Clogging reduction in geosynthetics using ultrasonic waves

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Abstract: This paper reports the effect of ultrasonic waves on the reduction of clogging of permeable geotextiles exhumed from two fine-grained soils. Six different geotextile specimens with varying thicknesses were used. Clogging characteristics have been evaluated by the amount of fines entrapped within geotextile pores before and after washing in an ultrasonic water bath. From the study performed it was found that; 1. washing efficiency for all clogged geotextiles was > 80% @ 5 minutes washing time, 2. transmissivity and permittivity of washed specimen improved nearly to 75% and above, and 3. among five nonwoven geotextiles tested, the thinnest one (type-A) was severely affected by clogging, however, ultrasonic cleaning helped to remove clogging efficiently. The in-plane and cross-plane flow capacities of the geotextiles have been measured and results are presented in a chart signifying ultrasonic washing effect.

Introduction: The controlled cavitations created by ultrasound in a liquid represent one of the effective and gentle ways to remove hard-soluble soils from different objects. In addition, cavitations can destroy microbes and algae, thus having a simultaneous disinfecting effect. As for the application of nondestructive tests in geosynthetics, ASTM (D7006-2003) provides a summary of equipment and procedures for ultrasonic testing of geomembranes using the pulse echo method. Usually ultrasonic measurements are used to determine the nature of materials in contact with a test specimen. Ultrasonic seaming technology (Bove and William, 1990) is well established in the manufacturing and packaging fields and has recently been applied to geomembranes. This technique is applicable for both factory and field seams for most types of geomembrane. There has not been any reported application of ultrasonic waves to the cleaning of clogged geosynthetics. The aim of this paper is to check the effect of ultrasonic waves in the reduction of clogging status and thereby improving flow capacity (transmissivity/permittivity) of exhumed geosynthetic drains embedded within fine-grained soils.

What is an Ultrasound Cleaner?: An ultrasonic cleaner is essentially a tub of liquid (Fig. 1), with an attached electronic device called a transducer, which generates high frequency sound waves and directs them into the liquid. As the sound waves pass through the liquid, they produce an effect known as *cavitation*, a rapid formation and instantaneous collapse of microscopic spaces throughout the liquid, a rate of millions per second.

How Ultrasound Works?: Ultrasound is created by generators, which produce high frequency electricity. This high frequency electricity is then converted to sound waves through a transducer, which literally makes these waves vibrate. As these vibrating sound waves travel through water, microscopic bubbles form (Fig. 1) and repeatedly implode upon a given surface. This powerful action removes visible and even microscopic dirt particles making a dirty mini-blind or any other object cleaner than alternative methods.

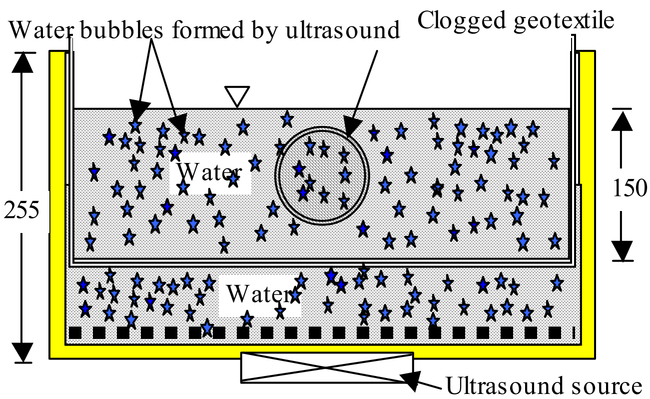

Fig. 1 Schematic of ultrasound equipment

Experiments: Details of the test procedures are given in Ghosh and Yasuhara (2003, 2004). Clogged geosynthetic specimens (120mm x 50mm wide) from Kanto loam and Silty clay-slurries were extracted after carrying out consolidation tests with staged loading from 20 kPa to 400 kPa. In order to assess the effect of clogging on the flow capacity of drains, both in-plane and X-plane permeabilities of the clogged specimens have been measured using apparatuses specifically developed for this purpose. After washing in the ultrasonic tub the flow capacities of the geotextile were obtained again.

Improvement of flow efficiency by ultrasonic washing

Ultrasonic washing efficiency is defined as the amount clogged mass washed out by waves to the total amount of clogged mass attached with a particular geotextile specimen. Fig. 2 presents various clogging indexes obtained from the experiments. Out of the five nonwoven geotextiles the A-type is the thinnest one and it was severely affected by clogging. Washing efficiency remained more than 80% (Fig. 2) and above for all geosynthetics tested. This signifies that ultrasonic washing method worked well in the cleaning of clogged geosynthetics.

Effect on transmissivity and permittivity of geotextile

The permittivity and transmissivity of washed specimens have been derived. Fig. 3 presents the variation of the permittivity and transmissivity ratios corresponding to geocomposite-A geosynthetics. Tests results indicate that ultrasonic cleaning of the exhumed geotextile specimen have increased flow efficiency significantly. Similar test have been conducted on nonwoven-A.

Keywords: Ultrasonic cleaning, geotextiles, clogging index, washing efficiency, clogging reduction index, fine-grained soils
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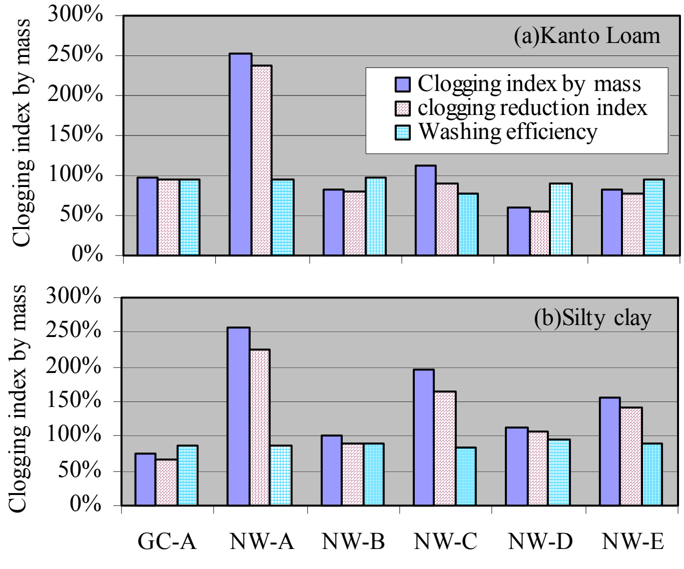

Fig. 2 Clogging index of geotextiles by ultrasonic waves

Fig. 4 presents variation in the x-plane and in-plane transmissivity. As confining pressure increases flow capacity of the clogged drain specimens also decreases. After ultrasonic washing of the specimens for 5 minutes the flow efficiency of the drain layers improved. With increasing confining pressure washed specimens showed less reduction in the flow capacity.

Conclusions

Based on the investigation carried out on 6 geosynthetics and two fine-grained soils it is confirmed that ultrasonic waves are effective in cleaning the clogged geotextile drain. In the present context cleaning exercise were done on exhumed drain specimens only. While cleaning with an ultrasonic probe is done in presence of some fluid medium (water in most cases) a proper methodology has yet to be derived to use the same technique in a field structures such as reinforced retaining wall constructed with fine-grained soil backfills. From the study performed it is found that 1. washing efficiency for all clogged geotextiles is > 80% @ 5 minutes washing time, 2. transmissivity and permittivity of washed specimen improved nearly to 75% and above, and 3. among five nonwoven geotextiles, type-A was severely affected by clogging, however, ultrasonic cleaning helped to remove clogging efficiently.

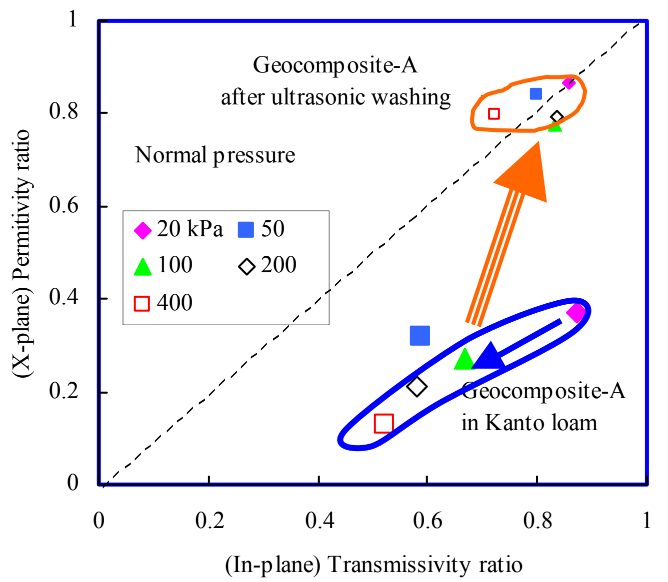

Fig. 3 Effect of ultrasonic washing on in-plane and x-plane flow

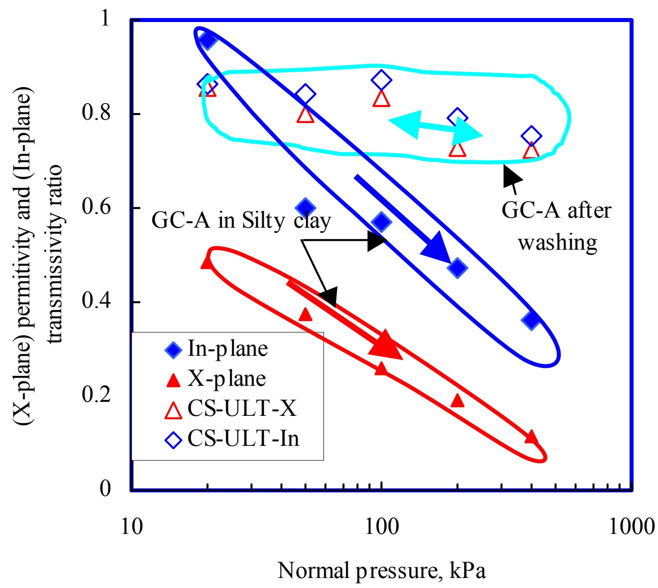

Fig. 4 Effect of confinement on the flow efficiency og GC-A

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