Post-liquefaction behaviour of undisturbed and reconstituted natural pumiceous sands

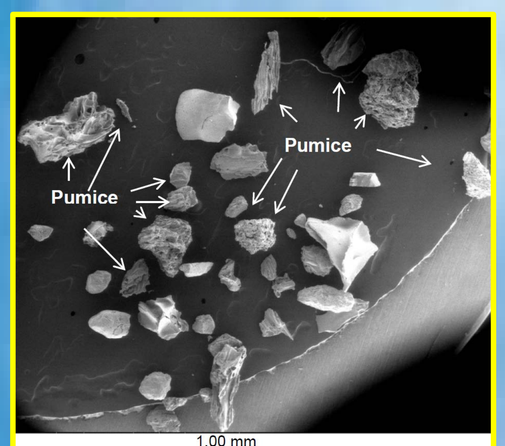
QuakeCoRE
NZ Centre for Earthquake Resilience

INTRODUCTION

Pumice particles, which originated from volcanic eruptions centred in the Taupo and Rotorua regions in the North Island, are frequently encountered in many engineering projects. These particles are then mixed with hard-grained materials and deposited as natural pumiceous (NP) sands. Pumice particles are highly crushable and lightweight, leading to difficulty in characterising their properties.

The post-liquefaction behaviour of NP sands is important not only for the purpose of investigating liquefaction-induced ground deformation but also for assessing their impact on buried structures, such as pile foundations.

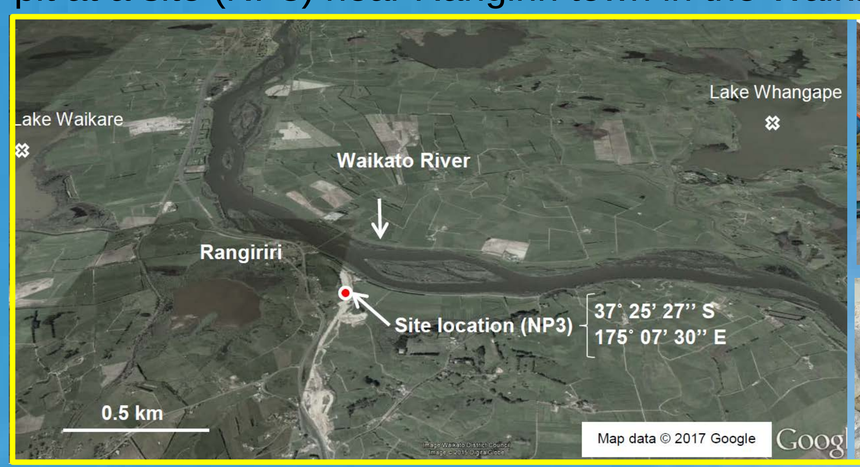
This research focuses on the difference between the post-liquefaction behaviour of undisturbed and reconstituted NP sands sourced from Waikato region.



TESTING PROGRAMME

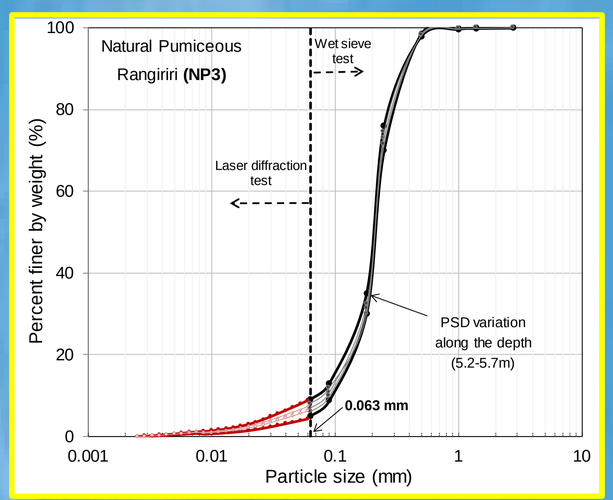
Materials used

Undisturbed NP sands were obtained as bulk samples from a test pit at a site (NP3) near Rangiriri town in the Waikato Basin.



- Index properties (NP3 samples):

Parameter	Value
G_s	2.54
D_{50} (mm)	0.21
C_u	2.45
e_{max}	1.74
e_{min}	1.04

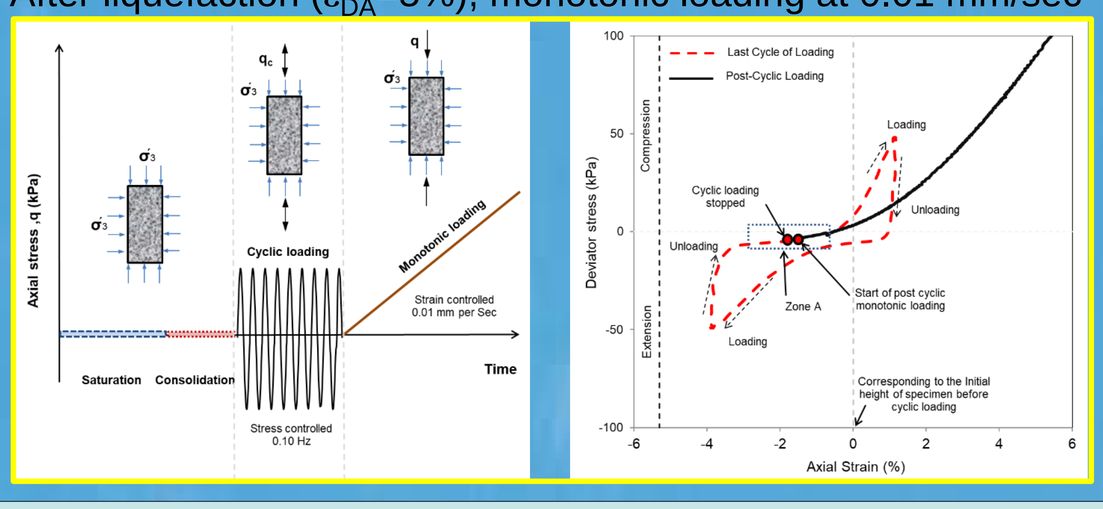


Specimen Preparation

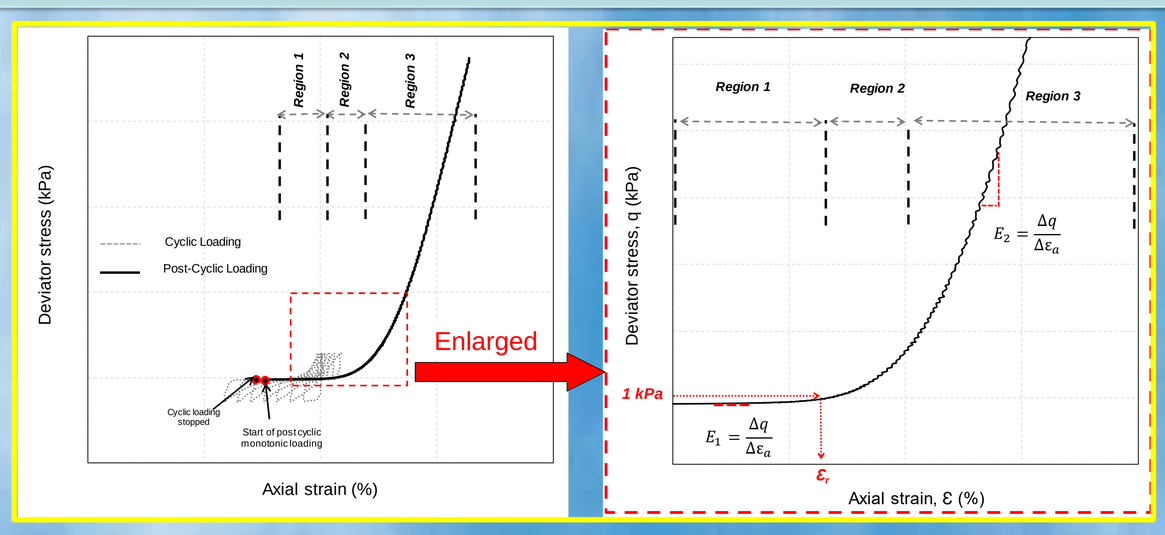
- **Undisturbed soil specimen**: after extruding using a hydraulic jack, samples were cut into four pieces using a band-saw and then trimmed to obtain specimen 126 mm high and 63 mm diameter.
- **Reconstituted specimen**: prepared to the same dimension by moist tamping method to avoid particle segregation and produce uniform specimen.

Multi-stage triaxial testing

- Isotropic consolidation (σ_c'=100 kPa)
- Cyclic loading @ 0.1 Hz under various cyclic stress ratios (CSR)
- After liquefaction (ε_{DA}=5%), monotonic loading at 0.01 mm/sec



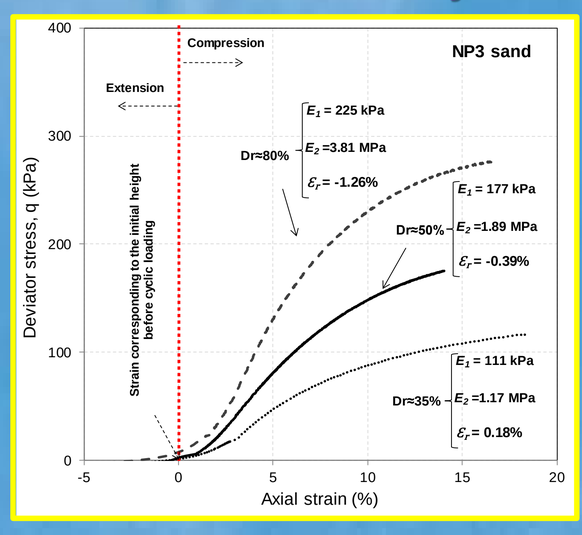
MODELLING OF POST LIQUEFACTION RESPONSE



Region 1: essentially zero stiffness and soil undergoes extensive deformation
Region 2: parabolic curve where the stiffness increases as a result of straining
Region 3: linear part of the stress–strain curve where the modulus is constant

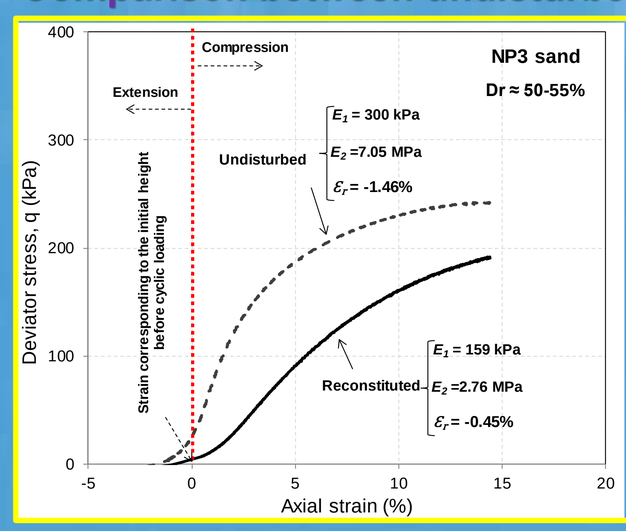
EXPERIMENTAL RESULTS

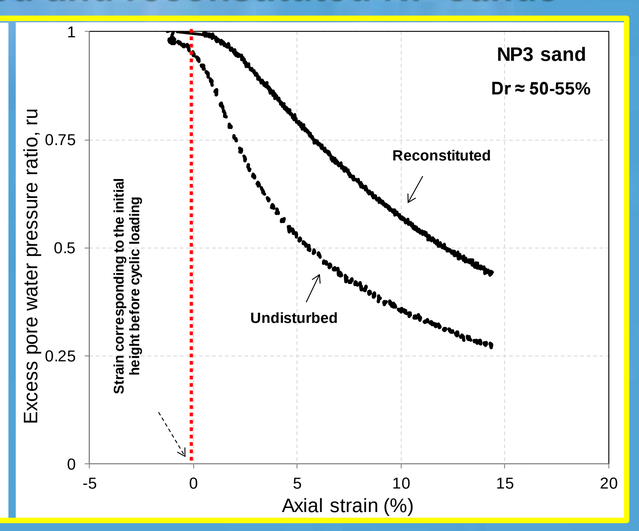
Effect of relative density on behaviour of reconstituted NP sands



- Relative density (*Dr*) plays an important role in the post-liquefaction response of NP sands; as *Dr* increases, the sand recovers its strength more quickly.
- Due to their irregular surface texture, the NP sands recover their strength at considerably smaller ε_r level and had higher E_1 values compared with hard-grained sands. However, due to particle crushing during the post-cyclic testing, the NP sands had lower E_2 values compared with hard-grained sands.

Comparison between undisturbed and reconstituted NP sands





CONCLUSIONS

Based on the results, the following observations were made on the undisturbed NP sands compared to the reconstituted ones:

(1) they started to recover their strength at lower strain (ε_r) level;
(2) the initial modulus (E_1) and modulus at recovery (E_2) were almost two times higher; and
(3) the rate of decrease in pore pressure was faster.

Thus, the inherent skeleton structure seems to remain more or less intact in undisturbed samples, contrary to the relative ease by which the uniform depositional structure of reconstituted samples was destroyed. Even though the undisturbed NP specimen liquefied during cyclic loading, the soil fabric and the structure of this soil sample was not totally destroyed during cyclic loading.

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