Wastewater plant benefits from new liquefaction mitigation solution

The magnitude 6.3 earthquake that struck Christchurch in February 2011 caused tragic loss of life and immense damage to buildings, roads and infrastructure. More than 7000 homes were 'red zoned', meaning the ground they were built on was considered too high risk for repairing or rebuilding.

Resin is precisely delivered under computer control into the ground below the Seaview Wastewater Treatment Plant, to densify soils and increase liquefaction resistance

The modular equipment has a small footprint, allowing day-to-day operations at the plant to continue without interruption

This seismic event spurred research into engineering solutions to help lessen the impact of liquefaction on buildings and structures. Liquefaction is the weakening of soil structure caused by earthquake shaking. Buildings and structures may sink into the liquefied soil, groundwater may rise out of it, or the land may develop large cracks. It is a problem that sandy, loose soils are particularly susceptible to.

Following a seismic event, communities can be profoundly affected, especially when vital assets such as water infrastructure are unable to function properly, resulting in significant disruption to the management of drinking water and sewage.

Under the national system for managing earthquake-prone buildings in New Zealand introduced on 1 July 2017, pumping stations and treatment plants must achieve an importance level of IL4, meaning the building and connected hydraulic services must remain operational following a seismic event.

In response, Wellington Water, jointly owned by Greater Wellington Regional Council and Lower Hutt, Porirua, Upper Hutt and Wellington city councils, committed to improve infrastructure resilience across its entire network.

GROUND-BREAKING PROJECT

To protect the community and the environment from potential wastewater contamination, and ensure the continuation of services following a major earthquake, Wellington Water sought a long-term asset preservation solution for the Seaview Wastewater Treatment Plant, which is located along an active seismic fault.

Seaview treats up to 53 million litres of water daily, servicing 146,000 residents in Upper Hutt and Lower Hutt, as well as local industries. Seismic strengthening of the Seaview Wastewater Treatment Plant pump station and milliscreen buildings formed part of the Hutt City 2018–2048 infrastructure strategy, developed to minimise the risk of failure of the buildings in a significant earthquake and avoid follow-on public health issues.

Mainmark Ground Engineering was engaged to treat the site with its new and proven Terefirm™ resin injection technology, making Seaview the first government-owned asset of its kind to be treated with resin injection in preparation for a seismic event, without having sustained any previous damage to date.

A PROVEN SOLUTION

Mainmark introduced Terefirm resin injection following several years of extensive testing and field trials in the Christchurch red zone. It is the first commercially viable, non-invasive liquefaction mitigation technique that can be applied beneath existing structures and is validated by geotechnical testing.

Theo Hnat, technical manager, Mainmark New Zealand, says, "We've always believed that our unique resin injection technique could be used to provide liquefaction mitigation, and we are very pleased that this is now a validated option.

"Terefirm is the result of years of hard work, commitment and scientific collaboration. Through the success of the Christchurch ground improvement trials, engineers and asset owners now have a viable alternative to consider for improving loose or liquefiable soils beneath structures."

The trials were funded by Mainmark with contributions towards field testing and peer review reporting by the Ministry of Business, Innovation and Employment (MBIE) and Earthquake Commission (EQC). The outcome from the trials resulted in an internationally peer-reviewed report, now available on the New Zealand Geotechnical Society website. The method has also been included in the MBIE Module 5: Ground Improvement of Soils Prone to Liquefaction.

To date, there have been few commercially viable options available to mitigate liquefaction vulnerability below an existing structure, without the structure itself being removed. The Terefirm methodology provides new opportunities for improving the earthquake resilience of existing buildings or infrastructure built on liquefaction-prone soils.

What makes the technique unique is that the solution can be applied beneath existing structures using a process that has been modified compared with other resin injection types, and involving equipment suitable for larger-volume injection.

HOW TEREFIRM WORKS

Seaview Wastewater Treatment Plant is operational 24/7 and has a number of buildings containing large pumps and generators that are hard to reach, with extremely low head room, and restricted access to only one person at a time.

"Wellington Water's council owners tasked us with ensuring our key treatment plants will be able to quickly resume operating after a major earthquake," says Tristan Reynard, Wellington Water project director for the Seaview site works. "Upgrading this plant while it remained operating presented a unique challenge, which Mainmark's solution, with its unique ability to be applied under existing structures, helped us to address."

Terefirm was particularly suited to site conditions and limited access at Seaview, allowing the ground to be treated beneath the existing milliscreen and pumping station buildings.

Through injection tubes driven into the ground through small penetrations (up to 20 mm) at regular intervals, material is injected into the target treatment zone to create the resin-soil matrix. Terefirm is applied with surgical precision in a controlled and relatively clean process to densify soil and increase liquefaction resistance.

During injection of the treatment zone, the low-viscosity resin both permeates the soil and penetrates under pressure along planes of weakness within the soil profile. The injected material then reacts by rapidly expanding to many times its original volume, resulting in compaction of the adjacent soils. This improves the soil characteristics and makes the ground less susceptible to liquefaction.

Extensive collaboration between Wellington Water, geotechnical engineering specialists Coffey, and Mainmark contributed to a successful outcome. Geophysical testing was carried out before and after, which included boreholes, cone penetration testing (CPT), direct-push crosshole testing (DPCT), and earth pressure cells.

The project, completed in August, needed to achieve the performance targets set out by Wellington Water's engineering team. Mainmark worked in close collaboration with Coffey, helping to achieve 100% NBS (new building standard) for SLS1 and SLS2 (serviceability limit states) based on the structures being IL4 with a design life of 50 years.

IMPROVING THE RESILIENCE OF COMMUNITIES

As New Zealand continues to rebuild and remediate homes, buildings and infrastructure to address the effects of seismic events, Mainmark will continue to collaborate with engineers, homeowners, government, councils and civil infrastructure owners to help strengthen and protect at-risk structures, from the ground up.

"Innovative liquefaction mitigation techniques like Terefirm resin injection can help make our communities more resilient in the event of a future earthquake," says Tristan Reynard. "For Wellington Water, this resilience was delivered without interrupting day-to-day operations at the plant. Similar upgrades would be highly beneficial for other critical infrastructure sites located in high-risk seismic regions across New Zealand, including Wellington and Christchurch."

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