Wetting Phase Water Retention Characteristics of Polyester Non-Woven Geotextiles

Kyushu University, Student Member, Peada Sagir Husain
Kyushu University, Fellow Member, Yasufuku Noriyuki
Kyushu University, Regular Member Adel Alowaisy
Kyushu University, Regular Member, Ishikura Royhei

Introduction:

Geotextiles are commonly used in engineering structures like earthen dams, retaining walls, roads, landfill liners to facilitate the filtration, separation or drainage functions. Non-Woven geotextiles are generally used in developing the capillary barriers because of its manufacturing process where materials are bonded together, either through chemical, heat or needle punching. In this Paper, ultimate shear strength will be determined and the primary focus will be on the investigation of the method based on how the Inclined Capillary Rise Test is performed to obtain the Geotextile's Water Retention Curve for four different types of Geotextiles for the wetting condition. In addition to a lack of standard approach, there is a need for simpler and more economically feasible laboratory testing which can characterize capillary barrier performance later on using WRC. A detailed process and the related explanation of the results of the Inclined Capillary Rise Test have been depicted herein.

Materials Used:

Four different types of nonw3oven geotextiles have been used in this study. This geotextile is manufactured by Japanese Company MAEDA KOSEN CO., LTD. According to the company, the basic information regarding those four different types of nonwoven Geotextiles is illustrated in below Table 1. Four Samples thickness varying from 3 to 10mm and Unit Weight varying from 100 to 800 g/m^2.

Tensile Strength Characteristics:

For these selected types of geotextile, a Tensile strength test was performed. For every geotextile, three consecutive Tensile Strength Test was performed to eradicate possibility of errors and the tensile strength values are shown here are the average of maximum and minimum of the three trials. The results of all tensile strength are shown in Table 1. It was found that S500 sample has maximum tensile strength within four samples.

Table 1: Basic properties of four different types Non-Woven Geotextiles and Ultimate Tensile Strength

Sample	Thick-ness (mm)	Unit Weight (N/m^3)	Ultimate Tensile Strength (MPa) (Experimental)
S100	3	2.94	0.85
S300	5	14.71	2.86
S500	10	24.52	5.88
S800	10	78.48	1.03

Inclined Capillary Rise Test

Testing

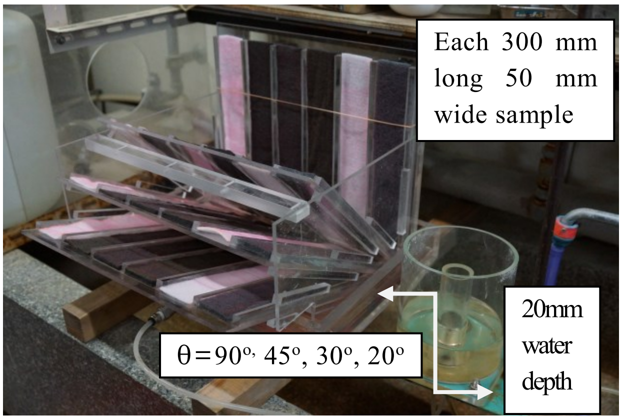

Fig 1 – Schematic Figure for Inclined Capillary Rise Test

Hydraulic conductivity and suction are normally estimated empirically from the Water Retention Curve. Here water retention curve for geotextiles was developed with a simple laboratory set up designed to perform Inclined Capillary Rise Tests. For wetting test conditions of these geotextiles, each specimen of 300mm long and 50mm wide were fixed in four different inclination angles where 20mm length of each sample was submerged into water for 24 hours.

Based on Capillary Rise Test matric suction for a given geotextile strip can be calculated as follows:

$$\Psi = \rho_w g h_c \qquad (1)$$

Where is the matric suction (Pa); ρ_w = density of water kg/m^3; g is the gravitational acceleration (m/s^2); h_c the height of specimen above the water table. Using Matric Suction formula, the suction rate was calculated using 90°, 45°, 30°, 20° angles. After 24 hours each sample strip was cut into 0.5mm and then Volumetric Water Content and Suction rate were calculated.

Results and Analysis:

Geotextile Water Retention Curve Characteristics

In the Fig 2, sample S100 - S300 WRC graph and Fig 3, S500 - S800 WRC graph has been drawn. Values of Volumetric Water Content for the sample S100 and S500 are near to the same with respect to suction values of each. Similarly, values of Volumetric Water Content for the sample S300 and S800 are close to each other but suction for S800 sample is quite higher than S300. It shows the water-absorbing capacity is high for S800 sample compares to S300. The low volumetric water content indicates that the geotextiles contain a very small amount of water when the suction is high (i.e.≤100 kPa for geotextiles). From Fig 4, it can be derived that the θ_s-θ_r and unit weight graph remains in the proximity of the best fit curve or all four samples. Fig 5 drawn as Air Entry Value (A.E.V) and Unit Weight of samples. This concludes that Nonwoven geotextiles have very low air entry values which will be able to drain/filter water at very low suctions (i.e. < 1 kPa).

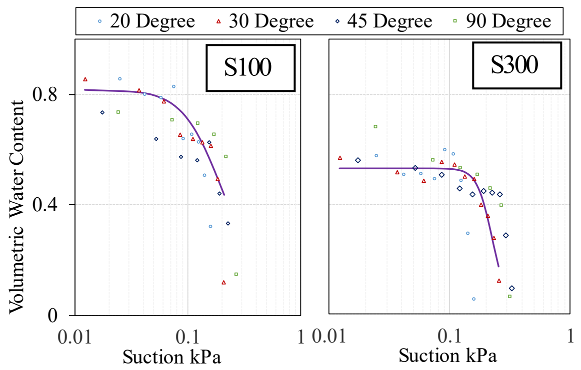

Fig 2: Water Retention Curve for S100 and S300

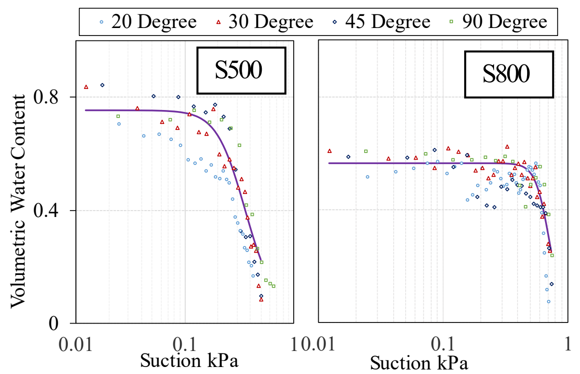

Fig 3: Water Retention Curve for S500 and S800

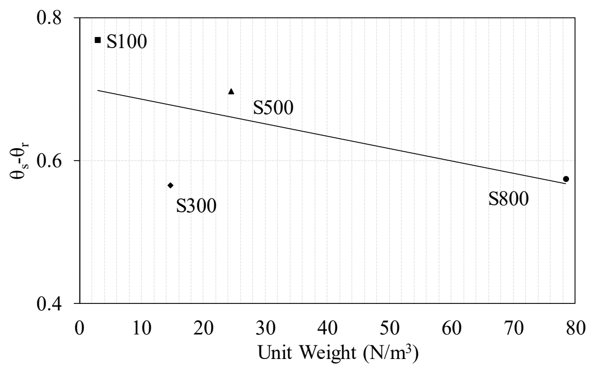

Fig 4: θs-θr and Unit Weight

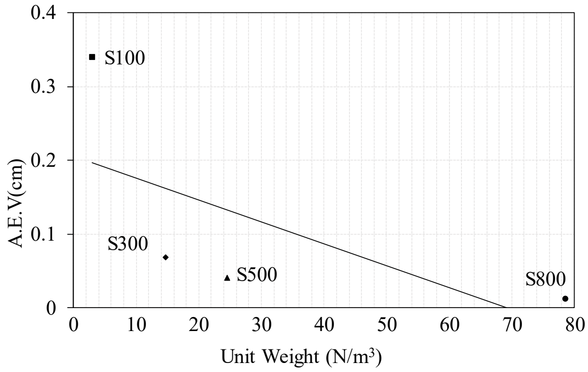

Fig 5: A.E.V and Unit Weight

Conclusions:

This paper mainly provides the retention characteristics of non-woven geotextiles which will be useful to understand the interaction between soil and geotextiles under unsaturated conditions. A simple modified inclined capillary rise test has been proposed. With changing inclination angle the best fit line has been drawn. From that best-fitted line, it observed that WRCs of geotextiles has the least minimum or negligible effect with respect to changing of inclination angle. Residual water content increasing gradually with increasing unit weight. θ_s-θ_r decreasing and air entry value also decreasing with increasing unit weight. The result of this testing program can be used in geoenvironmental applications, especially to develop capillary barriers.

Acknowledgement:

The authors express their gratitude to Laboratory Assistant Mr. Michio Nakashima for the assistance and support in these experimental tests. Heartfelt gratitude to Mr. Shinichiro Tsuji of MAEDA KOSEN CO. LTD for the assistance.

References:

1. Unsaturated Hydraulic Properties of Non-Woven Geotextile Based on Tilted Capillary Test. Luky Handoko, N Yasufuku, Harya Dananjaya; Geosynthetics Proceedings, Volume 27 (2012)

2. Measurement of geotextile- water characteristics curve using capillary rise principle. H Krisdani, H Rahardjo, E-C Leong; Geosynthetics International, 2008, Volume15, No – 2, pp 86-94

3. Stormont J. C., Henry, K. S. and Evans, T. M.: Water retention functions of four non- woven polypropylene geotextiles. Geosynthetics International, 4(6):661-672, 1997.

4. Geosynthetic capillary barriers: current state of knowledge J. G. Zornberg, A. Bouazza, and J. S. McCartney; Geosynthetics International, 2010, 17, No 5.