Design of a Novel Laminar Box for Evaluating the Seismic Performance of Soils

Conception d'une nouvelle boîte laminaire pour l'évaluation de la performance sismique des colonnes enroulées géosynthétiques

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ABSTRACT: A novel laminar box is developed for housing a weak clay (cu < 10 kPa) deposit remediated with geosynthet ic encased columns (GECs). The seismic excitations are applied to the laminar box by making use of a 10 ton capacity s haking table. The laminar box has the plan dimensions of 900 mm by 900 mm with a height of 1650 mm. Each laminae (which are 100 mm thick) of the laminar box is allowed to hover freely above each other thusly eliminating the transfer of drag between laminates during the seismic excitations phase of the testing program. The design of the laminar box provides the laminates not to be affected by the cumulative weight of the overlying lamina. The box also features a surcharg e application system that is conspired of four pneumatic pistons.

1 INTRODUCTION

A laminar box is typically designed to simulate the 1D response of a soil column under the action of seismic loads. The boundary conditions created by the model container walls have to be considered carefully, otherwise the field conditions cannot be simulated properly. The presence of rigid and smooth end walls in the case of a ground model introduce three serious boundary effects compared with a semi-infinite soil layer in the prototype: deformation incompatibility, stress dissimilarity and input excitation pattern dissimilarity (A.T. Carvalho et al. 2010). In order to tackle the boundary effects problems a novel laminar box is designed and commissioned at Bogazici University, Turkey. The Key features of the laminar box are as follows: (1) The laminar box is capable of housing slender geoengineering elements as it has a height of 1930 mm and a plan dimensions of 900 mm by 900 mm. (2) The laminar box

Figure 1. The laminar box assembly during testing

is fitted with a novel surcharge loading system that is used both for the consolidation of clay slurry and application of surcharge load during the course of the shaking table tests. (3) The laminar box has a pneumatic piston powered pile driving system that is capable of producing piles with varying diameters. Figure 1 depicts the completed design that the present study presents. (4) The acceleration and displacement of every lamina is monitored with accelerometers and laser displacement sensors during the course of the experimental stages.

Previous studies (Gibson, 1997; Prasad et. al., 2004; Meymand, 1998; Van Laak et. al., 1994; Pamuk et. al., 2007; Shen et al., 1998; Takashi et. al., 2001) on the dynamic soil response utilizing a laminar box relied on the stack of laminae separated by bearings which causes the movement of the lower lamina to be constrained by the cumulative weight of the overlying laminae.

The laminar box design described in this study relies on linear rods extending from the support frame holding each laminate vertically up. The laminae are riding on the rods on very low friction elements as to minimize the friction and create flexible boundary conditions.

The laminar box is comprised of 16 layers of 100 mm thick aluminum sigma profiles. There is working clearance of about 2 mm in between every laminate. This is done in order to eliminate friction between the laminates should there be any sagging of the aluminum under the action of the vertical loads. The sigma profiles are composed mostly of void spaces which reduces the overall weight of the container. The ratio of the weight of the lamina itself to soil housed by the lamina is as low as 6 %.

In order to maintain the consolidation of the weak clay material inside the laminar box an assembly of pneumatic pistons with an inner diameter of 160 mm and a stroke capacity of 800 mm is utilized. The surcharge loads are transferred to the weak clay surface by making use of steel plate that are extending from the laminar box. The steel plates used in the experiments are illustrated in Figure 2. There is a spacing of 10 mm between surcharge plates in order to maintain the drainage of the excess pore water pressure during consolidation stage of the experimental program.

Figure 2. The laminar box assembly during testing

In order to avoid the seismic loads coming directly from the base steel layer, a 300 mm deep portion at the bottom of the laminar box is designed. This box is intended to soften the large impedance difference between the steel and the soil. A total of 16 laser displacement sensors and accelerometers are utilized to track the motion of each laminate during the course of the dynamic loading. The vertical array of the accelerometers applied on the setup is illustrated in Figure 3. The laminar box assembly is also fitted with a pile driving system that can push a steel casing into the soil layer to create displacement piles. Once the dynamic excitation phase of the experiment is completed the geoengineering components inside the laminar box could be subjected to stress controlled vertical loading tests to reveal the bearing capacity characteristics.

Figure 3. Accelerometers used in the tests

2 CONCLUSIONS

A novel laminar box apparatus and its instrumentation is planned and executed at Bogazici University for the purposes of large scale shaking table tests. The laminar box is promising for the investigation of the dynamic phenomena such as liquefaction and dynamic load bearing properties of geosynthetic encased granular columns.

Figure 4. Pile driving mechanism

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