Performance of Non-Woven Geotextile as Capillary Barrier System

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1. Introduction

Heavy rainfall-related disaster is one of the most serious problems in Indonesia. This disaster is strongly correlated to water infiltration. Water infiltration rate can be decreased using capillary barrier system. A capillary barrier system is arrangement of layer of fine-grained soil over coarse-grained soil (Krisdani et al, 2008).

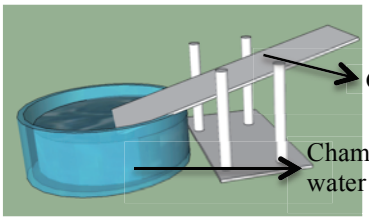
Many column test researches have been conducted to study 1D infiltration behavior. Zornberg et al. (2009) concluded that in constant head boundary condition, moving wetting front is in a saturated zone, while for constant flow rate boundary that flow rate is less than the saturated hydraulic conductivity, moving wetting front is in an unsaturated zone.

Bathurst (2009) conducted a 1D infiltration sand column test. The test showed that decrease in saturated permeability of geotextile created barrier in infiltration front advancement and caused ponding. In this study, no information about the condition of water content above geotextile after wetting front had reached the geotextile layer.

Figure 1 EX-80 of Polyfelt EX Geotextile from Mitsui Kagaku Sanshi Kabushiki Gaisha

2. Objectives

The objectives of this study are to increase a data density of capillary test and evaluate performance of geotextile as capillary break layer against 1D infiltration condition using vertical column test.



(a) Schematic figure of tilted capillary test

(b) Full figure of tilted capillary test

Figure 2 Tilted capillary apparatus

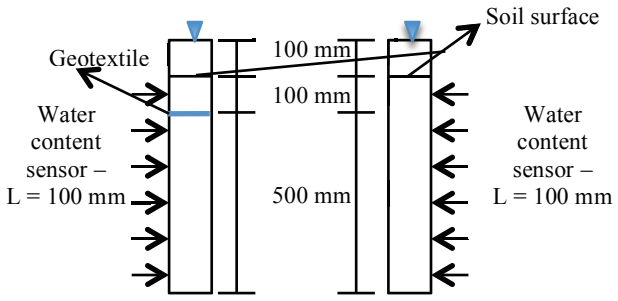
3. Materials

Non-woven geotextile named EX-80 of Polyfelt EX Geotextile from Mitsui Kagaku Sanshi Kabushiki Gaisha is utilized as material in tilted capillary test and vertical column test, while red soil is only used as capillary break in vertical column test. Red soil from Okinawa Prefecture with γ_d = 1.6 ton/m^3, water content (w) of soil = 8 % and k_s = 0.7 x 10^{-6} m/s is used as soil sample. Non-woven Polyfelt EX Geotextile is shown in Figure 1. Geotextile with thickness of 4 mm, weight per unit area of 400 g/m^2, longitudinal hydraulic conductivity of 1 x 10^{-2} cm/s, and lateral hydraulic conductivity of 1 x 10^{-1} cm/s is used as capillary break.

4. Experimental Method

Tilted Capillary Test

Capillary rise test was conducted to evaluate the behavior of geotextiles having thickness of 2 mm and 4 mm in unsaturated condition. A 300 mm long and 50 mm wide of geotextile was prepared as a sample and put in a tilted board with angle about 9^o, thus about 250 mm length of sample was on the above the water level of chamber filled water, while the rest of 20 mm length of sample was submerged. After equilibrium condition was reached, the sample was cut into 5 mm in length and then water content test was conducted. Figure 2 shows the full apparatus of capillary test.



(a) Schematic figure of vertical column test

(b) Full figure of vertical column test

Figure 3 Vertical column apparatus

Vertical Column Test

Vertical column test was conducted to evaluate performance of non-woven geotextile as capillary break. Red soil with γ_d = 1.6 ton/m^3, w = 8 % and k_s= 0.7 x 10^{-6} m/s was used in the cylindrical column with height of 700 mm and diameter of 100 mm.

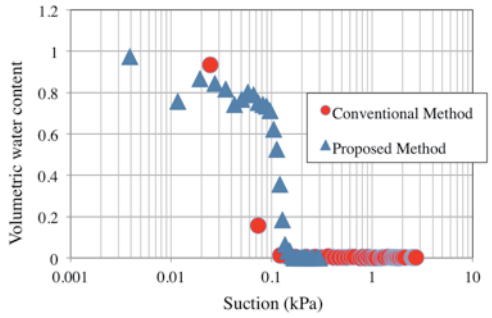


Figure 4 Water retention curve of conventional and proposed method

Elevation of 0 mm is represented a soil surface and minus sign means the elevation below soil surface. To record change of volumetric water content of red soil, six sensors is installed, distance of each sensor is 100 mm. First water content is installed at elevation of -50 mm, a second sensor is installed at elevation of -150 mm, and so on. A geotextile as a capillary break layer is installed at elevation of -100 mm. A constant head of 100 mm was applied to soil column as boundary condition for about one night. The whole of vertical column apparatus is shown in Figure 3.

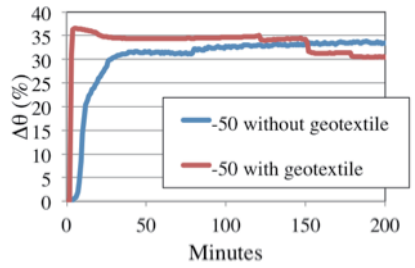


Figure 5 Change of volumetric water content vs time at elevation of -50 mm

5. Results and Discussions

Tilted Capillary test

Generally geotextile has small suction range, but in conventional capillary rise test it's difficult to record water content in small suction range and it becomes a shortage. In other hand, Figure 4 shows that proposed method (tilted capillary method) has ability to evaluate water retention properties of geotextile in small suction range.

Vertical Column Test

Figure 5 and Figure 6 show effect of geotextile against water infiltration. Figure 5 presents the curve of the change of volumetric water content versus time recorded by a sensor installed in elevation of -50 mm, while Figure 6 shows the data recorded by sensor installed in elevation of -150 mm. it's shown that increase of volumetric water content of soil overlain is higher than soil without geotextile. This condition is influenced by the water that can't be drained due to existence of geotextile as capillary break. For soil without capillary break, water easily infiltrated, so that the increase of volumetric water content of red soil in elevation -150 mm is faster than soil with geotextile, this behavior is shown in Figure 6.

After saturation of geotextile, geotextile drains water faster than red soil layer. Volumetric water content of red soil layer underlain by geotextile is decreased as shown in Figure 5. Moreover, after saturated condition, in Figure 6, the increase of volumetric water content of red soil layer overlain by geotextile is higher than red soil without capillary break layer.

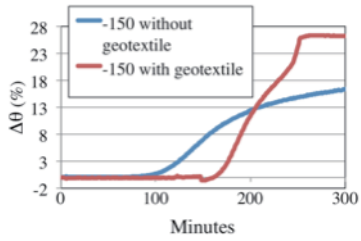


Figure 6 Change of volumetric water content vs time at elevation of -150 mm

6. Conclusions

A tilted capillary test has been developed to modify conventional capillary test having data density shortage in small suction. It has successfully increase data density to draw a smooth shape of geotextile water retention curve. Moreover, in the vertical column test result, geotextile as capillary break layer is able to work effectively. Furthermore, after certain time, when capillary break layer can't retain pounding water, the capillary break becomes ineffective layer.

7. References

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