

FACTORS AFFECTING LABORATORY TESTING OF GEOTEXTILES

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ABSTRACT:

In order to investigate the factors affecting index and engineering properties of a specific geotextile, different tests were conducted using both heat-bonded nonwoven and needle-punched nonwoven geotextile, namely: apparent opening size (AOS), wide-width tensile strength, permittivity, transmissivity, and puncture resistance. The effect of humidity on the pore size of the samples have been investigated. To check whether the clamping system has an effect on the strength of geotextiles, over 240 tests were conducted. The presence of air bubbles in water and its effect on the permittivity and transmissivity of geotextiles were also verified. Also investigated were the effects of higher strain rate on the tensile strength and puncture resistances. The results indicate that decreasing humidity slightly increased the AOS; higher strain rate and the use of hydraulic clamp increased the wide-width tensile strength; using de-aired water largely improved the permittivity and transmissivity; and increasing the strain rate decreased the puncture resistance. The effects of humidity and oxygen content were more pronounced and obvious in the case of needle-punched geotextile compared to heat-bonded nonwoven geotextile.

INTRODUCTION

In recent years, both woven and nonwoven geotextiles, have been used extensively in civil engineering applications. Many factors affect the index and the engineering property of the geotextile in the laboratory testing. The apparent opening size (AOS) is affected by the electrostatic phenomenon (Gerry and Raymond, 1983; Faure et al. 1990; Bliatia et al., 1995). The wide width tensile strength and the deformation characteristic in laboratory testing is affected by the strain rate and the specimen size (Shrestha and Bell, 1982). The hydraulic permittivity property is affected by the dissolved oxygen in the water (Halse et al., 1988). The hydraulic transmissivity of the geotextile is effected by the types of flow being laminar or turbulent (William et al., 1984; Cancelli et al., 1987). Moreover, the flow rate is effected by the time due to creep effect on the geosynthetic drainage (Hwu et al., 1990; Koemer et al., 1986; Cancelli et al., 1987 and Smith and Kraemer, 1987).

The objective of this paper is to investigate the factors affecting laboratory testing of geotextiles using two types of non-woven geotextiles, namely: needle-punched (NP-TS500, NP-TS700, NP-TS800) and heat-bonded geotextiles (HB-3267, HB-3407). Several tests were carried

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out under various conditions. The effect of humidity was investigated on the apparent opening size (AOS) test conducted using dry sieving method. The results of using different strain rate and clamping system on wide-width tensile strip test was also evaluated. Data of permittivity and transmissivity tests performed using tap and de-aired water were compared. The effect of strain rate was also evaluated on puncture resistance tests.

LABORATORY TESTING OF GEOTEXTILES

Apparent Opening Size (AOS)

The Apparent Opening Size (AOS) or O_{95} was determined by using the Standard Test Method for Determining the Apparent Opening Size of a Geotextile (ASTM D4751, 1994). Five specimens were cut along a diagonal line on the geotextile sample with each specimen being cut to fit the appropriate sieve pan.

The effect of humidity on O_{95} of nonwoven geotextiles is presented in Fig. 1. From the graph, it can be inferred that the effect of humidity on O_{95} is quite small. The O_{95} values of needle-punched nonwoven geotextile, NP-TS500, NP-TS700 and NP-TS800 increased by 3.5%, 3.2% and 5.0%, respectively, due to a decrease in humidity from 70-78% to 58-68%. On heat-bonded nonwoven geotextile, HB-3267 and HB-3407, the values of O_{95} merely increased by 0.24% and 1.44%, respectively, when the humidity decreased from 68-76% to 58-67%.

The above results indicate that a 10% change in humidity will only have a slight effect on the AOS of nonwoven geotextiles. The effect on needle-punched is more than that on the heat-bonded because the structure of the former easily traps the beads within the geotextile

Wide-Width Tensile Test

The ASTM D4595 (1994) described as the Standard Test Method for Tensile Properties of Geotextile by the Wide-Width Strip Method was followed in the testing. Specimens were cut 100 mm wide by 200 mm long along a diagonal line on the sample in both machine and cross machine directions. The specimen was then mounted centrally in the clamp. To verify the effects of the clamping system on the test, two kinds of clamps were used: hydraulic clamp (Fig. 2) and mechanical clamp. The specimen was pulled in tension until the specimen ruptures.

Effect of Clamping System on Tensile Strength

Figure 3 shows the effect of clamping system on the ultimate wide-width tensile strength in the machine direction. The results from the use of hydraulic clamp yielded slightly higher values than the corresponding values using the mechanical clamp at a strain rate of 10 mm/min. The ultimate strength of needle-punched geotextiles increased by 12.5%, 19.9% and 7.6%, respectively, for NP-TS500, NP-TS700 and NP-TS800. For heat-bonded geotextile, HB-3267 and HB-3407, the strength increased by 1.4% and 8.0%, respectively. The results in the cross-machine direction also indicate increasing ultimate tensile strength with increased strain rate.

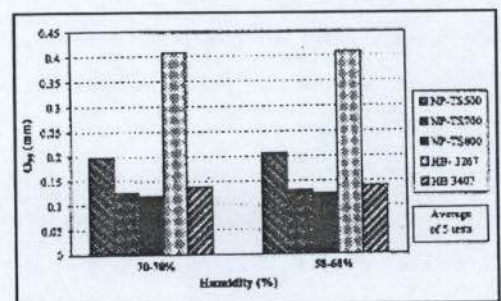


Fig. 1 Effect of humidity on O_{95} of nonwoven geotextile

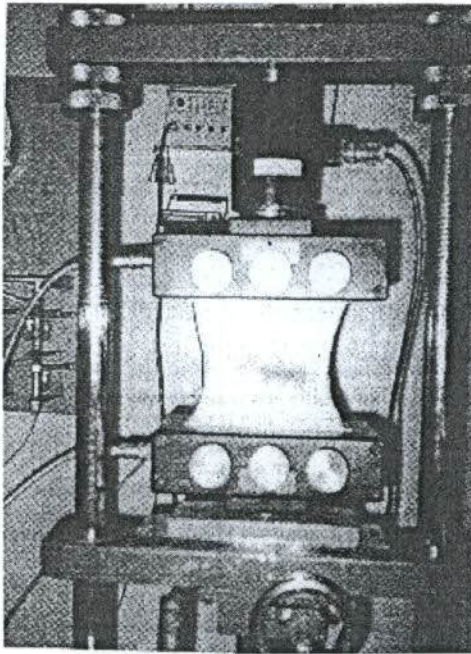


Fig.2 Tensile testing machine by using hydraulic clamp

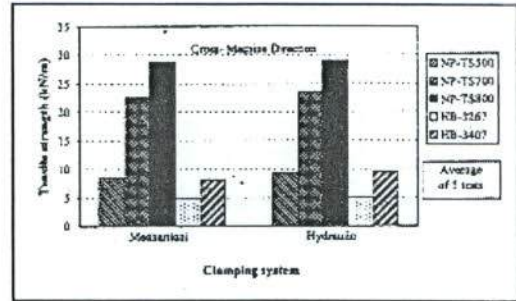


Fig.3 Effect of clamping system on the tensile strength Nonwoven geotextiles in machine direction

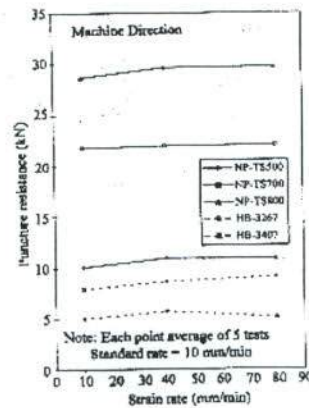


Fig. 4 Effect of strain rate on ultimate wide-width tensile strength For nonwoven / geotextiles tested in machine direction

Effect of Strain Rate on Tensile Strength

The increasing strain rate from 10 mm/min to 40 mm/min resulted to a slight increase in strength as shown in Fig. 4. The strength of needle-punched nonwoven geotextiles, NPTS500, NP-TS700 and NP-TS800 in the machine direction increased by 7.0%, 0.6% and 3.2%, respectively. For heat-bonded nonwoven geotextile, HB-3267 and HB-3407, 'the strength in the machine direction increased by 13.3% and 8.4%, respectively_The effect on strain rate to the strength of heat-bonded is small but in increasing direction. The effects of strain rate on the tensile strength of the geotextile in the cross-machine direction. The results are quite similar to the results in machine direction in a way that the strength generally increased with increasing strain rate.

Puncture Resistance

In the design of geosynthetic materials, focus is generally placed on the primary function that the material will be subjected. Whatever the required set of properties, however, the geosynthetic must be capable of being transported, installed and covered in its final position without failure. Of the various survivability guides that are available, all address some form of puncture or impact strength that the geosynthetic must be capable of sustaining. The Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products (ASTM D4833, 1994) was used to test the geotextile.

The effects of strain rate on puncture resistance are illustrated in Figs. 5 and 6. The decrease in strain rate from 320 mm/min to 160 mm/min increased the puncture resistance. The needle-punched nonwoven geotextiles, NP-TS500, NP-TS700 and NP-TS800, increased its puncture resistance by as much as 15.3%, 18.2% and 29.7%, respectively. For heat-bonded nonwoven geotextile, HB-3267 and RB-3407, the value of puncture resistance increased by 21.2% and 21.5%, respectively

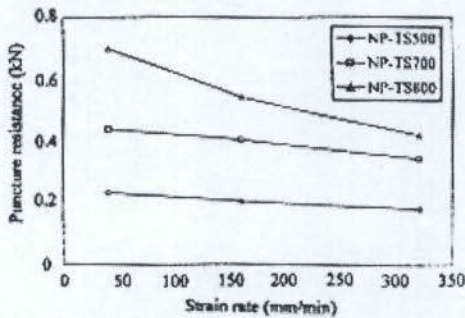


Fig.5 Puncture resistance versus strain rate of needle-punched nonwoven geotextile

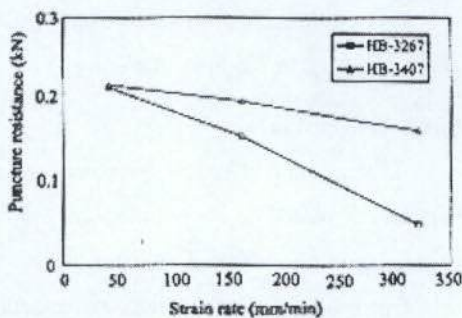


Fig.6 Puncture resistance versus strain rate of heat - gonded nonwoven geotextile

Constant Head Hydraulic Permittivity

The permittivity test evaluates flow characteristics of geotextiles in the cross plane direction. Permittivity is an indicator of the quantity of water that can pass through a geotextile in an

isolated condition independent of the thickness of the geotextile. The permittivity was obtained following the procedure from ASTM D4491 (1994) or the Standard Test Method for Water Permeability of Geotextiles by Permittivity.

The effect of using tap and de-aired water in permittivity test is demonstrated in Fig. 7. Permittivity of nonwoven geotextile is higher with the use of de-aired water than tap water. The permittivity of needle-punched nonwoven geotextiles, NP-TS500, NP-TS700 and NPTS800 increased by 5.7%, 10.1% and 21.2%, respectively when using de-aired water. Heat bonded nonwoven geotextiles, HB-3267 and HB-3407 yielded increasing values of 5.3% and 13%, respectively, with the use of de-aired water. The effect of using de-aired water on heatbonded nonwoven geotextile is less than that on the needle-punched geotextile since the former is thinner and has a larger pore size distribution where small air bubbles can pass easily.

Constant Head Hydraulic Transmissivity

The Standard Test Method for Constant Head Hydraulic Transmissivity (In-plane flow) of Geotextiles and Geotextile Related Products (ASTM D4716, 1994) has been utilized for measuring transmissivity. Three specimens, 100 mm wide and 300 mm long, were taken with their length parallel to the machine and cross machines directions along a diagonal line drawn across the sample. The specimens were measured for thickness at their four corners and then soaked in distilled water for 24 hours at room temperature.

Transmissivity results at different hydraulic gradients are plotted in Figs. 8 and 9. Higher value of transmissivity was observed when using higher

hydraulic gradient. The effect of tap and de-aired water on the transmissivity of NP-TS 800 are shown in Figs. 10 and 11. At 0.2 hydraulic gradient, the transmissivity of NP-TS800 in the machine direction yielded higher values when using de-aired water by as much as 4.9% to 14.6% at normal compressive stress ranging from 25 to 200 kPa. The decreasing of transmissivity was observed at higher values of normal stresses. The results at cross-machine direction is similar to that at the machine direction.

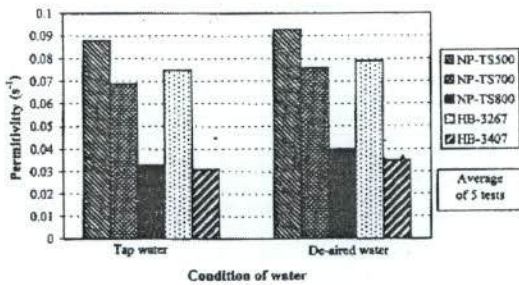


Fig. 7 Effect of tap water and de-aired water on the permittivity of nonwoven geotextiles

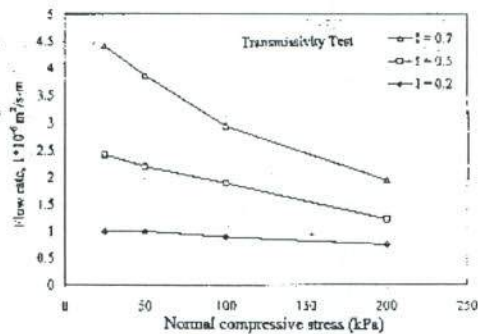


Fig.8 Flow rate versus normal compressive stress for NP-TS800 in cross-machine direction by

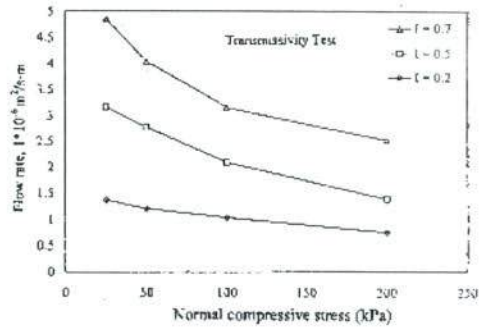


Fig.9 Flow rate versus normal compressive stress for NP-TS800 in machine direction by using de-aired water

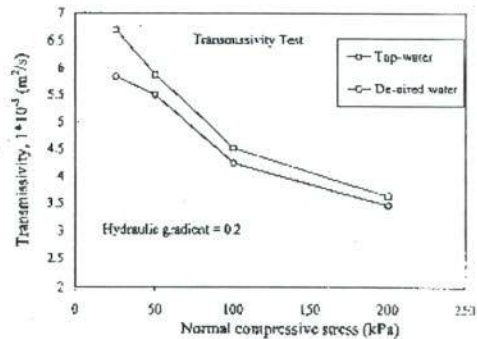


Fig.10 Transmissivity versus normal compressive stress for NP-TS800 In machine direction by using de-aired water

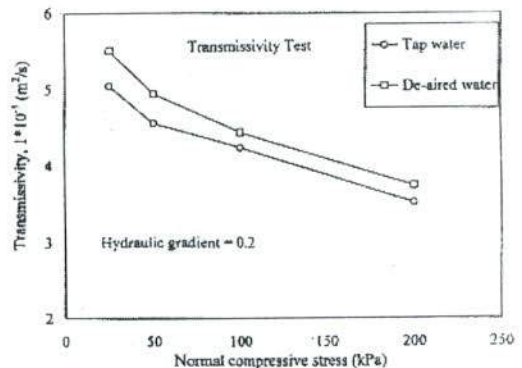


Fig.11 Transmissivity versus normal compressive stress for NP-TS800 in cross-machine direction by using tap and de-aired water

CONCLUSION

To determine the factors affecting laboratory testing of geotextiles, tests such as widewidth tensile, apparent opening size, permittivity, transmissivity and puncture resistance were conducted on needle-punched (NP-TS500, NP-TS700 and NP-TS800) and heat-bonded (HB3267 and HB-3407) nonwoven geotextiles. Fifty geotextile specimens were tested to check the effect of humidity on the opening size. A 10% increase in the humidity during apparent opening size tests slightly increased the O_{95} of the geotextiles. A total of 240 samples were tested to investigate how the clamping system affected the geotextile's tensile strength in both the machine and cross-machine directions. The use of hydraulic clamps gave higher values of tensile strength when compared to the values obtained using mechanical clamps. The advantages of using de-aired water over tap water in permittivity and transmissivity tests were verified. The use of de-aired water over tap water resulted to higher values in both permittivity and transmissivity tests. The effect of using a faster strain rate on the tensile strength in both directions and the puncture resistance of a geotextile were also investigated. A change in strain rate from 10 mm/min to 80 mm/min resulted to a slight increase in the ultimate tensile strength. However, an increase in the strain rate in puncture resistance tests yielded decreasing values. Moreover, the effects of humidity on AOS, and oxygen content of water on permittivity and transmissivity are much profound and obvious in the case of needlepunched than on heat-bonded nonwoven geotextiles.

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