DETAIL DESIGN AND PERFORMANCE OF A SMALL-SCALE LAMINAR SHEAR BOX FOR 1G SHAKING TABLE EXPERIMENTS

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Physical modelling is a powerful tool which has been used in the past few decades to simulate the behavior of various full-scale or reduced-scale geotechnical problems through the use of appropriate scale laws. While element tests are frequently used to obtain soil parameters and predict soil behavior, they are unable to provide observations of how soil and structures interact in real condition. For this reason, physical modelling is more valuable approach to understand the behavior of soil-structure systems. One of the requirements of physical modelling for geotechnical earthquake problems is the replication of semi-infinite extent of the ground in a finite dimension model soil container. In addition, geotechnical models cannot be directly mounted on shaking tables due to the requirements of confinement. To model the soil in shaking table in scaled physical modeling tests, a container is required to hold the soil in place and provide confining stresses. In literature, this container is referred to as “Soil Container”. The ideal container is one that gives a seismic response of the soil model identical to that obtained in the prototype, i.e. the semi-infinite soil layer 1D response under vertically propagating shear waves. The boundary conditions created by the model container walls have to be considered carefully, otherwise the field conditions cannot be simulated properly. To correctly model a problem of one-dimensional (1D) shear wave propagation through an infinite soil layer in a dynamic centrifuge test, Whitman and Lambe (1986) proposed the following three criteria for seismic simulation model container designs: (1) the container must maintain a constant horizontal cross-section during shaking; (2) the container must have zero mass and zero stiffness for horizontal shearing; and (3) the container must develop complementary shear stresses on the end walls of the container that are equal to those present on the horizontal surface (Whitman & Lambe, 1986). To fulfill the goal of each project and meet the condition of proposed problems, different model containers have been developed through these years; rigid container, rigid container with flexible boundaries, hinged-wall container, equivalent shear beam (ESB), laminar shear box (LSB), and active boundary container. Each of these containers have their own advantages and disadvantages.

In the first part of this paper, a full review of six different types of used soil container is presented and the main advantages and disadvantages of each are discussed. In addition, requirements and specifications of each model container for carrying out seismic model test in 1-g shaking table or augmented gravity field, N-g geotechnical centrifuge experiments (with N time earth’s gravity) are covered. As a result, laminar shear box is to be found the most common container due to the simplicity of design and modelling and also accuracy of large strain modelling problem. Many researchers concluded that laminar soil containers are the most advanced and efficient type of the soil containers.

In second part, detail design and construction procedures of newly developed laminar shear box at International Institute of Earthquake Engineering and Seismology (IIEES) as shown in Figure 1 are thoroughly presented. Then, performance of the container is assessed through acceleration response by series of 1 g shaking table test on dry and saturated loose sand.

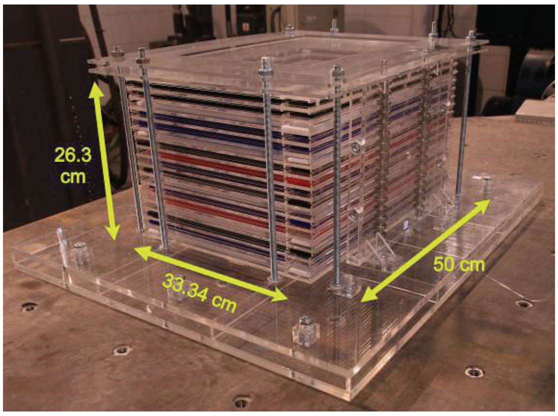

Figure 1. Overall view of the laminar shear box fastened on the IIEES shaking table.

PERFORMANCE OF THE DEVELOPED LSB

To investigate the performance of the constructed LSB in modelling 1D vertical wave propagation in finite soil column, a series of tests were carried out in both dry and saturated soil condition. In these tests, the soil model was subjected to the sinusoidal wave with 10 Hz frequency and approximately 0.3 g acceleration amplitude. Figure 2 compares acceleration time history and spectral acceleration of surface right-end and surface center for both dry and saturated condition by obtaining data from accelerometers mounted at the center of soil surface and right-end of the sand surface. The results show that the maximum difference between the response acceleration at the center and right-end of the model surface does not exceed 7%, which demonstrates that the boundary effect on recorded accelerations is found to be insignificant and the box is flexible enough to properly model the 1D soil column.

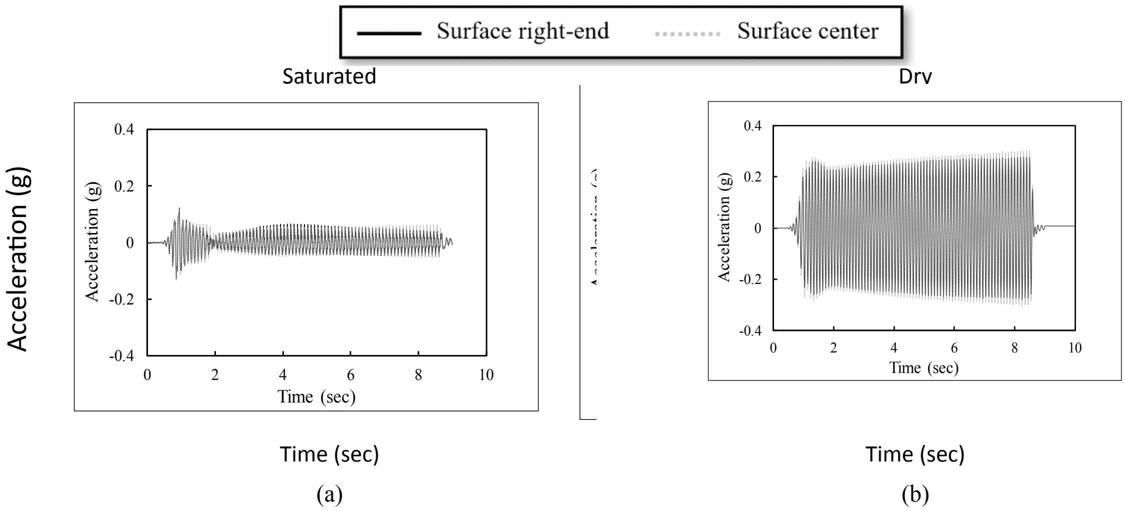

Figure 2. Comparison of acceleration response at surface center and right-end. (a) saturated and (b) dry soil

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Whitman, R.V. and Lambe, P.C. (1986). Effect of boundary conditions upon centrifuge experiments using ground motion simulation. *Geotechnical Testing Journal*, *9*(2), 61-71.