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FALLING HEAD TEST FOR GEOTEXTILE DRAINAGE CAPACITY

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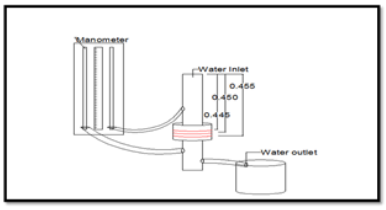
Graphical abstract



Abstract

One of the leading causes of roadway degradation in the world is contamination of the aggregate base which results in strength loss. Thus, it will decrease the effective aggregate thickness destroying the road support and reducing roadway performance. Authorities and practitioners have found out that using geotextile in road construction can overcome the problems. However, there are a few tests must be done before the geotextile can be approved by the responsible party for use in road construction. One kind of the test is permittivity test. This paper presents an analysis of developing a prototype of falling head test for geotextile drainage capacity (permittivity) according to ASTM standard D4491-99. The tests were carried out in order to ensure all the parts of the apparatus can work smoothly and can give the accurate output data. The type of geotextile used in this analysis is a non-woven geotextile. The test was performed using different number of the layers and finally the head. The permittivity value obtained from this apparatus satisfies the standard values of permittivity of the materials tested.

Keywords: Geotextile, prototype, permittivity, drainage, test

Abstrak

Salah satu punca utama kemerosotan jalan di dunia adalah pencemaran asas agregat yang mengakibatkan kehilangan kekuatan. Oleh itu, ia akan mengurangkan keberkesanan ketebalan agregat yang boleh menyebabkan kemusnahan sokongan jalan dan mengurangkan prestasi jalan. Pihak berkuasa dan pengkaji telah mendapati bahawa penggunaan geotekstil dalam pembinaan jalan raya boleh mengatasi masalah tersebut. Walau bagaimanapun, terdapat beberapa ujian perlu dilakukan sebelum geotekstil boleh diluluskan oleh pihak yang bertanggungjawab untuk digunakan dalam pembinaan jalan raya. Salah satu jenis ujian yang dijalankan adalah ujian ketelusan. Kajian ini membentangkan analisis penghasilan prototaip ujian "Falling head" untuk kapasiti saliran geotekstil (ketelusan) mengikut piawai ASTM D4491-99 Ujian telah dijalankan bagi memastikan semua peralatan yang digunakan boleh memberikan data output tepat. Jenis geotekstil digunakan dalam analisis ini adalah geotekstil bukan tenunan dan cebisan pakaian. Ujian ini telah dijalankan dengan menggunakan lapisan specimen dan titik akhir yang berlainan Nilai ketelusan yang diperolehi daripada alat ini memenuhi nilai-nilai piawai ketelusan bahan-bahan yang diuji

Kata kunci: Geotekstil, prototaip, ketelusan, saliran, ujian

1.0 INTRODUCTION

Geosynthetics are fast becoming commonly used materials in civil engineering infrastructure works. The geosynthetics polymeric product is generally used to solve civil engineering problems. Geotextile is one of the largest groups of geosynthetic. Prefix geotextile, namely 'geo' means earth and 'textile' means the fabric. Therefore, by definition ASTM 4439, the geotextile is defined as "A family made up solely of

geosynthetic textiles. Geotextiles are used with foundation, soil, rock, earth, or any other geotechnical engineering-related materials as an integral part of human made project, structure or system." [1]

Presently, available geotextile are divided into four main categories based on the manufacturing process [2] The first is the woven geotextile, that are produced by interlacing, usually at right angles, two or more sets of yarns (made of one or several fibres) or other elements using a conventional weaving process with a weaving loom. Secondly, is non-woven geotextile, a geotextile produced from directionally or randomly oriented fibres into a loose web by bonding with partial melting, needle-punching, or chemical binding agents (glue, rubber, latex, cellulose derivative, etc.) Knitted geotextile is a geotextile produced by interloping one or more yarns (or other elements) together with a knitting machine, instead of a weaving loom. Lastly, a geotextile in which fibres or yams or both are interlocked or bonded by stitching or sewing that called as snitched geotextile.

Geotextile have numerous application areas in civil engineering. They perpetually perform one or more of the subsequent basic functions when used in contact with soil, rock and/or any other civil engineering related materials. Commonly, it's used as separation, filtration, drainage, reinforcement and protection. In terms of separation is, the geotextile has to forestall intermixing of adjacent dissimilar soils and / or fill materials during construction and over a projected service period of the application under consideration. On the other hand, if a geotextile permit for adequate fluid flow with limited migration of soil particles across its plane over a projected service period of the application under consideration, it calls as a filter. If a geotextile collects a liquid and permit for adequate fluid flow with limited migration of soil particles within its plane from surrounding soil mass to various outlets over a projected service period of the application under consideration, its' said to perform the drainage (referred as fluid transmission) function.

Due to very wide ranges of application and tremendous variety of available geotextiles having widely different properties, selection of particular geotextile for the particular place is a very critical decision. The decision must be made before the actual mechanism of the geotextile material started on the applied place. That's why for the particular selection of a geotextile, the properties of the geotextile material should be correctly measured. The main properties that need to be considered is mechanical, hydraulic and physical properties [3]. However, among the various properties in hydraulic properties, permeability is the major importance that needs to be considered. These properties are interrelated such as the opening pore size of the fabric controls the filtration performance of geotextile [4]. According to permeability test, normally permeability value (K) and permittivity (Ψ) can be obtained from the test. Theoretically, based on Darcy's law for flow, measuring of how well a material will allow a liquid to pass and is related to the characteristic of the material known as permeability. On the other hand, purpose to measure the permittivity value (Ψ) is to know the flow rate of water for a known thickness of material [5].

A standard is basically a set of rules that identify what characteristics or attributes of specific products, services or processes should be. In a sense, standard containing technical specifications or other precise criteria to be used consistently and guidelines or definitions of characteristics, to ensure that any products, services or processes, are eligible for the purpose. British Standards (BS), European Norm (EN), Australian Standard (AS), Canadian General Standards Board (CGSB), Indian Standard (IS), International Standards Organisation (ISO) and American Society of Testing Materials (ASTM) all provide testing methods for geotextiles and related products.

This paper focus on falling head test of permeability and presents a simplified mechanism to fabricate an apparatus for the prototype falling head test of geotextile material and is designed and fabricated according to the ASTM D4491-99. The fabrications of the apparatus consist of using locally available materials having component parts of an upper part, middle part, lower part, discharge pipe and head measuring pipe. Besides that, this test using non-woven geotextile. The permittivity value obtained from this apparatus and a comparison between the standard value and the values obtained from standard range are also presented and discussed in this paper.

2.0 DESCRIPTION OF THE APPARATUS

2.1 Component Parts

- Upper part
- Lower part
- Middle part
- Water flow pipe
- Discharge pipe
- Manometer tube

2.2 Fabrication

The apparatus for the prototype falling head test of geotextile for drainage capacity is designed and fabricated according to the ASTM D4491-99. The fabrication of the apparatus consists using locally available materials. The installation of the apparatus to fit it for the test consists of the following arrangement:

- A used bottle that can consist of 1 liter water
- A 40 mm diameter of pvc pipe in the upper and lower parts
- A 60 mm diameter of pvc pipe for the middle part
- 3 nos of 80 mm for water flow and discharge pipe

- A 60 mm net for the plate of the specimens at the middle part
- Couple of manometer tubes

All the materials discussed above are accumulated and the apparatus has been fabricated as per ASTM designation. A schematic drawing and the specimen of the apparatus conforms to all of the above requirements and are shown in Figure 1 to 4.

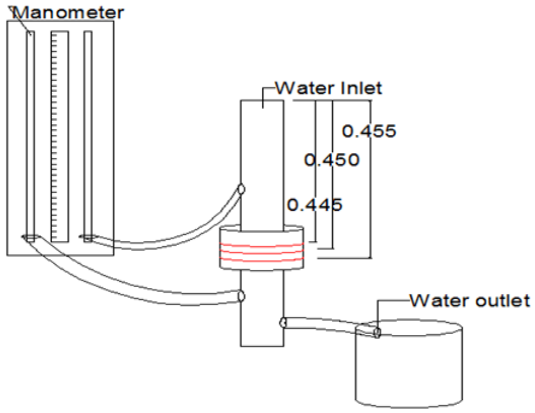


Figure 1 Schematic drawing prototype falling head test for geotextile drainage capacity

Figure 2 Prototype of falling head test for geotextile drainage capacity

2.3 Installation

The installation of the apparatus to fit for the test consists of the following arrangement:

- The used bottle has been sealed together with the upper part that consist of a stand pipe of diameter 40 mm with the help of glue pvc.
- All the parts are combined together with an order sequencing, which is starting from the upper part, continue with a middle part that consist of 60mm diameter and also put the net in the middle of it and lastly, followed by combining the lower part below of it.
- Two nos of the water flow was installed at upper and lower parts to channel the water to manometer tube and the last one are also installed at the lower part but it performs as discharge pipe.
- Scaling has been done on the pipe face for the head measurement
- All the parts have been checked, so that it can work accurately.

3.0 METHODOLOGY

3.1 Sampling

In order to obtain a representative value of permittivity, take four specimens equally spaced along a diagonal line extending from the lower left hand corner to the upper right hand corner of the laboratory sample as been shown in Figure 5. Neither specimen A or D shall be closer to the corner of the laboratory sample than 200 mm.

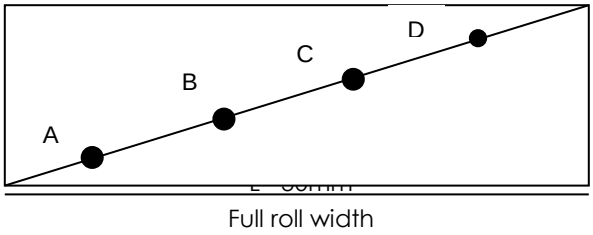


Figure 5 Specimen locations

Select the specimen A center located 200 mm from the corner as same as selection of specimen D. Followed by selecting specimen B located 200 mm from specimen A while specimen C midway between specimen B and D. All the specimens are located on a one line which is all the distance are same. Cut specimens shall fit the testing apparatus, example of this test the diameter of the specimen is 60 mm. The minimum size of the specimen according to the ASTM is 50 mm.

Generally, the number of layers of geotextile (2 to 5 layers) is placed upon one another and for this test, it conducted 1, 3 and 5 layers. Thus, normal stress of 2 kN/m^2 is imposed on the geotextile by the plate of

load, but the flow is only nominally restricted. In this case, based on the calculation that has been made the loading stress that has been provided on the geotextile is 600g.

3.2 Falling Head Test

The apparatus has been assembled with the specimen in place. The geotextile specimen of diameter 60 mm is to be positioned in the middle type of specimen part. A few, manipulated variables are implemented in this test which is a different final head and the layer of the specimens.

1. A pressure of 600 g out of 2 kN/m^2 as per field requirements has been applied by the plate loading.
2. By increasing the flow from the water supply, the beginning head has been marked at the upper part which is 620 mm. The stopwatch is started and when the water level is reached to reading level of the final head, which is 455 mm, 450 mm and 445 mm the time is recorded. All the required data has been recorded during the test conducted.
3. The above procedure has been repeated for calculating the permittivity for the remaining specimen.
4. Equation for the calculation of permittivity is given by the formula,

$$\Psi = \frac{k}{t} = 2.3\,\frac{a}{A\Delta t}\,log_{10}\,\frac{h_0}{h_f}$$

Where, Ψ = permittivity (s^{-1})
k = permeability (m/s)
t = thickness of the sample (m)
a = area of water supply standpipe (m^2)
A = total area of geotextile test specimen (m^2)
Δt = time change between h_0 and h_f
h_0 = head at the beginning of the test (m)
h_f = head at end of test (m)

4.0 RESULTS AND DISCUSSION

Referring to Figure 6, it shows that permeability value for specimen non-woven geotextile are increasing rapidly in different head and layers. The highest value of permeability is 0.0054 m/s at the head of 0.445 m with applying a layer of non-woven geotextile while the lowest value is 0.0045 m/s at the head of 0.455 m with applying five layers of the specimen on non-woven geotextile. Thus, its' shows that differentiation of the h_f is giving reflection by pressured water flow. It's due, when the h_f value becomes bigger, the reading level water stuck in the manometer tube that channel at the upper part become lower and it takes the shortest time to release water from the tube than the shortest length of the h_f in the water stuck in the manometer tube. Somehow, by using the different layer of the specimen also is the one of the factors with the higher thickness of the specimen the water will flow throughout the specimen take a long time and vise versa.

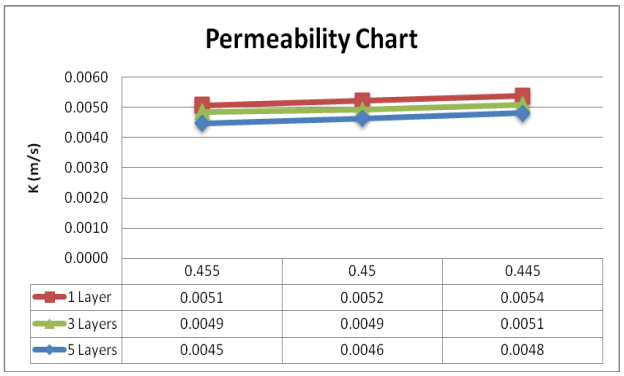


Figure 6 Permeability chart using non-woven geotextile with different layer and final head

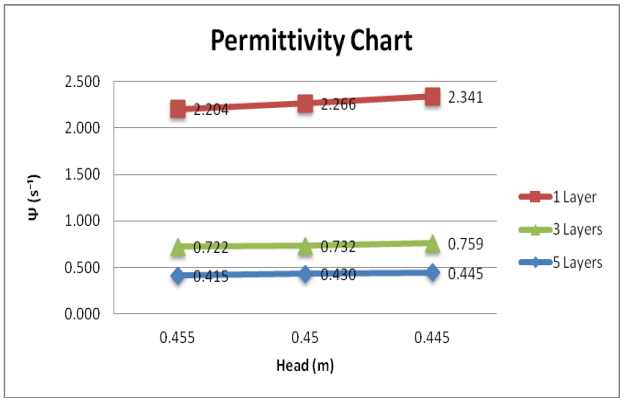


Figure 7 Permittivity chart using non-woven geotextile with different layer and final head

Based on Figure 7, it presents the permittivity chart for non-woven geotextile using this prototype design. Even though, this test conducted with different head and layer, the trends of the results are same which is increasing rapidly. However, the results of the permittivity are related to the permeability value. The value of permittivity comes out from divided the value of K which is permeability value with the thickness of the specimen. Commonly, when the higher number of the layer of the specimen is placed upon one another, the thickness will become higher. Thickness for one layer of the specimen is 0.0023m, three layers is 0.0067 and lastly for the five layers is 0.0108m. So, it presents the highest value is 2.341s^{-1} at the head of 0.445 m with applying one layer of the specimen while the lowest value is 0.415s^{-1} at the head of 0.455 m with applying five layers of the specimen. Permittivity value for single specimen is higher than others because the high flow rate caused by the relative high permeability of the

geotextile, and due to the smaller thickness it also allows water to pass through in shorter time than others. According to the data, the permeability value for geotextile using the prototype design are in the range of the standard test value (8 x 10^{-6} to 2 x 10^{-3} m/s) while the range of the permittivity of the standard value is (0.02 to 2.1 s^{-1}).[6]

5.0 CONCLUSION

An experimental study has been carried out by using locally available material for the fabrication and installation of the apparatus for the fabrication and installation of the apparatus for prototype of falling head test of geotextile for drainage capacity. According to the recorded data and their interpretation, the conclusion can be made

a. The apparatus is properly fabricated and installed based on D4491-99, ASTM standard and it also using the locally available material which is quite light and economical.
b. All the apparatus work properly as per requirement. In comparison collected data, which is the permeability and permittivity value for non-woven geotextile in the standard ranges.

Acknowledgement

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