1-2 cm resolution across the site with <1cm RMS estimated error (3D, relative). Settlements as high as 30 cm were recorded. From these settlement maps, differential settlements could be calculated to evaluate the quality of each improvement technique. Of the tested improvement techniques, those that formed stiffer crusts experienced less structurally damaging differential settlement.