

# Lattice-shaped Jet Grouting Configuration to Prevent Soil Induced Liquefaction at Christchurch Town Hall – New Zealand

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## Introduction

The Christchurch Town Hall has been significantly damaged by the earthquake sequence that occurred between 2010 and 2011 - liquefaction related damage and lateral spreading. As part of the building remediation works, it is intended to create a stabilized soil block to decrease the likelihood and severity of foundation movements caused by future earthquake-induced soil liquefaction. The design concept is based on overlapping **jet grout columns to form a cellular structure**, reducing the overall deformability of the ground and limiting the development of major shear strains.

## Design methodology

Liquefaction behaviour of the ground was simulated using a combination of soil parameters and jet-grouting columns subjected to the seismic motion registered during the 4th of September 2010 at Christchurch Resthaven Station (REHS). For this purpose, the soil response was investigated through a parametric analysis using finite element software PLAXIS2D. Soil behaviour was modelled according to the Hardening Soil constitutive model and the UBC3D-PLM constitutive soil model (Galvi et al., 2013), which is a 3D reformulation of that originally proposed by Puebla et al. (1997), designated as UBCSAND (Gerolymos et al., 2015).

## Liquefaction mitigation

The jet grout columns reduce the pore pressure ratio (PPR), by reducing the shear strains in the soil, inside the treated block. This ratio at a given depth in the soil profile typically represents the development of excess pore water pressure in relation to the initial vertical effective stress. The maximum pore pressure ratio is given as follows:

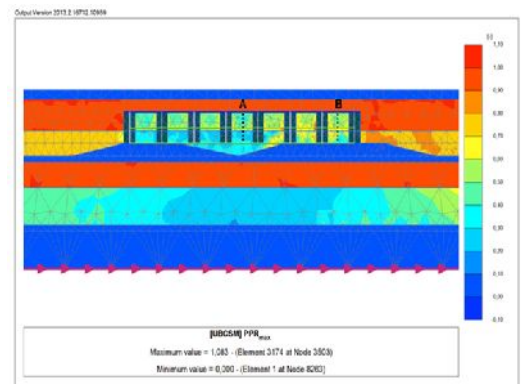
$$PPR_{\max} = 1 - \sigma'v / \sigma'v_0$$

## Target of the ground improvement solution

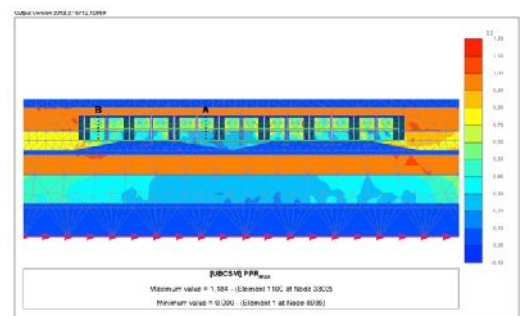
Maximum pore pressure ratio:  $PPR_{\max} = 0.5$

## Conclusions

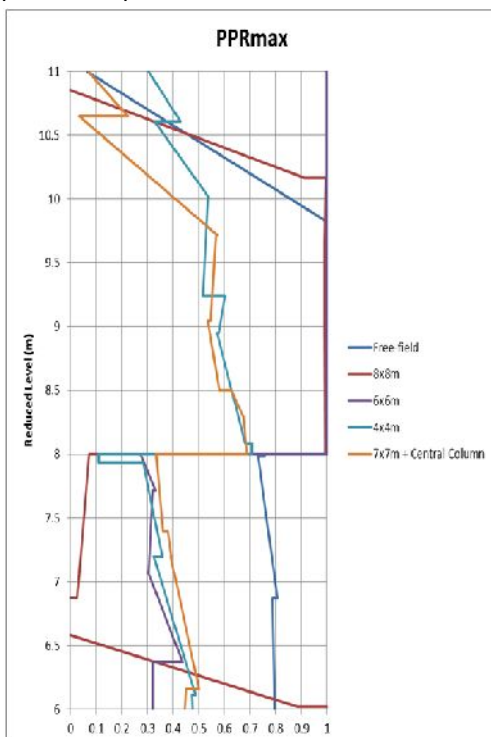
The results of the numerical analysis were evaluated in terms of pore water pressure ratios depending on the different cell configurations. It was demonstrated that, for the present case study, 8m x 8m and 6m x 6m spacing configurations are ineffective in terms of liquefaction mitigation. However, the cellular jet grout arrangements with configurations of 4m x 4m and 7m x 7m with an interior isolated jet grout column showed visible improvement in the soil response to seismic action and subsequent reduction of pore water pressures values.



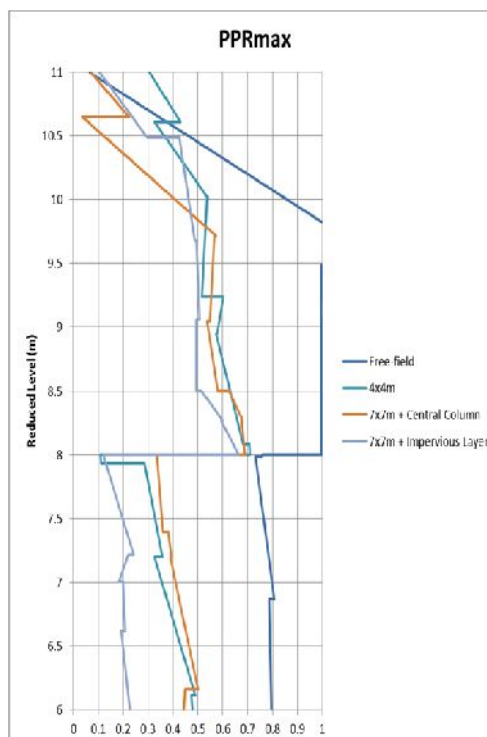
Maximum Excess Pore Pressure Ratio (4m x 4m configuration). Columns founded on a non-permeable soil.



Maximum Excess Pore Pressure Ratio (7m x 7m configuration + central column). Columns founded on a non-permeable soil.

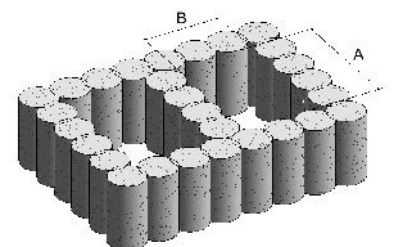


Pore Pressure Ratios Results for Section A and B (Case 1: columns founded on permeable soil).

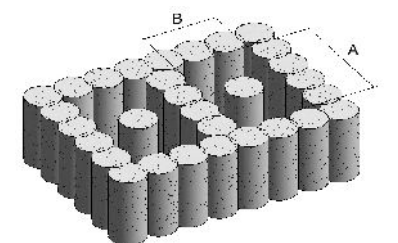


Pore Pressure Ratios Results for Section A and B (Case 2: columns founded on a non-permeable soil).

- A=8.0m; B=8.0m
- A=6.0m; B=6.0m
- A=4.0m; B=4.0m
- A=7.0m; B=7.0m + 2.5m diam. central column



lattice cellular structure with spacing A x B.



lattice cellular structure with spacing A x B and additional central column.