Accelerated Filtration Test of Geotextile Filters

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ABSTRACT: Acceralated filtration test method to assess long-term flow rate behavior of geotextile filters is developed. This method uses a flow colum with the site specific soil above the candidate geotextile and pass the de-aired water through the system under a constant head repeatedly with a period of several minutes. Flow rate measurements are made after several cycles of repeated flow until repetition reaches over 100 times.

This paper presents the results of acceralated filtration testing conducted on four different geotextiles. According to the test results, the reduction of the geotextile's permittivity due to particle clogging and blinding was observed depending on the type of geotextiles and hydraulic gradient. Based on the results of this work, the test proposed was confirmed to be used to evaluate the long-term clogging resistance of geotextile filters.

1 INTRODUCTION

Various geotextiles are now commonly used to prevent pass of soil particles from river embankments, revetments, etc. When geotextiles are used in river structures, they must be selected correctly to match the conditions where they are to be installed; geotextil filters must meet retention criteria, permeability criteria and clogging resistance criteria.

No standards have been established hitherto in Japan for the test methods or quality standards used to select geotextile filters; especially clogging resistance criteria need to be established. We therefore devised a new method of testing and evaluating the long-term clogging resistance of geotextile filters, and studied the validity of this method.

2 TEST METHOD

2.1 Types and Characteristics of Geotextile Filters Tested

Table 1 shows the types and characteristics of the geotextile filters used in the test. Four typical types of filters were used: Palmae (coryphaceae), spun-bonded nonwoven, needled nonwoven (light weight), and needled nonwoven (heavy weight).

Table 1 Types and characteristics of geotextiledefilters tested

Geotextile style	Polymer and type of fiber	Apparent opening size (A.O.S.) (mm)	Permittivity (l/s)	Thickness (mm)	Cross section
Palmae (coryphaceae)	Palm fiber	1.0	2.7	10.60	
Spun-bonded nonwoven type	Polyester	0.1	5.6×10	2.95	
Needled nonwoven (light weight) type	Short fiber nonwoven polyester geotextile	0.2	1.7	4.80	
Needled nonwoven (heavy weight) type	Nonwoven reinforced with woven geotextile	0.1	4.2×10	10.00	

2.2 Apparent opening size test using vibration

Figure 1 shows the apparent opening size test device. The tests were conducted using a geotextile filter cut to a diameter of 30 cm, fastening it to a wire sieve and vibrator to avoid wrinkling and sagging, then placing a fixed amount (about 10 to 20 g) of glass beads of particle size shown in Table 2 on the geotextile in the sieve. We then screened the beads for about 24 hours at 50 Hz and amplitude 3 mm while sprinkling water from the top of the sieve by a spray, and collected the beads that passed through. We obtained a particle size distribution curve, and used the 95% particle size as the apparent opening size. When obtaining this curve, the distribution of particles smaller than 75μm was measured using sedimentation analysis.

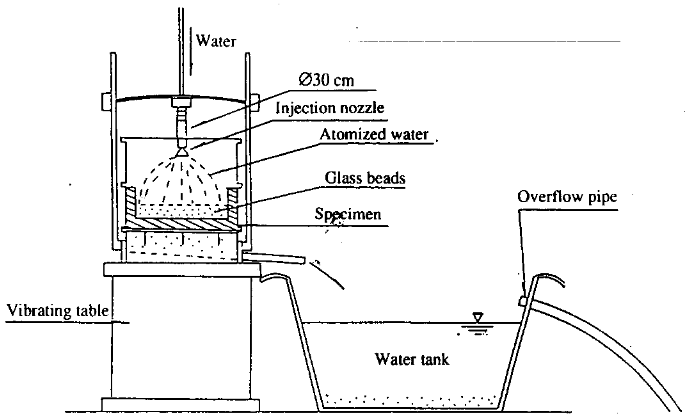


Fig. 1 Outline of apparent opening size test device

Table 2 Particle size of glass beads

Sieve name	Particle size (mm)
No. 4	3.962～4.699
No. 3	2.500～3.500
No. 2	1.500～2.500
No. 1	0.991～1.397
No. 0.80	0.710～0.990
No. 0.60	0.500～0.710
No. 0.40	0.350～0.500
No. 0.20	0.177～0.250
No. 0.15	0.149～0.177
No. 0.10	0.105～0.125
No. 0.07	0.063～0.088
No. 0.05	0.037～0.063

2.3 Permittivity test

To function as a filter, the permittivity of the geotextile must be greater than that of the soil on the surface where it is installed. We tested the permittivity of geotextiles by the constant head method, using the apparatus shown in Fig. 2. The test method consisted of submerging a patch of geotextile cut to a diameter of 10 cm in de-aired water for 24 hours, then installing it in the apparatus in layers (about 50 sheets), and removing the air bubbles from the surface.

The water supply tank was then filled with de-aired water to give the prescribed hydraulic gradient i, and the stand pipe was also filled with water. We then measured the volume and time of discharge from the overflow and measured the temperature of the water. To calculate the permittivity ϕv of the geotextile, we used the following equation:

$$\phi v = K_t / L$$

$$K_t = \frac{L}{\Delta H} \cdot \frac{Q}{A\,(t_2 - t_1)}$$

where,
ϕv: permittivity (l/s)
K_t: coefficient of permeability (cm/s)
Q: volume of discharge from overflow (cm^3)
ΔH: head difference (cm)
A: cross-sectional area of specimen (cm^2)
L: thickness of specimen (cm)
$(t_2 - t_1)$: measuring time (sec)

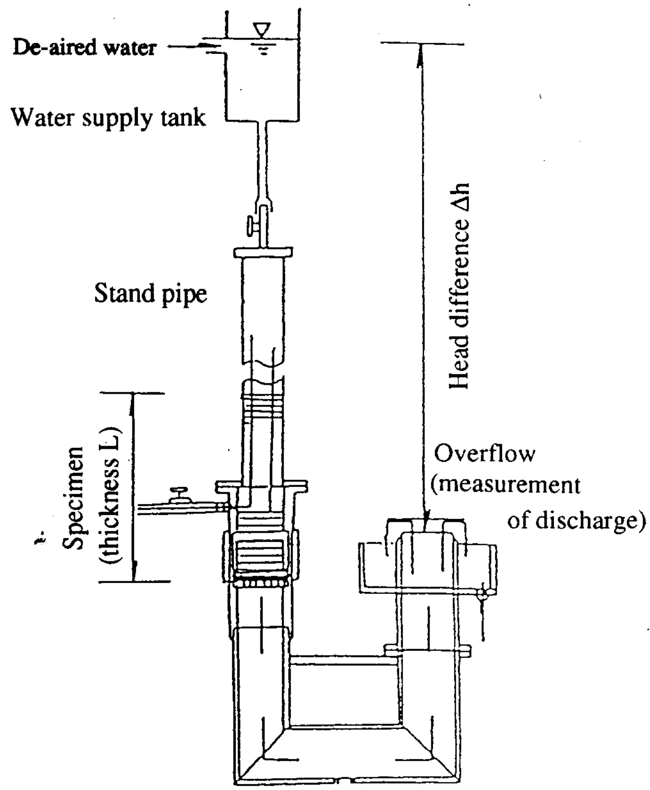


Fig. 2 Outline of permittivity apparatus

2.4 Accelerated Filtration Test

If geotextiles are installed in a soil with a high content of fine particles, then over time, fine particles may infiltrate the geotextile and clog it, accumulating on the surface to form a caked layer. This layer is not so permeable and affects the permeability of the geotextile.

We developed a new apparatus as shown in Fig. 3 to evaluate the resistance of geotextile to clogging, and conducted accelerated filtration tests using this apparatus. In the test, a geotextile of diameter 10 cm was fixed in the stand pipe after being submersed to saturation for 24 hours in de-aired water. Three layers of soil were compacted by dropping a 2.5 kg rammer 3 times from a height of 50 cm in a mold of diameter 8 cm and height 5 cm. These soil layers were then saturated by filing with water from the stand pipe (see Fig. 4).

When the soils were fully saturated, water was injected rapidly to enable water in the stand pipe to reach the set hydraulic gradient in order to speed up the start of clogging. Clogging was then induced by applying a pulse to encourage rapid drainage for a fixed number of cycles.

After the geotextile had been subjected to the set number of cycles, the permittivity was tested without removing the stand pipe similar to the permittivity test, and the change of permittivity was evaluated to determine the extent of clogging.

Figure 5 shows the particle size distribution curve for soil filled in the mold in this test. The specimen soil was Edosaki soil used for embankments mixed with 30% by weight of silt of particle size of less than 75μ, thus creating a soil with a high fine particle content. Three types of pulse with a hydraulic gradient i of 1, 10 and 25 were applied to the geotextile. The cycle of raising the water level for one minute and draining it for one minute was repeated several times, then the permittivity was measured.

3. RESULTS OF ACCELERATED FILTRATION TEST

Figure 6 shows the results of the accelerated filtration test. When a small pulse of hydraulic gradient i=1 is applied, the permittivity was not affected due to clogging as the cycles progressed. However, for a larger hydraulic gradient of i=10 or 25, the permittivity reduced somewhat over the first 20 cycles before stabilizing. The local hydraulic gradient at the top of a river is thought to be about 0.5, and thus relatively immune to clogging.

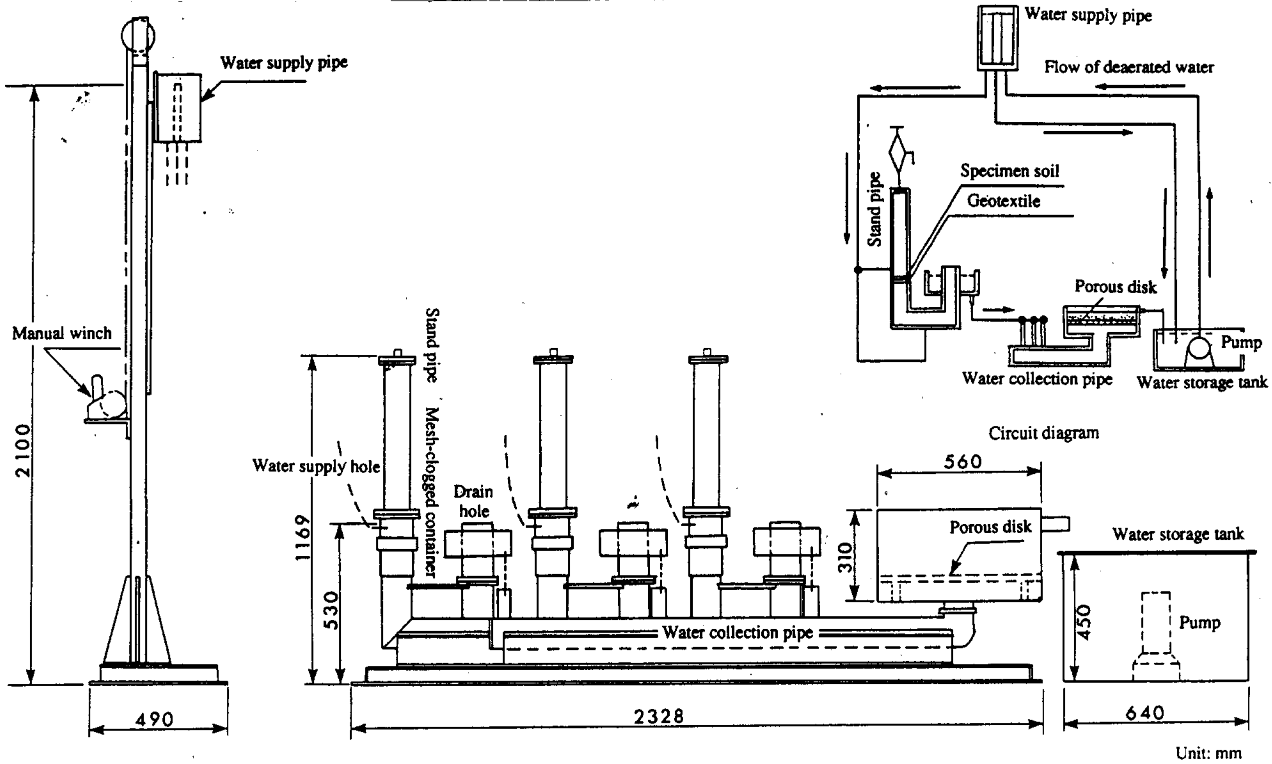


Fig. 3 Outline of accelerated filtration apparatus

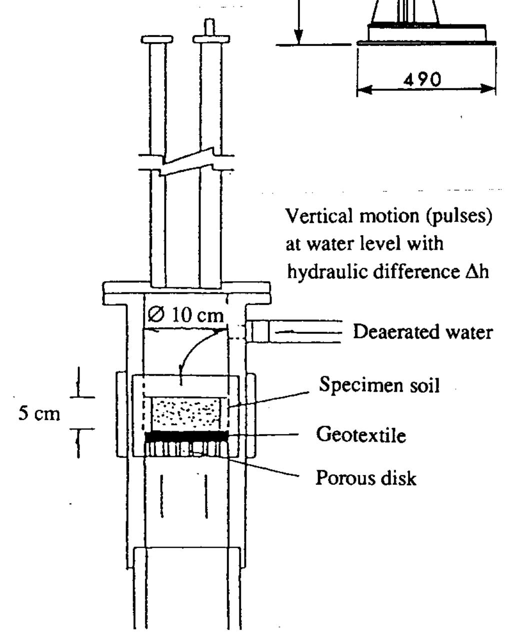


Fig. 4 Details of specimen in accelerated filtration apparatus

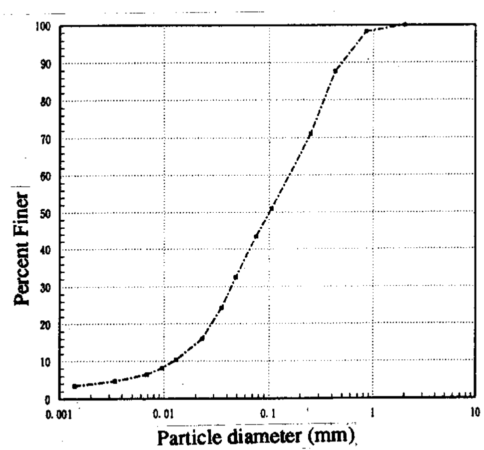
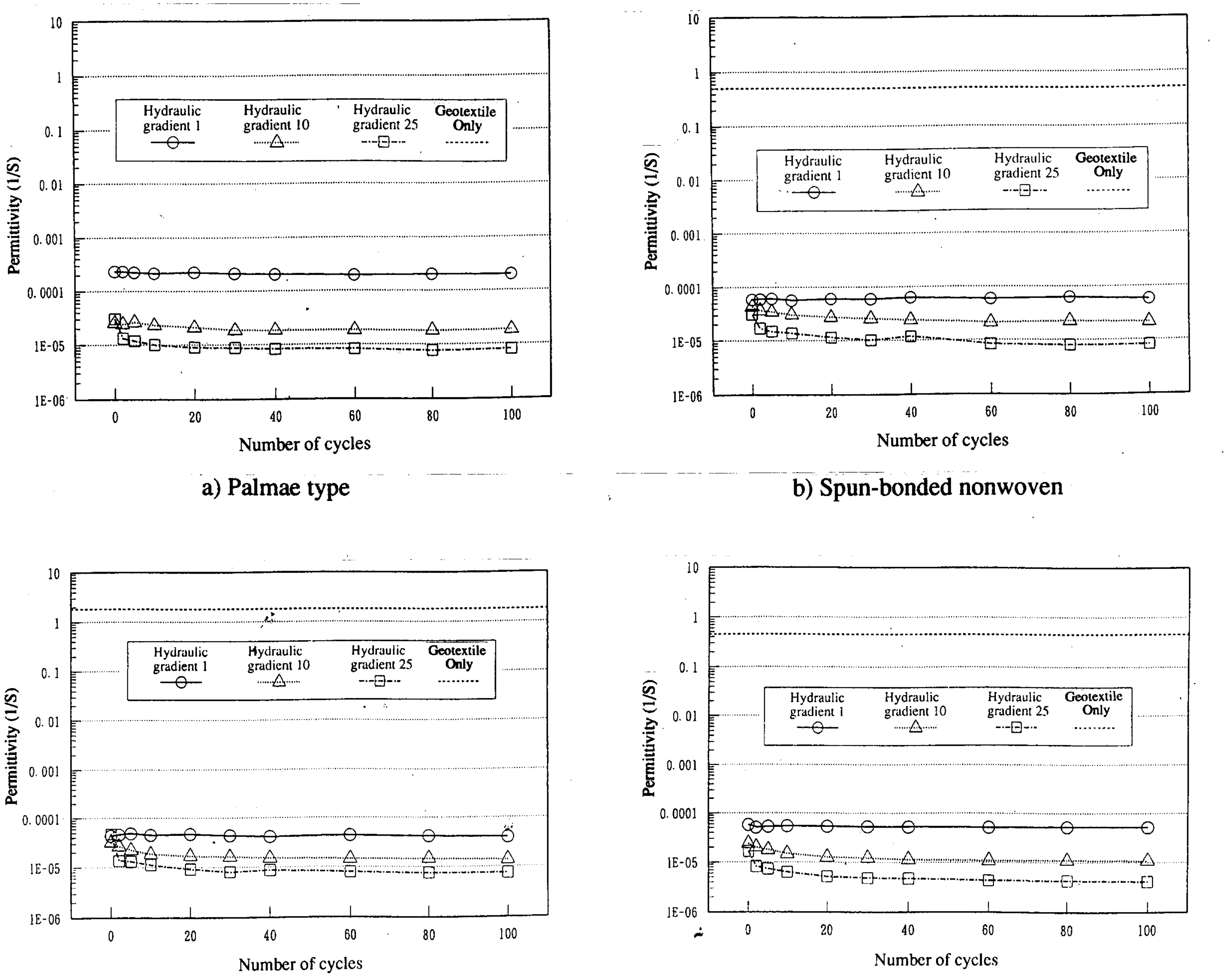


Fig. 5 Particle size distribution curve of soil used in filtration test



a) Palmae type

b) Spun-bonded nonwoven

c) Needled nonwoven (light weight)

d) Needled nonwoven (heavy weight)

Fig. 6 Results of Accelerated filtration test

We showed that the test method is very applicable for evaluating the long-term clogging resistance of geotextiles. One problem remaining to be solved is that if pulses are applied at a high hydraulic gradient, then the soil in the mold tends to become scoured or a water channel develops on the boundary with the mold. Countermeasures are thus needed and further data must be gathered on more soils in filtration tests.

4 CONCLUSION

We have devised a new accelerated filtration test for evaluating the long-term clogging resistance of geotextilefilters. The tests confirmed the applicability of the method using typical geotextiles. In accelerated filtration tests, the permittivity did not decline due to clogging when a pulse with a low hydraulic gradient was applied, thus geotextiles are resistant to clogging if the hydraulic gradient is small. We also confirmed that the test can be used to evaluate the long-term clogging resistance of geotextiles.

In the future, we will gather further data and resolve problems in applying the test, and determine quality standards for evaluating the ability of geotextiles to prevent clogging.

REFERENCES

1) R.M. Koerner et al. (1992), Geosynthetics in Filtration, Drainage and Erosion Control, Elsevier Applied Science.