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Technical Note

A Dynamic Filtration Test for Geotextile Filters

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ABSTRACT

Under certain unique situations a permeating liquid can approach a geotextile filter under dynamic conditions. Such hydrodynamic conditions can represent the ultimate challenge to the proper functioning of the filter, particularly from a soil retention perspective.

This short note presents a laboratory test method which can be used to simulate such hydrodynamic conditions. The soil (in total or its fine fraction) is added incrementally to the test setup. Dynamic pulses are then applied under controlled pressure conditions for a given time period. Flow rate, or permittivity, tests are then conducted in the conventional manner. The limiting behavior developed over successive soil increments can then be assessed.

The purpose of this technical note is to describe the test setup and illustrate the flow rate behavior under a variety of soil, geotextile and pulse intensity conditions.

INTRODUCTION

Dynamic filtration of geotextiles is required under certain somewhat unique conditions. These might be any one of the following:

- Highway edge drains with geotextile filters adjacent to faulted pavements having saturated subgrades.

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- Dynamic loads for geotextile filter/separators caused by railroads under saturated ballast conditions.
- Impact loads for geotextile filter/separators caused by landing aircraft when striking the pavement under saturated conditions.
- Erosion control filters for coastal waterways due to ship wash and wave turbulence.
- Various types of groundwater surges on geotextile filters caused by abrupt ground movements or mechanical equipment placed on, or within, the ground surface.

Note that the above situations are not the commonly encountered situations of static or even quasi-static hydraulic conditions for geotextile filters, but they are certainly plausible under the somewhat unique conditions stated above.

TEST METHOD AND RESULTS

The dynamic filtration test to be utilized in this Technical Note is essentially a flow rate test (or permittivity test) which is conducted after incremental periods of dynamic pulsing of the experimental system. Between each pulsing cycle, select increments of soil are added upstream of the geotextile. The configuration is shown in Fig. 1. The geotextile test

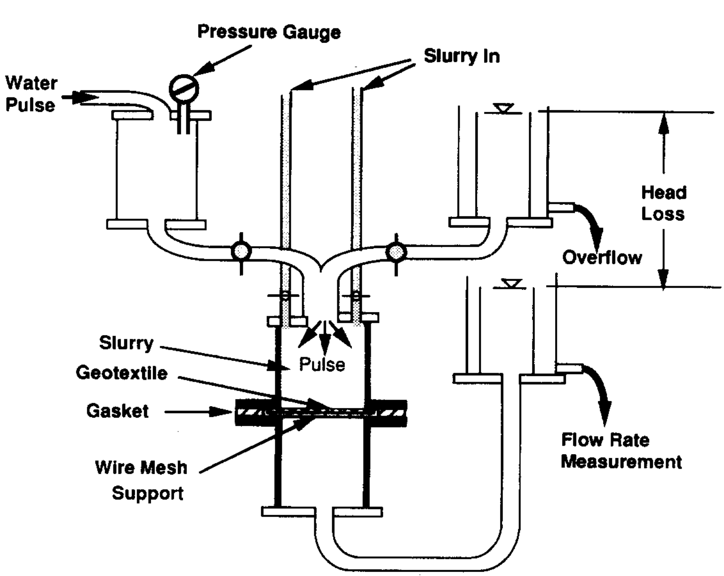


Fig. 1. Schematic diagram of dynamic filtration test set-up.

specimen of 150 mm diameter is mounted in the permeameter as shown. The soil is added in slurry form from two ports as shown. For these tests each increment of slurry was formed by adding 5 g of dry soil to 1000 ml of tap water. The valves are closed and dynamic pulses at a controlled pressure are then applied. For the test results to follow, the pulse rate was 2 to 3 pulses per second. Pulses were applied until the water in the upper cylinder became visually clear. This condition was generally reached after flow volumes through the system were about 15 liters of water. Between each cycle of adding soil and pulsing as described above, flow rate tests under a constant total head of 50 mm were conducted. Note that this is the ASTM D-4491 laboratory protocol for hydraulic permittivity testing with the geotextile in-isolation. A series of test results plotting the measured flow rate versus cumulative soil added to the system will be described.

Figure 2 illustrates the behavior of a 150 g/m^2 needle punched nonwoven geotextile to three different soils. The fly ash, with particle sizes less than the opening size of the geotextile moved completely through it. The well graded sand with particle sizes all larger than the opening size of the geotextile, initially decreased the flow rate and eventually came to equilibrium. The fine fraction of Le Bow soil (a well graded local soil consisting of sand, silt and clay and designated SW-ML) gradually decreased the flow rate until the limit of the system was reached. This lower limit is estimated to be about 5·0 ml/s flow rate or 0·010 s^{-1} permittivity. Clearly, soil type is an important consideration in dynamic soil filtration involving geotextiles.

Figure 3 test results are from the same soil as described previously, i.e. the Le Bow soil but now used in different size fractions. Note that the no. 80 sieve size (180 μm) (approximately the AOS of the geotextile) showed

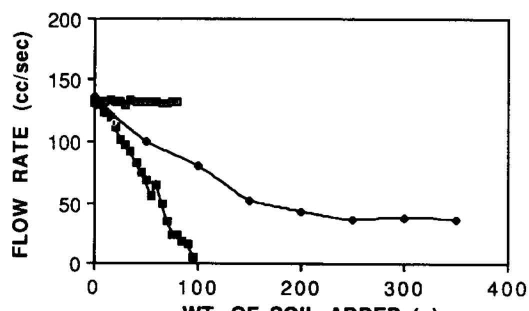


Fig. 2. Dynamic filtration test results on lightweight nonwoven needle punched geotextile. ⊡, Fly ash; ♦, well graded sand; ■, Le Bow soil with size fraction less than no. 100 sieve (150 μm).

a clogging tendency, the no. 100 sieve size (150 μm) took considerably longer to reach the lower limit and the no. 200 soil size (75 μm) passed through the geotextile in its entirety. Clearly, soil size is an important consideration in dynamic soil filtration involving geotextiles.

Using the soil fraction less than the no. 100 sieve (150 μm) of the Le Bow soil, a series of different types of geotextile filters was evaluated. Figure 4 shows these results where it can be seen that 95% of the soil mass passed through a very open woven monofilament geotextile, while 62% passed the 150 g/m^2 needle punched nonwoven, 60% passed the 240 g/m^2 needle punched nonwoven and only 10% passed the relatively tight 130 g/m^2 heat bonded nonwoven geotextile. Clearly, geotextile type is an important consideration in dynamic soil filtration involving geotextiles.

The last series of tests utilized the soil passing the no. 100 sieve size (150 μm) of the Le Bow soil and the 150 g/m^2 needle punched nonwoven

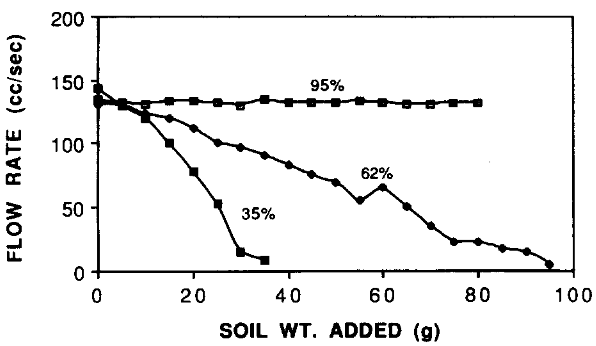


Fig. 3. Dynamic filtration response of lightweight nonwoven needle punched geotextile to various soil sizes. ⊡, < no. 200 sieve (75 μm); ♦ < no. 100 sieve (150 μm); ■, < no. 80 sieve (180 μm).

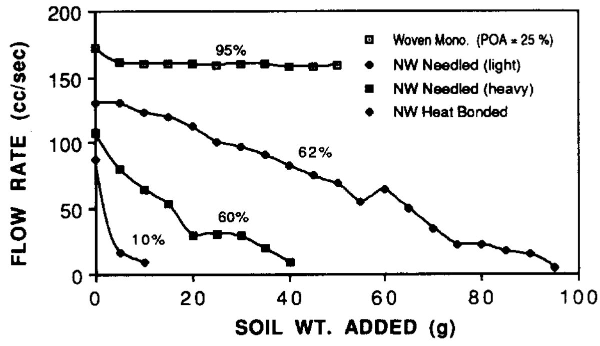
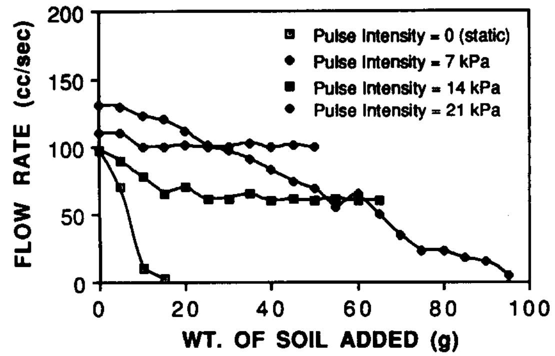
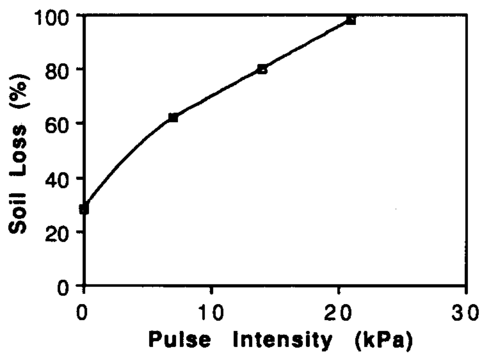


Fig. 4. Dynamic filtration response of various geotextiles to Le Bow soil with size fraction less than no. 100 sieve (150 μm).



(a)



(b)

Fig. 5. (a) Dynamic filtration response of lightweight nonwoven needle punched geotextile to various pulse intensities for Le Bow soil with size fraction less than no. 100 sieve (150 μm). (b) Loss of soil caused by increase in pulse intensity for lightweight nonwoven needle punched geotextile data from (a).

geotextile, but now varied the pulse intensity between soil increments. Note that the pulse intensity in the previous tests was approximately 7 kPa. Figure 5(a) shows the results, wherein the higher the pulse intensity the more soil is passing through the geotextile. The response is seen in Fig. 5(b) which plots the terminal results of the data shown in Fig. 5(a). Clearly, pulse intensity is an important consideration in dynamic soil filtration involving geotextiles.

CONCLUSION

The dynamic filtration test presented in this Technical Note is a very severe and accelerated test method which might be used to assess geotextile filter behavior under certain conditions. These were listed in the introduction. The three conclusions which can be reached upon performing this type of dynamic filtration test (as is the case with most filtration tests) are:

- excessive soil loss through the geotextile
- equilibrium flow rate conditions
- excessive clogging within, or above, the geotextile

This test method probably represents the worst case hydraulic conditions that a geotextile filter can sustain. While the authors are uncertain as to the test's ultimate applicability, it is felt that such a method along with some preliminary results should be in the literature for comments and/or continuation of the study.

ACKNOWLEDGEMENTS

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