Laboratory Procedure for Predicting Geocomposite Drain System Performance in the Field

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When geocomposite drain systems first came on the market in the early 1980s, no accepted laboratory methods existed for predicting their field performance. Because it appeared that these products had definite applications in USDA Forest Service projects, a test procedure was developed to evaluate them. This test procedure was designed to determine the flow capacity of the geocomposite drain systems subjected to varying lateral loads and hydraulic gradients. The test apparatus consists of a large triaxial chamber and special plumbing. Geocomposite test specimens are placed vertically in a mold 6 in. in diameter by 12 in. high, which is then filled with a compacted silty soil. Changes in flow rates through the specimens are measured as both gradient and lateral pressure are varied.

Originally called fin drains or prefabricated drain systems, geocomposite drain systems consist of a geotextile covering one or both sides of a core material. The geotextile permits water to pass through while retaining the soil, and the core transmits the water to the drain outlet. Currently, at least 15 manufacturers make more than 40 geocomposite drain systems. The primary differences in the products are the cores (which can vary from a dimpled polystyrene or polyethylene sheet to a nylon wire mesh to a polyethylene net) and the geotextile covering (which can be woven or nonwoven).

LABORATORY TEST PROCEDURE

When geocomposite drain systems were introduced, no accepted laboratory test methods existed for predicting their field performance. As a result, the USDA Forest Service developed a test procedure to simulate as closely as possible the conditions in the field to which these products would be subjected. The test was developed to determine the flow capacity of the geocomposite drain systems under varying lateral loads. A preliminary examination indicated two potential factors that could greatly reduce the flow capacity: (a) elongation of the geotextile into the core flow channels as a result of the soil pressures and soil creep and (b) compression or deformation of the core material by the lateral soil loads. Therefore, the test was designed to apply lateral loads to a geocomposite drain sample through a soil medium rather than a stiff platen, which would have compressed the core but would not have caused geotextile elongation.

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The developed test involves measuring the flow of water through a 6- by 12-in, sample of the geocomposite placed vertically in a silty soil. The soil (AASHTO Classification A-4) is compacted to a dry density of 100 lb/ft³ (85 percent of maximum density as determined by AASHTO T99) around the sample in a mold 6 in. in diameter by 12 in. high. The soil-geocomposite test specimen (covered with a latex membrane) is then placed in a large (12-in.-diameter, 40-in.-high) triaxial chamber. A system (Figures 1-3) was built to allow water to flow into the geocomposite sample at the bottom and out the top under varying (but constant for each test run) hydraulic gradients (0.3, 1.0, and 2.0) and confining pressures (5, 10, 15, 20, 25, and 30 psi). The water flow direction was selected so that the sample was always flowing at full capacity. The system was designed to ensure that its flow capacity was greater than the flow capacity of the samples under any confining pressure. The ends of the geocomposite samples were open to permit unrestricted flow of water into the samples. The type of soil used was selected to represent a low strength condition, and the gradients and pressures were selected to represent typical field application conditions.

The test is performed by measuring the flow rate for each sample at various combinations of hydraulic gradients and confining pressures, maintaining the confining pressure until the flow rate stabilizes. This is done to ensure that the effects of soil, fabric, and core creep are included in the results. The period required for this steady-state flow can vary from a few days to many weeks. A minimum of two complete tests is performed on each product evaluated.

Graphs plotting the steady-state flow rate versus confining pressure for each of the tested gradients and flow rate versus time for a given gradient and pressure are developed for each product. Samples of these graphs are shown in Figures 4–7. Consolidated results for typical products are shown in Table 1.

The results of the laboratory testing program show a wide range in performance of the different geocomposite drainage systems. Some products have more rigid cores, and their flow rates showed only slight decreases with increasing confining pressure (PP-1, PP-2, PP-4a, PP-4b). The decrease in flow (around 10 percent) is believed to be due to a reduction in the cross-sectional area of the geocomposite drain system caused by a combination of compression of the core and elongation of the geotextile into the flow channels. However, when the crushing strength of the core was exceeded, the flow rate dropped sharply. Figure 4 shows a dramatic decrease in flow in the PP-2 product when the confining pressure was increased



FIGURE 1 Laboratory test system.

from 20 to 25 psi, whereas Figure 5 shows a similar decrease in flow capacity of the PP-4a product when the confining pressure was maintained at 30 psi. Other geocomposite drain systems have more compressible cores. Flow rates for these products dropped markedly with increasing confining pressure. The PP-3a and PP-3b products, which have more compressible mesh cores, were especially susceptible (see Figure 4 for the PP-3b product).

When the confining pressure was increased during the test, the flow rate usually stabilized within a few days. However, the slow crushing process of one product (PP-2) caused the flow rate to gradually decrease over a period of months (Figures 6 and 7).

All products tested—with the exception of PP-2, which partially collapsed at 25 psi—had a minimum equilibrium flow rate of about 1 gal/min per foot of drain width when subjected to a hydraulic gradient of 1.0 and a confining pressure of 30 psi. The PP-2 product exceeded this value at a confining pressure of 25 psi.

FIELD INSTALLATIONS

In conjunction with the laboratory testing, three field installations of geocomposite drain systems were instrumented for future monitoring. These installations were placed behind fills or retaining walls. Instrumentation consists of piezometers placed upslope and downslope of the drains. Results of these installations, it is hoped, will validate the test procedure. However, at this date, sufficient time has not yet passed to allow any substantive data to be obtained.



Scale 1" = 10"

FIGURE 2 Test setup.



FIGURE 3 Test specimen.



FIGURE 4 Equilibrium flow versus confining pressure.

FLOW, GPM/FT



FIGURE 5 Equilibrium flow versus time: confining pressure increased from 20 to 25 psi.



FIGURE 6 Equilibrium flow versus time: crushing of PP-2 over 16 days.

30 PSI CONFINING PRESSURE, 1.0 GRADIENT



FIGURE 7 Equilibrium flow versus time: crushing of PP-2 over 500 days.

DRAIN EVETEME AT A CONFINING DRESSURE	
DRAIN SISTEMS AT A CONFINING PRESSURE	
OF 30 psi	

		Equilibrium Flow,		gpm/ft
Product	Gradient:	0.3	1.0	2.0
PP-1		3.0	5.2	7.5
PP-2*		0.6	1.2	1.8
PP-3a (1 layer	of core)	0.4	0.9	1.2
PP-3b (2 layer	s of core)	1.5	2.8	4.1
PP-4a		0.4	0.9	1.2
PP-4b		4.6	8.1	11.8
PP-5a (l layer	of core)	0.8	1.5	2.2
PP-5b (2 layer	s of core)	1.6	2.8	4.0
(System capacity		6.8	11.7	16.9)

* 25 psi confining pressure

RESULTS

1. The flow capacity of the geocomposite drain systems tested varies directly with the hydraulic gradient and inversely with the confining pressure.

2. The equilibrium flow of a product at a given confining pressure can usually be determined after a period of several

days. However, for some products, the confining pressure must be maintained for longer periods, up to several months.

3. The reduction in flow capacity of the geocomposite drain system may result from crushing or compression of the core material, elongation of the geotextile due to increased soil pressures, or some combination of these effects.

4. All products tested—except for the PP-2 geocomposite, which partially collapsed at 25 psi—had minimum equilibrium flow rates of about 1 gal/min per foot of drain width when subjected to a confining pressure of 30 psi and a hydraulic gradient of 1.0. The PP-2 geocomposite transmitted this volume at a confining pressure of 25 psi.

CONCLUSIONS

The initial impetus for developing this test method was the lack of a known accepted laboratory procedure for predicting field performance of the increasing number of geocomposite drain systems being marketed. ASTM 4716-87 [Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products] had not yet been published at the onset of this program, and as a result no comparison between the two test methods was made. Because most earth-retaining structures depend on their drainage systems for stability, it was imperative that a procedure be developed to ascertain the potential field performance of the geocomposites. Two possible conditions that can affect the geocomposites' ability to transmit water are (a) compression or crushing of the core and (b) stretching and filling of the passageways in the core by the geotextile. Thus, a test using geocomposite samples embedded in soil cylinders was developed. Results of the tests performed on a number of geocomposites showed that as the confining pressure increases, the flow decreases. Visual evaluations of the samples after the test showed that both core compression and geotextile stretch occurred to some extent in most of them. The test procedure appears to approximate field conditions. However, some considerations could modify or change it. Areas that could be considered for change would include soil type and condition, size of confining soil, size of geocomposite sample, confining pressures, and gradients. Further tests incorporating some of these variables are strongly recommended. However, any test developed in this regard should incorporate a soil-confining medium.