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ENHANCED DRAINAGE FOR GEOTEXTILES TUBES USING GEOSPACERS

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ABSTRACT

This paper focuses on using geospacers (aka geocomposite drains) to increase the available surface area of geotextile tubes so as to increase dewatering flow rates and decrease infill stabilization time. Two different infill soils are used along with two different geotextile types. These four combinations are laboratory evaluated using the "pillow test" without, then with a geospacer beneath the pillows. As will be seen, the geospacers decrease the infill stabilization times in all cases, but to varying amounts.

1. INTRODUCTION

The use of large diameter geotextile tubes has become the dewatering method of choice for most types of dredged soils, sediments and sludges around the world. They are used in dewatering projects large and small due to their flexibility, accessibility, performance, sustainability and excellent benefit/cost ratio. Geotextile tubes are constructed of high-strength, permeable, specially engineered textiles designed for containment and dewatering of high moisture content sludges and sediments. Hydraulic pressure is applied to the infill material which forces the water through the fabric leaving the gradually stabilizing solids behind. The issue of drainage time and efficiency between the tube and adjacent materials such as soil subgrade containers or stacked tubes is of concern. This is especially true with dewatering slurries having low permeability.

Indeed, massive quantities of waste, sludge and sediments have been pumped into geotextile tubes for containment, dewatering and decontamination over the last 25 years. Marinas, harbors, ports, paper mills, chemical companies, and power plants are just a few industries that have benefited from this technology. As high-volume dewatering systems, geotextile tubes are straightforward systems requiring minimum amounts of labor during actual operations. Geotextile tubes are available in a variety of sizes and styles depending on volume and nature of infill encountered on site. Many geotextile tube references are available, e.g., Fowler, et al. 2002, Gaffney 2001, Leschinsky, et al. 1996 and Pilarczyk 1977, most recently, new applications and designs are described for coastal areas using coarse grained soils (Lawson, 2015) and for inland areas using fine grained soils (Koerner, et al., 2015). See Figures 1 and 2 for typical applications.

(comp. of TenCate Geotube®)

Figure 1. Stacked geotextile tubes.

(comp. of TenCate-Mirafi)

Figure 2. Geotextile tube in a roll-off container.

2. MATERIALS USED FOR TESTING

Two geotextiles were used in this study with significantly different properties. One is a polypropylene, continuous filament, heatbonded nonwoven geotextile. The test property results of the geotextile are given Table 1. The other geotextile used in the study is a woven monofilament geotextile made of polypropylene. The test results are also given in Table 1.

Table 1. Test results of geotextile properties used in this study.

Property	Test Method	Units	Nonwoven Geotextile	Woven Geotextile
Mass per Unit Area	ASTM D5261	g/m^2	141	208
Thickness	ASTM D5199	mm	0.47	0.69
Apparent Opening Size	ASTM D4751	mm	0.20	0.43
Permittivity	ASTM D4491	1/sec	0.31	1.5
CBR Puncture Strength	ASTM D6241	kN	1.82	3.35
Trapezoidal Tear Strength	ASTM D4533	kN	0.33	0.48
Grab Tensile Strength	ASTM D4632	kN	0.65	1.59
Grab Elongation	ASTM D4632	%	71	32

Two different soils were used with each of the above geotextiles. One soil is a silt, classified by the Unified Soil Classification System (USCS) as a SM. It is actually a silty sand mixture dredged from the Delaware River near Philadelphia, Pennsylvania. The other soil was a concrete sand classified by the Unified Soil Classification System (USCS) as SW. It is a well-graded sand with very few fines. Both of these soils had 100% passing the #4 sieve.

The silt has been GSI's standard soil used to evaluate river dredged material where the sand is a typical beach sand used in geotextile tubes for shoreline protection. A combined grain size analysis for the two materials is shown graphically in Figure 3.

Table 2. Test results of soil properties used in this study.

Property	Test Method	Units	Silt Soil	Sand Soil
USCS Classification	NA	NA	SM	SW
Coefficient of Uniformity (CU)	ASTM D421 & 422	NA	8	6
Coefficient of concavity (CC)	ASTM D421 & 422	NA	2	2
Percent passing #200 sieve	ASTM D422	%	60	4
Permeability	ASTM D2434	cm/sec	2.8 E-5	1.3E-3
Plasticity Index	ASTM D4318	NA	8	3

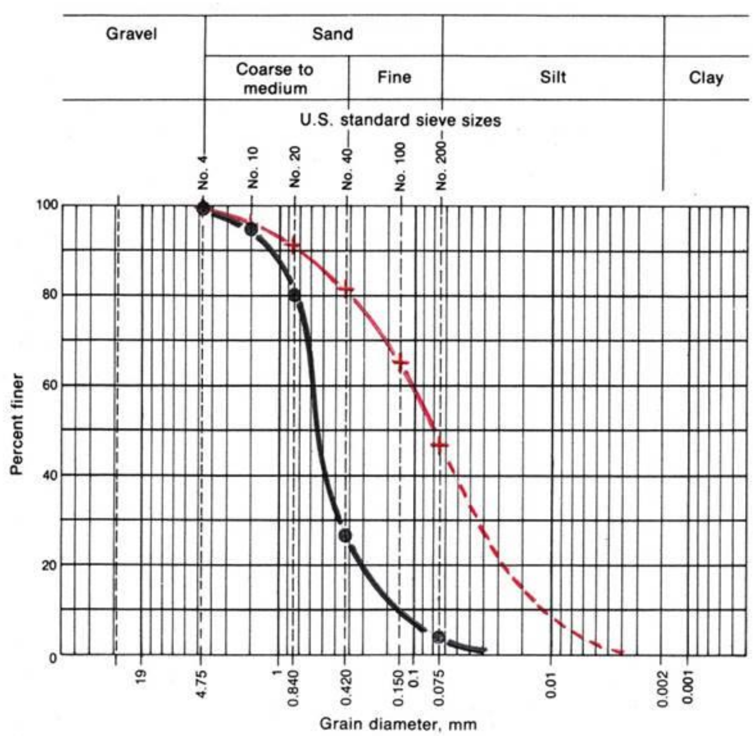

Figure 3. Test results of grain size analysis for the two soils used in this study.

The geospacer (in the classification category of prefabricated drainage composites) used is single sided-solid-cuspated-polystyrene core shown in Figure 4. It is 12.5 mm thick and has a compressive strength of 860 kPa. The

ASTM D4716 transmissivity value of the core is 1.85×10^2 m^2/sec at a gradient of 0.1 and a normal pressure of 100 kPa. The manufacturer originally supplied us with a complete geocomposite, i.e., with a geotextile bonded to the drainage core. This geotextile was stripped off of the drainage core and the geotextiles mentioned earlier were used for the tests.

Figure 4. Close-up photograph of the geospacer used for this project.

3. TEST PROCEDURE

The test procedure used in this study was ASTM D7880 "Test Method for Determining Flow Rate of Water and Suspended Solids Retention from a Closed Geosynthetic Bag." This test method was adapted from GRI test method GT15 "The Pillow Test For Field Assessment of Fabrics/Additives for Geotextile Bags, Containers and Tubes" in 2012.

Figure 5 shows the pillow test setup in which it can be appreciated that these are somewhat large-scale for laboratory testing. Figure 6 is a schematic of the test setup where an open tank containing the pillow is at the base of the assembly. The distance from the uppermost slurry tank to the pillow is such that 120 cm of hydraulic head can be imposed. The standpipe connecting the assembly is marked in 10 cm increments, each of which is used for time readings. In the context of soil laboratory testing, this is a"falling-head" hydraulic conductivity test. Section A-A through the pillow itself illustrates the tests being conducted first without and then with geospacers beneath the pillow. This is shown in the photographs of Figures 9 and 10. As mentioned, time readings were conducted at 10 cm intervals. The raw data was converted to flow rates and plotted against hydraulic head.

Figure 5. Experimental test setup.

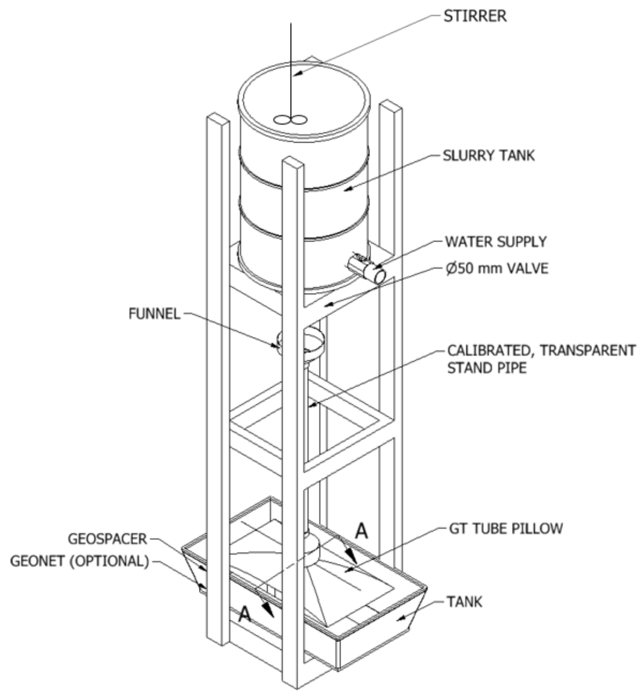

Figure 6. Schematic drawing of set-up with illustrations of the key components of the experiment.

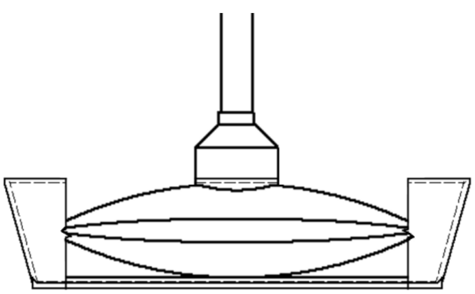

Figure 7. Section A-A without geospacer .

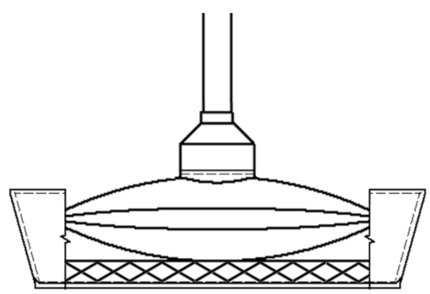

Figure 8. Section A-A with Geospacer

Figure 9. Photograph of geotextile tube pillow without geospacer.

Figure 10. Photograph of geotextile tube pillow test with geospacer.

4. TEST RESULTS

The results for the four experiments are presented in Figures 11-14. It should be noted that we used the exact same set-up and procedures for the tests contained in each graph. In all cases, we ran the test without a drain first and then the comparable test with the geospacer. After the first test was completed the soil filled pillow was picked up and the drain was placed below the pillow in the pan. Then the test was re-run. During this transition the filter cake on the inside of the pillow was disturbed very little thus assuring similarity between the test pairs.

5. DISCUSSION

Using four graphs of flow rate versus hydraulic head, the resulting behavior can be assessed. The four sets of graphs represent the different configurations discussed earlier. Figure 11 illustrates the nonwoven geotextile pillow infilled with concrete sand. This graph shows a four-fold increase in flow rate with the geospacer drain throughout the hydraulic heads tested. Figure 12 shows much the same response except for the fact that the flow rates through the woven geotextile are much greater than with the nonwoven. It should be mentioned that with this greater flow rate comes a possible trade-off of more fines in the effluent water. While the geospacer gave greater flow rates throughout the differences were not as great as with the nonwoven.

Figure 13 is a repeat of Figure 11 but now with silt as the infill instead of sand. As a result of introducing this soil a two order of magnitude lower flow rate is observed. That said, low rates with the geospacer are greater than without for all hydraulic heads. Figure 14 is a repeat of Figure 12 again with silt as the infill instead of sand. As with all of the curves the flow rate is higher with the geospacer than without. In this case, the response curves are similar to Figure 13 since the lower permeability silt is beginning to control the response. In both cases with the silt soil the nonwoven (Figure 13) and woven (Figure 14) geotextile pillows, the geospacer drain increased the flow rate measurably.

6. SUMMARY

This study experimentally evaluated flow rates through two different geotextile pillows as well as two different soil types. In all four cases a geospacer beneath the pillows resulted in greater flow rates (at all hydraulic heads) than without. Since efficiency in dewatering is enhanced with greater flow rates the use of a geospacer beneath geotextile tubes is certainly beneficial. When the geotextile tube surfaces are constrained further than just as the base, as in stacked tubes or tubes within a container, the improvements would likely be higher and probably in direct proportion to the amount of blocked surface area.

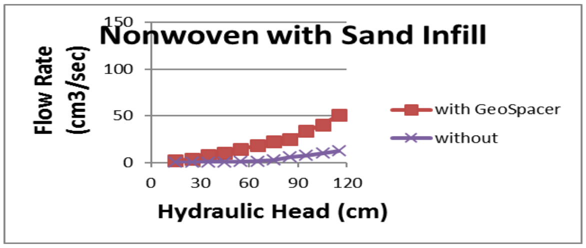

Figure 11. Nonwoven geotextile with sand infill.

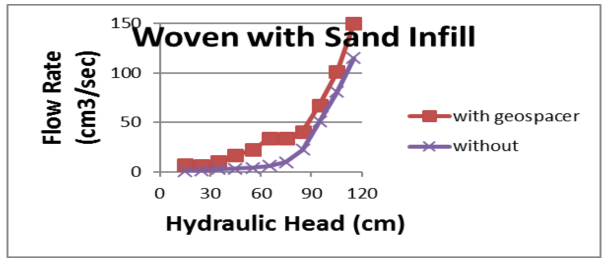

Figure 12. Woven geotextiles with sand infills.

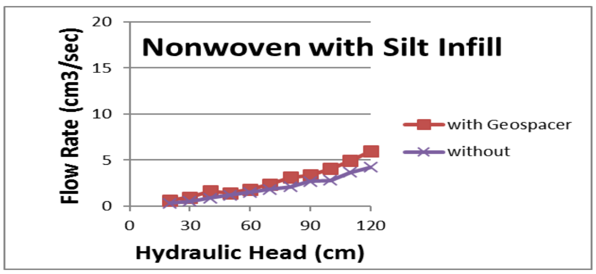

Figure 13. Nonwoven geotextile with silt infill .

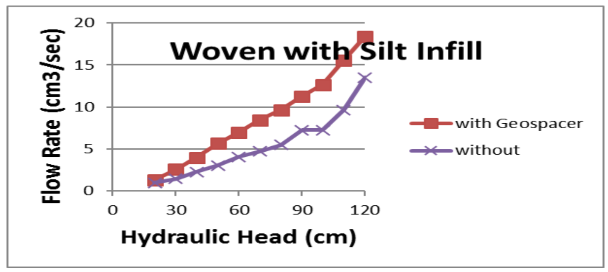

Figure 14. Woven geotextile with silt infill.

Inasmuch as there are an incredible number of geotextiles available and essentially an infinite number of soil infill types available, the use of the pillow test appears to be an excellent screening test. It can be conducted in a laboratory setting directly or at a project site. In all cases, dewatering in geotextile tubes should be optimized so as to make the technology more economical than it already is.

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