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Kyoto University LEAP-GWU-2015 tests and the importance of curving the ground surface in centrifuge modelling

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ABSTRACT

This paper presents a description of testing procedure and results of the LEAP-GWU-2015, and an investigation of the effect of the radial gravity field in centrifuge modelling. Dynamic responses of two models are compared. One had a planar surface with a 5° slope relative to the base of the container; the other had a curved surface to maintain a constant slope angle with respect to the radial g-field. For the centrifuge tests employed in this study, the slope and base excitation are in the tangential direction to spinning centrifuge. Results show that spikes in acceleration records due to cyclic mobility associated with lateral displacements appeared on both models. However, for the plane surface model, acceleration spikes in the negative (upslope) direction are more prominent and the residual downslope ground deformation was larger. Larger lateral displacement was observed in the plane model, while surface displacements in the curved model are smaller and uniform along the length of the model. For the plane model, the radial gravity acting near the slope top is almost constant and gradually increases towards the slope toe which causes a net increase in effective slope angle. Through the comparison the importance of curving the model ground surface is recognized as leading to uniform lateral displacements along the length of the model surface.

1. Introduction

The goal of this study is to visualize and evaluate the effect of radial gravity for two well-defined sloping model tests. The tests were part of the LEAP-GWU-2015 project [1]. A series of centrifuge model testing was conducted under the specific model setup provided by the organizer. The geotechnical centrifuge employed in this study is the one in the Disaster Prevention Research Institute, Kyoto University (DPRI-KU), in which the longer side of a sand box is placed parallel to the arm rotation plane. Firstly, we describe the model preparation procedure and specifications of the sensors for future references. Secondly, results of the two model tests are compared to illustrate the effect of radial gravity. In centrifuge model testing, it is a physical restriction that the centrifugal acceleration or gravity field in a model ground is radial. Because variation of the centrifugal acceleration on the surface is small when the arm length is large, the effect is usually assumed to be minor [2]. Under such a condition, the effect is usually ignored and results are interpreted as if the prototype ground surface is flat. However, if the arm length is short a planer surface simulates may simulate a curved surface in prototype. The effect may be more prominent under extreme conditions such as liquefaction.

To conclude the VELACS project, Scott [4] emphasized that the issue of quality control in physical modelling had to be clarified before moving on to a next step. This is still true after 20 years. Although the effect of the radial gravity is well known among physical modelers, these effects have been hardly reported and kept abstract. This study discusses these effects in particular to dynamic problems with well-defined saturated sloping ground, and finally confirms the importance of curving the ground surface in centrifuge modelling.

2. Model preparation

A beam centrifuge with a radius of 2.5 m is utilized in DPRI-KU. A shaking table is mounted on a swinging platform attached on the arm. The shaking direction is tangential to the arm rotation. By the specification given by the LEAP organizing committee (summarized by [1]) (Fig. 1), the centrifugal acceleration is determined to be 44.4 G with a sand box whose inner dimension is 45 × 15 × 30 (cm). In this study, the tests were carried out for two types of the sloping model ground, i.e., curved [Fig. 1(a)] and plane [Fig. 1(b)]. The curved surface model

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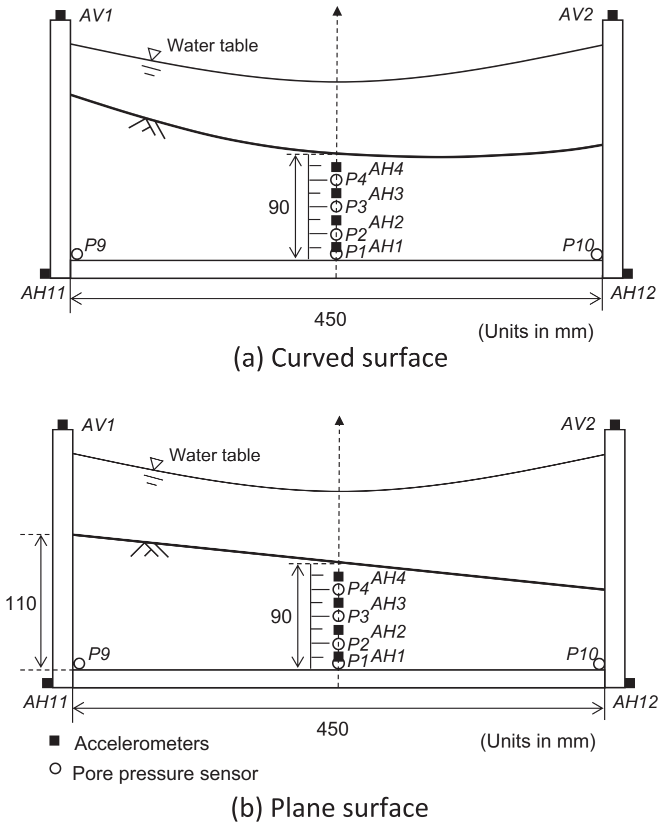

Fig. 1. Specified model ground and sensor locations (Model scale): (a) Curved surface and (b) Plane surface.

Fig. 2. Construction of model ground by sand pluviation method. Height of outlet was determined by calibration.

was the condition specified by the organizing committee for the type of centrifuge similar to DPRI-KU. A model test with a plane surface was conducted additionally to evaluate the importance of the curvature of the surface.

Model ground was constructed by the sand pluviation method with the device shown in Fig. 2. Before making the model ground,

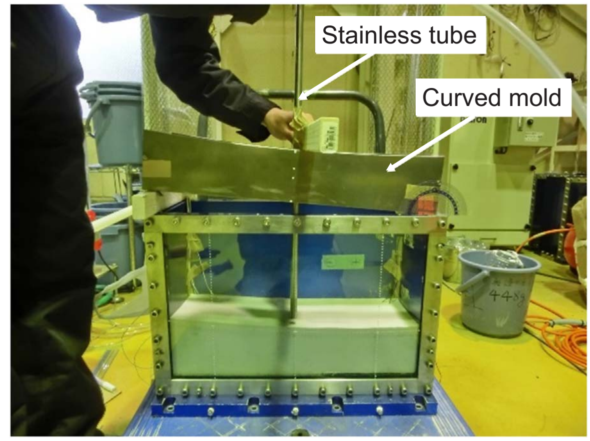

Fig. 3. Inclined curved surface was made by removing sands with a stainless tube attached to a vacuum. Height of the suction opening was adjusted by the mold whose top edge was curved with a circular arc with 2.5 m radius.

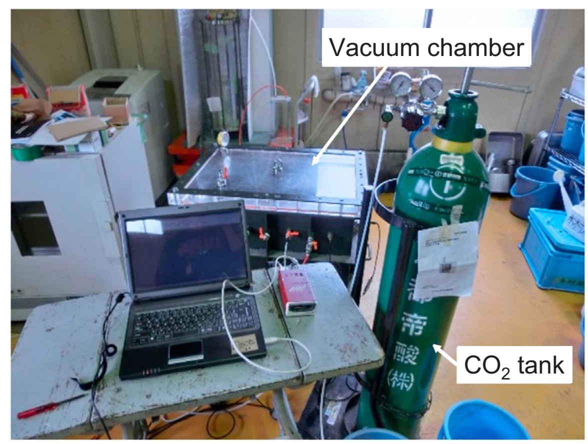

Fig. 4. Vacuum chamber and CO_2 tank.

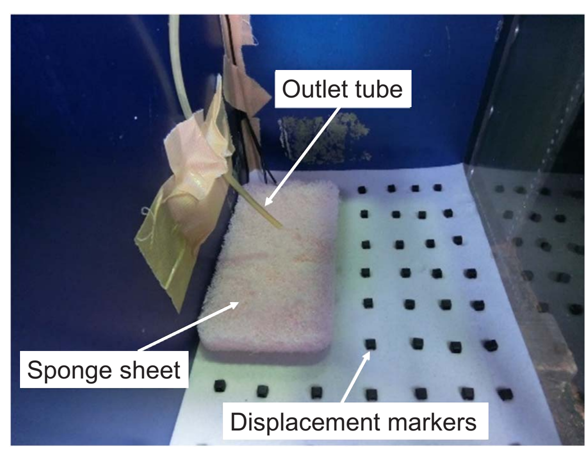

Fig. 5. Ground saturation procedure in a vacuum chamber. Viscous water is dropped from an outlet tube. A sponge sheet to protect the sand surface is carefully placed on the model ground.