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Calibration and Prediction of Centrifuge Experiments on Liquefiable soils in LEAP 2020

〇Zhiyuan TANG, Kyohei UEDA, Ryosuke UZUOKA

1. Introduction

During the past few years, efforts and developments in computational modeling of geo-materials greatly increased the accuracy of the prediction of the liquefiable soils. Combining the numerical simulations with laboratory and centrifuge model tests, researchers can acquire a better understanding of the mechanism inside the ground. Nevertheless, despite the efforts, the results of numerical simulation always have a certain degree of discrepancy with the experimental results. Therefore, it is necessary to highlight that exercises of verification and validation of numerical simulations are still needed to promote the reliability of numerical models for the liquefaction predictions.

LEAP (Liquefaction Experiments and Analysis Projects) is a joint project that pursues the verification, validation, and uncertainty quantification of numerical liquefaction models based on centrifuge experiments and laboratory tests. LEAP-2020-RPI is one of the LEAP's exercises, whose main objective is to perform a series of centrifuge experiments and laboratory tests with numerical simulation to characterize the response of the sheet-plie retaining structures on liquefiable sand. This poster will provide a brief introduction to the LEAP experiments and details of the numerical simulation carried in this work.

2. Physical Modeling

Figure 1 shows the experimental set-up and proposed instrumentation for LEAP-2020-RPI, a prototype model with 20.2 m long, 5 m deep at both sides of the sheet-pile with two layers of different relative densities. Several sets of pore water pressure sensors and acceleration sensors were used in this centrifuge tests to measure the X-axial acceleration and excess pore water pressure responded to the earthquake wave. The main object is to measure the displacement of the sheet-pile located near the center of the container box during the dynamic phase.

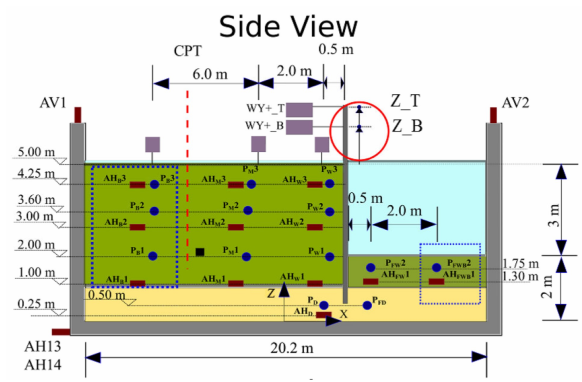

Figure 1. The experimental Set Up and proposed instrumentation for LEAP 2020

From the experimental results, it is clear that the dynamic response is closely related to the relative density. In this project, 55%, 65% and 75% relative density is validated. Lower density specimens show more susceptible to liquefaction, less dilative response of soil deposits and rapider accumulation of seawards displacement by the sheet pile. Higher density specimens show less susceptible to liquefaction, more highly dilative response of soil deposits and lower speed of accumulation of seawards displacement by the sheet pile.

3. Element Tests

For this model calibration, a strain space multiple mechanism model incorporating a stress-dilatancy relationship is used as an effective stress model of Ottawa F65 sand. One new calibrated parameter set is derived from cyclic direct simple shear tests in GWU and an old series of calibrated parameter sets based on the torsional tests in Kyoto University, shown in Figure 2, are used in this numerical simulation.

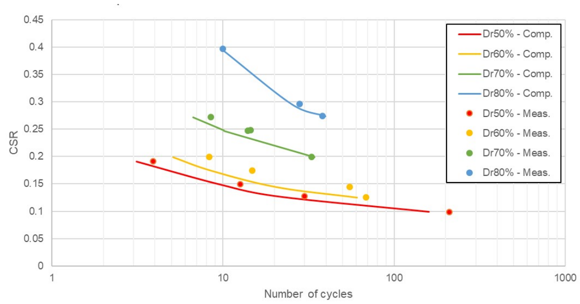

Figure 2. Measured and Computed Liquefaction Resistance Curve for γDA=7.5%.

4. Numerical Model for centrifuge tests

Based on the characteristics of the models, and using the calibrated parameters, the analysis was carried out under 2-D plane-strain conditions, aiming to simulate the models in prototype scale. Self-weight analysis and dynamic analysis were carried on the numerical model in sequence, respectively. Figure 2 shows the mesh and the boundary conditions.

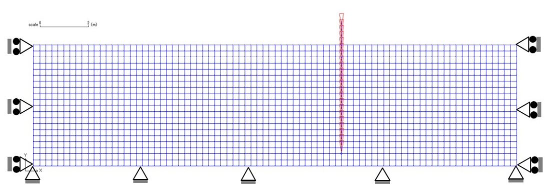

Figure 3. FEM Mesh and Boundary Conditions

5. Comparison among Physical and Numerical Models

Numerical models with 5 different parameter-sets of liquefiable soil layer were developed in this study in order to investigate the effect of the earthquake wave on the displacement of the sheet-pile. The displacement of the sheet-pile in the numerical results show the same tendency compared with the experimental results. In total, The X acceleration shows good agreement on the experimental results, while for some points near the sheet pile, large vibration occurs both in simulation and experiments.

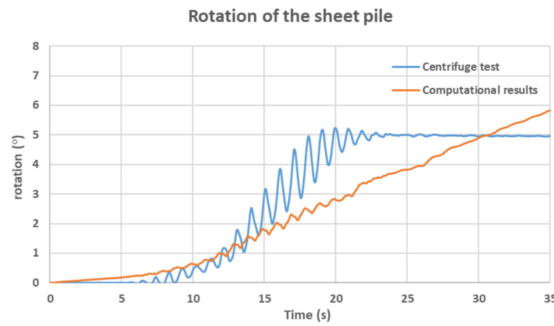

Figure 4. Comparison between the experimental tests and numerical simulation of KU1

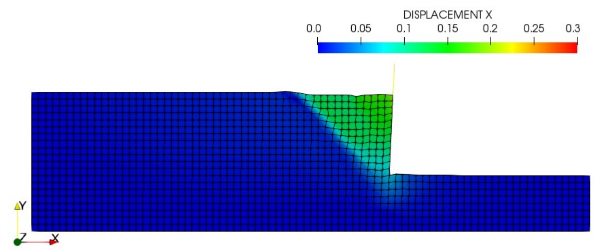

Figure 5. Displacement X of the soil element in the numerical simulation KU1 at 30 s.

6. Conclusions

Based on LEAP tests, a FEM model is set up and calibrated parameter-sets of liquefiable sand are used in this study. The acceleration of the numerical simulation shows good agreement on the experiments, while the pore water pressure values are all negative in the target position. The visualized graphics show that the displacement of the soil elements shows good agreement on the experiments. The negative pressure is triggered by the earthquake wave near the landside of the sheet pile only.

Reference

[1] Kutter Bruce L et. al. (2019) "Model tests and numerical simulations of liquefaction and lateral spreading". ISBN 978-3-030-22818-7.

[2] Iai S et.al. (2011) "Dilatancy of granular materials in a strain space multiple mechanism model". IJNAMG, 35(3)

[3] LEAP-Asia-2018: Stress-strain response of Ottawa sand in Cyclic Torsional Shear Tests. https://doi.org/10.17603/DS2D40H.