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Experimental Investigation of Acoustically Enhanced Dewaterability of Unconsolidated Soils

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1. Introduction

In many countries, sustainable development involving remediation of the environment is important, and requires as its foundation an investigation of water flow through porous media[1), 2)]. Especially in Korea, rapid population growth has increased demand for developing a sustainable remediation technology including the river-bed clean-up. However, techniques always have a problem with high water content. The techniques regarding the river-bed cleaning are completed with removing water of waste materials. The behavior of the fluid flow rate through porous media has been well known since Darcy[3)] developed a quantitative description of saturated water flow through a homogeneous porous medium within a vertical column. Since then, various investigation have been undertaken to increase the flow rate[4), 5), 6), 7)]. In this study, we investigated an innovative technique for reducing the water content in unconsolidated soils using vibrational energy generated from a flexible transducer. The principal goal of this method is to accelerate the movement and permeation of water through water pores, so that the water drains out easily with the aid of vibration. Vibrations are generated at various frequencies and amplitudes. We conducted experimental investigations on this new remediation technology, to examine how flow is affected by vibration.

2. Laboratory Experiments

The vibration is generated with the PVDF film as a flexible transducer at various frequencies. A goal of this study is to investigate whether the effects of sound waves generated from a PVDF film can reduce water content in unconsolidated soils. The main equipment used in this study consists of the PVDF film as a flexible transducer, a function generator (Tabor – 8020), and an amplifier (EPA-104). The test setup includes graduated cylinders, a soil box, a stopwatch, and gravel (Fig. 1). The test procedures are as follows. First the gravel for drainage is placed into the soil box and the perforated film is covered with the gravel. If necessary, the perforated film may be placed between the sandy soil and gravel to avoid mixing. Next, the soil is placed into the soil box. Using the graduated cylinder to measure a given volume of water, the water is added to the soil box until saturation. The volume of water is noted and used to calculate the initial water content. The setup is nearly complete when the water is added to the soil box until the soil is saturated. In the last step, vibration energy is applied to contact the transducer on top of the soil, and the transducer film is connected with the function generator. The rate of flow is measured using the other graduated cylinders every five minutes.

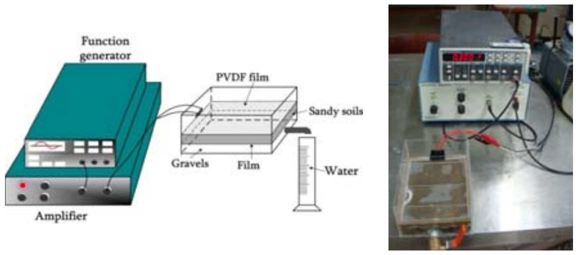

Fig. 1 Test Set-up

With the different frequencies, we observed and measured the water outflow from the soil box. Test conditions included soil types and the amplitudes that are summarized in Table I.

Table I. Test conditions

Frequency (kHz)	Amplitude (Volts)	Soil type (mixing ratio of sandy and clayey soil)
0.1, 1, 10, 20, & without vibration	10, 40, 100, 400	7:3, 5:5, 3:7

2. Results and Discussions

As shown in Fig. 2, there are significant differences with and without vibration, especially in the initial stage. The test condition for the figure was sandy clay (7:3) with 400 and 100 volts of amplitude. It is seen that the vibration greatly shortens the time needed for dewatering. Vibration reduces nearly half of the required time for draining

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of 450 ml. Fig. 2 shows that the effect of vibration on dewatering remained almost constant over 25 min of application with different test conditions. Fig. 3 shows changes in the dewatering around 25 min of application with different test conditions at frequency of 10 kHz.

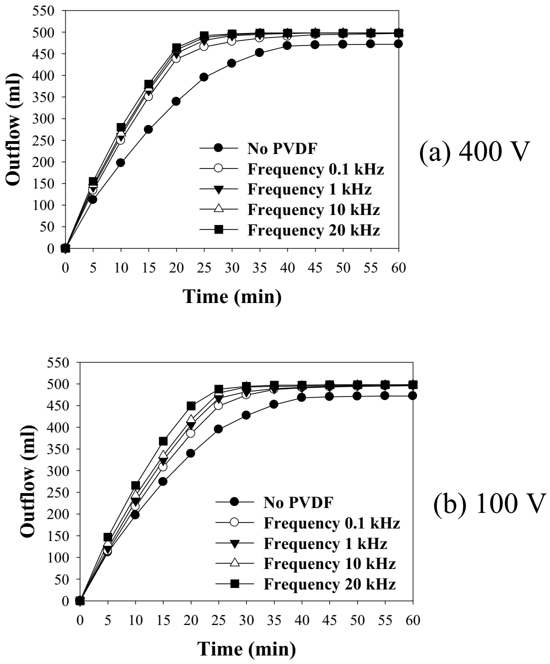

Fig. 2 Water outflow with time

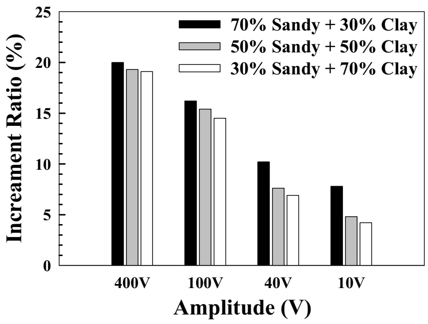

Fig. 3 Dewatering of Different Test Conditions (Soil type and Amplitude)

The dewatering of soils due to vibration increased markedly. On the basis of the test results, the effect of vibration on dewatering varies with test conditions. It can be strongly related with the acoustic pressures. The acoustic pressures were obtained using hydrophone(GRAS 10CC), and shown in Fig. 4.

3. Conclusions

In this study, we investigated experimentally the effect of vibrational energy on dewatering of porous media. Laboratory experiments used an innovative technique to reduce the water content in unconsolidated soils by using fexible transducer. The results of this investigation show that vibration treatment significantly increases the amount of outflow. The effectiveness of ultrasound varies with conditions such as soil types, soil density, sonication power and frequency. Thus, further studies are warranted to optimize the effect of different conditions on the dewatering of sonicated soil specimens. However, they support continued investigations into the pratical application of ultrasonic waves in the remediation environment. This work may result in new river-bed remediation or other related technologies.

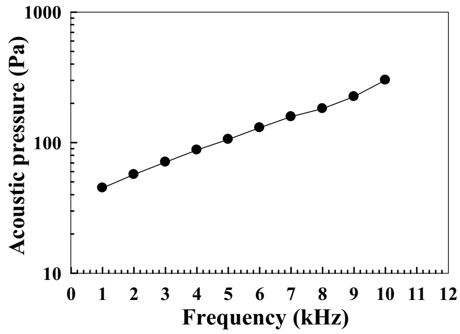

Fig. 4. Acoustic Pressure vs. Amplitude and Frequency

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