APPENDIX 5.4

DEWATERING SEWAGE SLUDGE WITH GEOTEXTILE TUBES

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ABSTRACT

Municipal sewage was placed in geotextile bags for the purpose of evaluating the dewatering and consolidation capabilities of large geotextile tubes and effluent water quality. A proposed ASTM test method for determining the flow rate of suspended solids from a geotextile containment system for dredged material was used to conduct tests to determine the efficiency of different combinations of geotextile filters. As water passed through the geotextile bag, samples were collected during, immediately after and for several days to determine the total percent suspended solids (TSS), heavy metals, and bacterial count. The quality of pore water or effluent passing through the geotextile container systems proved to be environmentally acceptable for discharge into the Mississippi River and/or return to the plant. The test results indicated a significant reduction in the sludge volume in the geotube

INTRODUCTION

Purpose. The purpose of this demonstration test was to evaluate the dewatering and consolidation capabilities of large geotextile tubes for municipal sewage sludge and the water quality of the effluent passing through the geotextile filter fabric.

Scope. The scope of this report is to present the results of the laboratory and field tests, to evaluate the filling methods and techniques, and to evaluate the consolidation and dewatering behavior of a geotube filled with sewage sludge

Background. The United States Environmental Protection Agency and the Mississippi Department of Environmental Quality have restricted the use of many types of waste lagoons such as those operated by municipal drinking water and sewage waste water treatment facilities. They have issued orders to restrict the use of these facilities, but have failed to provide an economical solution for future waste disposal

Keywords; Geotextile containers, geotubes, bags, sewage sludge, dewater, consolidation, dioxins, PCB, PAH, heavy metals, pesticides, disposal, beneficial uses

BACKGROUND AND CASE HISTORIES

Since the late 1980's, several thousand geotextile bags, tubes and containers ranging in sizes from 1 to 3000 cubic meters have been successfully filled with a variety of fill materials in the Netherlands, Germany, France, Japan, Brazil, Australia and the US for submerged stability berms, groins, sill structures for controlling thalweg erosion, scour protection around piers, contraction dikes, dredge material containment and disposal of clean and contaminated materials Dewatering applications for fine grained soil from navigation dredged material maintenance projects and sludge lagoons have been limited. Geotextile containers filled with dredged material offer the advantage of ease of placement and construct-ability, cost effectiveness, minimal impact on the environment, and confidence in containment In addition to filling with sandy materials, geotextile containers filled with fine grained maintenance dredged material provide the opportunity for beneficial use, storage, and subsequent consolidation of this material in dike construction and wetland construction. It has been demonstrated that these geotextile containers retain about 100 percent of the fine grained maintenance dredged material, therefore retaining the contaminants.

During the past 15 to 20 years, various types of containers have been used. Geotextile tubes such as, Geotubes and GeoContainers copyrighted by Nicolon Corporation, were hydraulically filled with fine grained sand, and extensively used on the northern shores of the Netherlands for barrier dikes for subsequent hydraulic fill behind the dikes.

The Waterways Experiment Station, WES, US Army Corps of Engineers, Vicksburg, MS demonstrated in 1992 that geotextile tubes 4.6 m (15 ft) wide and 15 2 m (5 00 ft) long and 1. 5 m (5 ft) high could be filled with fine grained dredged material for potential use by the Corps of Engineers for dike construction and wetland creation at Gaillard Island Dredged Material Disposal Island, Mobile, AL. Vegetation growth through containers was very promising with natural propagation taking place after the tubes are filled and begin to consolidate The dredged material, at an initial wet bulk density of 1 3 gr/ml in the geotubes, consolidated 70% from an initial height of about 1 2 m (48 in.) to about 0.4 m (15 in) in about two months.

Geotextile containers, which are dumped either from dump trucks or split hull, bottom dump hopper barges; have been successfully used to construct underwater stability berms, closures for repair of breached dikes, groins, and thalweg scour protection. These containers have been hydraulically and mechanically filled inside split hull, bottom dump hopper barges, moored in place, and dumped Design concepts for material tensile strength, seaming requirements, and properties with regard to creep, abrasion, ultraviolet protection, tear, and puncture are presently being documented under the Construction Productivity Advancement Research program at WES.

SEWAGE SLUDGE DEWATERING TESTS

Introduction. GEOTEC Associates and the Nicolon Corporation have successfully demonstrated that large geotextile bags and geotubes can filter and dewater sewage sludge and retain almost 100 percent of the fine materials. In August 1995, Nicolon provided, at no cost, two geotextile bags and one geotube for filtration and consolidation testing. Lime and aluminum sulphate wastes from the Eagle Lake and Culkin Water Districts, Vicksburg, MS, disposal lagoons were placed in the geotextile bags and closely monitored.

Successful testing is not always enough to convince municipalities of the merits of the geotextile bags and tubes. Several suggested uses of the tubes and bags were rejected for various reasons The City of Vicksburg's Engineering Department considered their use, but they had already committed to constructing a belt press plant. They did suggest we contact Rose Mary Bagby, Manager of the Vicksburg Waste Water Treatment Plant, which we did. Again we conducted a successful demonstration, this time using sewage sludge.

The US Environmental Regulatory Agency has required waste water managers under 40 CFR, Part 503 Regulation and Specific Guidelines, to find other alternatives for dewatering and disposal of sewage sludge, preferably beneficial alternatives, such as combining green waste, fly ash, kiln dust, and/or lime waste and dewatered sewage sludge for land applications. They have been directed to discontinue use of lagoons and submit alternative methods of disposal for approval.

Bag Test Results. There was limited control over the percent solids for filling the bags on any given day from the sludge digester However, there did not appear to be much difference in the time of dewatering of the lower or higher percent solids content materials. The higher moisture content sludge material took about 5 days and the lower moisture content materials took about 4 days to achieve about 90 percent consolidation There also did not appear to be a significant difference in the dewatering capabilities of the non-woven polyester, Bag 1, versus the polypropylene inner liner, Bag 2. The percent solids, moisture content and wet density approached approximately the same density in about the same amount of time regardless of the initial sludge properties. After a soil filter cake builds up on the fabric, the total suspended solids (TSS) for both bags stabilized. The initial percent solids in Bags 1 and 2 was 6.6 to 14.9%. The maximum percent solids increase for Bags and 1 and 2 was 31% and 33%, for 128 and 132 days, respectively The Total Percent Solids, TSS, passing through the non-woven polyester geotextile fabrics, Bag 1, performed slightly better than the non-polypropylene fabrics, Bag 2 TSS for effluent water passing through the polyester fabric was less than 26 mg/l after 11 minutes of drainage and consolidation time. These tests are non-conclusive and it is recommended that a battery of tests be conducted under a more controlled environment

Heavy Metal Tests. Heavy metal content tests were conducted on the effluent water samples passing through the inner liner and outer fabrics for Bag 1 (polyester non-woven inner liner) and Bag 2 (polypropylene non-woven inner liner) The results of these tests indicated that Arsenic was 1.4 to 1.52 mg/l in the un-filtered sludge and was 0.008 mg/l to ND after passing through the geobag fabrics. Chromium was 1.9 to 4.8 mg/l in the un-filtered sludge and ND after filtration through the geobag. Nickel was 3.2 to 5.8 mg/l before and 0.13 m/l to ND after passing through the geobag The detection limits for Arsenic, Chromium and Nickel was 0.005, 0.04 and 0.01 mg/l respectively.

GEOTEXTILE GEOTUBE TESTS

Introduction. The Nicolon Corporation provided a surplus geotube from a US Corps of Engineers project, Baltimore District, for this research project The geotube consisted of a 5.3 N/m^2 (16oz/sy) non-woven polypropylene inner liner and a woven polypropylene outer liner for support. The geotube was 4.6 m (15 ft) wide and 9.1 m (30 ft) long.

Outer Geotube Liner Properties The outer bag liner consisted of Nicolon Geolon GT 500, which is a woven polypropylene fabric that was initially used in geotube construction Contractors had a problems with failure of these fabrics because they would not, monitor the inlet pressure during filling. Another problem with woven polypropylene fabric is that they have tendency to fail under high loads due to creep. Because of their low creep properties it is recommended that polyester fabrics be used in all geotube designs unless otherwise specified. The woven polypropylene fabric had a an ultimate wide width tensile strength of 70 KN/m (400 pli) in the warp and weft. The tests were conducted using ASTM D4595 and ASTM D4884. The maximum strain was 20 percent in the warp and weft, respectively. The apparent opening size (AOS) was a US Standard sieve number 40-70.

Inner Geotube Liner Properties. The inner geotube liner consisted of a 5.3 N/m^2 (16 oz/sy) non-woven polypropylene geotextile fabric. The polypropylene inner liner has an average thickness of 185 mils. The average grab tensile strength for the polypropylene was 61 KN/m (350 pli). The purpose of the non-woven fabric was for retention of the fine sludge material. The AOS for the polypropylene non-woven fabric was a US Standard sieve number 100

Geotube Seam Strength. The woven polypropylene fabric seams for the geotube was about 44 KN/m (250 pli) in the warp and weft. All seams were "J" seams. Seams consisted of type 401 double lock stitch that was sewn with a double needle Union Special Model #80200 sewing machine. The machine is capable of sewing two parallel seams about 0.6 cm (0.25 in.) apart. The thread was a 2 ply 1000 denier passing through the needles and 9 ply 1000 denier passing through the looper.

Filling the Geotube. A 15 cm (6 in.) high wooden frame was constructed to form a box 4.9 m (16 ft) wide and 9.7 m (32 ft) long. The box was lined with a 4 mil thick visqueen liner to contain the effluent water from the geotube Figure 1 shows the geotube, wooden frame and visqueen liner after filling.

Geotube Data Analysis The required pressure, 207 Pa (0.3 psi), to fill the geotube to a height of 1.5 m (5 ft) was determined using a computer program, GEOCOPS A plot showing the required pump pressure, tube height, cross-sectional area and fabric tensile strength for the geotube during various stages of consolidation is shown in Figure 2. The geotube consolidated 90 percent of its initial height, or area, in the first 26 days after filling. Using geotechnical consolidation theory and an initial measured percent solids of 8 percent, an assumed specific gravity of 2.5, the wet bulk density was determined to be 1.05 gr/ml. After 32 days the wet bulk density was 1.13 gr/ml and percent solids was 19.2% and after 65 days the wet bulk density was 1.27 gr/cc and the percent solids was 21%. after 65 days.

Volume loss and flow rates during the primary self weight consolidation of the sewage sludge in the geotube averaged about 0.06 m^3 (15 gallons) per foot-day or 1/3 meter. After about 26 days loss rates decrease as the geotube accumulates solids during consolidation. The geotube held about 2 cubic yards per linear foot for a 4.6 m (15 ft) wide tube or approximately 45.4 m^3 (12,000 gal), whereas a 1.2 m (48 in.) circumference bag, 1.5 m (5 ft) long, only held 0.18 m^3 (48 gallons). The geotube held about 1.5 m^3 (404 gal) of sludge per foot or 1/3 meter. The results from the bag tests may not be used directly to predict geotube performance

The geotube had an initial percent solids of 8.0% at a height of 1.5 m (60 in.) and 21.4% solids at a height of 0.44 m (17.5 in.) after 65 days of consolidation. The geotube was 0.4 m (15 in.) high after 120 days. Ninety percent consolidation occurred in the geotube in about 26 days versus 4 to 5 days for the geotextile bags. At 90% consolidation the geotube dropped to a height of 0.5 m (21 in.). Based on past experience it was estimated that the geotube would subside to about 0.4 m (15 in.) as a result of self weight consolidation or about 23 percent solids or a reduction of about 75 percent of the initial volume.

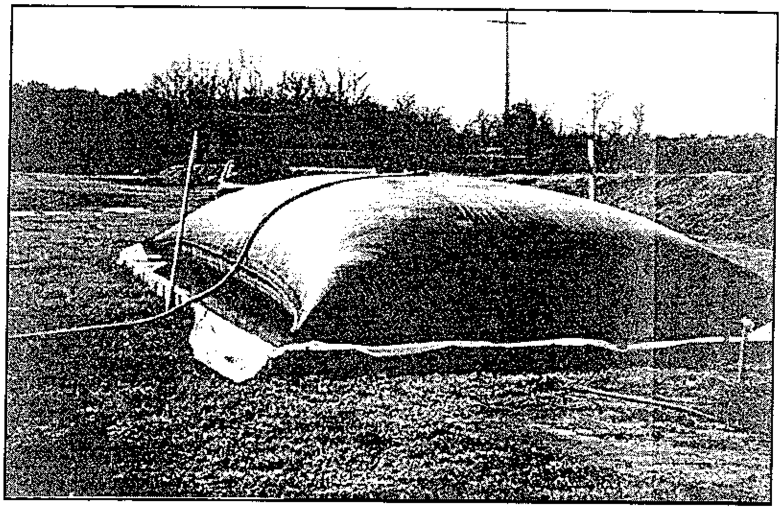

Figure 1 Geotextile tube being filled to a height of about 60 inches with sewege sludge from digester by gravity flow

CONCLUSIONS AND RECOMMENDATIONS

It was concluded that the geotextile bags and the geotube were capable of retaining the fine grained sewage sludge and that these materials respond similarly to the soil characteristics of maintenance dredged material. It was shown that the geotextiles are capable of filtering the sludge so that the effluent water passing through the fabrics will meets the 30 mg/1 discharge requirements in less than 11 minutes of drainage time. It was also concluded that this new and innovative technology is capable of competing economically with other alternative dewatering techniques for sludges. This technique is passive, and does not require extensive or constant labor and maintenance of equipment. This technique is capable of increasing the percent solids to about 22 to 25 percent in relatively short periods of time. This concept of containing sewage sludge has proven to be construction-practical, technically and economically feasible and environmentally acceptable to other disposal alternatives.

It is recommended that additives such polymers, fly ash, or highly oxidized water etc.; be added during or after consolidation in the geotubes to achieve a greater bacterial reduction. One alternatives is to do nothing and let the dewatered sludge stabilize naturally in the tube. It is also recommended that small to medium size water and waste water treatment plants consider the use of this new and innovative technology for dewatering sludge. Transportable geotubes have been developed for 6.1 to 12.2 m (20 to 40 ft) long dump trucks and/or trailers. The geotubes can be loaded onto the trucks after dewatering. Vacuum consolidation systems are also available for transportable geotubes. Current research is be conducted to substantiate this research effort through actual full scale project. This concept of containing sewage sludge has proven to be construction practical, technically and economically feasible and environmentally acceptable to other disposal alternatives.

This new and innovative technology has been successfully used to dewater fine grained, contaminated dredged material that contained dioxins, PCB's, PAH's, pesticides and heavy metals for the Port Authority of New York and New Jersey, Miami River and the Port of Oakland, CA. This is the first successful use of geotextile tubes for dewatering sewage sludge for beneficial uses in the United States. Research using this process for dewatering pork and dairy farming waste, paper mill waste, fly ash, mining waste, chemical sludge lagoons and several other waste streams is being conducted at the University of Illinois.

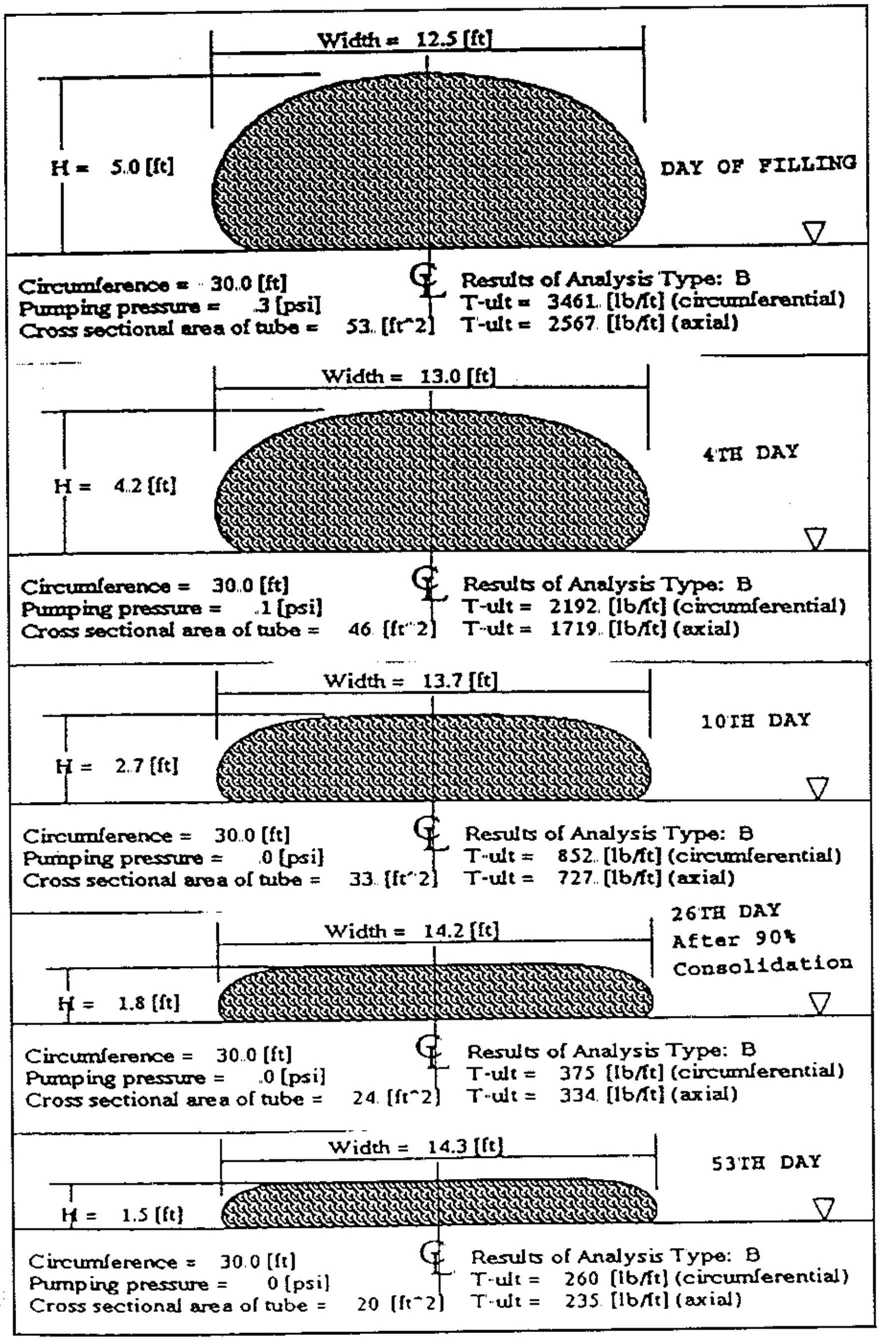

Figure 2 GEOCOPS plots showing theoretical geotube shapes, heights, cross-sectional areas, and required fabric tensile strengths and dimensions of the geotube after filling and during consolidation

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REFERENCES

Duarte, F., Joseph, J., and Satterlee, G. 1995 Construction of Geocontainer and Geobag Contraction Dikes to Eliminate Dredging at Red Eye Crossing, *in Proceeding of Ports '95 ASCE*, New York, N.Y.

Fowler, J., Toups, T. and Gilbert, P. 1995. Geotextile Contained Contaminated Dredged Material, Marina Del Rey, Los Angeles and Port of Oakland, California. *Fourteenth World Dredging Congress*, Amsterdam, The Netherlands, 14-17 November 1995

Pilarczyk, K.W. 1994 Novel Systems in Coastal Engineering, Geotextile System and Other Methods, an Overview, *Rijkswaterstaat, Road and Hydraulic Engineering Division,* Delft, The Netherlands