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# Laboratory Testing of Geotextile Fabric Filters
# Essai laboratoire des géotextiles filtrants

Geotextile filters are being utilized without a true evaluation of their flow capacity or filtration abilities for field application conditions. Laboratory testing should reflect properties of importance for field applications rather than those associated with theoretical analyses. At the same time, these properties must be consistent with the theoretical concepts involved. With this in mind, Caltrans has developed tests for evaluating Geotextiles for site specific applications. The tests evaluate: "Flow Capacity," a parameter similar to permeability that assumes each fabric has unit thickness; and "Plugging Flow Capacity," a parameter for evaluating filtration potential and soil fabric interaction flow capability. Testing utilizes 6 inch diameter samples with 5 inch diameter test areas and a horizontal parameter. Fabrics are evaluated directly with soil or by using glass beads to simulate representative soil sizes. The methods, their evolution, and some example data are presented.

On utilise des geotextiles filtrants sans evaluer leur capacites du flux avec les donnees issues des chantiers. Est plus utile que les essais du laboratoire mesurent les qualites utiles pour l'application en site que les proprietes associes avec l'analyse theoretique. A la meme les proprietes doit etre d' accord avec la theorie. Selon que CALTRANS a formule des essais pour evaluer les geotextiles avec les donnees issues des chantiers. Les essais mesurent capacite du flux, une parametre comme la permeabilite (par presomption que tous les textiles sont d'epaisseur uniform) et la capacite du flux tamponne la parametre pour evaluer la capacite filtrante potentielle et la capacite au flux du textile en contact du sol. Les essais utilisent des echantillons (au diametre du 15.24 cm) avec un espace du 12.6 cm pour mettre le textile a l'epreuve et un parametre horizontal. On analyse les textiles avec le sol ou des perles du verre pour simuler le granule normal du sol. On presentera ici la methode et son developpement et quelques donnees du cas.

Because of the tremendous potential for application of geotextiles as filter elements in drainage facilities, a method of evaluating them is necessary. Dissatisfaction with the available test procedures and their results led to the establishment of the test methods herein described. The factors of primary interest when using any filter system are its flow capabilities and its filtration characteristics. The filtration ability and the potential for plugging or clogging as well as the water flow capacity are indicators of the potential effectiveness.

Because fabrics are normally to be used in a single layer and the fact that they are thin and easily deformable, their true permeability is of less importance to their application than is their flow capacity per unit area, hereafter called Flow Capacity. In an effort to devise tests that would have direct applicability, the Flow Capacity and Plugging Flow Capacity tests were developed. The Plugging Flow Capacity measures the potential for filtration and reduced flow capabilities in conjunction with glass beads; for specific job applications the subject soils may be used in place of the beads.

The sample size and the initial testing techniques were selected to be compatible with existing soil testing criteria. Even with this rather large scale of testing, a five inch diameter sample, the nonwoven fabrics seem to exhibit a high degree of variability. Adjacent samples cut from a large fabric panel may exhibit Flow Capacities varying by hundreds of percent. The fabrics do, however, appear to vary within the same order of magnitude. While this kind of variation on an absolute materials comparison basis is normally unacceptable, when dealing with soils permeability, variations of an order of magnitude are commonplace. Thus, if the fabrics are dealt with on an order of magnitude basis, as are soils, the variations associated with them are acceptable. Using an order of magnitude acceptance criteria, the test for Flow Capacity and Plugging Flow Capacity are suitable measures of the potential of fabrics, both with regard to flow and filtration capabilities. The methods provide for relatively rapid evaluations of fabrics as well as offering a basis for comparing the types of fabrics available. The test methods were initially developed for use with nonwoven fabrics. They have, however, been used to compare some woven and some hybrid fabrics as well.

The test procedures are designed to evaluate the fabrics properties when subjected to the least desirable installation conditions, i.e., with the downstream side of the fabric exposed to open air rather than submerged or in contact with drainage aggregate. The application of results from these test methods, in conjunction with measured soil permeabilities, should enhance the objective design of fabric filtration applications. In general, the Flow Capacity and the Plugging Flow Capacity should both be one order of magnitude greater than the permeability of the soil to be drained. Additionally, the 85% size of the soil should be filtered and the 50% and 15% sizes should not produce greater head rise than the 85% size.

Application of these test methods and their results will require site specific design. The manufacturers should, however, be able to provide tables of information listing the Flow Capacity and Plugging Flow Capacities, by grain sizes, for their fabrics thus permitting application of the fabrics in many cases from manufacturers tables and the soil mechanical analysis and permeability. Additional experience, by others, with these test methods and their applications would be of great value in determining their value in the geotextile industry. To date, only one researcher has evaluated the system and the applicability of the results. In my opinion, the results and their application are superior to the EOS test method and its application.

## GEOTEXTILE FABRIC FLOW CAPACITY

The following test method is for evaluating the flow characteristics of geotextile fabrics for use in subdrainage applications. The Flow Capacity is a measure of the water flow capability consistent with the application configuration. Where permeability measures an absolute flow potential, Flow Capacity evaluates flow capability under operational conditions.

### Apparatus and Materials Required

1) Horizontal permeameter, with sample holder, see Figure A-1.
2) High volume, 25 gpm, and low constant pressure, 2 psi, water source.
3) Spirit level.
4) Constant elevation head reference.
5) Scale, 12 inch, to measure distance from reference to both the entrance head and exit head to nearest 0.1 inch.
6) Flow evaluation media, a stopwatch and calibrated catch bucket.
7) Record sheets.
8) Wrenches and screwdriver for assembly and dismantling.
9) Three fabric samples six inches in diameter.

### Procedure

Install the first test sample in the concentric ring compression retainer as illustrated in Figure A-2. Assemble the permeameter and sample holder as shown in Figure A-1. Position the permeameter under the water source and above the drain facility, Figure A-3. Level the downstream channel, the portion through which the water leaves the fabric. Initiate water flow in sufficient quantity to completely submerge the inlet side of the fabric sample, leaving ample freeboard. Adjust flow to achieve a steady head.

When steady state flow is achieved, the Flow Capacity can be evaluated. Both the inlet head, H1, and the outlet head, H2, are measured as distances from the constant elevation reference. Record as H1(i) and H2(i) on the data sheet, where i is the sample number, i.e., H11, H12, etc.

Using the calibrated catch bucket, intercept the outlet flow and measure the time required to fill the bucket. Do this three times and record the average value as T(i).

Repeat the above procedure for the second and third samples.

Record the calibrated bucket volume, Q, in gallons and the sample test diameter, D, in inches, the permeameter inside diameter at the sample.

### Calculations

The Flow Capacity is the average value obtained using the three test runs. First calculate the individual Flow Capacities, FC(i), then average these values to determine FC, the Flow Capacity.

Formulae:

$$H(i) = H1(i) - H2(i)$$

$$A = D^2/4$$

$$CF = 1.66 \times 10^6 \text{ for feet/day}$$

$$CF = 2.54 \text{ for centimeters/second}$$

$$FC(i) = \frac{Q(CF)}{T(i)\,H(i)A}$$

$$FC = \frac{FC(1) + FC(2) + FC(3)}{3}$$

i = the sample number

### Reporting

Report all three FC(i) values and the FC value so the variation is apparent. Also list the respective H values and the cloth brand.

### Example

Fabric Type: Example

| H1(i) | H2(i) | T(i) | H(i) | FC(i) |
|---|---|---|---|---|
| 10.7 | 0.75 | 29.0 | 9.95 | 1617 ft/day |
| 10.55 | 0.80 | 28.1 | 9.75 | 1703 |
| 11.25 | 1.25 | 31.1 | 10.0 | 1500 |

Q = 5.41 gallons

D = 4.95 inches

$$FC = \frac{1617 + 1703 + 1500}{3} = 1607$$

## PLUGGING FLOW CAPACITY

The following test method is for evaluating the filtration and plugging potential of geotextile fabrics for use in subdrainage systems. This test is an extension of the Flow Capacity test. This test utilizes glass beads to represent soils requiring drainage and filtration. If the $D_{50}$ and/or $D_{85}$ soil grain sizes are larger than a sieve size range of 60 to 100 and the soil is well graded, the filtration parameter need not be considered for the $D_{50}$ size, only the fabric plugging by the $D_{15}$ size and the filtration of the $D_{85}$ size. The $D_x$ grain size is the size D for which x% of the soil is finer than D. If all soil particles are greater than a 60 sieve size and the soil is well graded, then filtration is probable and plugging unlikely with the currently available fabrics. Particles finer than the 325 size, clays, normally do not readily dissociate and therefore the available nonwoven fabrics should also work with those soils that are essentially composed of these very fine clay particles. The Plugging Flow Capacity should be evaluated but will not reflect the cohesion and aggregation associated with these soils so may disallow a suitable fabric. The size ranges above and below the 100 to 400 sieve sizes can be evaluated when appropriate size beads are available.

Apparatus and Materials Required

1) Horizontal permeameter, with sample holder, see Figure A-1.
2) High volume, 25 gpm, and low constant pressure, 2 psi, water source.
3) Spirit level.
4) Constant elevation head reference.
5) Scale, 12 inch, to measure distance from reference to both the entrance head and exit head to the nearest 0.1 inch.
6) Flow evaluation media, a stopwatch and calibrated catch bucket.
7) Record sheets.
8) Wrenches and a screwdriver for assembly and dismantling.
9) Three samples of the fabric to be tested, six inches in diameter.
10) Glass beads, sieve size ranges: 60 x 100, 70 x 140, 100 x 200, 140 x 270, 200 x 325, 270 x 1000.

Procedure

Install the first sample in the concentric ring compression retainer as illustrated in Figure A-2. Assemble the permeameter and sample holder as shown in Figure A-1. Position the permeameter under the water source and above the drain facility, Figure A-3.

Level the downstream channel, the portion through which the water leaves the fabric. Initiate water flow in sufficient quantity to completely submerge the inlet side of the fabric sample, leaving ample freeboard. Adjust the flow to achieve a steady head.

When steady state flow is achieved, the Flow Capacity can be approximated. Both the inlet head, H1, and the outlet head, H2, are measured as distances from the constant elevation reference. Record as H1 and H2 on the data sheet.

Using the calibrated catch bucket, intercept the outlet flow and measure the time required to fill the bucket. Do this three times and record the average value as T.

After establishing the untreated Flow Capacity, glass beads are introduced into the flow stream. Wash five grams of the glass beads which span the $D_{85}$ soil size into the flow stream as illustrated in Figure A-4. Adjust to steady state flow, if necessary, and remeasure and record H1(i), H2(i) and T(i), where (i) is the total weight of glass beads introduced; i=5, 10 or 15; i.e., H1(5), H2(5), T(5), H1(10), etc. Add a second five gram dose of $D_{85}$ size beads. After steady state is again achieved, remeasure and record H1(i), H2(i) and T(i). Add another five grams of the $D_{85}$ size beads and adjust to steady state flow remeasuring and recording H1(i), H2(i) and T(i). (Addition of more than 15 grams of beads becomes a test for bead permeability, not fabric Plugging Flow Capacity.) Repeat this entire procedure including the untreated Flow Capacity for the $D_{50}$ and $D_{15}$ glass bead sizes. Use separate record sheets and fabric samples for each size of glass beads.

Record the calibrated catch bucket volume, Q, in gallons, and the sample test diameter, D, in inches, the permeameter inside diameter at the sample.

Calculations

The Flow Capacity, FC, is approximated using H1, H2 and T in the PFC(i) equation in place of H1(i), H2(i) and T(i), respectively. The Plugging Flow Capacity, PFC, is calculated for each bead size and designated by the soil size represented. A $PFC_{15}$, a $PFC_{50}$ and a $PFC_{85}$ are calculated. The PFC value used is the minimum calculated for the given bead size. Three PFC values are calculated, one for each five gram addition of beads, for each grain size tested.

Formulae:

$$H(i) = [H1(i) - H2(i)]$$
$$A = D^2/4$$
$$CF = 1.66 \times 10^6 \text{ for feet/day}$$
$$CF = 2.54 \text{ for centimeters/second}$$
$$PFC(i) = \frac{Q(CF)}{T(i)\ H(i) A}$$

$PFC_{15}$ = the minimum value of PFC(i) when using the $D_{15}$ grain size equivalent glass beads.
$PFC_{50}$ = the minimum value of PFC(i) when using the $D_{50}$ grain size equivalent glass beads.
$PFC_{85}$ = the minimum value of PFC(i) when using the $D_{85}$ grain size equivalent glass beads.
i = the sample identification, the total weight of glass beads added to that time (5, 10 or 15).

Reporting

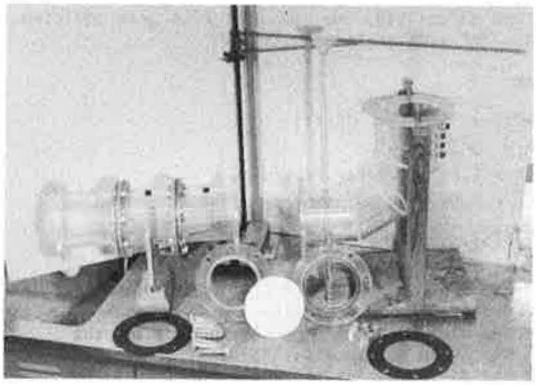
The $PFC_{15}$, its respective PFC(i) values and corresponding heads should be listed. A similar listing for the $PFC_{50}$ and $PFC_{85}$ should also be reported as well as the FC approximations. The $D_{15}$, $D_{50}$ and $D_{85}$ size glass beads used should be listed and the fabric type and brand should be presented.

Example

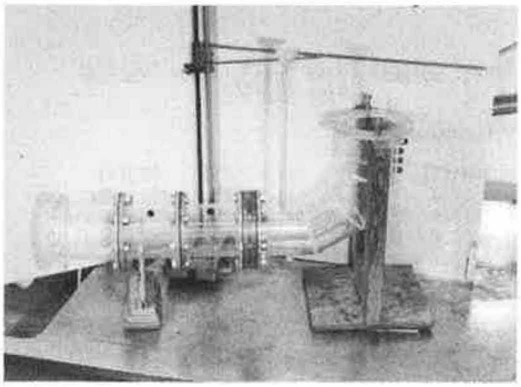
Fabric Type: Example, $D_{85}$, 60-100; $D_{50}$, 100-200; $D_{15}$, 200-325

PFC(o) = FC approximation

| | i | H1(i) | H2(i) | H(i) | T(i) | PFC(i) |
|---|---|---|---|---|---|---|
| $D_{85}$ Size | 0 | 17.6 | 12.4 | 5.2 | 15.4 | 5827 ft/day |
| | 5 | 17.6 | 10.6 | 7.0 | 15.4 | 4329 |
| | 10 | 17.7 | 8.2 | 9.5 | 15.7 | 3129 |
| | 15 | 17.7 | 6.1 | 11.6 | 16.3 | 2468 |
| | | | | | | $PFC_{85}$ = 2468 ft/day |
| $D_{50}$ Size | 0 | 17.7 | 12.8 | 4.9 | 16.0 | 5952 |
| | 5 | 17.7 | 9.4 | 8.3 | 16.4 | 3428 |
| | 10 | 17.7 | 5.1 | 12.6 | 20.5 | 1807 |
| | 15 | 17.85 | 7.8 | 10.05 | 49.0 | 948 |
| | | | | | | $PFC_{50}$ = 948 ft/day |
| $D_{15}$ Size | 0 | 17.7 | 12.4 | 5.3 | 15.5 | 5680 |
| | 5 | 17.7 | 9.1 | 8.6 | 16.0 | 3391 |
| | 10 | 17.6 | 5.7 | 11.9 | 20.9 | 1876 |
| | 15 | 17.8 | 6.1 | 11.7 | 43.8 | 910 |
| | | | | | | $PFC_{15}$ = 910 ft/day |



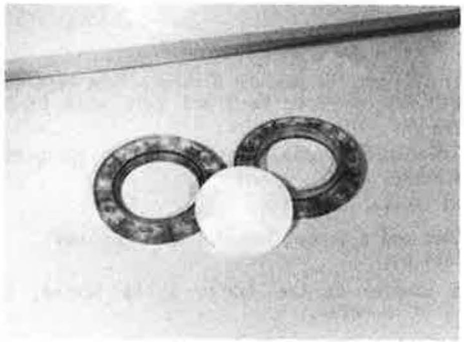
Permeameter with sample holder, gaskets and sample, the white disc.



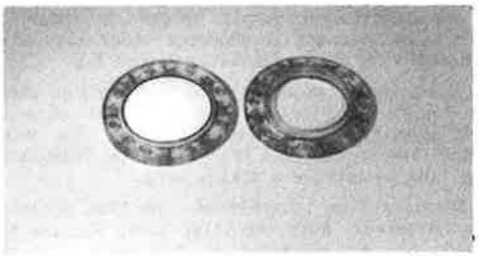
Fully assembled permeameter and sample holder.

PERMEAMETER WITH SAMPLE HOLDER

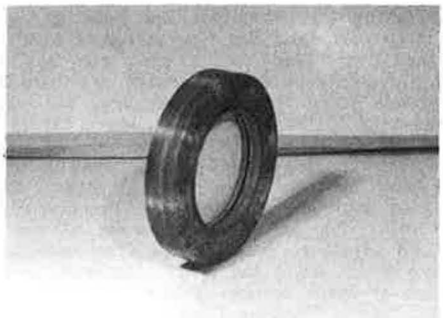
Figure A-1



Two piece sample holder with sample, white disc.



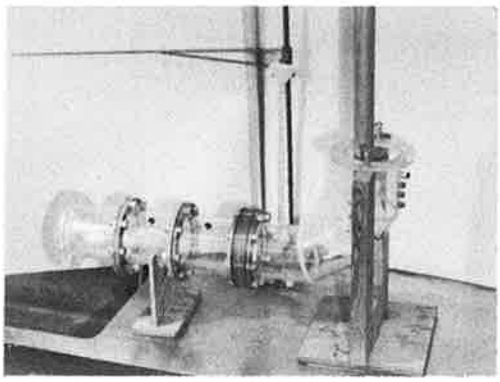
Sample holder with sample inserted into left hand section.



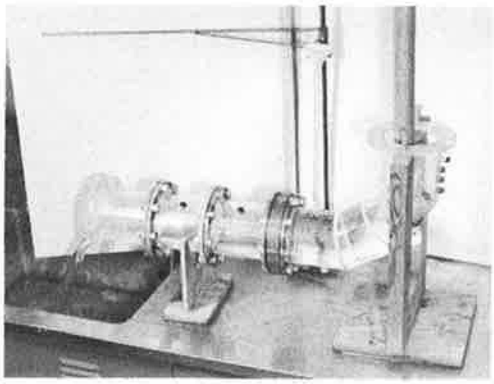
Fully assembled sample holder with sample.

SAMPLE HOLDER

Figure A-2



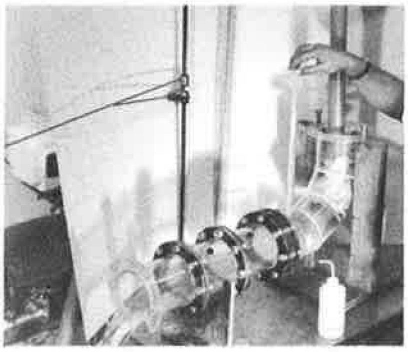
Permeameter positioned over drain and under water inflow pipe.



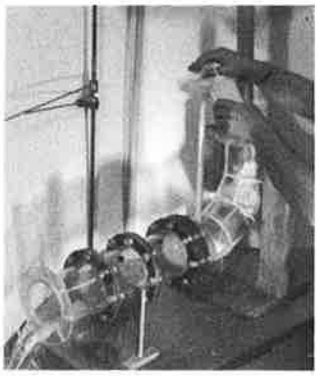
Permeameter with a steady state flow condition.

WATER INLET AND DRAINAGE FOR PERMEAMETER

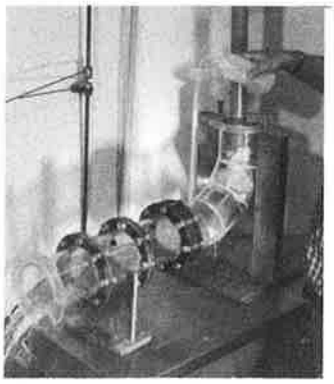
Figure A-3



Pouring in premeasured glass beads.



Washing beads out of vial.



Thoroughly washing funnel and introduction tube to assure total bead introduction.

GLASS BEAD INTRODUCTION

Figure A-4