SIMULATOR, NOHGUCHI BOTTLE, OF SOIL LIQUIFACTION FOR EDUCATION

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Summary For the purpose of science education a method of the demonstration of soil liquefaction by earthquake was considered. As a result, experiments of various phenomena caused by liquefaction become possible in a closed bottle in small size by adjusting the densities of materials in the bottle under a similarity law.

INTRODUCTION

The phenomenon of soil liquefaction generated by seismic vibration of earthquake in nature is one of the most interesting demonstrations for science education because it illustrates the strange behaviors that go beyond the realm of common sense. The conventional methods for the educational demonstration are not necessarily easy. Hutter[1] introduced a simple experiment for soil liquefaction by the Nohguchi bottle which was a closed plastic bottle filled with water, push-pins and sand developed by Nohguchi[2]. The bottle named *Licky* can easily simulate this phenomenon any time, anywhere and on many occasions. The simulator comprises a closed bottle, fluid, granular material and some push-pins with plastic ball. This simulation is always set up by shaking or turning the bottle upside down to mix the fluid and granular material and by settling the granular material. The liquefaction is generated by giving the bottle a light mechanical shock, and as a result under certain conditions the push-pins completely buried in the granular material partly rise up to the surface of the sediment of the granular material and under other conditions the push-pins standing on the surface of the sediment sink into it. In this paper we introduce the fundamental theory of the law of similarity and the mechanism for setting up this apparatus.

MECHANISM FOR SETTING UP

The mixing and settling for setting up have two meanings. One is to make the saturated sand loosely settled because such loose sediment is necessary for the occurrence of liquefaction. Another is to reset the push-pins at the same position with initial state. This depends on the density of the mixing multiphase fluid formed only during the mixing and settling of granular material. There are three kinds of densities: the fluid, the sediment and the mixing multiphase fluid.

Sinking phenomenon caused by liquefaction

When the density of push-pin is lower than that of the mixing multiphase fluid, the pins rise up to the settling surface of the mixing multiphase fluid during the settling, so that the pins stand on the surface of the sediment after the settling. Then, if a mechanical shock is given to the bottle, the pins partly sink into the sediment by liquefaction.

Rising phenomena caused by liquefaction

When the density of push-pin is higher than that of the mixing multiphase fluid, the pins sink into the mixing multiphase fluid during the mixing and settling and are buried in the sediment. Then, if the density of pin is lower than that of the sediment, the pins rise up to the surface of the sediment by liquefaction caused by a mechanical shock to the bottle.

SIMILARITY

The similarity of this demonstration is governed by the Froude number determined by the thickness of sediment as a characteristic length, the terminal velocity of an isolated particle of the granular material in the fluid as a characteristic velocity. Under this similarity it is easy to do the experiment even in the 3ml bottle as well as the 500ml bottle. This is very advantageous for the demonstration for the purpose of education.

CONCLUSIONS

In this method, by adjusting the density of mixing multiphase fluid, it becomes possible to set up the demonstration of various phenomena caused by liquefaction in a closed bottle. As a result, anyone can repeat the experiment several times within a minute. Moreover, also experiments in a very small size become possible under the similarity, so the bottle can easily simulate the liquefaction phenomena anytime, anywhere and in a low cost.

References

[1] Hutter K.: Kinetic and Continuum Theories of Granular and Porous Media. SpringerWienNewYork, 20-23, 2000.

[2] Nohguchi Y.: Liquefaction Simulator “Licky” for Science Education. Report of the National Research Institute for Earth Science and Disaster Prevention, ***61***, 2001.