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LEAP-UCD-2017 Centrifuge Test at Kyoto University and an Analysis of the Re-liquefaction Response

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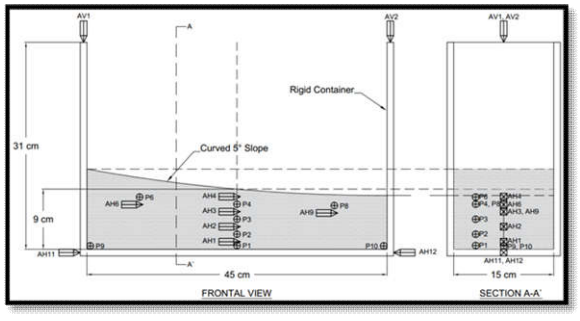
LEAP (Liquefaction Experiments and Analysis Projects) is a joint project that pursues to verification, validation and uncertainty quantification of numerical liquefaction models, based on centrifuge experiments. "LEAP-UCD-2017" is one of the LEAP's exercises, which main objective is to perform a sufficient number of experiments to characterize the median response, and the uncertainty of a specific five-degree sloping deposit of sand; as a part of this collaborative project, nine facilities around the world developed centrifuge experiments for this exercise.

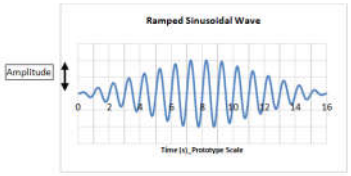
1.- Centrifuge Test at Kyoto University

This paper will present a review of the specifications, model preparation, testing process, and results of the experiments performed in the installations of the "Disaster Prevention Research Institute" at Kyoto University; three experiments were performed, and the latter two will be presented: KyU2 (Dr=67%) and KyU3 (Dr=60%)

A uniform-density, five-degree slope model inside a rigid container was specified for this exercise, as seen in the next picture (a scaling ratio of 44.44 has been selected for experiments at Kyoto University).



The specified procedure includes a shake sequence of 6 input motions; each motion consist of ramped sinusoidal 1Hz wave (see Figure below). Motions 2, 3 and 5 were considered as "destructive" and motions 1, 4 and 6 as "non destructive".



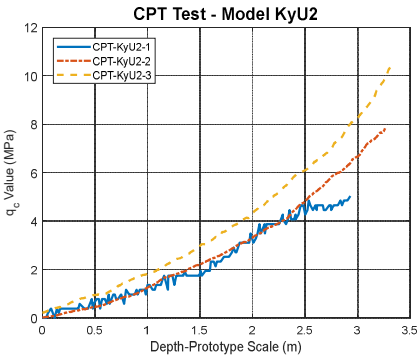
Motion	Amplitude (g)
Motion 1	0.015
Motion 2	0.15
Motion 3	0.25
Motion 4	0.015
Motion 5	0.25
Motion 6	0.015

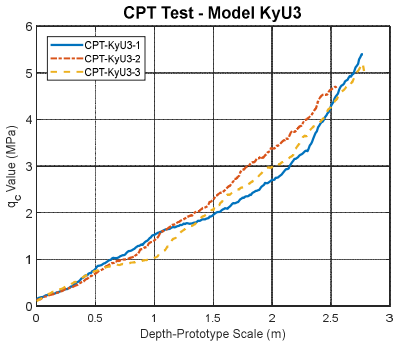
Due to the presence of high-frequency noise in the achieved motions, and taking into account that higher frequency components have some but relatively small effect on the behavior of the model, this project (as a first approximation) started working with the next hypothesis about the effective PGA.

$$PGA_{effective} = PGA_{1Hz} + 0.5*PGA_{hf}.$$

Where: "PGA_{1Hz}" represents the PGA of the achieved motion of the 1 Hz component, and "PGA_{hf}" represents the higher frequency components of the ground motion.

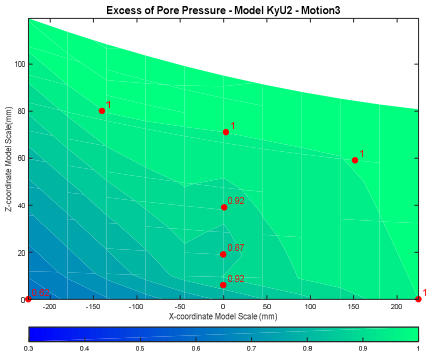
Additionally, three Cone Penetration Tests in each experiment were performed (before each destructive motion) with a new 6 mm Mini-CPT provided by UC-Davis.

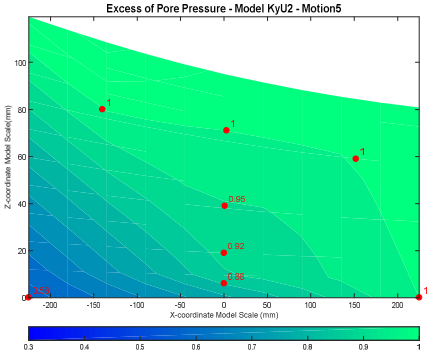




2.- Re-Liquefaction Response

Re-liquefaction process (also known as multi-liquefaction) is that, repeatedly soil liquefaction process occurs in the same place. In the series of Canterbury Earthquakes (2010-2011) and the Tohoku Earthquake (2011), multi-liquefaction process and its effects have been evidenced, receiving great interest in geotechnical society. Recent studies found that it is clear that not just liquefaction process is able to re-occur at the same site, but also the damage caused by re-liquefaction could be more severe than the previous liquefaction.





In order to analyze the re-liquefaction behavior in this exercise; a comparative analysis taking into account the "developed-liquefaction" (expressed by the "Ratio of Excess Pore Water Pressure") and the results of the "Cone Penetration Resistance Test", will be presented. Models "KyU2", "KyU3", "Ehime1", and "Ehime3" (models performed at the facilities of Ehime University) were selected for this comparison.

It will be shown that no relation between liquefaction resistance, and CPT Test (q_c value) was found for re-liquefaction process; due the characteristics, further studies are required to understand the behavior of soils under re-liquefaction processes; so, future research plans will be presented.