On good ground

EQC is sponsoring innovative ground improvement techniques that will not only strengthen land in Christchurch to allow resilient rebuilding but may offer a solution for vulnerable land in other parts of the country.

BY NICK HELM, FREELANCE WRITER, TENPOINT COMMUNICATIONS

Stone columns before blast trial.

ONE OF THE LASTING EFFECTS of the Canterbury earthquakes is the land damage. The major events, particularly the 22 February quake, caused tectonic subsidence and severe liquefaction in many parts of eastern and central Christchurch. The subsidence meant that the non-liquefying soil layers had become much thinner, increasing the vulnerability to liquefaction damage in future earthquakes.

Strengthening liquefaction-prone land

In response, EQC launched a programme to investigate several unconventional ground remediation techniques in an effort to find practical, cost-effective and consentable methods to strengthen residential land that is vulnerable to liquefaction

'The first stage of the Land Improvement Programme involved testing in the residential red zone to evaluate different ground improvement methods that could be used to strengthen the upper few metres of land to reduce the liquefaction vulnerability,' says Dr Hugh Cowan, General Manager Reinsurance, Research and Education at EQC. The work, which was completed in 2013, was led by Dr Sjoerd Van Ballegooy of the geotechnical engineering firm Tonkin & Taylor and supported by a number of research partners, sponsors and contractors from New Zealand and the United States.

'The second stage, which is currently under way, is a land repair pilot programme, which involves installing those methods in real-life situations where people are repairing or rebuilding their homes.'

Four strategies identified

Simply reinstating the original ground level using fill had been ruled out in earlier research, so EQC focused on trialling techniques that could stiffen and densify the upper soil and restore its strength and performance, despite the lower overall ground level.

'Most of the techniques were adapted from methods used on large-scale civil construction projects and scaled down for residential properties in Christchurch,' says Dr Cowan.

The first method, rapid impact compaction, uses a falling weight to repeatedly compact the ground surface. This improves ground density down to several metres and is particularly suited for sandy soils in areas where there is adequate distance from neighbouring buildings.

Low-mobility grout involves injecting concrete bulbs into the ground to squeeze the surrounding soil and increase the soil density.

Short stone columns work on a similar principle by pushing gravel into the ground instead of concrete to improve ground density and also stiffen the soil. The technique offers advantages on sandy sites, but it also requires a clear site.

For sites with vibration or space constraints, soil cement mixing can be used. Where the structure is still in place, horizontal soil mixing can be used. This creates horizontal cemented columns in the target layer that confines the soil and suppresses soil deformation during earthquake shaking.

Quakes recreated to test methods

'Test sites were selected from a careful analysis of geotechnical information to ensure that the engineering properties of the soil layers closely matched the majority of soil conditions that would be encountered in the rebuild where ground improvements would be most relevant,' says Dr Cowan.

The effectiveness of the remediation was tested in two ways – controlled blasting and an earthquake simulator known as T-Rex.

'The levels of shaking in the soil directly beneath the T-Rex machine were strong enough to liquefy the unimproved ground, whereas for most of the methods, greater levels of shaking were required to trigger liquefaction. For some ground improvement methods, the T-Rex machine was unable to trigger liquefaction, even at the strongest levels of shaking,' he says.

'Explosives were also used to induce large-scale liquefaction to test the performance of the ground improvements overlying a thick layer of liquefied soil. The stiffened and strengthened upper soil layers for most of the ground improvement methods mitigated the occurrence of liquefaction ejecta over the improved areas and also reduced the differential ground surface settlement compared to the natural unimproved soil.'

However, the trials showed low-mobility compaction grouting did not perform as expected and was unlikely to be successful as a shallow-ground improvement method in a scaled-down residential application. This technique was not used for the pilot.

Moving on to real-world remediation

'The first pilot programme focused on bare land properties, where the house has been demolished and needs to be rebuilt. We're using stone columns, driven timber piles, in situ soil mixing and gravel raft construction on these sites. There are 28 properties in the pilot – 18 in Christchurch and 10 in Kaiapoi. This stage is coming to a close,' he says.

'We are about to start installing a ground improvement method on a number of properties with repairable houses. This work uses horizontal soil mixing, which can be used to improve land under existing houses without the need to jack the building up or temporarily remove it,' he says.

'There will be several properties in this part of the pilot, and the work will go on over the next few months.'

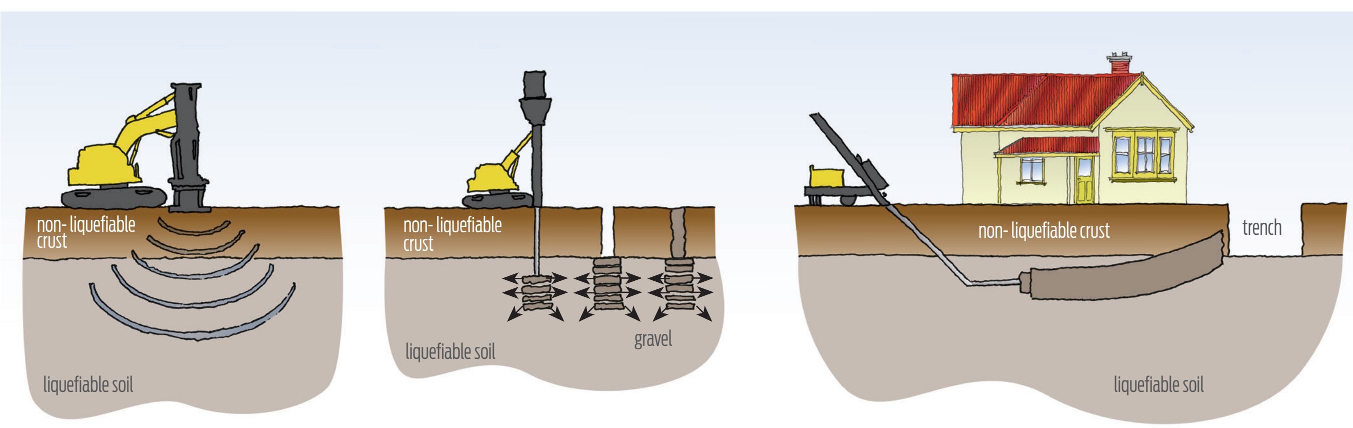
Will inform guidance document

Once the pilot is complete, the lessons learned from applying these methods will become publicly available. EQC is working with MBIE to refine the ground improvement method specification and incorporate it into *Guidance: Repairing and rebuilding houses affected by the Canterbury earthquakes*.

'This means homeowners in Canterbury can apply these methods and have confidence in the way their land, and the buildings on them, will perform in future earthquakes,' says Dr Cowan.

'It also means the methods will be available throughout New Zealand if homeowners or developers want to build on land that has similar characteristics to the sandy and silty soil areas in Christchurch.'

For more Visit www.eqc.govt.nz/canterbury.



Rapid impact compaction

Stone columns

Horizontal soil mixing