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Enhanced Drainage Capability Installed in Soft Clays due to Vibration Energy of PVDF(polyvinylidene fluoride) Film

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In this study, we investigated an innovative technique for enhancing the performance of the cylinder vertical drain using vibration energy of polyvinylidene fluoride(PVDF) film. The principal purpose of this method is to accelerate consolidation, decrease the settlement time, and decrease the clogging of small particles into the drain by vibration. Vibrations were generated using PVDF film with various frequencies. The test results demonstrated that the higher consolidation rates were observed for the clay specimens at elevated frequencies. The application of vibration energy significantly increased the filterability of soft clays.

There are several techniques developed that can be used in reducing consolidation time of soft clay deposits at dredging and reclamation sites. One of the most effective methods is vertical drain method. The vertical drain method, however, has two weak points: clogging and smear zone. The clogging and smear zone obstructs the pore water flow through the soil particles and seriously influences the consolidation rate. New technique needs to be developed for the more effective drain method.

Vibration is used widely in engineering, medicine and in many aspects of daily life. Especially, dewaterability of sludge was enhanced using ultrasound[1, 2, 3], and contaminants trapped in soil particles could be removed easily through ultrasonic vibration[4]. These studies show high usage rates and good effects on complex phases (soil, water, oil, etc.) of ultrasonic vibration. However, most equipment that can produce ultrasonic vibration already tuned around 28 kHz of frequency, and it is not easy to investigate the effect of frequency only on many cases. Polyvinylidene fluoride film (PVDF) could be a solution to the difficulty of frequency change which has a wide range of frequency application from 1Hz to 100MHz. In this study, we used PVDF to generate wave energy around the vertical drain for the purpose of effective decrease of the clogging and consolidation time.

The main equipments for the study consist of PVDF film, function generator, and amplifier (Fig. 1). The PVDF can work well with the function generator at any frequency or voltage. Laboratory experiments were conducted using these equipments to investigate the effect of vibration on clogging at drain and consolidation of very soft clay. Test conditions include water contents of soft clay slurry, voltage, vacuum pump pressure, frequencies. Throughout the experiments, all the conditions remain the same except frequencies. The water contents of clay slurry was 210%, voltage was 15 volts, and vacuum pump pressure was 30 psi, respectively. Frequencies from the PVDF were 0, 4, 7 kHz.

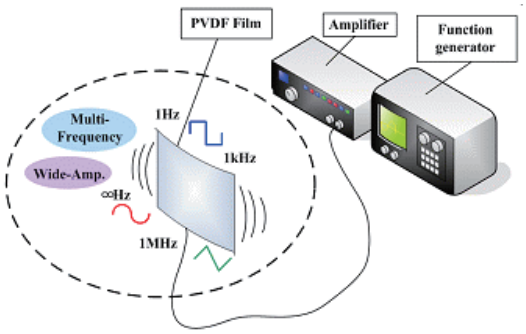


Fig. 1 PVDF system

Test procedures are as follows. First, pour clay slurry about 20l into a bath and locate the vertical drain which is connected to vacuum pump. (Fig. 2) Then, apply vibration energy to the vertical drain which contacts with PVDF flim and run the vacuum pump at the same time. Finally, measure the outflow from the vertical drain.

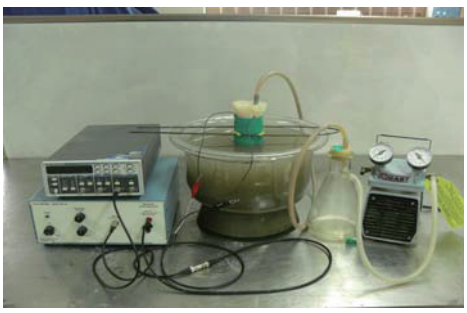


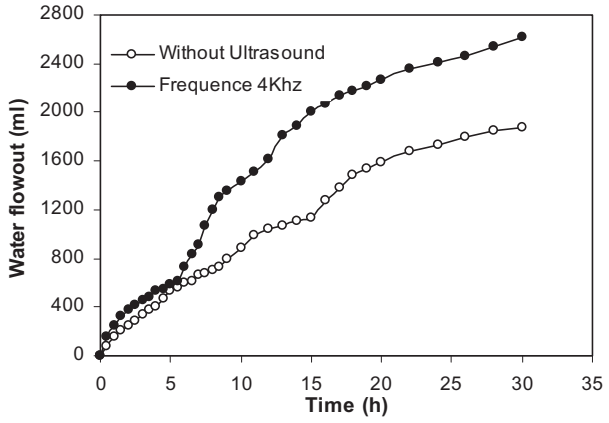
Fig. 2 Test set-up

Before putting the vertical drain into the bath, the PVDF film was inserted inside the vertical drain

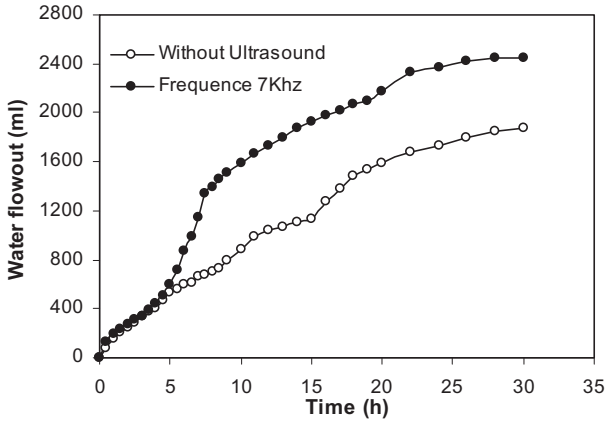
(Fig. 3) to exposure vibration. With different frequencies in PVDF film, observe and measure water outflow from vertical drain.

Fig. 3 PVDF film inserting to drain

Figure 4 shows water outflow from vertical drain versus time with different frequencies.



(a) Outflow of pore water in case of 4 kHz



(b) Outflow of pore water in case of 7 kHz

Fig. 4 Outflow of pore water with time

It is seen that vibration energy due to PVDF film into the drain increases water flow through the drain significantly.

The final water contents and displacements of specimens of 0, 4, and 7 kHz were 178%, 174%, and 176% and 5,1 cm, 5.8 cm, and 5.6 cm, respectively. This phenomenon can be explained as follow. When the vibration was attenuated in soil particles, the viscosity of the pore liquid decreases and flow rate through the porous media increases. Therefore, it can be inferred that the application of vibration energy reduced drainage clogging.

In this study, we investigated the effect of vibration energy on the suppression of the clogging phenomenon observed over time in drainage materials. Clay specimens were prepared from slurry and then vibration with various frequencies was applied directly to the samples during testing using PVDF film. From the results of this investigation, we concluded that vibrational treatment significantly reduces the amount of clogging, the consolidation time, and the water content of soil samples. However, the extent of improvement varied with test conditions. By carrying out further studies, including a wider range of test conditions, vibration energy may prove to be beneficial in the enhancement of drainage material filterability commonly used in vertical and horizontal drain methods.

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