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Thesis

Modeling of Liquefaction Behaviour in Heterogeneous Soils Using FLAC

Abstract

Seismically induced liquefaction has caused extensive damage during several earthquakes. The occurrence of liquefaction during earthquake loading is often regarded an undrained phenomenon due to the short duration of ground shaking, and the presumption that the undrained conditions represent the worst-case scenario. However, element tests in the laboratory have shown that conditions worse than the undrained-state may be possible depending on the boundary conditions. Field evidence of liquefaction and associated failures after the cessation of earthquake loading further support such contention.

Mitigation of liquefaction potential is one of the most important and interesting research areas in geotechnical earthquake engineering. Since the design engineer has to solve complex boundary value problems, which are getting more complex than ever due to the increased demands presented by the stricter building codes, the use of computer modeling has become essential. Such numerical simulations play an increasingly significant role in better understanding the mechanics of the behaviour of soils in-situ, which may be heterogeneous, and subjected to complex boundary conditions. The use of numerical ‘experiments’ has become an ideal tool to further improve the practice of geotechnical engineering.

The main objective of the research reported herein is to better understand the role of spatial heterogeneity on the overall behavior of the soil mass. Realistic numerical analysis, which involved both undrained, and coupled stress-flow analysis of simpler geometries were undertaken for this purpose. The Numerical tool FLAC (“Fast Lagrangian Analysis of Continua”) has been used to model the behaviour of different soils under seismic loading. This project involves three main analyses: a comparison is made between proSHAKe and FLAC to understand the general performance of FLAC. A series of undrained and coupled analyses are conducted on a level ground model to understand how the heterogeneity in soil will affect the liquefaction resistance of each model. Based on the overall performance of each soil model during and after seismic loading, a ranking is presented for the liquefaction resistance of the models. Finally, a series of analyses are conducted to determine the heterogeneity effects on a slope model during earthquake and in post-earthquake loading. Both the response of the uniform, and heterogeneous soils have been modeled in level ground and slope analysis. Spatial variability has been simulated by using alternative layers of loose and dense soils, and alternating pockets of loose and dense soils. It has been demonstrated that the response of the deposit, or at least portions of it are adversely affected by the heterogeneity.

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Supervisor

Sivathayalan