“Helical Piles for Underpinning of Shallow Foundations on Soils Susceptible to Liquefaction: A Pilot Study”

Project Sponsors: Deep Foundations Institute and Ram Jack Systems Distribution

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Project Abstract: The main objective of this research is to experimentally evaluate the performance of helical piles as an alternative solution for mitigating the settlement of shallow foundations in liquefiable soils. Post-disaster reconnaissance of areas affected by earthquakes has documented extensive damage to shallow foundations of structures within liquefaction-prone areas. For example, the 2010 and 2011 earthquakes in New Zealand caused severe and widespread liquefaction throughout the town of Christchurch and subsequent damage in more than 20,000 residential homes.

Helical piles could be a cost effective solution for retrofitting low story buildings in areas susceptible to liquefaction. In addition, helical piles have the benefit of fast and easy installation with minimal equipment. Installation is considered low-impact, low-disturbance and can be employed in low overhead conditions. Therefore, this research aims at evaluating the seismic performance of helical piles underpinning shallow foundations located on liquefiable soils.

Our research focuses on conducting an extensive series of experiments using the 1-g shake table facility at the University of Nevada, Reno (UNR) to study the seismic response of helical piles in liquefied soils. The results of the study will be used to inform countermeasures to reduce building settlements in such events. This research is divided into two main components: (1) to validate scaled shake table experiments using the data from the recent large-scale shake table experiment at UCSD, (2) to carry out an extensive series of experiments to evaluate the behavior of helical piles in liquefied soils. The proposed experimental research includes a comprehensive parametric study to quantify the effects of several parameters on the efficiency of helical piles to mitigate liquefaction-induced building settlements. The following sections further detail the experimental program.

Task #1: Validation using Large-Scale Shake Table Experiments
In order to establish the effectiveness of scaled experiments, our first series of experiments will include validating the results using the large-scale shake table experiments recently carried out at UC San Diego and led by Prof. Amy Cerato. We will build a scaled model of the large-scale experiment and attempt to validate the scaled model results.

Task #2: Shake Table Experiments on Helical Piles in Liquefied Soils

We will carry out an extensive series of 1-g shake table experiments to investigate the effects of several parameters on the behavior of helical piles in liquefied soils including:

1) Underlying soil properties.
2) Ground motion characteristics.
3) Model building structure and pile specifications.

Each model will consist of a denser non-liquefiable layer at the base and overlain by a loose liquefiable sand of variable thicknesses. The scaled model experiments will be fully instrumented to quantify these effects.

Task #3: Experimental Data Interpretation

The collected data, which will be comprised of time histories for different parameters measured by the employed instrumentations, will be interpreted and analyzed. Our focus when interpreting the data is to quantify the effects of different parameters discussed on the response of helical piles in liquefied soils.

Task #4: Comparative Study with Other Types of Deep Foundations

Other types of deep foundations, such as steel driven piles, will be employed to conduct a comparative study on the response of different types of deep foundations in liquefied soils. This task will enable us to extend the findings of this study to other foundation types and result in a broader impact to the deep foundation community.

Task #5: Delivery of Draft and Final Report

We will compose a technical report documenting experimental data and the analysis results. A draft report will be initially issued for the PAB and the HPTC members to review and provide comments. We will incorporate these comments in our final report.

Schedule: We project to complete this pilot study in one year (12 months).

Research Team: The research team consists of Dr. Ramin Motamed (Principal Investigator) and one full-time graduate student. The Project Advisory Board (PAB) members consist of Mr. Gary Seider (Hubbell Power Systems, Chair of HPTC), Dr. Amy Cerato (Univ. of Oklahoma), Mr. Darin Willis (Ram Jack), Mr. John Pack (Helipile), Dr. Howard Perko (Magnum), Mr. Ben Vance (STRATA), and Mr. Kwabena Ofori-Awuah (KCI).