Research Project Highlight

Liquefaction evaluation of gravelly soils: An integrated laboratory testing and numerical modeling approach

TSRP Topic: Geotechnical - G1

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Start-End Dates:
1/15/2021-1/15/2022

Abstract
In recent years, liquefaction of gravelly soils has significantly affected the performance of ports in both the 2014 Cephalonia earthquakes in Greece and the 2016 Kaikoura earthquake in New Zealand. Still, the characterization of gravelly soils and assessment of liquefaction hazards in a reliable, cost-effective manner has always been a challenging problem in geotechnical engineering practice. In this project a coordinated plan that combines unique large-scale laboratory testing and high end 2D dynamic numerical analyses is pursued to investigate the effects of gravelly soil liquefaction on the performance of CentrePort at Wellington, NZ, during the 2016 Kaikoura earthquake. Specifically, a series of monotonic and cyclic simple shear tests (refer to Project image (a)) on specimens from New Zealand of different relative densities, for a range of vertical loads and CSR values to characterize the monotonic and cyclic simple shear response and develop CSR vs # of cycles to liquefaction curves that can be used to calibrate the constitutive models subsequently used in the numerical analyses task. Furthermore, the tests will also provide data on both post-liquefaction residual strength and post-liquefaction volumetric reconsolidation strain. The effect of different specimen preparation techniques will be investigated (dry pluviation, wet pluviation), as well as the variability in response due to changes in the soil specimen composition (e.g. grain size distribution and presence of fines). The model and input parameters for the 2D Dynamic FLAC analyses will then be formulated (refer to Project image (b) for previous work) and the analyses will be performed using the three commonly used constitutive models (PM4Sand, UBCSand, and URS/ROTH) for modeling pore pressure generation during seismic shaking and triggering of liquefaction. Finally, parametric 2D dynamic analyses on the CentrePort model will be conducted to investigate the effect of various input parameters on the gravelly soil liquefaction

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triggering and post-liquefaction response, as well as the effect of using different constitutive models for liquefaction.

Deliverables

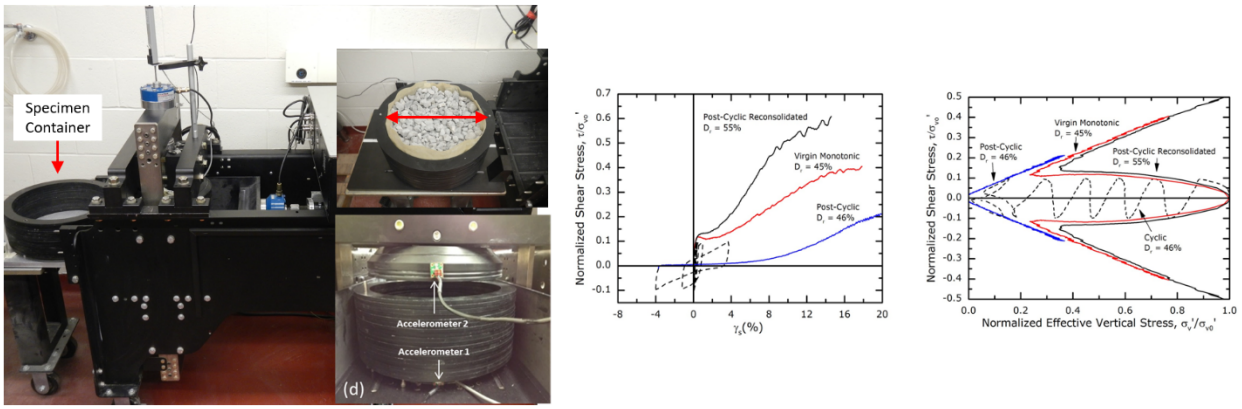
A PEER report and several conference and journal papers describing the laboratory testing of gravelly soils as well as the numerical modeling analyses of the CentrePort at Wellington, NZ.

Research Impact

One of the most challenging problems in geotechnical engineering is characterizing gravelly soils in a reliable, cost-effective manner for routine engineering projects. Such deposits are encountered widely, and their liquefaction is commonly a critical consideration in the stability of our nation's ports, dams, levees and in general, civil infrastructure. Dam engineers are frequently called upon to assess the potential for liquefaction in gravels that are in the dam foundation soils with no proper guidelines and liquefaction mitigation costs often run into millions of dollars. This study will complement additional ongoing research efforts by the PI and her collaborator from NZ and provide a fundamental understanding as well as practical guidance on assessing liquefaction triggering and post-liquefaction response of gravelly soils, both with simplified procedures but also dynamic analyses. The improved procedures will enhance the resiliency of these facilities and will help avoid unnecessary expenses when gravel liquefaction is not really an issue, or more importantly, highlight the need for stabilization when gravel liquefaction is indeed expected. The PI will initiate a virtual gravel liquefaction database that will be able to index and document all available case histories of gravel liquefaction.

Project Images

(a) Large Size Cyclic Simple Shear testing device (left) and representative monotonic and cyclic test results (right). (Hubler et al. 2017, Zekkos et al. 2018)



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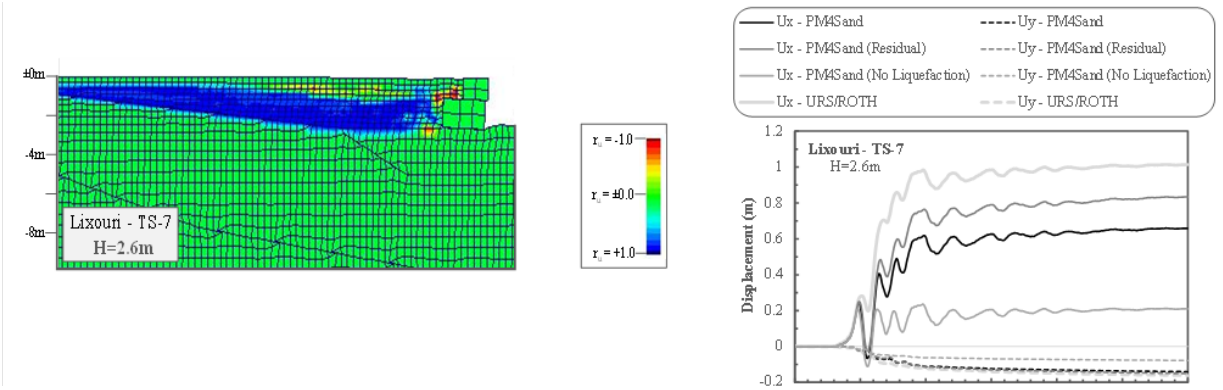
(b) 2D FLAC Dynamic Analyses on the port of Lixouri, in Cephalonia Greece, that experience gravel liquefaction during the 2014 earthquake (pore pressure ratio on the left and displacements on the right). (Zalachoris et al. 2021)



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