SERRI Report 70015-002

2008 Geotextile Tubes Workshop

SERRI Project: *Increasing Community Disaster Resilience Through Targeted Strengthening of Critical Infrastructure*

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Through Targeted Strengthening of Critical Infrastructure

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16. Abstract

The objective of this report was to disseminate information from the *2008 Geotextile Tubes Workshop* held at Mississippi State University. A group of experts were invited to present past and present work in which they were/are involved related to the use of geotextile tubes. The participants were also asked to participate in two panel discussions led by a member of the research team. One panel discussion pertained to the use of geotextile tubes for construction of walls in a flooded area while the other dealt with rapidly dewatering fine grained soil with geotextile tubes. This report contains summary information written by the Mississippi State University research team and the full presentations made by the invited participants.

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The authors are also grateful for the financial support provided by the SERRI program under Task Order 4000064719. Funding for the workshop was not included in the task order, but all other efforts related to this multiple part research program were provided. In addition, due gratitude is extended to everyone employed at DHS and ORNL who worked diligently with the authors to make this project a success. A great deal of the success of this research can be attributed to the efforts of DHS and ORNL personnel.

A list of invited participants is provided within the report. The authors are indebted to these individuals for their selfless contributions to this effort. Ms. Walaa Badran (Graduate Research Assistant) of Mississippi State University is owed thanks for her countless efforts in formatting of the invited participant presentation slides. Dr. Sandra Harpole (Associate Vice President for Research), Dr. Donna Reese (Associate Dean of Bagley College of Engineering), and Dr. Dennis Truax (Civil and Environmental Engineering Department Head) aided in the success of the workshop by speaking at the workshop and providing general assistance, which is greatly appreciated.

Dr. Mohammed A. Gabr of North Carolina State University and Dewey W. Hunter of Ciba Corporation are owed special thanks for their courteously review of this report. The positive feedback provided was important to the successful completion of this document.

1.0 INTRODUCTION

The *2008 Geotextile Tubes Workshop* was held at Mississippi State University November 17 through 19 of 2008. The workshop was cosponsored by: 1) Department of Civil and Environmental Engineering (CEE) and Office of Research and Economic Development at Mississippi State University (MSU); and 2) Coastal and Hydraulics Laboratory (CHL) of the US Army Corps of Engineers Engineer Research and Development Center (ERDC). The workshop was held as part of a larger research effort, which is described in the following paragraph.

The work presented in this report was developed in partial fulfillment of the requirements of Task Order 4000064719 issued by the Department of Homeland Security (DHS) through its Southeast Regional Research Initiative (SERRI) program administered by UT-Battelle at the Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. The research was proposed by members of the CEE department to SERRI in a document dated 1 June 2007. The proposed research was authorized by UT-Battelle in its task order dated 10 December 2007. This task order included a scope of work defined through joint discussions between MSU and SERRI. Work on the project was initiated on 1 January 2008.

The work presented in this document is stand alone in the sense that it fully describes the *2008 Geotextile Tubes Workshop*, but is a complimentary document in that the purpose of the workshop was to gain information for use within other portions of Task Order 4000064719. The general objectives of the entire project were to investigate means for rapidly using on-site materials and methods in ways that would most effectively enable local communities to rebuild in the wake of a flooding disaster. Within this general framework, several key work components were defined and the resulting tasks from the 9 September 2008 task order are shown below.

- *Task 1: Erosion Control-Erosion Protection for Earthen Levee.*
- *Task 2: Bridge Stability-Lateral & Uplift Stability of Gravity-Supported Bridge Decks.*
- *Task 3: Levee Breach Repair-Closure of Breaches in Flood Protection Systems.*
- *Task 4: Pavement Characterization and Repair.*
- *Task 5: Emergency Construction Material Development-Staging Platform Construction.*
- *Task 6: Fresh Water Reservoir-Restoration of Fresh Water Supplies.*

The division of the research effort into the tasks shown above was essentially an internal work division created at *MSU*. It is useful for providing a context of the research described in this report and other reports developed during the research effort. It also allowed the work to be broken into manageable portions so that key components could be reported in separate volumes to allow readers to obtain only the work related to their needs. The work contained herein is directly associated with Tasks 5 and 6. This report is the second deliverable item of the research project, hence the designation of the report as *SERRI Report 70015-002* of Task Order 4000064719. Work related to Task 6 was also submitted in *SERRI Report 70015-003*; these two reports represent full completion of Task 6. Full completion of Task 5 will be presented in subsequent reports.

Attendance and participation at the workshop was by invitation only. Participants included (in alphabetical order) those listed below. In addition to those named multiple MSU administrators, staff, and students were also in attendance.

- Dr. Shobha K. Bhatia, Syracuse University
- Dr. Barry R. Christopher, Christopher Consultants (Provided Presentation but was unable to attend workshop due to illness)
- Ms. Jody Dendurent, TenCate Geosynthetics
- Dr. Jack Fowler, Geotec Associates
- Dr. Isaac L. Howard, Mississippi State University
- Dr. Mohammed A. Gabr, North Carolina State University,
- Mr. Douglas A. Gaffney, Ocean and Coastal Consultants, Inc.
- Mr. Ed Herman, US Army Corps of Engineers, Mobile District
- Mr. Dewey W. Hunter, NAFTA Dredging, Ciba Corporation
- Dr. George R. Koerner, Geosynthetic Institute (GSI)
- Dr. Dov Leshchinsky, University of Delaware
- Mr. Nate Lovelace, US Army Corps of Engineers, Mobile District
- Mr. Brian Mennes, Texas Commission on Environmental Quality
- Dr. Don Resio, USACE Engineer Research and Development Center (ERDC)
- Dr. Chris L. Saucier, Mississippi State University

- Dr. Miriam Smith, Mississippi State University
- Mr. Benjamin Thomas Jr., Oak Ridge National Laboratory
- Mr. Ed Trainer, TenCate Geotube
- Dr. Thomas D. White, Mississippi State University

This report only presents information from the *2008 Geotextile Tubes Workshop*; this report is not a literature review, nor does it present any research results related to other portions of this project. This report fully addresses deliverable Task 6d, which is to: organize a roundtable workshop to discuss ideas and experiences related to rapid development of underwater walls using geotextile tubes and to disseminate the best approach to rapidly design and construct geotextile tube walls for a fresh water reservoir. In addition the report provides information related to dewatering and construction of walls which was valuable information used in completion of Tasks 5d and 5g.

A brief description of geotextile tube technology is provided in Section 2. Summaries of the workshop presentations are included in Section 3. Information shared during the workshop panel discussions is summarized in Section 4. Section 5 discusses workshop findings as interpreted by the research team and summarizes the workshop as a whole. Finally, the full presentations given by the invited participants are provided in Section 6.

2.0 DESCRIPTION OF GEOTEXTILE TUBES

Geotextile tubes are manufactured by sewing together multiple sheets of geotextiles (typically woven) using polyester or polypropylene fabrics to create an enclosed tube. Tubes constructed of nonwoven geotextiles are not common in the US, but are used more frequently in Europe. Geotextile tubes may be filled with sand, dredged material, water, and in some cases, light-weight slurry. Geotextile tubes are similar in concept to geotextile bags, geotextile containers, and geomembrane tubes. Trademarked names for various types of geotextile tubes and similar structures include Geotube®, Geobag®, Geocontainer®, WaterStructures®, and AquaDam®.

Geotextile tubes are factory manufactured with a range of dimensions. Typical circumferences are between 4.57 to 18.29 m (other circumferences manufactured) and typical lengths are 61 m or less. Geotextile tubes may be placed individually or stacked. They have been used in a variety of Civil Engineering applications. Applications of geotextile tubes can typically be broken up into two categories: (1) structural applications, and (2) dewatering applications. In structural applications, geotextile tubes have been used as dikes or breakwaters for the prevention of beach erosion and the protection of coastal infrastructure. They have also been used for slope protection, to prevent scour under bridge piers and other structures, and to protect tunnels and underwater pipelines. Structural tubes are typically engineered to resist short and long term forces.

Geotextile tubes have been used to dewater dredged materials and contain contaminated materials. In such cases, the dredged and/or contaminated material is pumped into the tube, which acts as a confining mechanism. As the liquid escapes from the tube, solid particles are trapped inside. The pumping process is repeated (in some cases) until the tube is full. Eventually, the solids can be handled as relatively dry material, increasing options for transportation and disposal.

3.0 CONFERENCE PRESENTATION SUMMARIES

Both major application categories (structural applications and dewatering) were of interest to the research conducted under Task Order 4000064719. The use of geotextile tubes for structural applications was slightly favored when planning the workshop, but dewatering applications were significantly represented. In the remainder of this section, brief highlights of the workshop presentations are given as interpreted by the report authors and organized according to the following topics: (1) analysis and design of geotextile tubes, (2) use of geotextile tubes for structural applications, (3) use of geotextile tubes for dewatering applications, (4) quality-assurance and quality-control of geotextile tubes, and (5) case histories. Refer to Chapter 6 for the complete presentations given by the invited participants.

3.1 Analysis and Design

Dr. Leshchinsky (Section 6.9) provided an overview of a self developed design method for geotextile tubes. The method assumes a non-yielding foundation, and is based largely on material from the references provided at the beginning of the presentation. One objective in design of a geosynthetic tube is to evaluate the post-filled geometry of the tube, which is correlated to the storage capacity and required strength of the geosynthetic material. It was noted that the post-filled height of a geotextile tube is very difficult to control if the tube is filled in a pressurized condition. However, the height is more easily controlled if the tube is filled with soil. In some cases, tube height may be increased if the tube is placed in a confining trench.

Dr. Leshchinsky has developed a Windows-based computer program called GeoCops (original version was DOS based) that may be used to evaluate the geometry of a filled geosynthetic tube. He provided a brief overview of the mathematical formulation behind GeoCops, and demonstrated that the results of GeoCops provide a good match to experimental data. Additional information on GeoCops is available from the developer upon request.

Construction sequencing and seam strength were stated to be the two most critical factors in geotextile tube design (structural design with geotextile tubes poses additional challenges). During filling, fluid is pumped into the tubes under pressure. Geotextile tubes are typically constructed of medium to high strength geotextile material and as a result, have low efficiency seam strengths. If fluid pressure is too high, seam failure may occur. A reduction factor of 45 to 50% should be applied to design geotextile strengths to take into account possible seam failures.

Dr. Fowler (Section 6.4) provides consulting services for geotextile tube design and construction. He uses a software program called GETube Design to calculate fabric stresses during the critical time of filling and installation when the fill material is fluid. In his presentation, Dr. Fowler provided an overview of various dredging and geotextile tube filling methods for both structural and dewatering applications.

Dr. Gabr (Section 6.5) presented an overview of currently available design methods for geotextile tubes, including the method presented by Dr. Leshchinsky. He also provided an extensive list of references regarding the design of geotextile tubes, which may be found at the end of Section 6.5. It was emphasized that there is a significant lack of well-documented design procedures for geotextile tubes in the literature.

Dr. Gabr discussed design procedures that evaluate the geotextile tubes internal stability during filling and during the lifetime of the tube, as well as the tubes external hydrodynamical stability. One significant issue in design includes determining the hydrodynamic pressures both on the front and the back of the tube when they are used in coastal protection applications. Dr. Gabr presented two references for evaluating hydrodynamic pressures (i.e. Shin and Oh 2007; Liu 1981; see Section 6.5) but stressed that more research is needed. It was noted that in many cases the assumption that geotextile tubes are rigid bodies is made when in fact they are not rigid bodies. It was also stated that external stability calculations are performed assuming geotextile tubes are rigid bodies.

Mr. Lovelace (Section 6.10) provided practical factors to be considered in design and construction using geotextile tubes. He pointed out that schedule (and thus cost) is strongly affected by general climate, tidal variations, seasonal rains, and seasonal winds that can cause construction to be more difficult. Along these lines, run-off should be controlled to avoid constructing in the wet. The foundation for the tube is critical and in some cases, a foundation must first be constructed. A mild trench or "cradle" in the foundation will help prevent geotextile tube rollover. Another critical design factor for routine applications is the scour tube, which, if heavy enough, may be used to tie off the main tube. During construction, care should be taken when terminating the tubes; damage often begins at the end of the tube and progresses along the length of the tube. For long-term applications, it is critical that adequate fill be placed on top of the geotextile tubes. Mr. Lovelace recommended constructing a "test tube" whenever possible to confirm both the expertise of the installer and the installation process. This recommendation aligns with other comments regarding the need to ensure the methods used are appropriate and contractors are qualified.

3.2 Structural Applications

Both Mr. Trainer (Section 6.12) and Dr. Fowler (Section 6.4) discussed several applications and case histories of geotextile tubes used for structural applications. Marine applications of geotextile tubes include but are not limited to:

- Core of a sand dune
- Core of rip rap breakwaters

- Core of rip rap jetties
- Underwater structures
- Diversion dikes
- Dredge material containment

Mr. Gaffney (Section 6.6) discussed the use of poor-quality material in geotextile tubes designed for structural purposes. “Poor” quality materials are typically considered to be low-strength fine-grained soils such as silts and clays and are often cohesive. These poor quality materials are commonly used when tubes are filled with dredged material. Cohesive materials within the tubes undergo consolidation and become denser with time. Waves and currents on the tubes may pull fines out of the tubes, an erosive process termed “piping.” Piping is worse for uniformly graded fine-grained soils.

Mr. Gaffney discussed a project in which geotextile tubes were used for emergency coastal erosion control in New Jersey. For this project, approximately 275 linear meters of geotextile tube was constructed in 1997 using imported sand at a cost of about $163,000. Mr. Gaffney also discussed an ecosystem restoration project on Drakes Creek in Tennessee developed by the US Army Corps of Engineers, and the case history of the Nyack Municipal Marina on the Hudson River. More details on these projects can be found in Section 3.5.

Mr. Trainer emphasized that for sand dune protection, a scour apron is necessary on both sides of the main structural tube. The apron should be taut on the seaward side of tubes in order to dissipate wave energy. Similar to Mr. Lovelace, Mr. Trainer pointed out that a high volume of water escapes the tubes during pumping and consolidation when using sand, and that the escaping water can erode nearby soil. The run-off can be controlled with scour aprons.

A presentation provided by Dr. Christopher indicated widespread acceptance of viable new technologies require excessive time. Many non-technical issues were noted regarding implementation of geotextile tubes in a variety of structurally oriented applications within the Strategic Highway Research Program (SHRP2). They included: 1) lack of knowledge about the technology; 2) lack of policies to encourage new technology use; 3) lack of qualified contractors, personnel, materials, and equipment; and 4) lack of profit or return on investment.

3.3 Dewatering

Geotextile tubes are often used to dewater fine-grained sediments. With time, water escapes the geotextile tubes and as a result, the shapes of the tubes change. Dr. Fowler listed factors for estimating consolidation, bulking, and shrinkage: (1) in-situ density, percent solids, or moisture content of the fill material prior to dewatering, (2) in-situ density or percent solids or moisture content of the fill material after dewatering (target value), (3) gradation and/or Atterberg Limits (LL, PL, & PI) of the fill material, (4) settling time, and (5) polymer requirements. The bulking and shrinking of the fill material varies based on dredging scenarios and the properties of the fill. Dr. Fowler discussed several dewatering case histories, which are presented in Section 6.4.

Mr. Hunter (Section 6.7) discussed the chemistry and use of polymers in treating fine-grained sediments dewatered within geotextile tubes. Polymers are only effective for soils such as silts and clays (soils that pass the No. 200 sieve). Chemical treatment may be used on problematic sediments (i.e. contaminated soils) and improve dewatering process efficiency. It was noted that Ciba manufacturers on the order of 200 flocculants. There are several ways in which the dewatering process is improved through the use of polymers. Polymers may be used to improve the solids-liquid separation with time. As a result, the amount of water discharged during the dewatering process is increased. Finally, polymers improve the solids removal efficiency, or capture rate. The capture rate is defined in Eq. 1.

$$C_R = \frac{S_{In} - S_{Out}}{S_{In}} \qquad (1)$$

Where,

C_R = capture rate

S_{In} = solids in

S_{Out} = solids out

Mr. Hunter provided test results where an organic clay sample from New Orleans (referred to in this research as *Soil 2*) was tested at the Ciba laboratory in October of 2008 in the presence of *MSU* research personnel. An 11.51% slurry was evaluated using TenCate's *Geotube*® *Dewatering Test* (*GDT*), which is informally referred to as a *Pillow Test* in some instances. Summary details were provided by Mr. Hunter in Section 6.7, and full details will be made available in future reports within Task Order 4000064719 related to dewatering soil.

A demonstration was performed during the workshop by Mr. Hunter using *Soil 2*. The initial percent solids of the sample were 6.2% (the sample was diluted to 6.2% solids for visualization during the demonstration). A settling column demonstration and a gravity flow drainage test were performed. The settling column demonstration separated large quantities of water from the solids in seconds, and immediately after the demonstration the columns were carefully transported to the laboratory where the clean water was pumped out of the top of each of the two columns to allow measurement of the moisture content (Eq. 2) and the percent solids (Eq. 3). The gravity flow drainage test was performed and passed around to participants for visualization (took only a few minutes). Thereafter, a sample was taken from the apparatus used to perform the experiment and tested for moisture content and percent solids. The results of the two settling column demonstrations were: 1) $w_{\%}$ of 347 and 388; and 2) $TS_{\%}$ of 22.4 and 20.5. Results of the gravity flow drainage test were: 1) $w_{\%}$ of 285; and 2) $TS_{\%}$ of 26.0.

$$w_{\%} = \frac{w_w}{w_s}(100) \tag{2}$$

$$TS_{\%} = \frac{w_s}{w_w + w_s}(100) \tag{3}$$

Where,

$w_{\%}$ = moisture content expressed as a percentage

w_w = weight of water (g)

w_s = weight of solids (g)

$TS_{\%}$ = total solids expressed as a percentage

Dr. Bhatia (Section 6.2) discussed on-going research being performed at Syracuse University, which included discussion of the capture rate (Eq 1). The goal of the research is to evaluate the rate and efficiency of the dewatering process using geotextile tubes, both with and without the use of polymers. Specific goals of the research include: (1) evaluating the relationship between geotextile properties, sediment characteristics, and dewatering parameters, (2) evaluating the use of polymers for enhancing the dewatering process, and (3) assessing the suitability of test methods in predicting field dewatering performance. The research presented consisted of performing laboratory tests using a non-plastic silt. Preliminary conclusions and observations include that piping of fine-grained material increases when a non-woven geotextile is used, and that polymers are effective in decreasing piping and enhancing the dewatering process but only up to a "critical polymer dose" level.

3.4 QA and QC of Geosynthetics and Geotextile Tubes

Dr. Koerner (Section 6.8) discussed geosynthetic material characteristics and corresponding laboratory testing. He emphasized the leadership role of manufacturers in geotextile and geotextile tube applications. He pointed out that project specifications generally contain check lists on the manufacturers only; in other words, project specifications often control the quality of geosynthetic product as a correlation to achieving desirable construction properties, but they do not provide performance guidelines. The most commonly used geotextile tube specification is GRI-GT10, Application Specification for "Coastal and Riverine structures," which was developed in 1999. Similar to Dr. Leshchinsky, Dr. Koerner noted, that the "strength" of the tube is controlled by seam strength.

3.5 Case Histories

Field-Scale Test of Rapid Repair of Levee Breach

Dr. Resio presented results from a Department of Homeland Security (DHS) sponsored research program titled "Rapid Repair of Levee Breach" initiated in 2007. Project team members include representatives from the US Army Corps of Engineers Engineer Research and Development Center and the private sector (Oceaneering and Kepner Plastics). Dr. Resio and his colleagues at the Engineer Research and Development Center (ERDC) conducted a demonstration at the U.S.

Department of Agriculture's Agriculture Research Service's Hydraulic Engineering Research Unit Laboratory in Stillwater, Oklahoma in which they used a geomembrane tube, partially filled with water, to block a 2.43 m wide breach in a quarter scale levee. The tubes were transported by helicopter and floated into place using the water flowing through the breach. Further research is ongoing but according to Dr. Resio the results of the initial tests in Oklahoma are promising.

Bolivar Island, TX

Dr. Fowler discussed a case history in which polyester geotextile tubes were used for shore protection on the Bolivar Peninsula along the Texas Coast. Approximately 5,500 linear meters of tubes were constructed in 2000. A UV shroud was placed above the tubes to protect them from long-term UV exposure. Dr. Fowler did note, however, that polyester was not an ideal material for these tubes but did not elaborate. The tubes protected structures along the coast line during Tropical Storm Allison in June 2001. Though the tubes were initially buried, they were exposed during the storm. The tubes were successful in protecting the coast line in 2001 and as a result, an additional 4,500 linear meters of geotextile tubes were placed. The same tube system also protected the coast during Hurricane Ike in 2008.

Coastal Protection During Hurricane Ike

Dr. Gabr made a presentation on performance of geotextile tubes during Hurricane Ike. Nine geotextile tubes were used to protect 12.2 km of shoreline. The tubes had circumferences of 9.14 m and lengths of 76.20 m. The factors of safety for sliding, overturning, and bearing capacity were determined based on the assumption that the geotextile tubes were rigid bodies. Furthermore, it was assumed that the tubes had an oval shape and that the contact width at the base of the tube was 80% of the longest diameter. Two significant problems that developed during and after the hurricane included: (1) erosion developed on the landward side of the tubes, and (2) some tubes were overtopped while others were completely buried. Overall, the geotextile tubes provided sufficient protection for landward structures.

Temporary Dam in Morocco

Mr. Trainer discussed a temporary dam constructed in Morocco using Geotube® units. (Geotube® is the registered name held by TenCate for their geotextile tubes.) The dam was approximately 70 m long. The fill height of the tubes was 3 m. The existing rock walls were first smoothed by placing concrete. The first Geotube® unit was placed, and then the second was placed 3 m from the first. The gap between the bottom tubes was filled with sand and then covered with a geotextile. The third and final Geotube® unit was installed on top of the other two units and intermediate sand. A membrane was then placed over the entire structure. Once the dam was created, water was pumped out from one side of the dam to allow construction.

USACE Drakes Creek Restoration

Mr. Gaffney discussed an ecosystem restoration project on Drakes Creek in Tennessee for the US Army Corps of Engineers. A U-shaped dike-contained channel was constructed using geotextile tubes. The purpose of the channel was to increase the discharge velocity of silt-laden stream water into a larger river. Approximately 640 linear meters of geotextile tubes, with circumferences of 13.72 m, were constructed. The tubes were filled with dredged material which consisted of a wide range of material from organics to silty sand to 125 mm stone. The river was dredged to increase depth and the new river alignment provided improved habitat. The project was constructed in 2000 and in 2008 the geotextile tube dikes remained in place and were functional.

Nyack Municipal Marina

Mr. Gaffney made a presentation on use of tubes at the Nyack Municipal Marina on the Hudson River. The project consisted of removing approximately 1,375 m^3 of river sediment quickly and cost-effectively in a populated setting. The dredged material consisted of plastic and organic silt (MH and OH). Competing alternatives to the use of geotextile tubes included open air disposal and filter presses. The material was placed in geotextile tubes and mixed with a polymer to enhance the dewatering process. Mr. Gaffney noted that dewatering and consolidation of dredged material occurs faster in geotextile tubes than in standard self-weight consolidation procedures. Another benefit of using geotextile tubes for dewatering is that they are not a “batch process.” One factor, however, to consider in river dredging problems is the vast amount of large debris in river bottoms. At the Nyack Municipal Marina project, the dewatered/treated sediment was subsequently mixed with lime and used in building a parking lot. The material was stabilized with 15% lime and tested using a hand held vane shear device practically identical to the *shear* device used in Task 5 of the research conducted by the MSU research team under Task Order 4000064719. When asked about the hand held vane shear device, Mr. Gaffney had no positive or negative feelings towards it.

<u>Gaillard Island</u>

Dr. Leshchinsky presented information on a project conducted on Gaillard Island. During the project, moisture content data was taken along a geotextile tube. The results of the moisture content data can be seen in Table 1.

Table 1. Moisture Contents within Geotextile Tube at Gaillard Island

Time (days)	Location (m)	Unit Weight (g/cm^3)	Moisture Content (%)
0	0	1.25	214
	70	1.19	284
	140	1.17	308
30	0	1.35	127
	70	1.29	153
	140	1.19	286

4.0 PANEL DISCUSSIONS

4.1 Panel Discussion: Structural Applications

A safe water supply is central to the survival and recovery of flooded communities. The Environmental Protection Agency (EPA) and World Health Organization (WHO) assume 2 liters of water is needed per individual per day for ingestion. When water for cooking, first aid, and sanitary needs are added to the ingestion requirements, the amount of fresh water required in a community can easily reach 40 L per day per individual. For a community of stranded residents (lasting days to weeks) and aid workers (lasting days to months), the reservoir required to store an adequate fresh water supply would have to be quite large. In addition, distribution of the water may be challenging, so that placement of the fresh water supply at specific locations to optimize the needs of the community would address a primary need in the aftermath of a disaster.

During the panel discussions, the workshop participants discussed the design issues associated with constructing emergency reservoirs using geotextile tubes. The concept of developing a water reservoir for a disaster area where potable water could not be trucked in was said to be a potentially valuable concept. One example provided was an offshore location such as an island that had been struck by a hurricane. Participants agreed that a decision tree was important to guide the responder in making logical decisions based on the disaster, materials available, constraints, site, and timeline. No such decision tree currently exists.

For discussion purposes a typical emergency reservoir, 3.05 m tall with dimensions of 61 m square, and a design life of 6 months was considered. However, a floating water reservoir was also mentioned as an option. This could be performed by taking two water filled geomembrane tubes and attaching a geomembrane between them. Treated water could be pumped onto the geomembrane causing it to sink below the floating perimeter.

There are many challenges associated with designing emergency reservoirs using geotextile tubes. These challenges are discussed in the following paragraphs. Further research into the applications and design of such reservoirs is being performed at Mississippi State University.

Planning

Large diameter geotextile tubes are not as readily available, and therefore, a reservoir would likely be constructed from smaller stacked tubes. A minimum of three days was said to be required to obtain standard tubes from the manufacturer in the majority of cases. It was noted that dewatering tubes are more readily available. Special-order tubes would take longer to obtain. According to Dr. Fowler, one water filled geomembrane tube could be filled on the order of 3.7 m high. The overall tone of the participants seemed to favor a stacked system that did not rely on a single tube that was very tall, regardless of the fill material. For stacked flexible tubes, it should be recognized that there is currently no widely accepted method for designing a wall constructed of a group of flexible tubes.

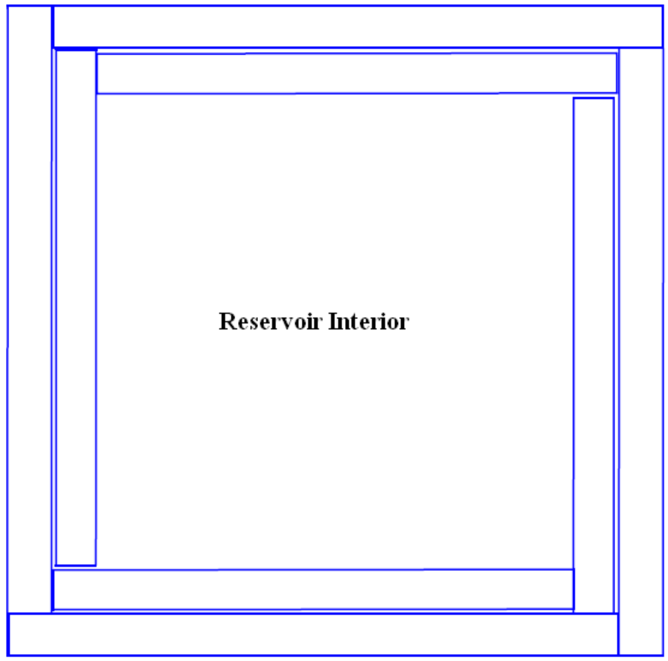
Challenges include the difficulty in obtaining permits for marine construction, and the high cost of rapid equipment mobilization. Furthermore, soft marine soils may experience large short-term settlements that could adversely affect construction.

When selecting a site to construct the reservoir, the preferred location for construction is a hard and flat surface (e.g. parking lot). Puncture resistant specifications for the tubes and/or specifications to identify the procedures for site preparation would be needed. The site should be cleared of all obstructions before placement, which could be difficult in flooded areas. Location of utilities would need to be performed and the material acquisition boundaries defined for this application.
During the planning stage, designers should recognize that water filled tubes eliminate the need for a dredge. The acquisition of fill material from the local area should be considered.

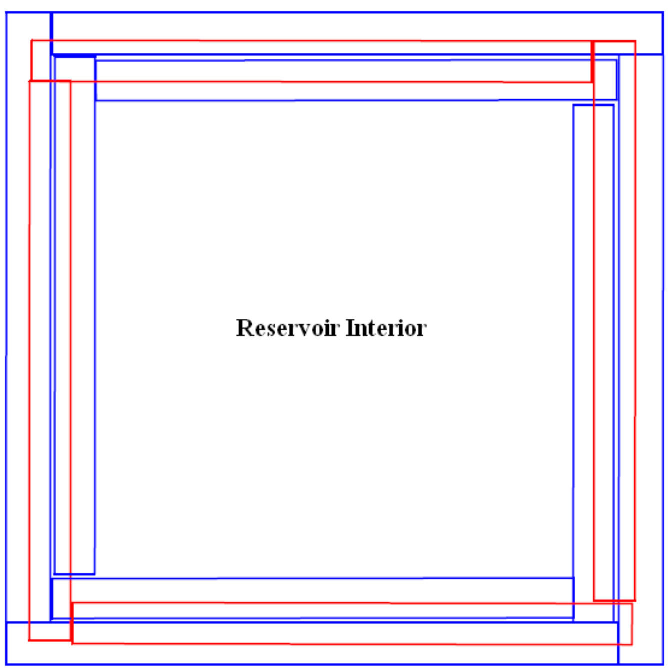
Construction
A reservoir constructed with a single tube providing the required height could be easier to build and avoid some problems at the corners of a square reservoir. It was mentioned, though, that if tubes need to be stacked that an elliptical shape could pose some problems: (1) the outside perimeter of the tubes would experience high stresses, and (2) tube placement is not very accurate. The reservoir, therefore, would more likely be built in a square configuration, stacking the corners in a configuration similar to that of a log cabin, as sketched in Figure 1.

If tubes are filled with water, seaming the bottom two tubes together will probably be necessary provided the tubes do not contain a baffle. It was recommended that seams be sewn with a union special, which is a hand held device (110 V). To check the seam, a peel test was recommended at a threshold value of 40%. It was noted that it will be difficult to seam and weld membranes in a disaster situation. A hot wedge welder was also mentioned.

Settlement, thermal variations leading to expansion and contraction, and leaking that results in reduced wall height could be potential concerns. If the walls of the reservoir are filled with contaminated material it will probably need to be treated at the end of the process. Polymers could be useful for this application.



(a) Bottom Row of Tubes



(b) Bottom and Top Rows of Tubes

Figure 1. Schematic of Stacked Tubes to Form a Reservoir

4.2 Panel Discussion: Dewatering Applications

The discussion began with posing a general problem: area flooded with 2.44 to 3.05 m of water and a subsurface soil profile with 7.6 m of clay covering sand. The goal was to use the material beneath the water as an emergency construction material. Dr. Fowler was of the opinion that it was essential to find suitable material.

Conversation related to use of the material focused on movement of the material from beneath the water to the construction site. One component discussed was the *DryDredge*™. It is a dredge that uses a positive displacement pump fed by a clamshell bucket. This dredge was mentioned as a means of transporting low water content material.

Dewatering technology (i.e. polymers) were also discussed during the panel discussions. A dredge on a barge could pump material (10% to 30% solids) onto a second barge with a clarifier (this could either be a standard clarifier or a geotextile tube). The material would be held on the barge for a short time (e.g. 1 hour) and then be transported into either a mixer for stabilization materials or into the geotextile tube. A general flowchart was sketched to highlight the major steps required to perform the functions using dewatering polymers. This method would transport high water content materials, dewater them, and then use the dewatered mass for filling the geotextile tubes.

It was noted that construction time for a reservoir made of geotextile tubes could be considerable; a production rate on the order of 110 wet metric tons per hour was mentioned using the *DryDredge*™. It was crudely estimated during the panel discussion that the method using polymers could theoretically produce on the order of the same amount of material as the *DryDredge*™. Regardless of the transport mechanism, the material could be placed in a mixer for soil stabilization and then moved to the final location, or moved to the final location and stabilized in place.

5.0 SUMMARY OF WORKSHOP FINDINGS

Several important points can be taken from the workshop. First, a consensus was not reached regarding the appropriate uses and/or approaches to implement regarding the two primary project goals (construction of structural walls and rapid dewatering of material for immediate re-use in construction). A wealth of information was presented and discussed, but a clear consensus was never achieved.

The significance lies in the immediate nature in which a large disaster must be addressed. To effectively use geotextile tubes in this environment, planning, training, and demonstration exercises are needed beyond that currently in existence for both applications discussed. Provided the invited participants adequately represent the geotextile tube industry as a whole, implementation of rapid geotextile tube projects could be problematic as of the date of the workshop. Select participants indicated construction time of comparable projects in normal conditions with typical personnel and equipment resources could take a few weeks.

One subject discussed by the group and echoed by Dr. Koerner is that there is a lack of quality-assurance and quality-control (QA and QC) during the design and installation of geotextile tubes. Dr. Koerner and Mr. Trainer pointed out that there are a lot of geotextile manufacturers, but designers need to consider only geotextile tube manufacturers, and they need to consider specialty contractors to build with the geotextile tubes (often in conjunction with dredgers). Currently, different construction techniques exist based on geographically available equipment. The workshop group agreed that there is a need to develop a pre-certification system for geotextile tube installers, who then can be on a list for rapid response.

It was suggested that the certification system could be similar to that of the International Association of Geosynthetic Installers (IAGI), though IAGI is currently not relevant to geotextile tubes since they do not have current geotextile tube test protocols. It was suggested that the Geosynthetics Institute (GSI) could certify geosynthetic tube installers and develop standard tube specifications and standards of practice for tube installation. The result would be standardization of tube materials, fabrication, and installation. Pre-certification of emergency response contractors was specifically endorsed by multiple participants, notably Mr. Gaffney, Mr. Trainer, and Mr. Lovelace.

The previous discussion is applicable to structural and dewatering applications within a disaster environment. Items applicable to only one of the two categories have been separated. They can be found in the following sections.

5.1 Summary of Findings for Structural Applications

There was found to be a lack of well documented design procedures for structural applications. External hydrodynamical stability is the parameter that appears to be the least understood for this application in terms of geotextile tube stability in structural applications. Rigid bodies are often assumed. This assessment was based largely on data provided by Dr. Gabr. On the other hand, internal stability methodologies and software appear to be fairly well developed.

Two distinct categories of structural applications were found to exist depending on the material filling the tubes: 1) sand, i.e. select material, or 2) fine grained material such as silt or clay, i.e. non-select material. The use of select materials to fill geotextile tubes for structural applications was, in general, strongly preferred. The use of non-select material (e.g. silt and clay) was a point of contention. Specific details regarding non-select material use were discussed without producing directed or immediately applicable end products. Some participants were of the opinion that non-select materials with very low initial percent solids were worth investigation while other participants were less optimistic and in turn less supportive of the concept. Dr. Koerner indicated that there were potential problems with fine grained material inside a geotextile tube used for structural applications prior to consolidation of the material. Non-select material applications were presented during presentations of invited participants but they were not rapid projects (at least not rapid based on the needs of a disaster environment). Rapid dewatering and/or cementitious stabilization of non-select materials were also discussed and felt to be potentially viable options by some participants.

Construction practices were discussed but not conclusive. It was mentioned that the best practice was to fill one geotextile tube, fill it all at once, and match equipment with the geotextile tube volume. Movement of material to where the geotextile tubes are to be filled was philosophically debated. When using select material, the lack of affinity for water was noted to allow 10 to 15%

solids slurry to fill a geotextile tube more evenly and more quickly than say 30% solids. Sand was slurried and pumped into Geotube® units in a project at the NASA Wallace Flight Center.

Additional items discussed during the workshop that are noteworthy are provided in the following bullets.

- Polyurea coated tubes could provide some benefits to a freshwater reservoir. This coating has been sprayed onto geotextile tubes before and after deployment. The top portions of the tubes could be sprayed with the coating to increase puncture resistance and make them more impermeable while the bottoms of the tubes remain untreated.
- Traditional applications cost \$245 to \$825/m including material and construction costs according to Mr. Trainer. Offshore work requiring divers is noticeably more expensive, but the costs associated with emergency construction using geotextile tubes does not appear to be way out of line with disaster recovery.
- The *USACE* is considering slurrying and pumping material on upcoming projects on the Mississippi coast in a wetlands area in conjunction with filling geotextile tubes.
- According to Mr. Lovelace, the first geotextile tube placed on the project is often the worst.
- Mr. Lovelace indicated marsh buggies can be useful when building with geotextile tubes.
- Mr. Trainer indicated patching material for geotextile tubes can be purchased at local retailers (e.g. building supply stores).
- Care should be taken when terminating geotextile tubes since damage often begins at the ends of tubes.
- Many of the problems faced by the Strategic Highway Research Program included in a presentation provided by Dr. Christopher appear to be similar to challenges of emergency use of geotextile tubes.
- The *Dry DREdge™* presented by Dr. Fowler can pump many materials at in-situ density with no free water. This attribute is valuable for use when attempting to produce an emergency construction material such as in Task 5 of Task Order 4000064719. Photos were provided of material pumped at 70% solids.

- Geotextile tubes were used as the main structural component for ecosystem restoration and made beneficial use of poor quality dredged material in work presented by Mr. Gaffney.
- Acquisition of fill material from the local area was noted to be very important.
- Levee breach work of Dr. Resio shows significant promise for rapid construction using geotextile tubes. Effective levee repair must be conducted within hours.

5.2 Summary of Findings for Dewatering Applications

Rapidly dewatering material for immediate re-use as an emergency construction material was discussed at the workshop. The majority of this dialogue occurred during the corresponding panel discussion. Items discussed during the workshop that are noteworthy are provided in the following bullets.

- Dr. Bhatia's research indicates polymer tends to decrease permeability of the filter cake.
- Mr. Hunter noted that most polymer companies keep little inventory in the current markets so warehousing may be needed.
- Ciba has a containerized liquid polymer makedown system ideal for disaster dewatering needs. It is completely enclosed, can be transported on a commercial tractor-trailer, and only requires external water and power. The difficulty could be the limited number of these units commercially available. Smartfeed™ is another mobile feed chemical system for polymers.
- Dewatered sediments are commonly left much longer than would be possible in the current project, but the percent solids achieved appear sufficient for development of emergency construction material. For example, the Fox River sediments averaged 50% total solids. The challenge to researchers is balancing an acceptable percent solids with tolerable dewatering times.
- Many tools exist in current practice that make rapid dewatering worth investigation, but research and planning is needed before a method would be ready for implementation.

SECTION 6.O
PRESENTATIONS GIVEN BY INVITED PARTICIPANTS

Fourteen presentations were given during the course of the workshop. The initial presentation was given by one of the report authors outlining the workshop and use of the information obtained. The remaining thirteen presentations were given by invited participants. The presentations have been included in essentially the same form as they were presented at the workshop. All presentations have been placed into a standard format for consistency within this report, and some presentations have been slightly adjusted from the form in which they were presented to preserve space. Any modifications that could have affected the content were discussed with and approved by the presenter. The thirteen presentations given by the invited participants are provided in alphabetical order.

Section 6.1

Geotextile Tubes Workshop

Statement of Workshop Goals: Isaac L. Howard

Mississippi State University
Civil and Environmental
Engineering Department

Mississippi State University
Office of Research

US Army Corps of Engineers Research and Development Center Coastal and Hydraulics Laboratory

Geotextile Tubes Workshop

Part of a research project funded by:

the US Department of Homeland Security (DHS) through UT Battelle at Oak Ridge National Laboratory under SERRI.

SERRI
Southeast Region
Research Initiative

Geotextile Tubes Workshop

<u>Overall objective of SERRI project:</u>

Develop materials, and design and construction procedures that may be rapidly deployed to protect and restore infrastructure during flooding events.

Six Tasks:

1: Levee Erosion Protection During Overtopping
2: Bridge Deck Stability
3: Levee Breach Closure
4: Rapid Pavement Repair

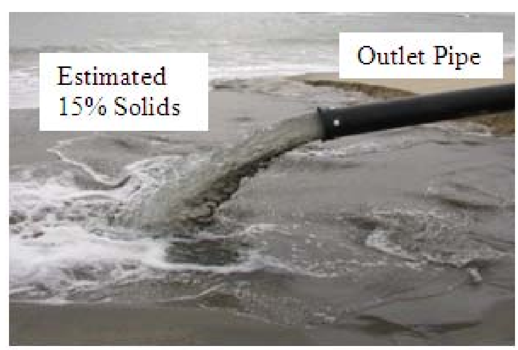
5: Emergency Construction Material
6: Geotextile Tubes – Fresh Water Reservoir

Geotextile Tubes Workshop

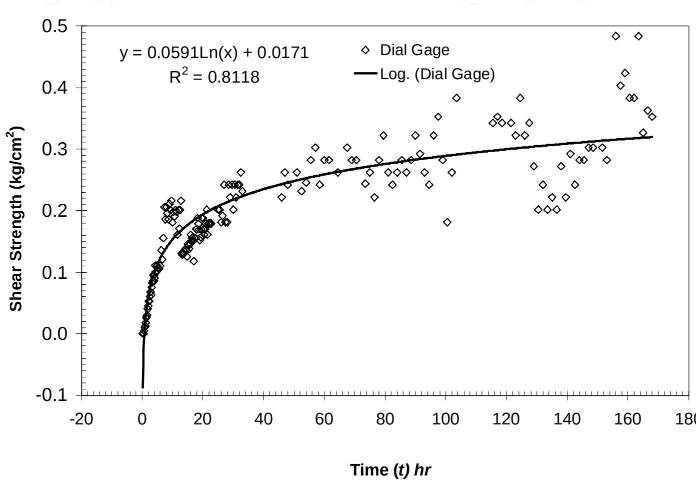
Task 5 Goal:

Develop Emergency Construction Material Using a Variety of Techniques Including Rapidly Dewatering Dredged Soil Using Polymers and Geotextile Tubes

(e) Output of High Percent Solids



(f) Output of Low Percent Solids



Geotextile Tubes Workshop

Task 5 Goal:

Develop Emergency Construction Material Using a Variety of Techniques Including Rapidly Dewatering Dredged Soil Using Polymers and Geotextile Tubes

(a) Synthetic Liner

(b) Pouring Stabilized Slurry Into Mold

(c) Shoveling Stabilized Slurry Into Mold

(d) Massaging Out Large Air Pockets

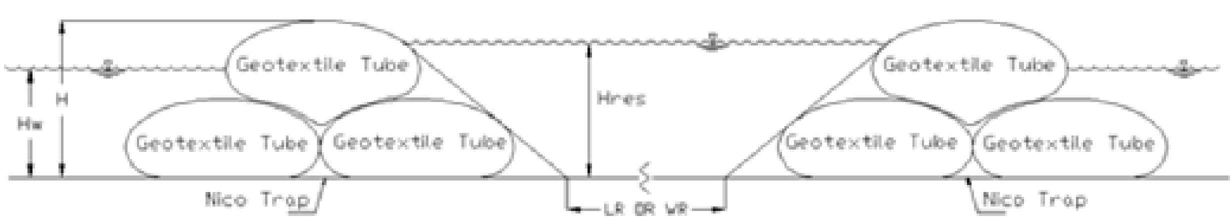
(e) Striking Off Surface

(f) Final Product

Geotextile Tubes Workshop

Task 6 Goal:

Optimize geotextile tube use in disaster environments

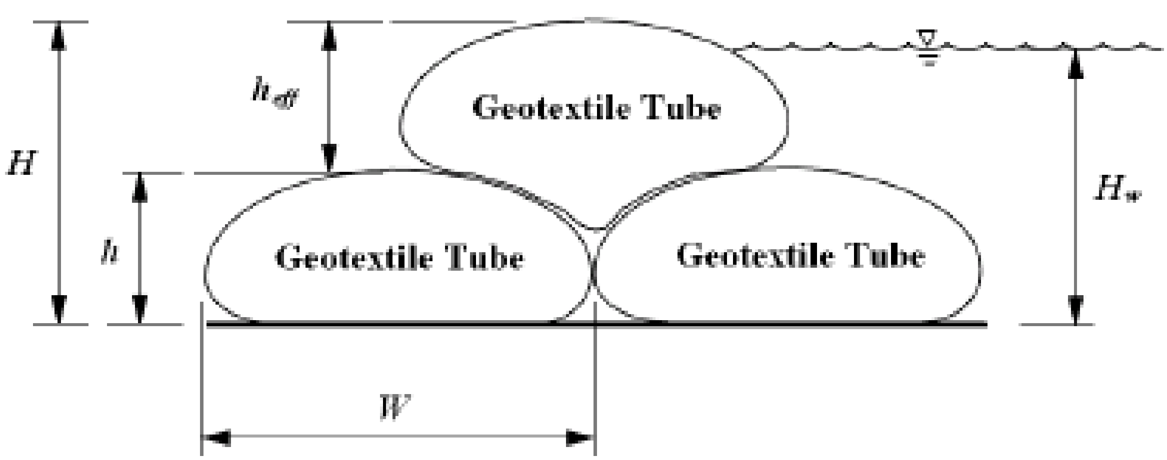


Geotextile Tubes Workshop

<u>2008 Workshop Goal:</u>

Gather, synthesize, and disseminate current knowledge regarding State-of-Practice of the design and use of geotextile tubes.

Consider: design, specifications, construction, case studies, etc.



Geotextile Tubes Workshop

Dissemination of Information:

- **Presentations will be <u>directly</u> published in the form of <u>conference proceedings</u>.**

- **Information discussed during panel discussions and breakout sessions will be <u>recorded, edited, and published</u> in a final report.**

- **Individual contributions of information during these general discussions will remain <u>anonymous</u>.**

Geotextile Tubes Workshop

Attendees:

Government Agency?

University/College?

Manufacturer?

Consultant?

Institute?

Emergency Management?

Other?

Geotextile Tubes Workshop

November 17 – 19, 2008

Mississippi State University

Welcome!

Section 6.2

2008 Geotextile Tubes Workshop

Nov 17-19 2008, Starkville MS

- ***Presentation Title:***

  Laboratory Study on the Role of Polymers in Rapid Dewatering

- ***Author:***

  Shobha K. Bhatia, PhD

- ***Affiliation and Contact Information:***

  Civil and Environmental Engineering

  Syracuse University, Syracuse, New York 13244-1190

Jointly Sponsored by:

•Mississippi State University Civil and Environmental Engineering Department

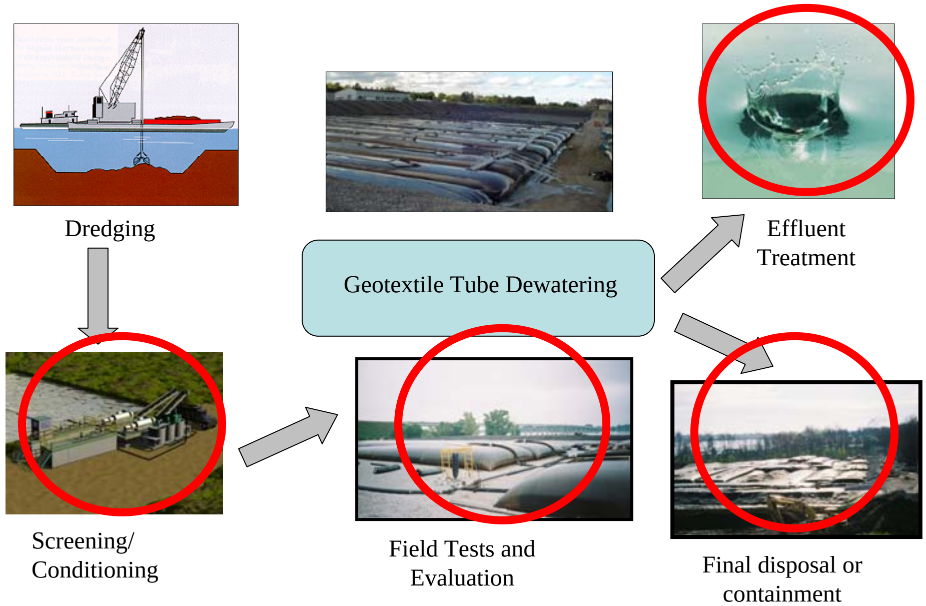
•Mississippi State University Office of Research

•US Army Corps of Engineers Research and Development Center Coastal and Hydraulics Laboratory

Research Objectives

- To conduct a systematic laboratory study to evaluate relationship between geotextile index properties, sediment characteristics and dewatering parameters;
- To evaluate the use of polymers for enhancing dewatering parameters;
- To asses the suitability of test methods in predicting field dewatering performance;
- To develop design recommendations for designers and engineers.

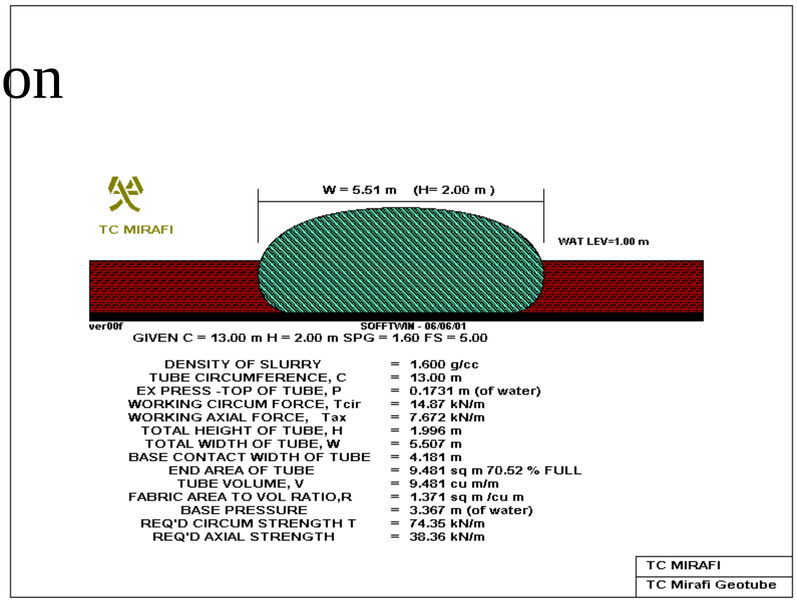
1

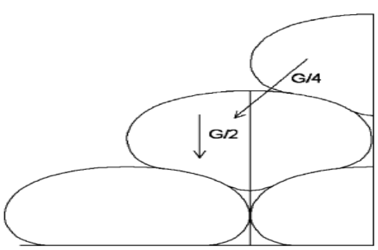


2

Project Implementation

- **Design** - Geotextile, No. of tubes, configuration of tubes, dewatering rate, and efficiency
- **Lab Testing –** Small scale (Jar Sedimentation, Falling Head and Pressure Filtration Test)
- **Field Testing -** Hanging Bag Test, GDT, Demonstration Test, Full Scale Test





3

Geotextile tubes design considerations

1) Type of geotextile, geometry and number of tubes
2) Deformed shape
3) Final configuration

Dewatering Parameters

1) Filtration Efficiency (%) = $(TS_{initial} - TSS_{final})/TS_{initial}$

where, $TS_{initial}$ = total solids in slurry; TSS_{final} = total suspended solids in filtrate

2) Dewatering Time

4

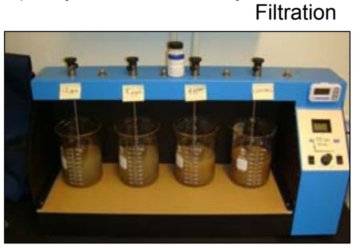
Geosynthetic Research Laboratory


Capillary Flow Porosimetry


Pressure Filtration


Falling Head Test


Hanging Bag Test [Small & Large]


Jar Test


Streaming Current Detector

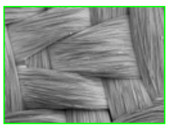

Filtrate Quality Evaluation

5

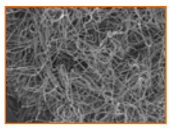
Geotextiles used in the study

W1 - monofilament

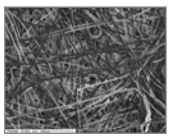
W2 - multifilament



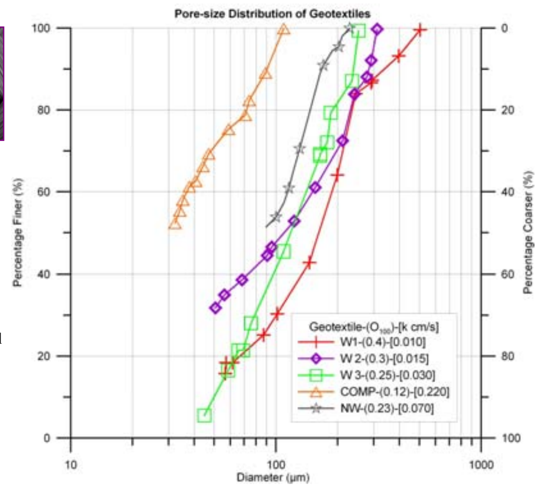
W3 - multifilament



COMP –needle punched

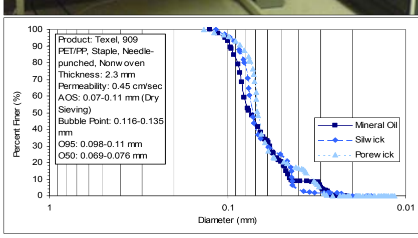


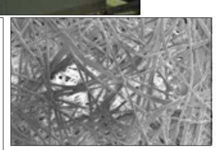
NW – non-woven

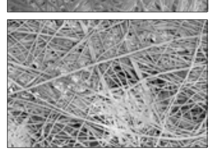


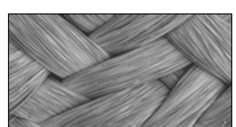
6

Pore size, volume, permeability, density, surface area, and adsorption









W2 - multifilament

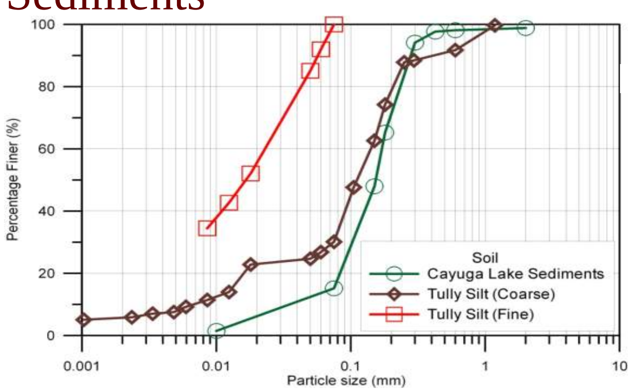
7

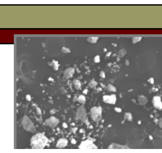
Geotextile Properties

Geotextile	Structure-polymer type[1]	Mass/ unit area (g/m^2)	Thickness (mm)	Bubble Point[2] (mm)	AOS[3] (mm)	ψ[4] (s^{-1})	Grab tensile strength MD x CD [5] (kN/m)
W1	W, MF-PP	585	1.04	0.40	0.425	0.37	96.3 x 70
W2	W, MU-PET	600	1.33	0.30	0.27	0.37	175 x 175
W3	W, MU-PET	813	1.73	0.25	0.15	0.38	175 x 175
NW	NW, NP-PP	550	0.5	0.23	0.2*	0.41	100 x 100
C	COMP-PET,PP	906	3.27	0.12	0.045	0.39	184 x 183

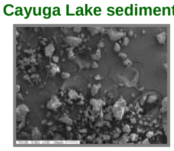
[1]W: Woven, NW: Non-woven, COMP: Composite, MF: Monofilament, MU: Multifilament, NP: Needle punched, PP: Polypropylene, and PET: Polyester;
[2]Bubble Point (as per as ASTM D6767-02);
[3] Manufacturer value *Estimated;
[4]ψ (permittivity); and [5]MD: Machine direction and CD: Cross direction.

Sediments

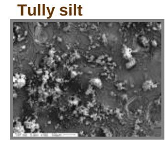




Cayuga Lake sediments



Tully silt

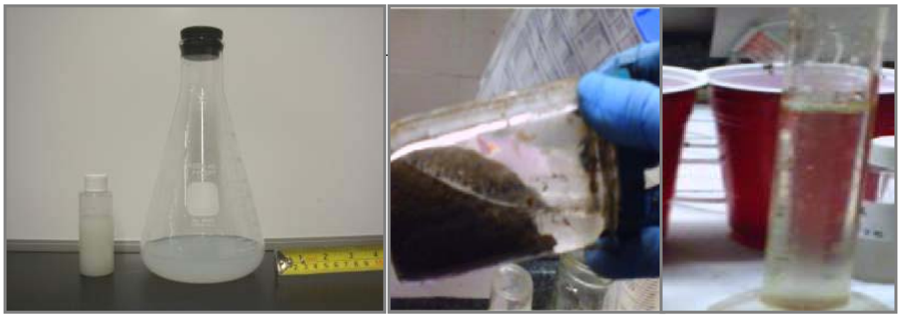


Tully silt (Fine)

Property → / Materials	D_{10} (mm)	D_{30} (mm)	D_{60} (mm)	C_u*	C_c†	S_o‡ (m^2/kg)
Cayuga Lake sediments	0.08	0.1	0.18	2.25	0.7	350.8
Tully Silt	0.007	0.077	0.13	18	6.51	438.12
Tully Silt (Fine)	0.001	0.007	0.022	22§	2.22§	938.46

*C_u: coefficient of uniformity = D_{60}/D_{10};†C_c: coefficient of curvature = $(D_{30})^2/(D_{10})(D_{60})$
§Estimated; ‡S_o is the specific surface area using the method proposed by Chapuis and Légaré (1992)

Polymer



Solve 154 Performance trial courtesy of WaterSolve, LLC

- "Solve 154 was determined to flocculate and dewater Tully Silt most effectively compared to other chemical conditioning products"- WaterSolve, LLC (2007)

- Solve 154*: Water-in-Oil Emulsion Anionic Flocculent Polyacrylamide Copolymer
  *proprietary and chemical composition has not been disclosed

10

Assessment of Dewatering Performance

Small Laboratory Tests

- Jar Sedimentation Test (JST)
- Falling Head Test (FHT)
- Pressure Filtration Test (PFT)

Large Scale Tests

- Hanging Bag Test (HBT)
- Geotube Dewatering Test (GDT)

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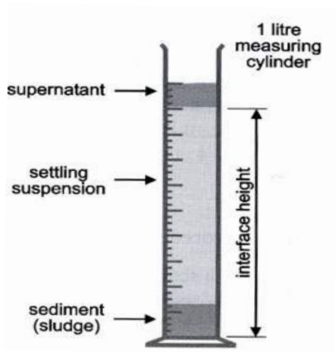
Jar Sedimentation Test (JST)

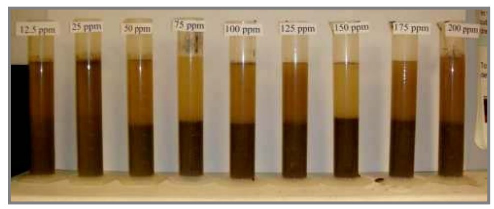
To determine:

- Initial settling rate (u_i)
- Final proportion of settled sediments (S_p)
- Need for chemical conditioning if $u_i < 0.1$ cm/s



Wakeman and Tarleton (2007)

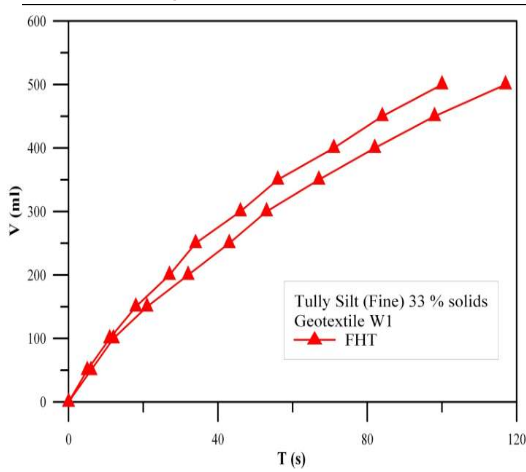
JST (Tully silt fine) without polymer



JST (Tully silt fine) with polymer

12

Falling Head Test Results



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SU Pressure Filtration Test Setup

- Objective: To determine FE and FR of geotextiles under pressure
- Volume of Slurry: 0.6 L
- Test Duration: 1-2 hrs

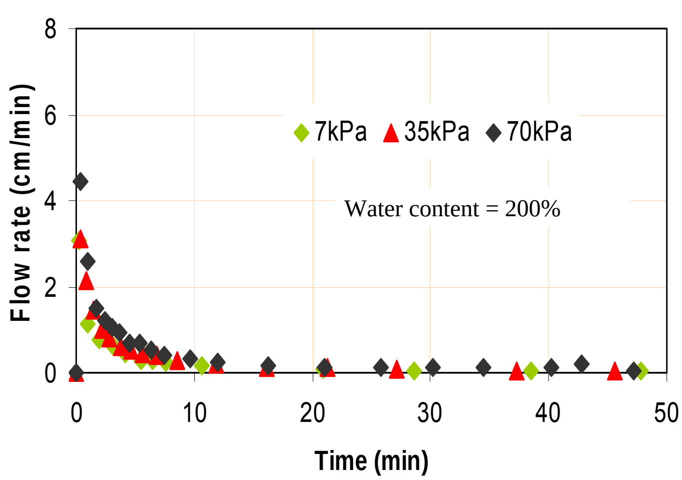

PFT Test


Filter cake


Filter cake and filtrate

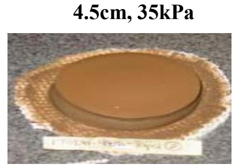
14

Flow Rate -Tully Silt



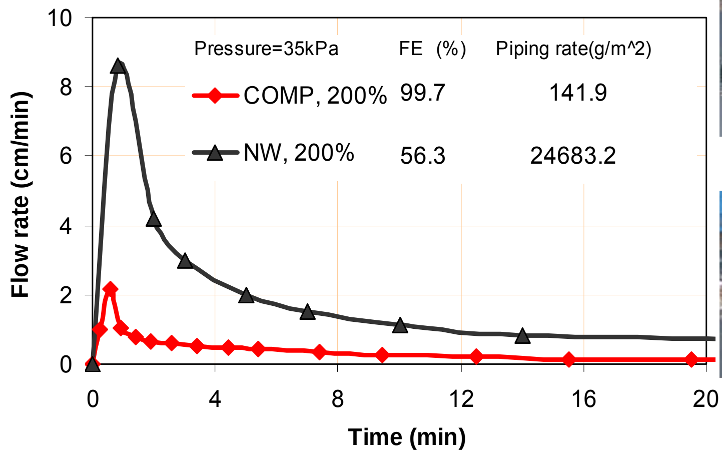

7.0cm, 7kPa

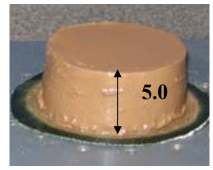

4.5cm, 35kPa


4.3cm, 70kPa

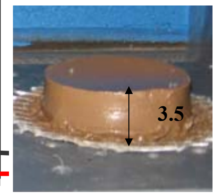
W2 15

Results for Tully Silt with Nonwoven and Composite Geotextiles





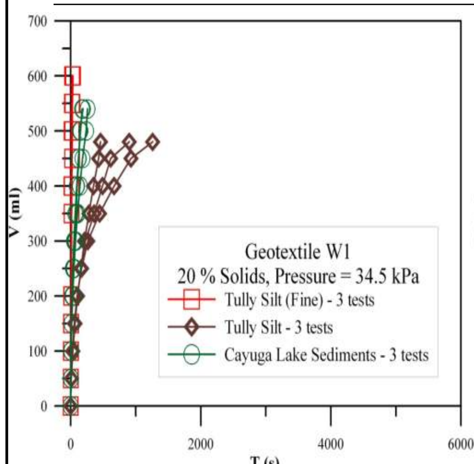
200%,Comp

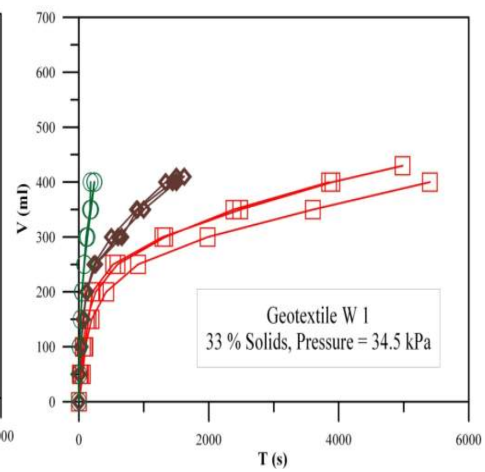


200%, NW

16

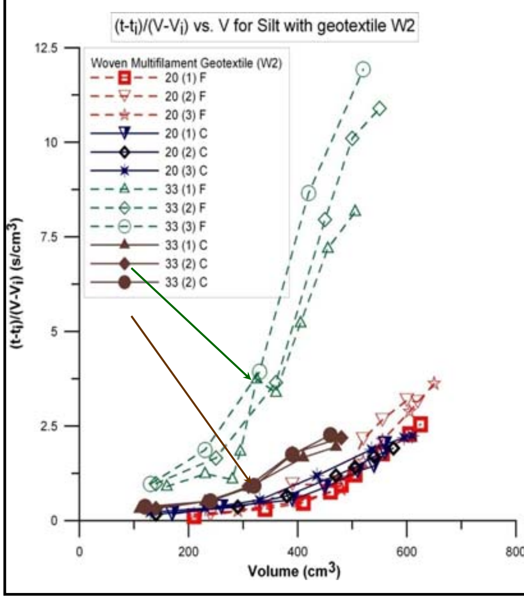
Typical Pressure Filtration Test Results





17

PFT Results: Cake Resistance

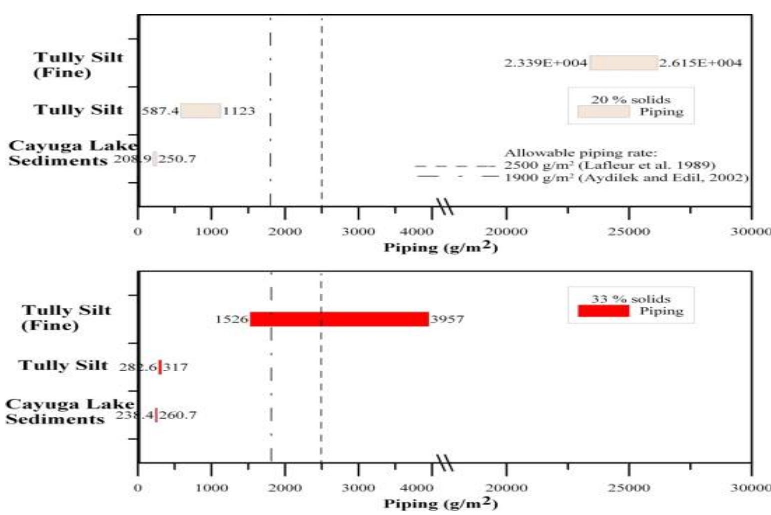


- Non-linearity in the (t-ti)/(V-Vi) vs V plot indicates permeation through a formed "sedimented cake"
- Cake resistance increases with time resulting in increase of dewatering time
- Cake resistance is directly proportional to the solids percentage

Applied Pressure: 35 kPa

18

Soil Piping



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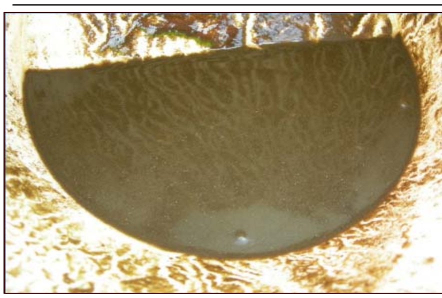
Enhancement of Dewatering

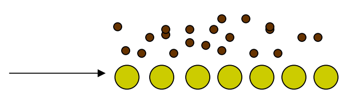
- Chemical conditioning
  - Solve 154 was used to condition Tully silt (Fine) at 33 % solids
- Jar test
  - Ensure mixing conditions and estimate range of optimal polymer dosage
  - Polymer dosage
    - Varied from 0 to 200 ppm in 25 ppm increments
  - Mixing energy
    - Velocity gradient (G) varied from 50 to 200 s^{-1} for optimal dose
      (Recommended by WaterSolve, LLC to correspond to anticipated G in practice)
- Pressure Filtration and Other Tests
  - Optimal dewatering conditions (Polymer dosage and mixing)

20

Evaluation of Chemical Conditioning



Before dosing flocculent



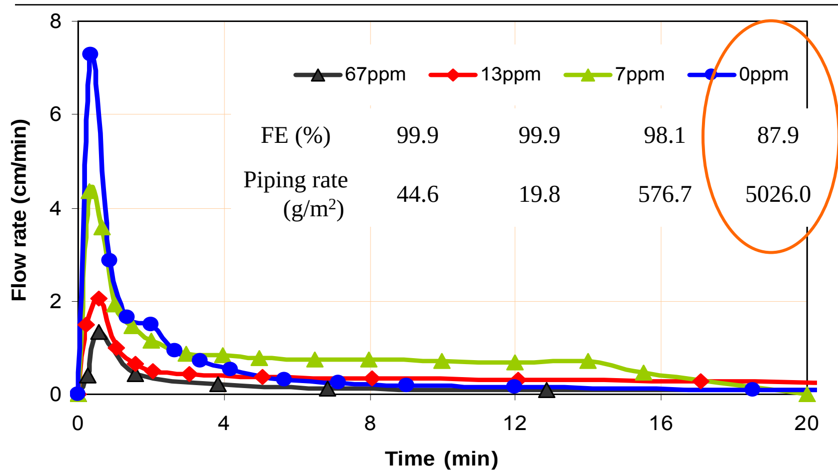
Geotextile

After dosing flocculent

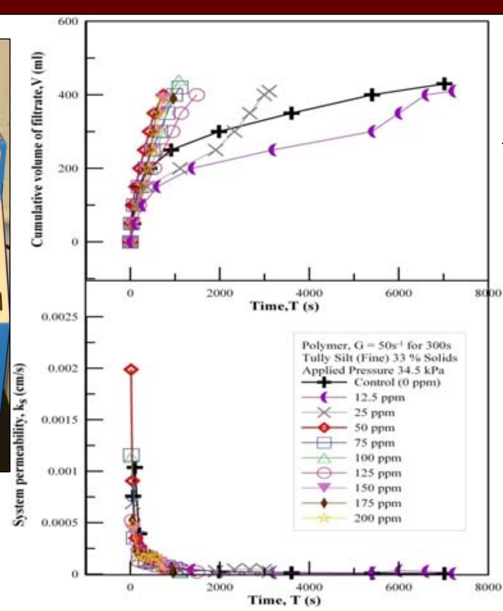
21

Tully Silt – Polymer Conditioning

Silt with W2 at 33% solids content, 35kPa conditioned by flocculent Magnafloc336 (Ciba)



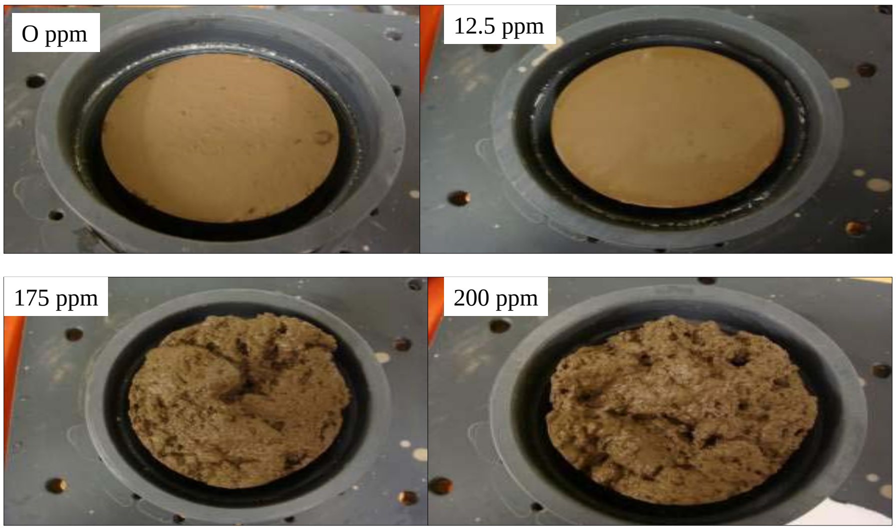
22



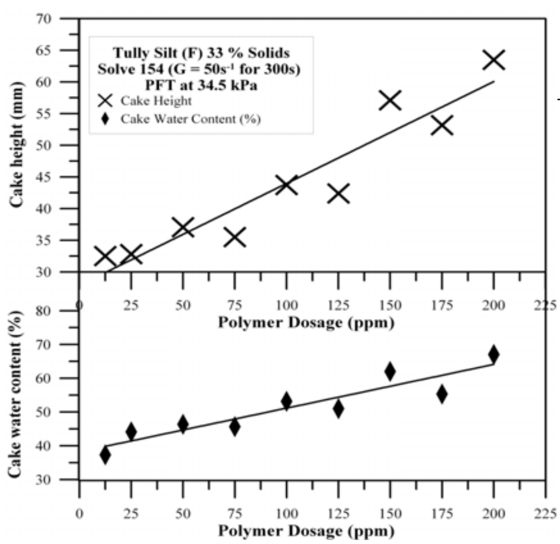
Temporal flow characteristics for dewatering polymer treated Tully silt (Fine) at 33 % using geotextile W1

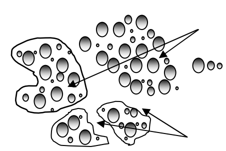
23

Variation of Filter Cake with Polymer Dose



24



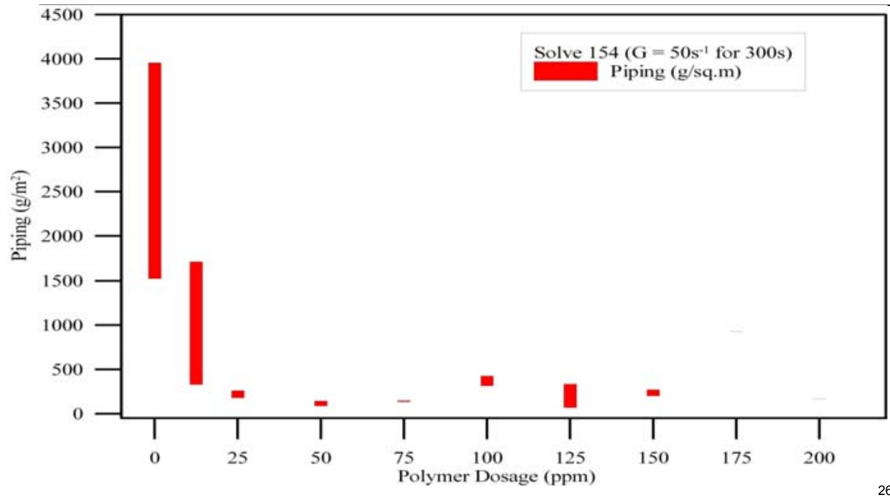


Inter and intra floc moisture content

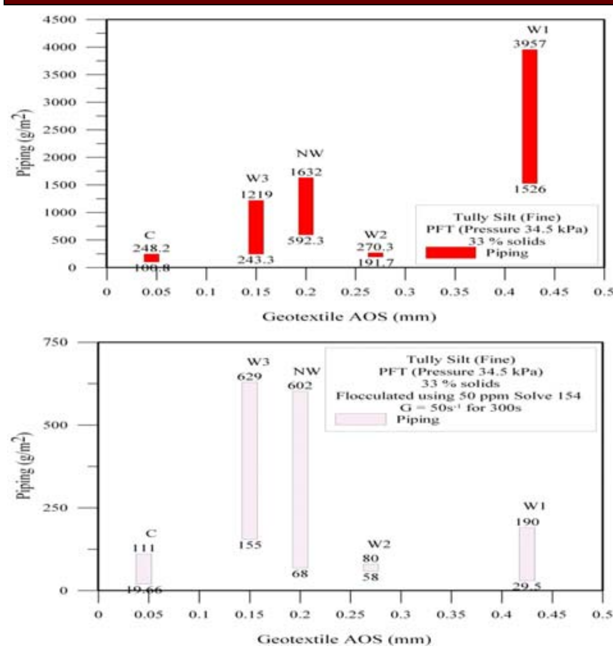
Variation of Cake Height and Water Content With Polymer Dosage

25

Range of piping observed for different polymer dosage



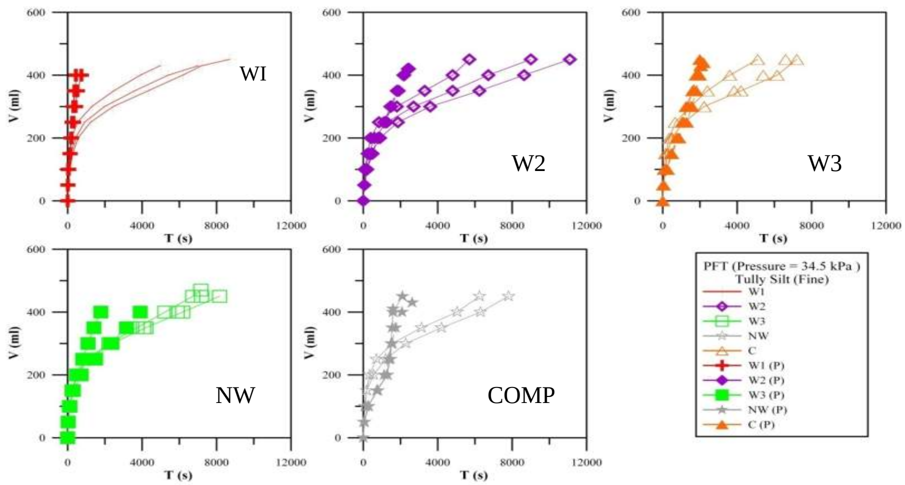
26



Variation of piping with and with and without polymer conditioning

27

Influence of Geotextile Type with and without Polymer



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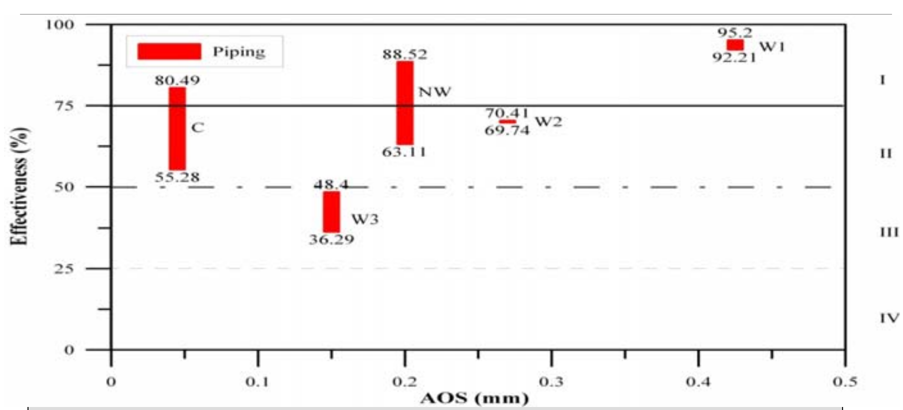
Effectiveness of Polymer Conditioning



$$\text{Effectiveness}(\%) = \left(\frac{P_{TS(F)} - P_{TS(F)+P}}{P_{TS(F)}} \right) x100$$

where

$P_{TS(F)}$ = piping with Tully silt (Fine), $PT_{S(F)+P}$ = piping with polymer-conditioned Tully silt (Fine)

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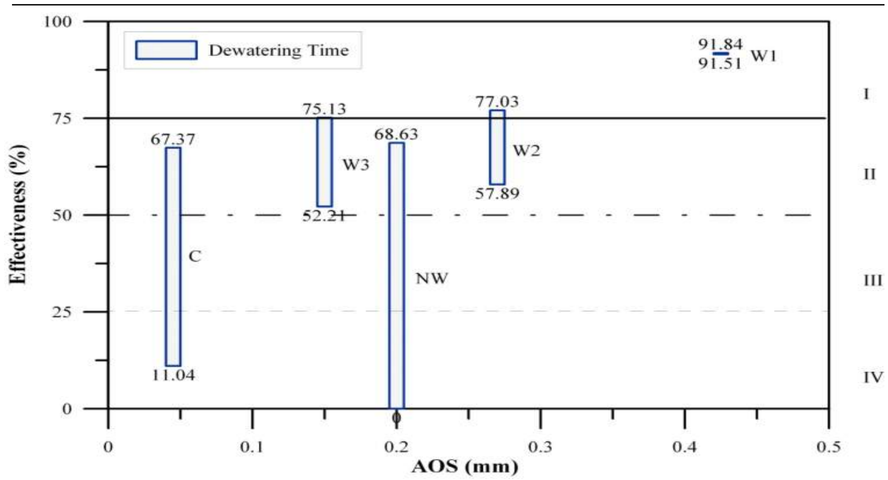
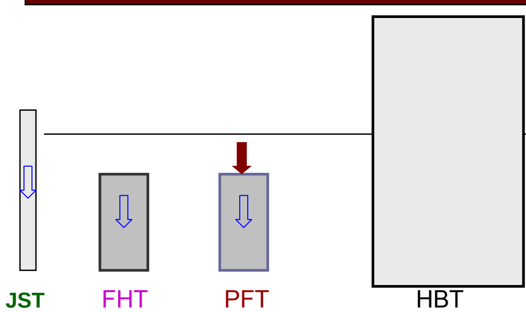
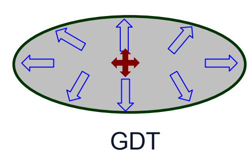
Effectiveness of Polymer Conditioning



30

Comparison of Test Methods





	JST	FHT	PFT	HBT	GDT
Area Sampled (cm²)	-	40-60	40	1.43X10^5	variable
Flow condition	Vertical, 1-D	Vertical, 1-D	Vertical, 1-D	Vertical and Radial, 2-D	Radial, 3-D
Volume of Slurry (L)	1.0	1.25	0.8	200	30-500
Pressure Applied	NO*	NO*	YES	NO*	YES

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*** Dewatering is under gravity**

Hanging Bag Test Results

HBT test

HBT 1

HBT 2

HBT (Polymer)

Filtrate characteristics

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Geotextile Tube Demonstration (GDT) Test

- ❑Sediments slurry is rapidly filled to a predetermined height to facilitate dewatering under a pressure of 6.0KPa.
- ❑Filtrate samples are collected and upon completion of the dewatering, the bag is cut open to assess final percentage solid.

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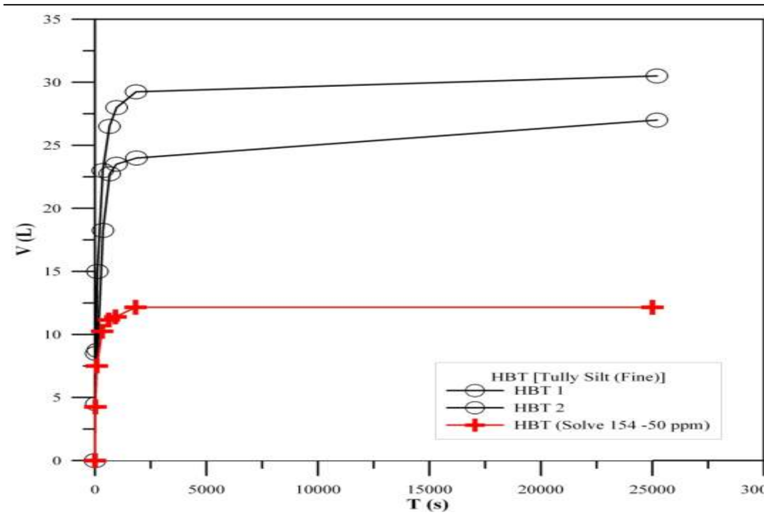
Typical HBT Results



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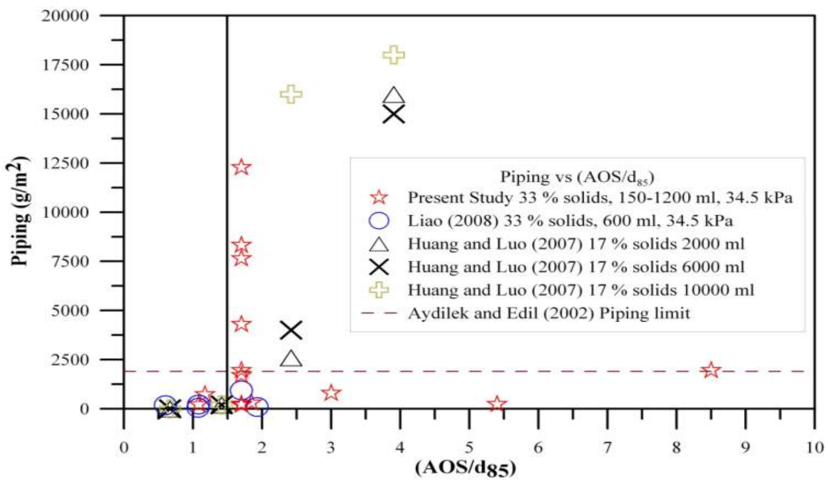
Small and Large Scale laboratory Test Results on Tully Fine at 33% solid content

Parameter	FHT	HBT	GDT	PFT
Dewatering Efficiency (%)	125.2	127.8	132.0	126.0
Percent Piping (%)	75	56	85	78
Filter Cake Height (mm)	5.3	110	3.9	6
Filter Cake Moisture Content (%)	34.6	33.2	29.3	34.0
Filtrate Volume / Initial Slurry Volume	0.87	0.73	0.81	0.88

35

Influence of Index Properties on Dewatering



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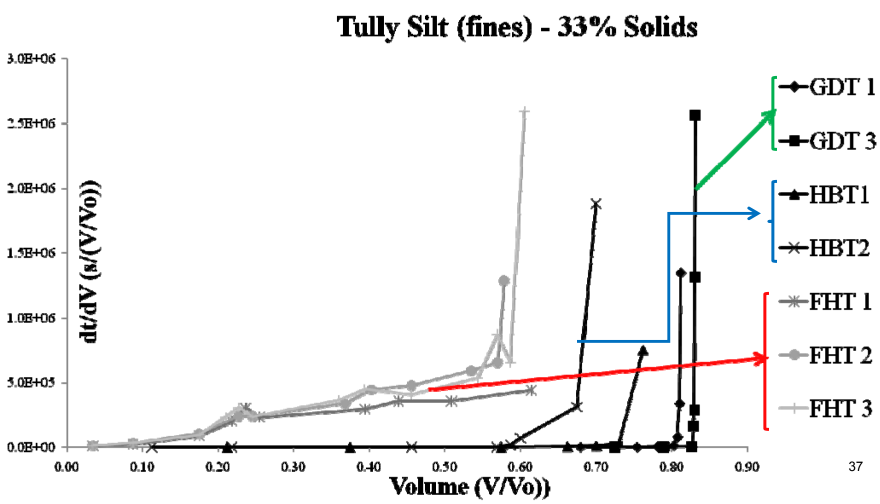
Falling Head, Hanging Bag and Geotextile Tube Demonstration Test



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Preliminary Conclusions

- Fundamental understanding of sedimentation is essential to understand dewatering of dredged sediments
- $(AOS/d_{85}) \leq 1.5$ was found to be a conservative retention criterion to limit piping to 1900 g/m^2 (Aydilek and & Edil, 2002) for dewatering natural sediments
- Polymer use was found to be effective in optimizing dewatering by minimizing piping and DT
- A new criterion is proposed to limit the piping value to 800 g/m^2 for dewatering polymer-conditioned sediments

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2008 Geotextile Tubes Workshop was conducted as part of a research project funded by the US Department of Homeland Security (DHS) through UT Battelle at Oak Ridge National Laboratory under the Southeast Region Research Initiative (SERRI).

End of *Laboratory Study on the Role of Polymers in Rapid Dewatering* by *Shobha K. Bhatia*, PhD.

Section 6.3

2008 Geotextile Tubes Workshop

Nov 17-19 2008, Starkville MS

- ***Presentation Title:***

  Mainstreaming Geotextile Tube Implementation

- ***Author:***

  Barry R. Christopher, PhD, PE

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•Mississippi State University Civil and Environmental Engineering Department
•Mississippi State University Office of Research
•US Army Corps of Engineers Research and Development Center Coastal and Hydraulics Laboratory

"An important scientific innovation rarely makes its way by gradually winning over and converting its opponents... What does happen is that its opponents die out and that the growing generation is familiarized with the idea from the beginning."
— Max Planck

Sounds like Civil Engineers, but we can no longer wait for the opponents to die out.

1

Mainstreaming New Technologies

- In the US, widespread acceptance of viable new technologies requires excessive time
- New initiatives under the Strategic Highway Research Program II are to:
  - Identify technical and non-technical issues that preclude or delay widespread use of new technologies
  - Develop mitigation measures to overcome obstacles

2

SHRP2
STRATEGIC HIGHWAY RESEARCH PROGRAM

SHRP2 Renewal Objective 1: Rapid Renewal of Transportation Facilities
SHRP2 Renewal Objective 2: Minimal Disruption of Traffic
SHRP2 Renewal Objective 3: Production of Long-Lived Facilities

SHRP2 STRATEGIC HIGHWAY RESEARCH PROGRAM

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

3

R02. Geotechnical Solutions for Soil Improvement, Rapid Embankment Construction and Stabilization of the Pavement Working Platform

Anticipated Products

- **Mitigation measures to overcome obstacles to more widespread use of soil improvement technologies**
- **Guidelines and methods for selection, design, QA/QC, costs, and specifications for soil improvement technologies applied to:**

❖ **New embankments and roadways over unstable soils (Element 1)**

❖ **Embankment widening (Element 2)**

❖ **Stabilization of base, sub-base, and subgrade layers (Element 3)**

4

RO2 Team

- RYAN BERG, RYAN R. BERG & ASSOCIATES, INC.
- DONALD BRUCE, GEOSYSTEMS, L.P.
- BARRY CHRISTOPHER, CONSULTANT
- JIM COLLIN, THE COLLIN GROUP, LTD.
- GARY FICK, TRINITY CONSTRUCTION
- GEORGE FILZ, VIRGINIA TECH
- JIE HAN, UNIVERSITY OF KANSAS
- JIM MITCHELL, VIRGINIA TECH
- VERN SCHAEFER, IOWA STATE UNIVERSITY (PRIME CONTRACTOR)
- DENNIS TURNER, THE TRANSTEC GROUP
- LINBING WANG, VIRGINIA TECH
- DAVID WHITE, IOWA STATE UNIVERSITY

- PLUS ADVISORY BOARD OF DOT REPRESENTATIVES AND DESIGN/BUILD CONTRACTORS

5

Top 10 New Technologies

Element 1. New embankments & roadways over unstable soils	Element 2 Embankment widening
1. Column Supported Embankments	1. Column Supported Embankments
2. Geosynthetic Reinforced Platforms	2. Reinforced Soil Slopes
2. Continuous Flight Auger Piles	3. Continuous Flight Auger Piles
2. Vibro-concrete Columns	3. Geosynthetic Reinforced Platforms
5. Stone Columns	3. Vibro-concrete Columns
5. Deep Mixing Methods	6. Deep Mixing Methods
7. Reinforced Soil Slopes	6. Stone Columns
8. Vibrocompaction	8. Light Weight Fills
9. Rammed Aggregate Piers	9. Rapid Impact Compaction
10. Light Weight Fills	10. Rammed Aggregate Piers
-- Geotextile Tubes ??	- - Geotextile Tubes??

6

Categorized Bibliography (developed for each technology)

- Technology Overview
- Site Characterization
- Analysis Techniques
- Design Procedures
- Design Codes
- Construction Methods
- Construction Time
- Equipment/Contractors
- Construction Loads
- Contracting
- Construction Specs
- QC/QA
- Performance Criteria
- Monitoring
- Geotechnical Limitations
- Non-geotechnical Limitations
- Case History
- Environmental Impacts
- Initial Costs
- Life Cycle Costs
- Durability
- Reliability

7

Identified Technical Issues

1	Lack of simple, comprehensive, reliable, and non-proprietary analysis and design procedures
2	Costs for design, construction, QC/QA, and/or maintenance
3	Construction time
4	Time from installation to full effectiveness
5	Lack of established engineering parameters or performance criteria
6	Lack of effective QA/QC procedures
7	Lack of easy-to-use tools for selecting technology
8	Technology immaturity

8

Technical Issues Continued

9	Need for a specific project delivery method
10	Lack of site characterization information
11	Performance uncertainty
12	Lack of long-term performance data
13	Environmental impacts of the technology
14	Lack of accessible case histories
15	Construction loads
16	Vibrations
17	Lack of suitable model specifications

9

QA/QC Measures for Each Technology			
1	Existing QC/QA procedures and measurement values	QC	Material Related
			Process Control
		QA	Material Related
			Process Control
2	Performance Criteria	Material Parameters	
		System Behavior	
3	Emerging QC/QA procedures and measurement values	QC	Material Related
			Process Control
		QA	Material Related
			Process Control

10

Task 4

- Identify and discuss the non-geotechnical project-specific parameters that constrain the full utilization of the application of the identified geotechnical materials and systems

11

Non-Technical Issues

1	**Lack of knowledge about the technology**
2	**Lack of organizational structure and policies to encourage use of new technologies**
3	**Absence of champion or technical leadership**
4	**Lack of qualified contractors, personnel, materials, and equipment**
5	**Liability**
6	**Proprietary product/process**
7	**External pressures on agency**
8	**Project conditions (ROW, geometry, scale, utilities, sequence, and impact on project construction time)**

12

Non-Technical Issues Continued

9	Traffic management
10	Public impact
11	Existing market protection
12	Environmental impacts on the technology
13	Lack of profit or return on investment
14	Weather
15	Requirements for waste disposal

13

•Mitigation Strategies

- Initially 10 Strategic Categories

  Promotional

  - Collaboration

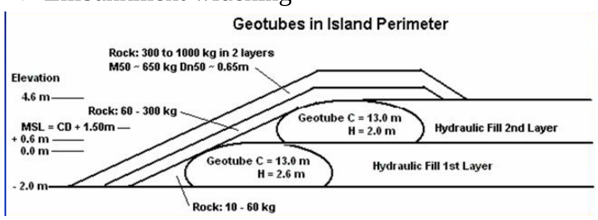
  1. Demonstration/R&D
  2. Specifications and Bidding
  3. Case History/Database
  4. Preparation of Manuals
  5. Internal SHRP
  6. Outreach
  7. Additional Supporting Information
  8. Back Analysis

14

Geotextile Tube Applications within SHRP II

- New embankments and roadways over unstable soils

- Embankment widening



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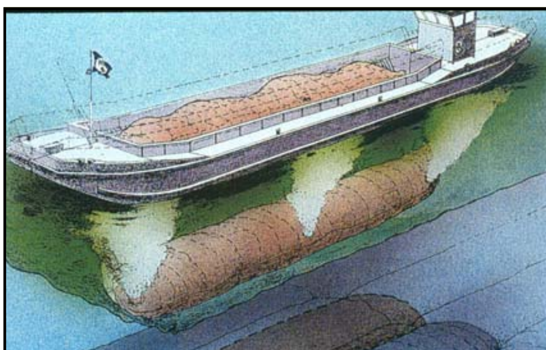

Geotextile Tubes for Below Water Soft Foundation Embankment Construction

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Combined Technologies for Accelerated Construction

- Geotextile tubes and Electro Osmosis with Conductive Geotextiles
- Geotextile tubes and Vacuum Consolidation
- Hydraulically Constructed MSEW
  - requires facing system developed and improved analysis for pretensioned geotextiles

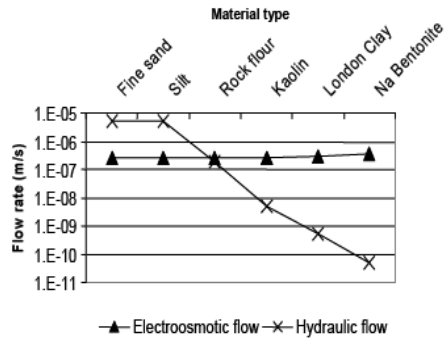
17

Geotubes and Vacuum Consolidation

- The technology is the process of combining hydraulic fill, vacuum consolidation (and possibly horizontal drains in the geotextile tube) to allow the use of both waste and non waste flowable materials and potentially expedite construction of embankments in some regions.

18

Geotubes and Electro Osmosis (e.g. with Electro Kinetic Geotextiles)



EK drainage bag

Comparison of hydraulic & electrokinetic flow rates.

(Photo and figure from Jones, 2008, EuroGeo4)

19

Combining Technologies – Hydraulically Constructed MSEW

20

Workshop Recommendations for Geotextile Tubes (all applications)

- Review list of technical & nontechnical issues
  - Identify the degree of interference with widespread use (High, Medium, Low, None)
- Identify QA/QA measures
  - Existing for materials and processes, performance measures, and emerging measurement methods (e.g., smart geotextiles
- Identify improvement requirements & methods for above
- Review mitigation strategies to improve widespread use

21

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End of *Mainstreaming Geotextile Tube Implementation* by *Barry R. Christopher*, PhD, PE.

Section 6.4

2008 Geotextile Tubes Workshop

Nov 17-19 2008, Starkville MS

- ***Presentation Title:***

  Geotextile Tubes, Design, Applications and Case Histories

- ***Author:***

  Jack Fowler, Ph.D., PE

- ***Affiliation and Contact Information:***

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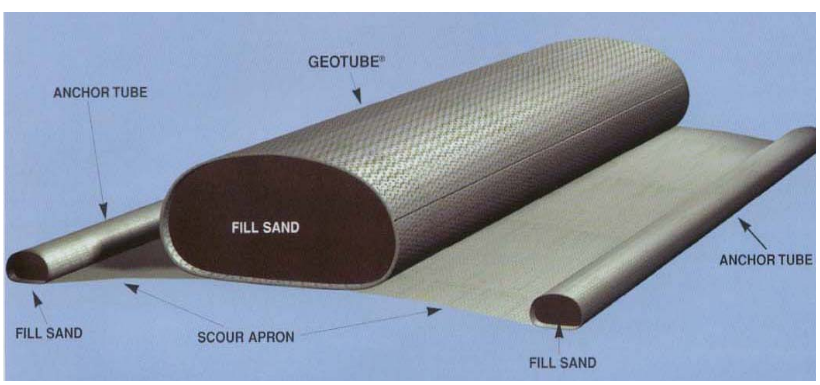
•US Army Corps of Engineers Research and Development Center Coastal and Hydraulics Laboratory

What are Geotextile Container Systems?

1

Typical Marine Installation



2

Panels Being Sewn

Manufactured by sewing multiple sheets of high strength woven polyester or poly-propylene fabrics with high strength seams

3

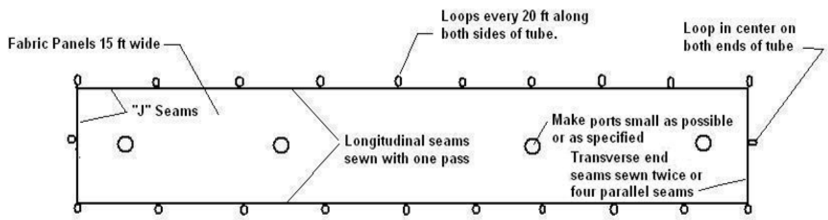
Rolling Up Tube

4

Tube Design Plan View

Circumference and Length as Required
Circumfernces are normally 15, 30, 45, and 60 ft

Loops are nylon or polyester
2 inch wide seated belt straps



All seams are sewn with one pass parallel to the longitudinal axis of the tube. End seams are sewn twice. All seams are "J" seams. The seams consist of type 401 double lock stitch that is sewn with a double needle Union Special Model #80200Z sewing machine. The machine should be capable of sewing two parallel seams about a quarter inch apart. The thread is High Tenacity 12 ply 12,000 denier passing through the needles and 9 ply 9,000 denier passing through the loopers. Seams are 3.5 to 4.0 stitches per inch. Field Tech Pricise-Rick Smith-910-653-5200 yarn source in NC.

Note: Injection ports as required. Ports located 10 ft from each end and on 50 ft spacing for remainder of the tube or as specified

Typical Fabrication Plan

5

GETube Design Software

Software is available to calculate fabric stresses during the critical time of filling and installation when the fill material is fluid.

Jack Fowler 601-636-5475
jfowler@geotec.biz

6

Typical Input Data for GETube Computer Program

- Material Bulk Specific Gravity, 1.6 to 2.0
- Factor of Safety, 5.0
- Circumference, 30, 45, and 60 ft
- Tensile Strength, 500 to 1000 lb/in
- Water Depth

7

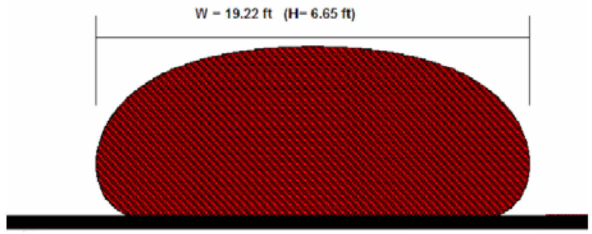
GETube Input Parameters

Select any two Parameters and the others will be computed

- C = Circumference of the tube
- H = Height of the inflated tube
- T = Tensile Strength of the tube fabric
- V= Volume to which the tube is filled
- P = Excess Pressure above the top of tube
- R = Ratio of the fabric area to tube volume

8

Typical Output Data for 45 ft Cir Tube



GIVEN C = 45.00 ft T = 520.00 lbs/in SPG = 1.60 FS = 5.00

DENSITY OF SLURRY	= 99.84 pcf
TUBE CIRCUMFERENCE, C	= 44.98 ft
EX PRESS -TOP OF TUBE, P	= 0.7003 ft (water) 0.3035 psi
WORKING CIRCUM FORCE, Tcir	= 104.0 lbs/in 1248.0 lbs/ft
WORKING AXIAL FORCE, Tax	= 82.59 lbs/in 991.03 lbs/ft
TOTAL HEIGHT OF TUBE, H	= 6.651 ft
TOTAL WIDTH OF TUBE, W	= 19.22 ft
BASE CONTACT WIDTH OF TUBE	= 15.47 ft
END AREA OF TUBE	= 109.5 sq ft 68.04 % FULL
TUBE VOLUME, V	= 4.057 cu yd/ft 819.3 gal/ft
FABRIC AREA TO VOL RATIO,R	= 1.232 sq yd/cu yd
BASE PRESSURE	= 4.915 psi 11.34 ft (water)
REQ'D CIRCUM STRENGTH T	= 520.0 lbs/in 6240.0 lbs/ft
REQ'D AXIAL STRENGTH	= 412.9 lbs/in 4955.2 lbs/ft

9

Filling Methods

- Hydraulic
- Mechanical
- Positive Displacement

10

Hydraulic Dredges

- Suction Cutterhead Dredges
- Horizontal Cutterhead Dredges
- Submergible Pumps
- Eductor Dredges
- Positive Displacement Dredges

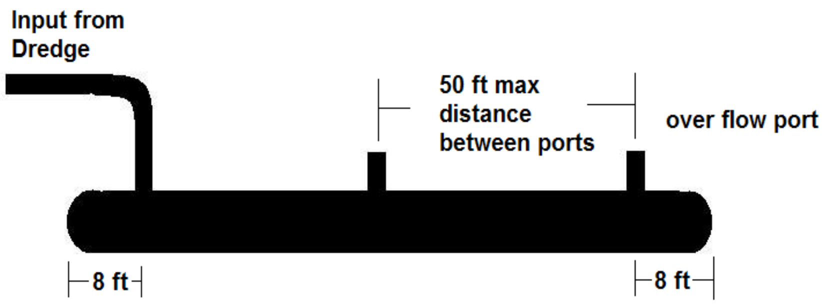
11

Mechanical Methods

- Mechanical placement of soft fluid mud using hoppers.
- Mechanical placement of sand into Tubes using hoppers and water flooding the hoppers.
- Mechanical conveyor belts and hoppers.

12

Installation Techniques



Typical Geotextile Tube being filled

13

Overview of Various Dredging and Tube Filling Methods

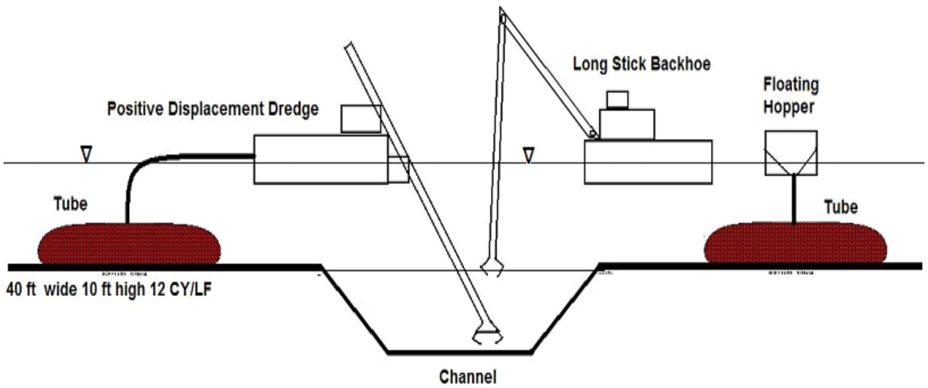
14

Hopper Method

When fill material is not available at site, sand can be imported and installed using hopper methods.

15

Filling Tubes Underwater



16

Dredge Method

Most common method of filling Tubes.

17

Hand Dredge Method

Where large pumping equipment is not available small hand held equipment can be used for filling Tubes.

18

Alternate Pumping Methods

Pumping methods can be modified to comply with local permits or site limitations.

19

Dry Fill Method

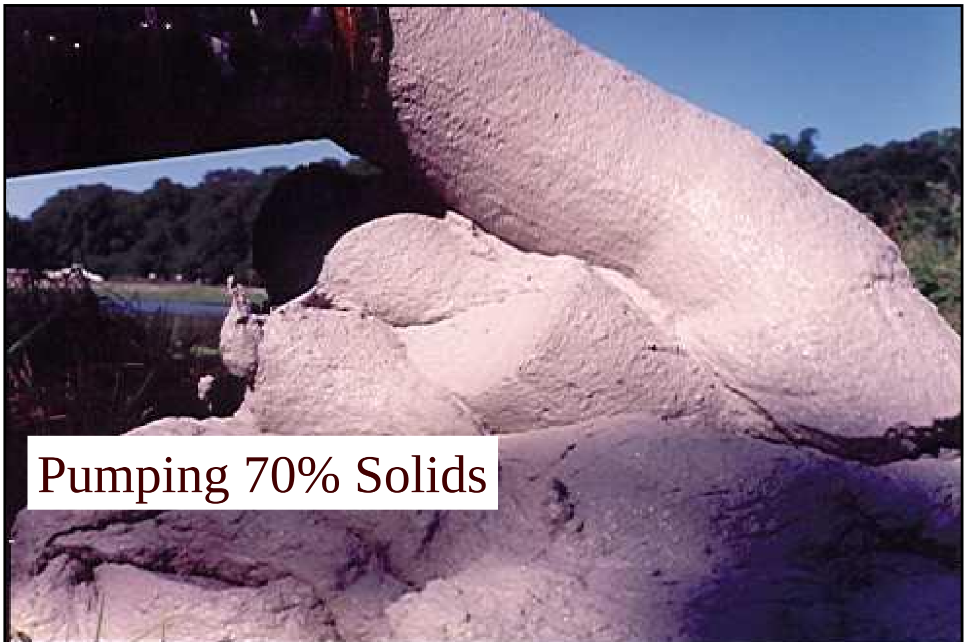
Mechanical means of filling Containers or Sand bags.

20

21

Pumps Material at In-situ Density With No Free Water

22



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Potential Dewatering Applications

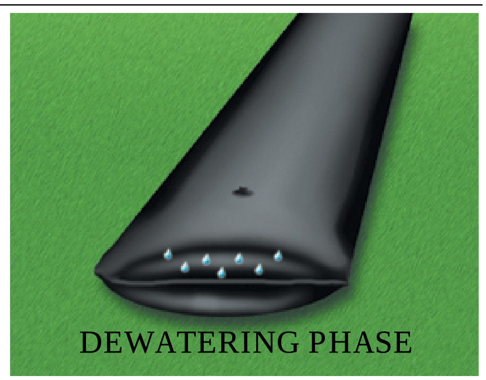
- Fine Grained Dredged Material
- Municipal Sewage Sludge
- Agricultural Waste
- Pulp and Paper Mill Sludge
- Fly Ash
- Mining and Drilling Waste
- Industrial By-Product Waste
- Coal Sludge

24

CONTAINMENT AND DEWATERING

25

CONTAINMENT AND DEWATERING



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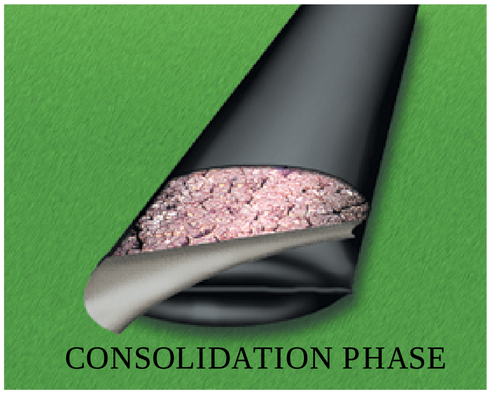
CONSOLIDATION AND DESICCATION



27

Gaillard Island, AL, 1991

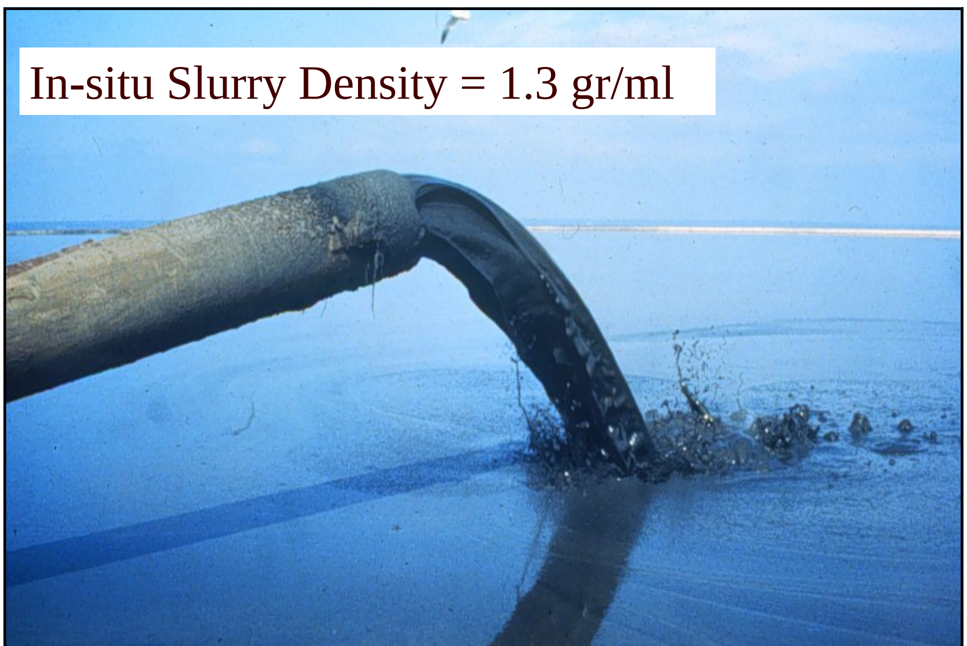
Mobile District
Corps of Engineers Geotextile
Tubes filled with fine
grained
dredged material

28

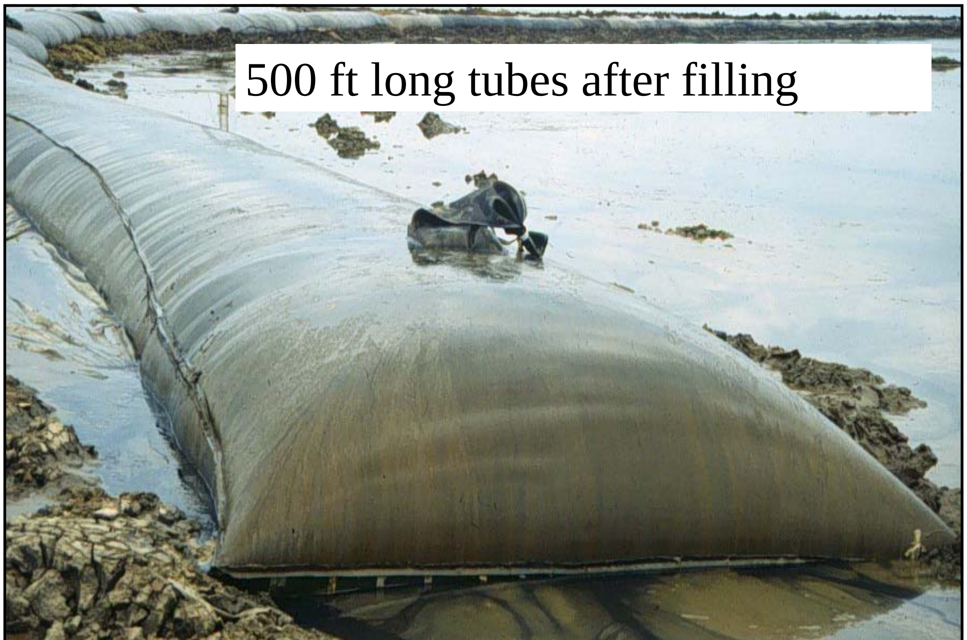
30” Diameter Pipe, Dave Blackman 6’ suction cutterhead dredge

29

In-situ Slurry Density = 1.3 gr/ml



30



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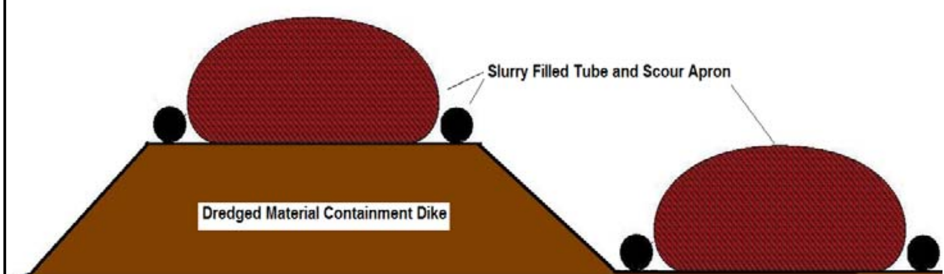
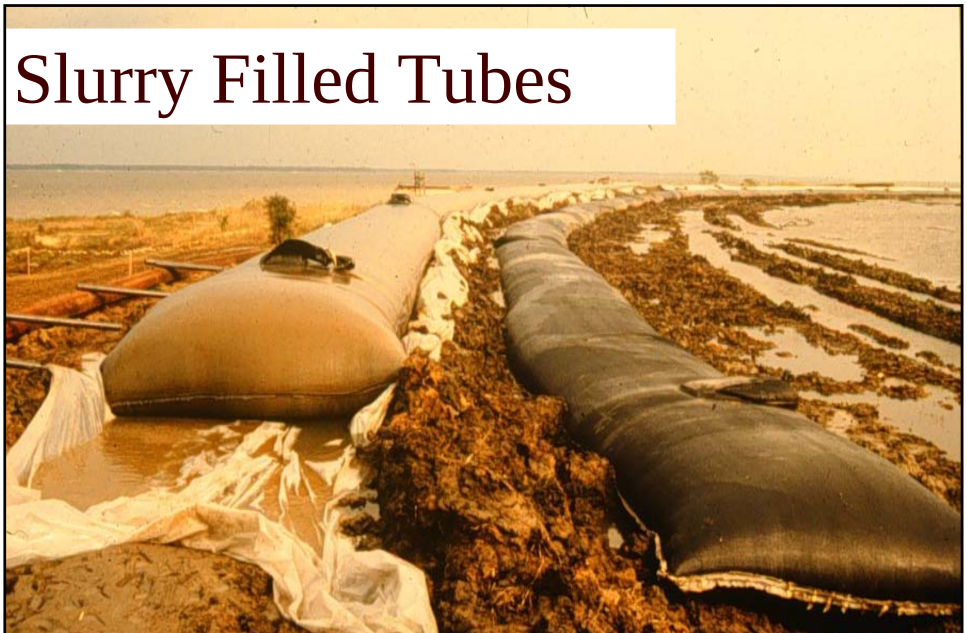
Slurry Filled Tube Design



Slurry Filled Tube and Dike Design

32



33

34


Dried
slurry after
one year

35


Vegetation growth after 30 days

36

CULKIN WATER DISTRICT
Dewatering Alum Sludge, Vicksburg, MS

Alum Sulfate
Pond
Desiccation
Cracks

37

Culkin Water

Alum
Sludge
In Hanging
Bag Test
Showing
Clear Water
Effluent

38

Culkin Water Hanging Bag Test

Alum Sludge

Effluent

Water

39

40

41

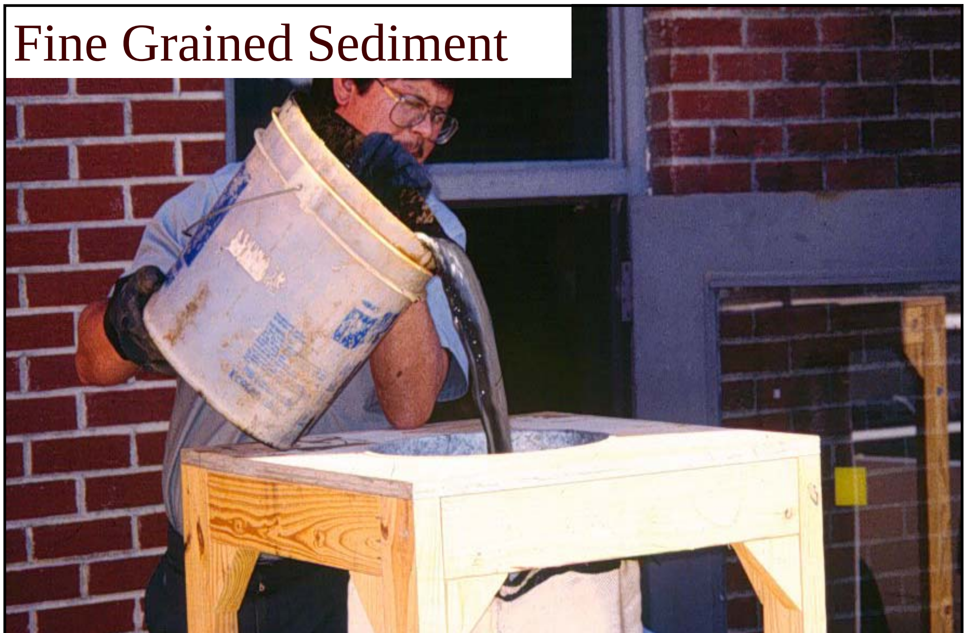
Hanging Bag Test-Dewatering

Vicksburg, MS

Sewage Treatment Plant

42

Fine Grained Sediment



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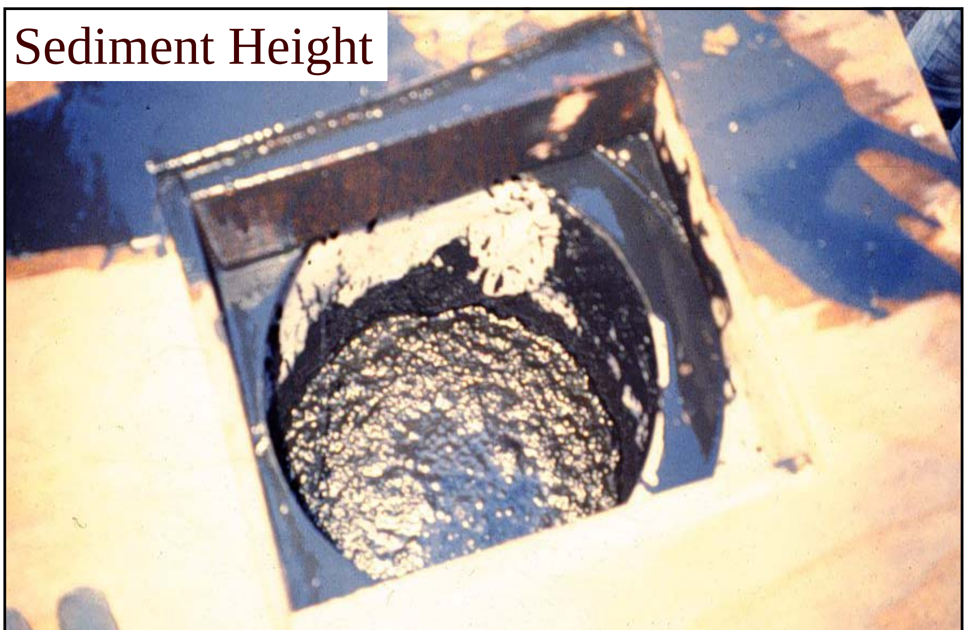
Sediment Height



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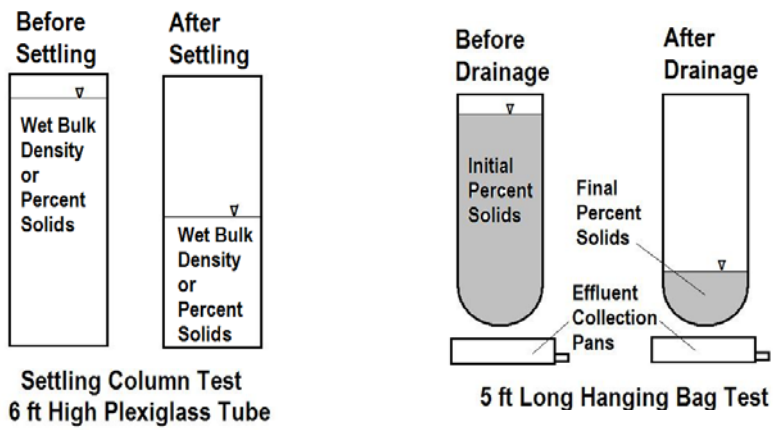
45

46

Settling Column and Hanging Bag Tests



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Geotechnical Fill Material Properties Required for Estimating Consolidation, Bulking & Shrinkage Factors

- In Situ Density or Percent Solids or Moisture Content
- Density or Percent Solids or Moisture Content after dewatering (Target value)
- Specific Gravity of the Solids
- Gradation
- Atterberg Limits (LL, PL, & PI)
- Geotechnical Classification
- Settling Time
- Polymer Requirements

48

Shrinkage factor for DM in Tube after filling, dewatering, consolidation and desiccation drying. Bulking is inverse of Shrinkage factor.

$$\text{Shrinkage Factor} = \frac{V_{dw}}{V_o} = \frac{e_{dw} + 1}{e_o + 1} \quad \text{or} \quad \frac{\gamma_0 - 1}{\gamma_{dw} - 1}$$

where, e_{dw}, γ_{dw}, and V_{dw} are values in Tube after dewatering, consolidation and desiccation drying.

Where in situ, e_o = water content x specific gravity

Where γ_0 = in situ density

49

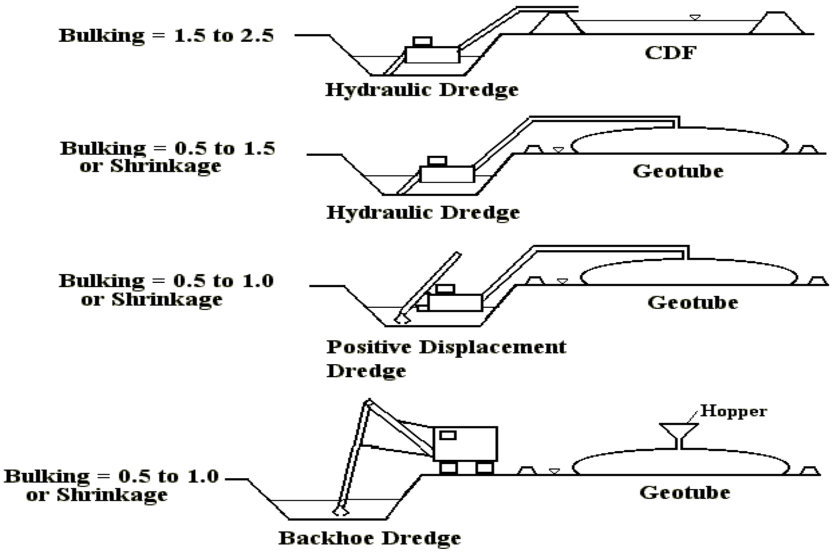
Example Calculation for the Shrinkage Factor

$$\text{Shrinkage Factor} = \frac{V_{dw}}{V_o} = \frac{e_{dw} + 1}{e_o + 1} \quad \text{or} \quad \frac{\gamma_0 - 1}{\gamma_{dw} - 1}$$

$$\text{Shrinkage or reduction Factor} = \frac{1.2 - 1.0}{1.4 - 1.0} = 0.5 \text{ or } 50\%$$

50

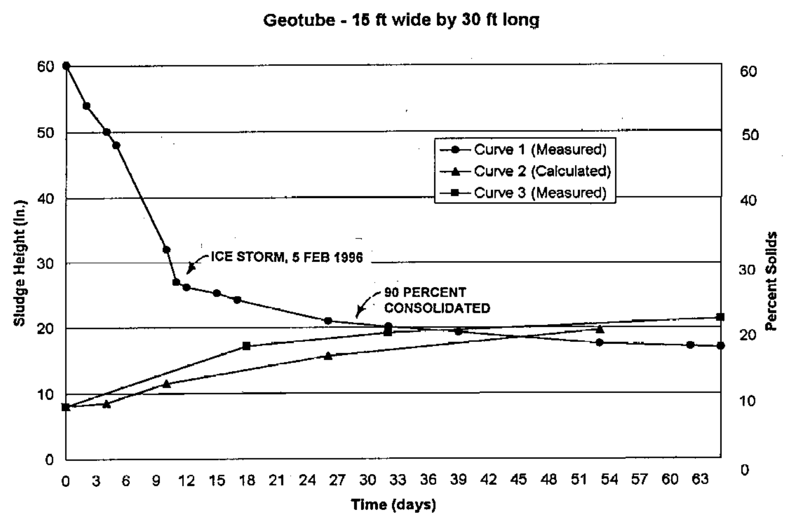
Bulking and Shrinkage Factors for Different Dredging Scenarios with Fine Grained Materials



51

52

Target Percent Solids



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Soil Properties Before, During and After Dredging

In Situ Soil Properties and Percent Solids being Dredged

Specific Gravity of Solids	Water Content Ww/Ws	Void Ratio e=Vv/Vs	Percent Solids S%= Ws/Wt	Wet Bulk Density (Gs+e)/(1+e) Wt/Vt	Dry Bulk Density Gs/(1+e) Ws/Vt	Wet Bulk Density Wt/Vt	DryBulk Density Wt/Vt	Wet Bulk Density Wt/Vt	Dry Density Ws/Vt	Shrinkage or Bulking Factor (e+1)/(e+1)	Volume In Situ to be Dredged	Dry Tons	Remarks
	%		%	gr/ml	gr/ml	pcf	pcf	tons/cy	tons/cy	SF	Wet cy		
2.7	300	8.1	25	1.187	0.297	74.1	18.51	1.000	0.2499		2,000	500	In Situ
2.7	1150	31.1	8	1.053	0.084	65.7	5.26	0.887	0.0710	3.52	7,044	500	Bulked in Pipeline
Soil Properties Afer Decantation or Dewatering in the CDF or Tubes													
2.7	122	3.3	45	1.395	0.628	87.1	39.2	1.175	0.5289	0.47	945	500	Target %S in Tube

Dewatering in CDF or Tubes / Tubes Required and Cost

Percent Solids S%	Volume of Fine Grained Material Reduced	Total Vol Fine Plus Coarse Material	In Situ Bulking or Shrinkage Percentage	Tubes Circum-ference	Final Tube Height	Final Tube Volume	Required Tube Length	Required Number of Geotubes 100 Feet Long	Fabric Required for Tubes	Cost per Linear ft	Tube Cost per job	Tube Cost per In Situ Wet Cy	Tube Cost per Dewatered Wet Cy	Tube Cost per Dry/Ton
				ft	ft	cy/ft	ft		sy	$/ft	$	$/cy	$/cy	$/dry ton
				15	3.5	0.6	1,575	15.8	2,625	$16.25	$ 25,595	$ 12.80	$ 27.08	$ 51.20
Ws/Wt	Wet cy/job	Wet cy/job		30	5	2	473	4.7	1,575	$24.25	$ 11,459	$ 5.73	$ 12.13	$ 22.92
45	945	945	-53%	45	7	4.2	225	2.3	1,125	$33.00	$ 7,425	$ 3.71	$ 7.86	$ 14.85
				60	7.4	6.3	150	1.5	1,000	$42.60	$ 6,390	$ 3.20	$ 6.76	$ 12.78
Roll Off Box Bag		Length, ft	22	22.5	5	1.4	675	31	1,688	$24.00	$ 16,201	$ 2.30	$ 17.14	$ 32.41

Assumed Dredge Production Rate into CDF or Tubes

Percent Solids S%= Ws/Wt %	Production Volume gpm	Dredge Operating Time hrs/day	Dredge Operation Time per job day/job	Production Volume Wet cy/day	Production Volume Wet ton/day	Production Volume Dry ton/day	Production Wet Tons per job	Production Dry Tons per job	Production Volume Dredged Wet cy/job (Equate to Bulked Vol)	Percent Coarse Grained Material Wet cy	Volume of Coarse Grained Material Wet cy/job	Volume of Fine Grained Material Wet cy/job	Remarks
8	300	7	12	624	553	44	6,640	531	7,485	0%	-	7,044	Bulked in Pipeline

Storage Area Required

Tube Circum-ference	Tube Width	Lay Down Area Per Tube	Required Lay Down	Required Lay Down
ft	ft	sf	sf	Acre
15	7.5	750	11,813	0.27
30	12.5	1250	5,907	0.14
45	19	1900	4,275	0.10
60	26	2600	3,900	0.09

Note: Tube cost may vary. These calculations and cost are very dependent on the test results of saturated geotechnical properties such as specific gravity, air and gas content, percent solids, water content, density, gradation, Atterberg Limits, permeability, drainage, use of polymers and dredge production and the assumptions in the table may not be represe

54

Soil Properties Before, During and After Dredging (Cont'd)

Soil Properties Before, During and After Dredging

In Situ Soil Properties and Percent Solids being Dredged

Specific Gravity of Solids	Water Content Ww/Ws %	Void Ratio e=Vv/Vs	Percent Solids S%= Ws/Wt %	Wet Bulk Density (Gs+e)/(1+e) Wt/Vt gr/ml	Dry Bulk Density Gs/(1+e) Ws/Vt gr/ml	Wet Bulk Density Wt/Vt pcf	DryBulk Density Wt/Vt pcf	Wet Bulk Density Wt/Vt tons/cy	Dry Density Ws/Vt tons/cy	Shrinkage or Bulking Factor (e+1)/(e+1) SF	Volume In Situ to be Dredged Wet cy	Dry Tons	Remarks
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Soil Properties Afer Decantation or Dewatering in the CDF or Tubes													
2.7	122	3.3	45	1.395	0.628	87.1	39.2	1.175	0.5289	0.47	945	500	Target %S in Tube

Dewatering in CDF or Tubes				Tubes Required and Cost										
Percent Solids S%	Volume of Fine Grained Material Reduced	Total Vol Fine Plus Coarse Material	In Situ Bulking or Shrinkage Percentage	Tubes Circum-ference	Final Tube Height	Final Tube Volume	Required Tube Length	Required Number of Geotubes 100 Feet Long	Fabric Required for Tubes	Cost per Linear ft	Tube Cost per job	Tube Cost per In Situ Wet Cy	Tube Cost per Dewatered Wet Cy	Tube Cost per Dry/Ton
Ws/Wt	Wet cy/job	Wet cy/job		ft	ft	cy/ft	ft		sy	$/ft	$	$/cy	$/cy	$/dry ton
				15	3.5	0.6	1,575	15.8	2,625	$16.25	$ 25,595	$ 12.80	$ 27.08	$ 51.20
				30	5	2	473	4.7	1,575	$24.25	$ 11,459	$ 5.73	$ 12.13	$ 22.92
45	945	945	-53%	45	7	4.2	225	2.3	1,125	$33.00	$ 7,425	$ 3.71	$ 7.86	$ 14.85
				60	7.4	6.3	150	1.5	1,000	$42.60	$ 6,390	$ 3.20	$ 6.76	$ 12.78
Roll Off Box Bag	Length, ft		22	22.5	5	1.4	675	31	1,688	$24.00	$ 16,201	$ 2.30	$ 17.14	$ 32.41

55

Dredge Production Rate into Tubes or CDF

Assumed Dredge Production Rate into CDF or Tubes

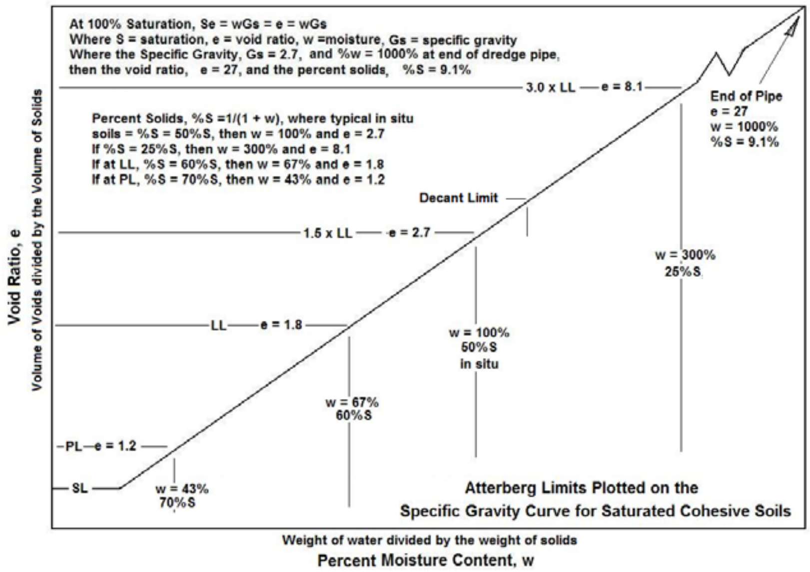
Percent Solids S%= Ws/Wt %	Production Volume gpm	Dredge Operating Time hrs/day	Dredge Operation Time per job day/job	Production Volume Wet cy/day	Production Volume Wet ton/day	Production Volume Dry ton/day	Production Wet Tons per job	Production Dry Tons per job	Production Volume Dredged Wet cy/job (Equate to Bulked Vol)	Percent Coarse Grained Material Wet cy	Volume of Coarse Grained Material Wet cy/job	Volume of Fine Grained Material Wet cy/job	Remarks
8	300	7	12	624	553	44	6,640	531	7,485	0%	-	7,044	Bulked in Pipeline

Storage Area Required

Tube Circum-ference ft	Tube Width ft	Lay Down Area Per Tube sf	Required Lay Down sf	Required Lay Down Acre
15	7.5	750	11,813	0.27
30	12.5	1250	5,907	0.14
45	19	1900	4,275	0.10
60	26	2600	3,900	0.09

56

Void Ratio vs Moisture Content



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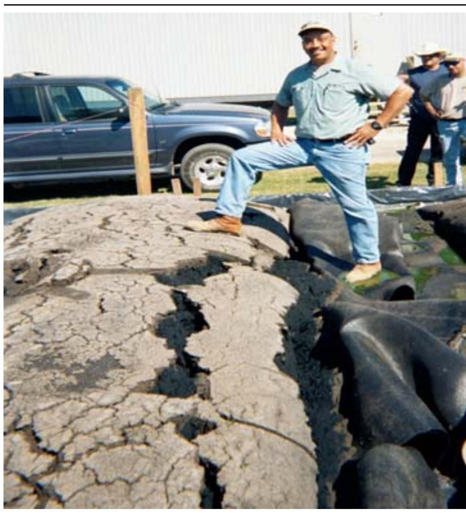
58

Sewage Sludge Filled Tube

59

Desiccated Sewage Sludge



60

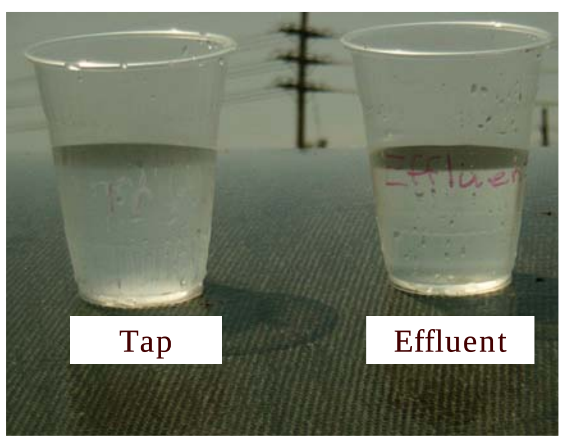
MILLENNIUM PLANT

215 HP Nomad III Horizontal Cutterhead dredge pumping at a rate of 3,000 gpm at 10% solids.

61

MILLENNIUM PLANT

Tap water on left compared to effluent water on right immediately following collection from Geotextile Tube



62

Millennium Plant

Titanium
Sulfate Dioxide
65% Solids

63

Wellston Ohio Coal Sludge

30 ft Cir
100 ft Long
Geotextile
tube
Showing
Elevation

64

Century Mine Hanging Bag Test

Water effluent quality very clear with polymers

65

Century Mine Hanging Bag Test

Slurry at 63.5% Solids second day of drainage with polymers

66

20 CY Roll Off Box

67

Wooden Pallets for Drainage

68

20 ft Long Bag Prior to Filling

69

Filling Roll Off Box Bag

70

Roll Box Bag Filled

71

Effluent from Roll Off Box

72

5 CY Roll Off Box Bag

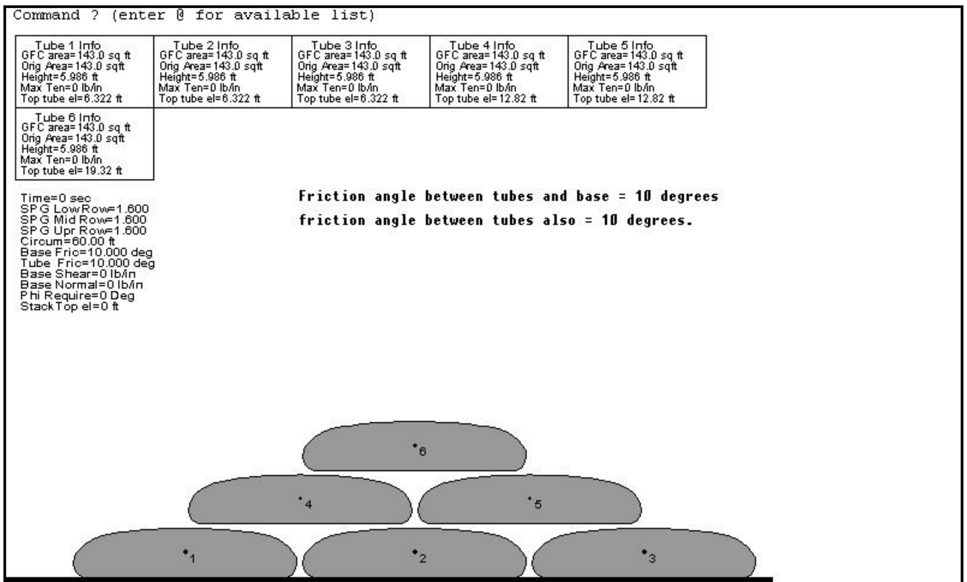
73

20 CY Roll Off Box Filled

74

Dumping Roll Off Box Bag

75



Geosynthetic Reinforced Inflatable Tube Simulator (GRITS)
Developed by John B. Palmerton (Deceased Spring 2006)

76

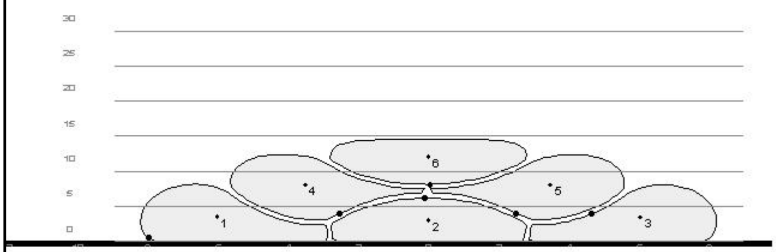
Command ? (enter @ for available list)

Tube 1 Info	Tube 2 Info	Tube 3 Info	Tube 4 Info	Tube 5 Info
GFC area= 142.0 sq ft	GFC area= 139.1 sq ft	GFC area= 142.0 sq ft	GFC area= 142.8 sq ft	GFC area= 142.7 sq ft
Orig Area= 143.0 sqft	Orig Area= 143.0 sqft	Orig Area= 143.0 sqft	Orig Area= 143.0 sqft	Orig Area= 143.0 sqft
Height=8.179 ft	Height=6.210 ft	Height=8.079 ft	Height=9.327 ft	Height=9.244 ft
Max Ten=213.7 lb/in	Max Ten=379.0 lb/in	Max Ten=262.0 lb/in	Max Ten=296.3 lb/in	Max Ten=295.6 lb/in
Top tube el=8.512 ft	Top tube el=6.542 ft	Top tube el=8.412 ft	Top tube el=12.77 ft	Top tube el=12.72 ft

Tube 6 Info
GFC area= 143.1 sq ft
Orig Area= 143.0 sqft
Height=6.481 ft
Max Ten=87.22 lb/in
Top tube el= 14.91 ft

Time=4.432 sec
SPG LowRow=1.600
SPG Mid Row=1.600
SPG Upr Row=1.600
Circum=60.00 ft
Base Fric=10.000 deg
Tube Fric=10.000 deg
Base Shear=-264.6 lb/in
Base Normal=3573 lb/in
Phi Require=4.234 Deg
StackTop el=14.91 ft

Friction angle between tubes and base = 10 degrees
friction angle between tubes also = 10 degrees.



Stacked Tubes Wrong Method

78

Stacked Tube Right Method

79

Filling Stacked Tubes

80

Stacked Tubes, Fly Ash

81

Marine Applications

- Core of a sand dune
- Creation of Wetlands
- Core of Rip Rap Breakwaters
- Core of Rip Rap Jetties
- Underwater Structures
- Diversion Dikes
- Dredge Material Containment

Beneficial Uses Of Dredged Material Filled Geotextile Tubes

Coastal and Riverine Applications

82

83

Shoreline Protection

84

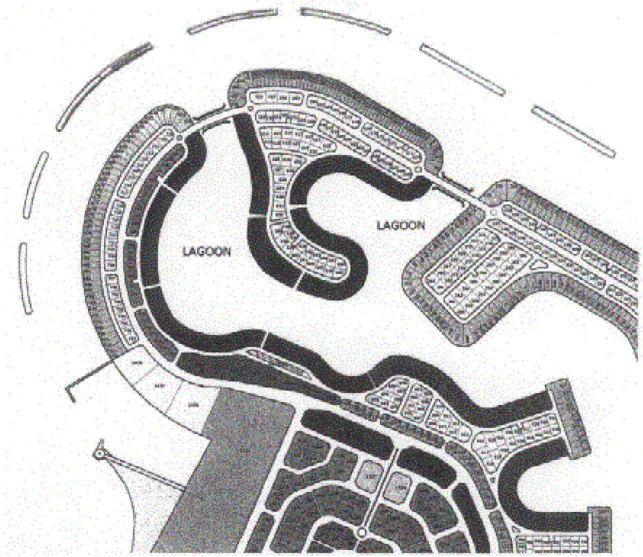
Shoreline Protection

85

Shoreline Protection

86

Offshore Breakwater Protection, Amwaj Island



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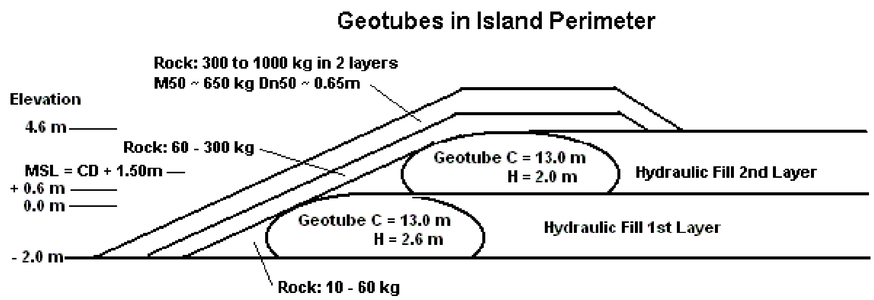
Tube During Filling, Amwaj Is

88

Outside Perimeter Design, Amwaj, Island



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Amway Island

90

Bolivar Peninsula, Texas Coast

18,000 LIN. FT. Of Tube Protecting Shoreline

Installed 2000

Coastal Beach Application of Polyester Geotextile Tubes

91

Bolivar Peninsula, TX

Note the nonwoven shroud that covers the exposed portion of the Tube. The shroud is for increased UV protection.

92

Bolivar Peninsula, TX

Tube sections were joined to create a relatively even elevation for the total length or the installation.

93

Bolivar Peninsula, TX

Backhoe places sand to cover the Tube and create the new sand dune.

94

Bolivar Peninsula, TX

Tubes are buried in the dune to act as monolithic structure to combat destructive wave energy.

95

Bolivar Peninsula, TX

Tube was exposed during Tropical Storm Allison, June 2001.

96

Bolivar Peninsula, TX

Tube was exposed during Tropical Storm Allison, June 2001.

97

Bolivar Peninsula, TX

The Tube installation protected structures along the coast line during the storm saving the community millions of dollars in repair.

98

Bolivar Peninsula, TX

The Tube project on Bolivar Peninsula was so successful that it has been extended another 15,000 linear ft.

99

Bolivar Beach Tubes after Ike

100

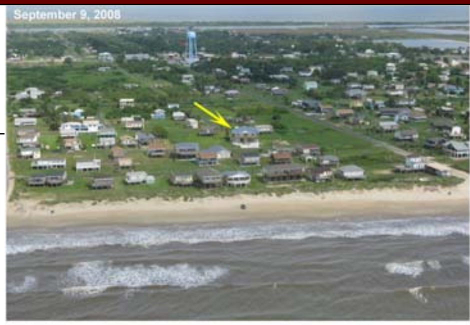
Bolivar Tubes after Ike

101

Bolivar Beach Tube after Ike

102

Crystal Beach before and after Hurricane Ike



103

Pirates Beach after Ike

104

Fine Grained Volcanic Sand

Aleutian Islands
Nelson Lagoon, AK
2005

105

Shoreline Erosion on Nelson Lagoon

106

Placing Scour Apron and Scour Tubes

107

Tube during placement

108

Tube after placement

109

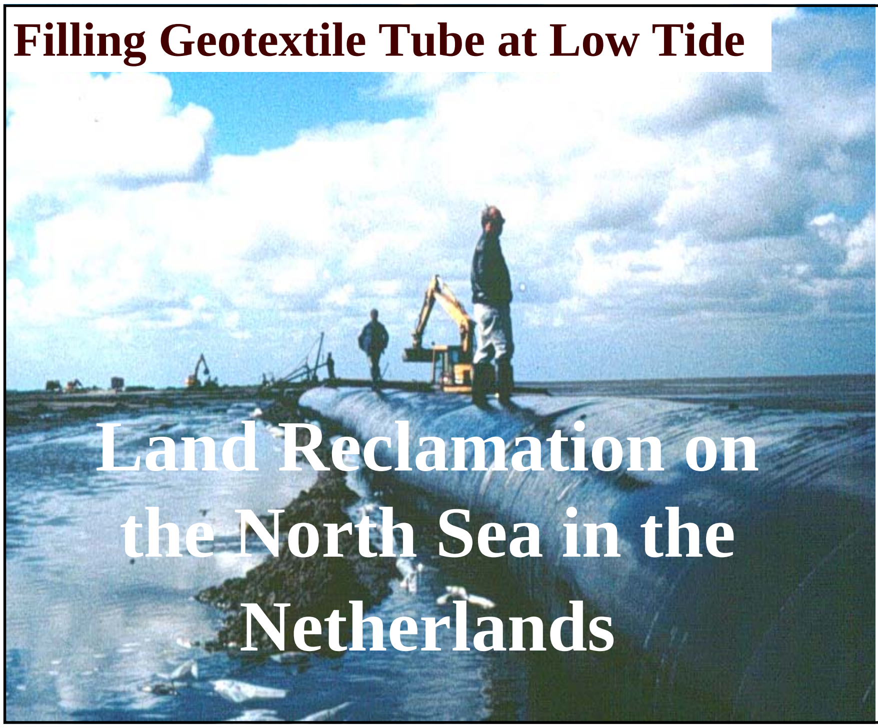
Filling hopper with front end loader

110

Water exiting the tube

111

Filling Geotextile Tube at Low Tide



112

Filling Geotextile Tube at High Tide

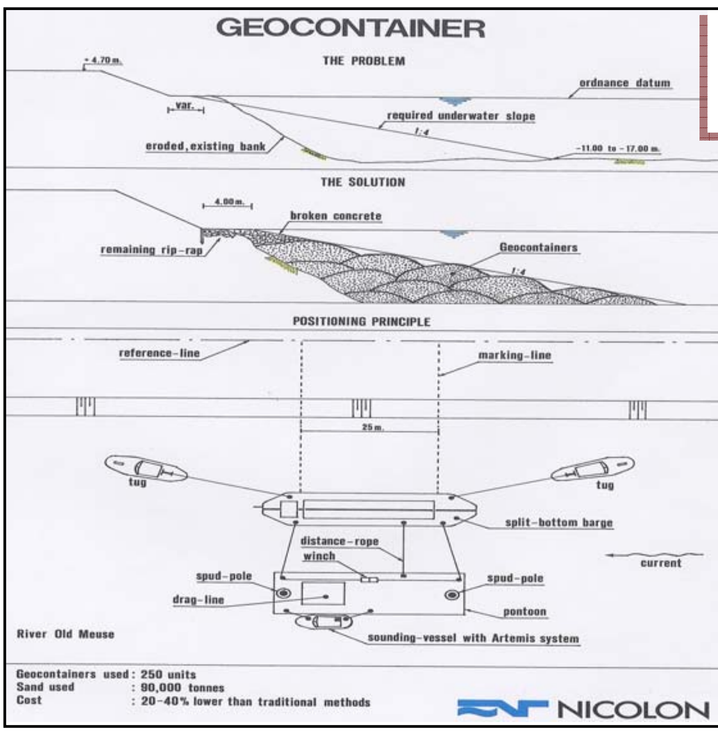
113

Parallel Geotextile Tubes in Perimeter Dikes

114

Sand Fill behind Geotextile Tube Dike

115



Container Placement

Geotextile Containers For Below Water Scour Protection

Port Of Rotterdam
Rotterdam, The Netherlands

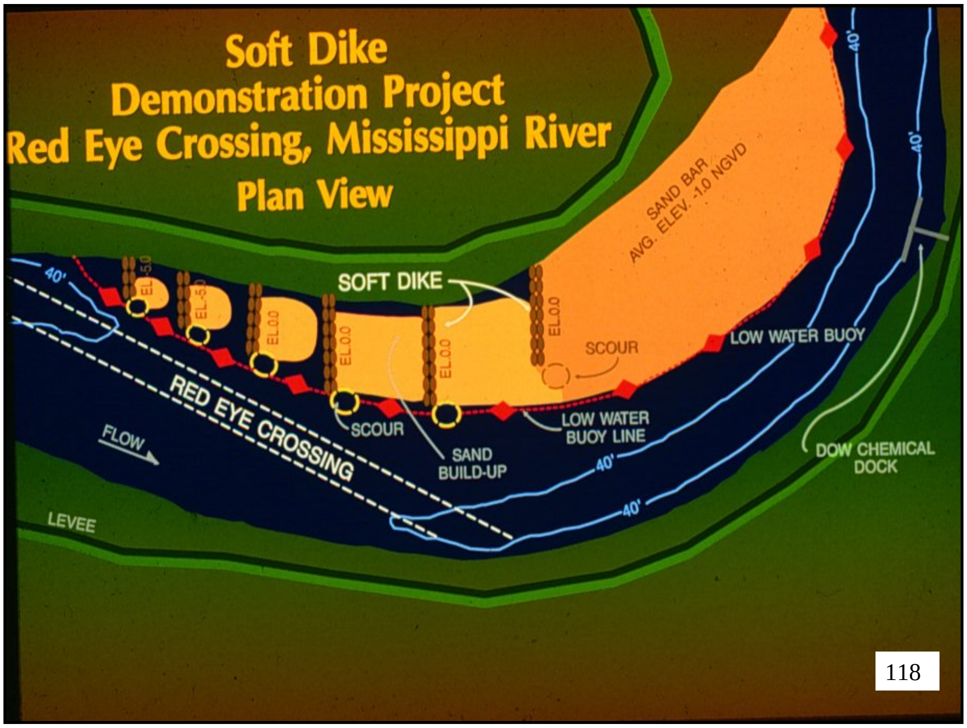
116

Sand Bag and Container Application to Control River Sediments

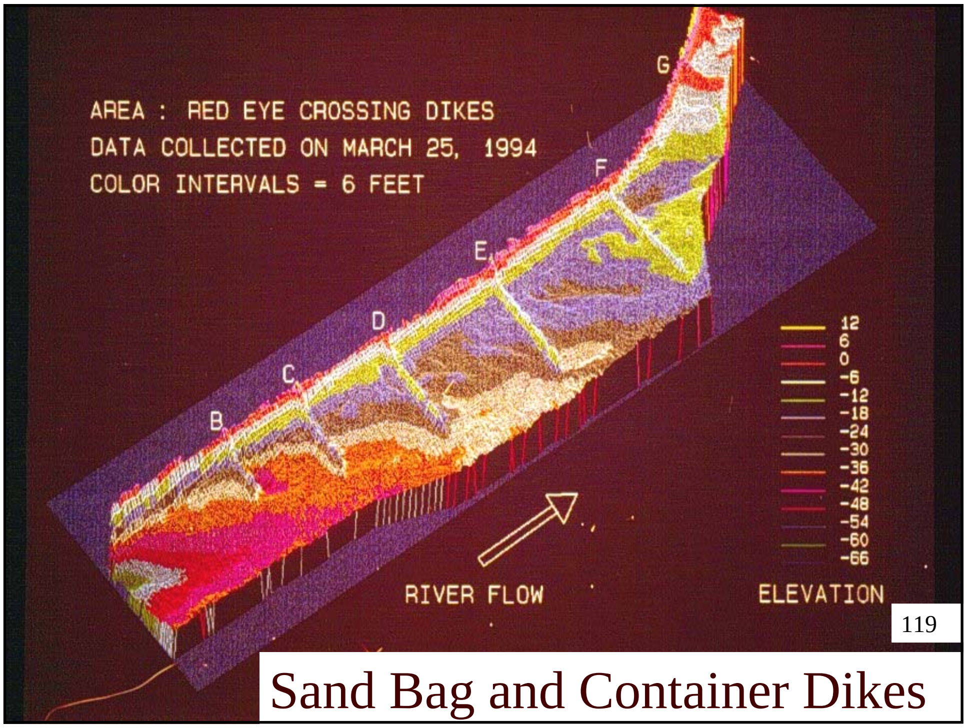
Red Eye Crossing, Mississippi River

Baton Rouge, LA
1993 to 1994

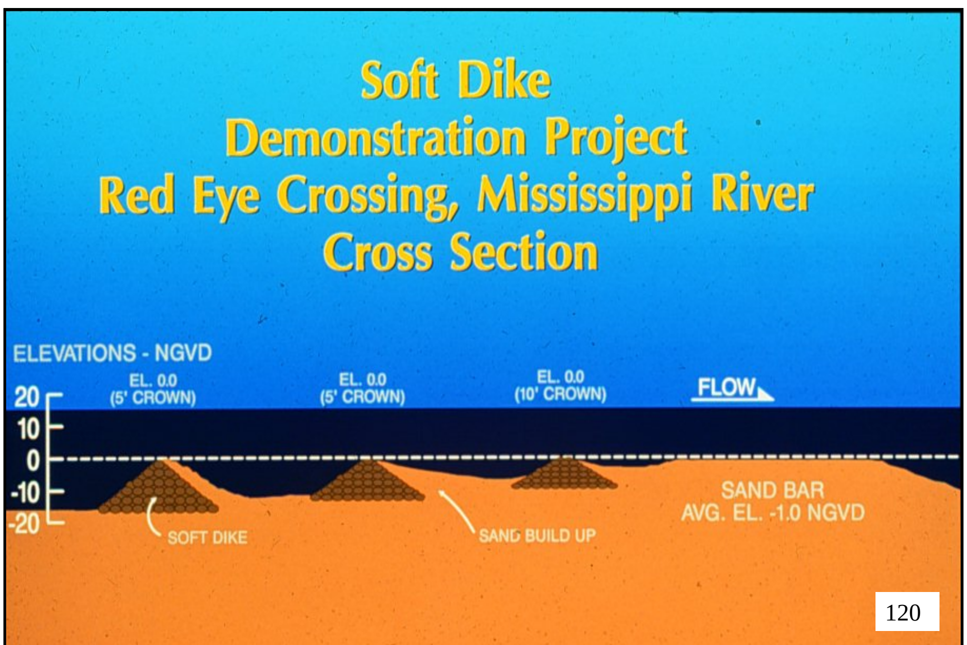
117



118



Sand Bag and Container Dikes

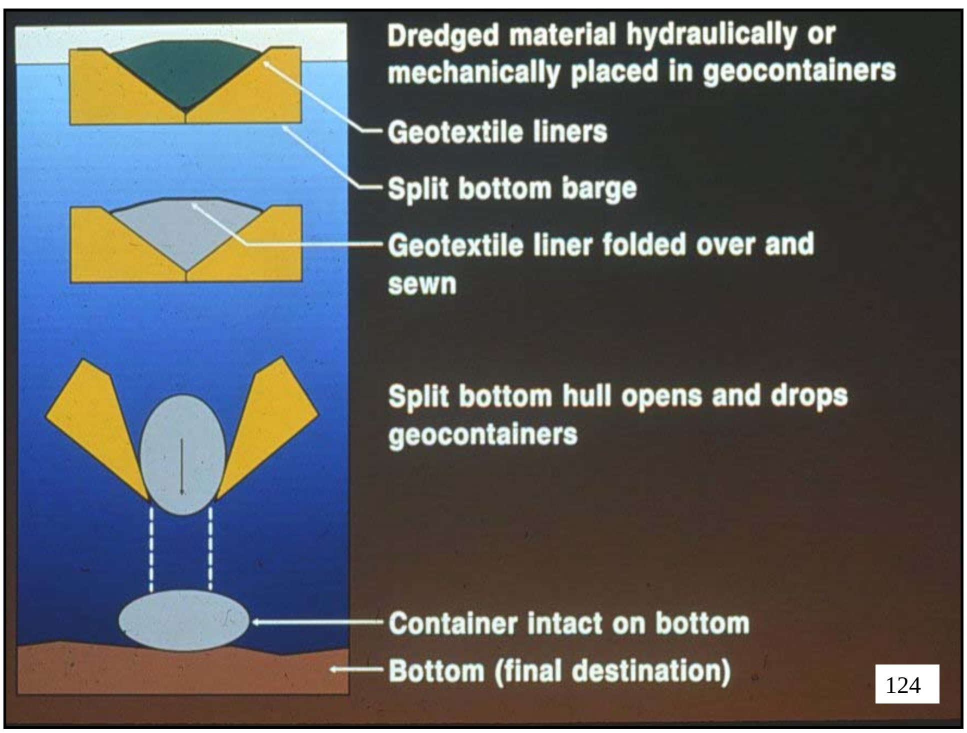


Three bag dikes and three container dikes

Instrumented sand bag

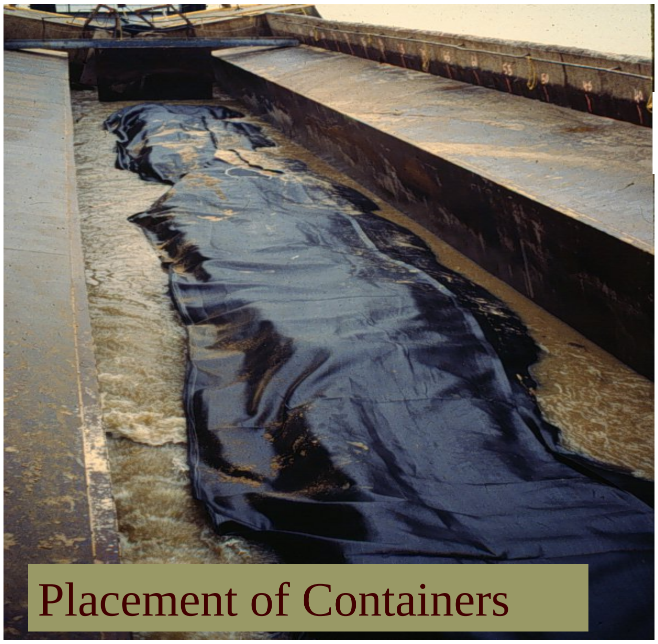
122


Sand Bag Placement
123


Dredged material hydraulically or mechanically placed in geocontainers
Geotextile liners
Split bottom barge
Geotextile liner folded over and sewn
Split bottom hull opens and drops geocontainers
Container intact on bottom
Bottom (final destination)
124


Filling
Containers
125

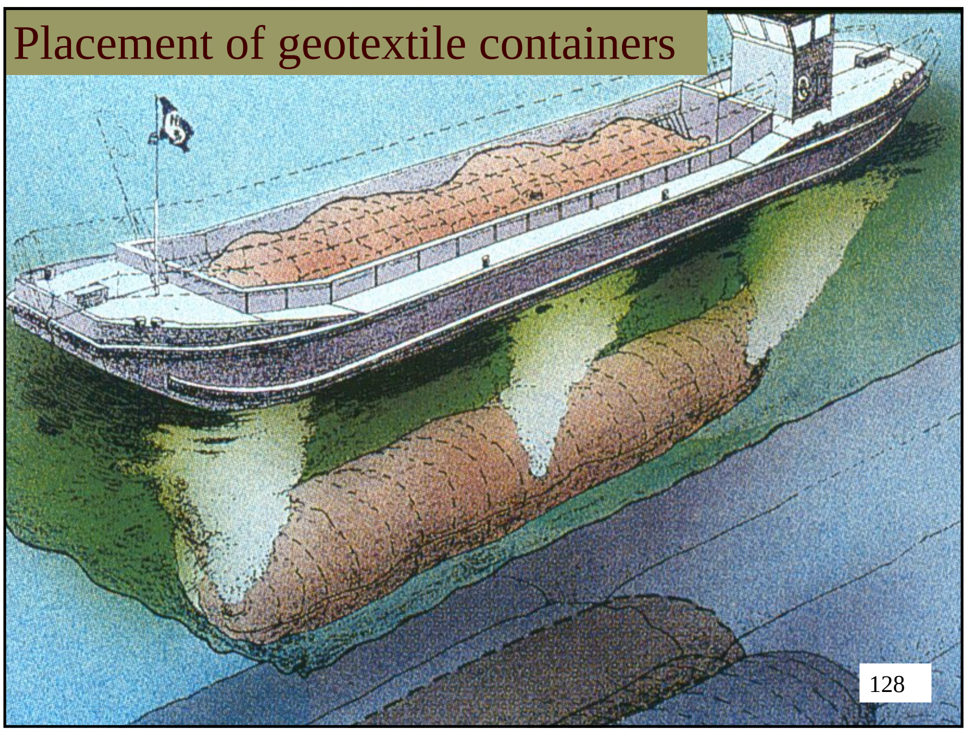

Sewing Containers
Closed
126



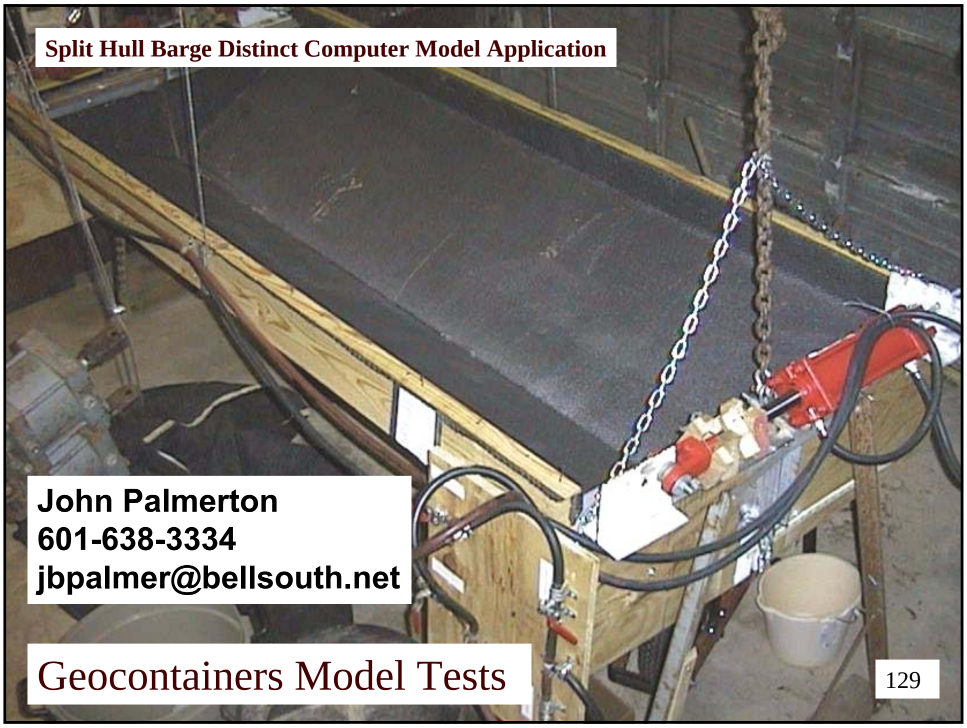
Placement of Containers

127

Placement of geotextile containers



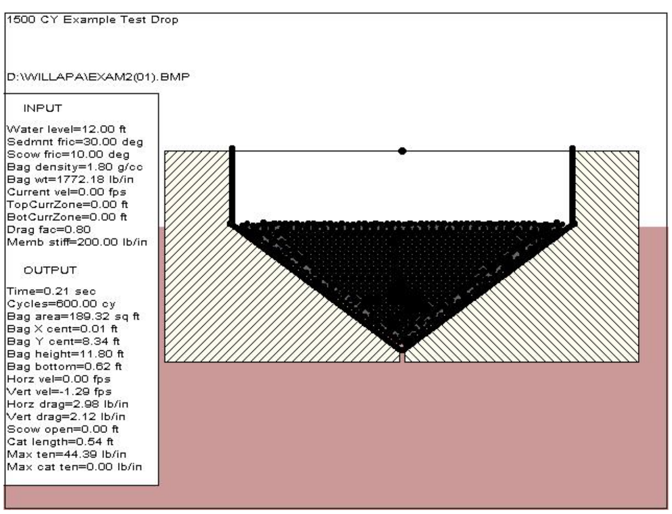
128



Geocontainers Model Tests

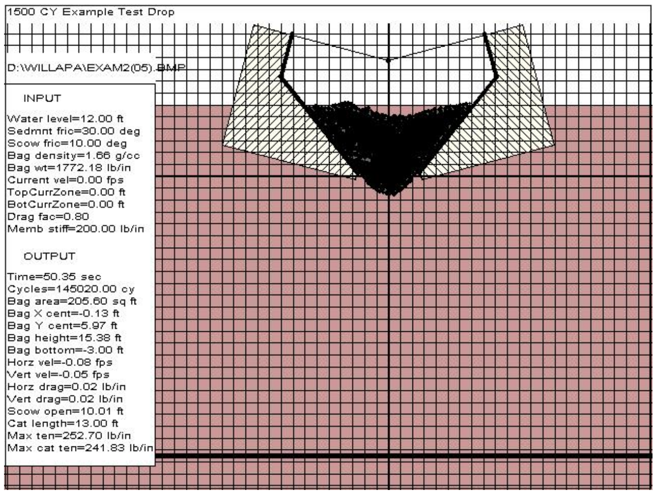
129

Split-Hull Scow Container Drop Simulations



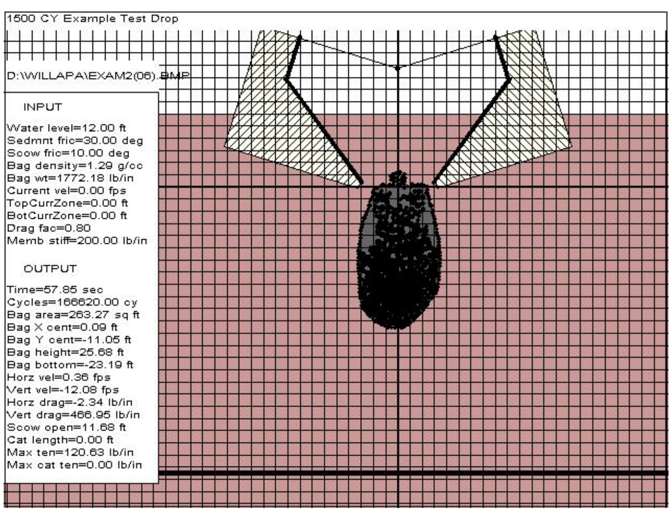
130

Split-Hull Scow Container Drop Simulations



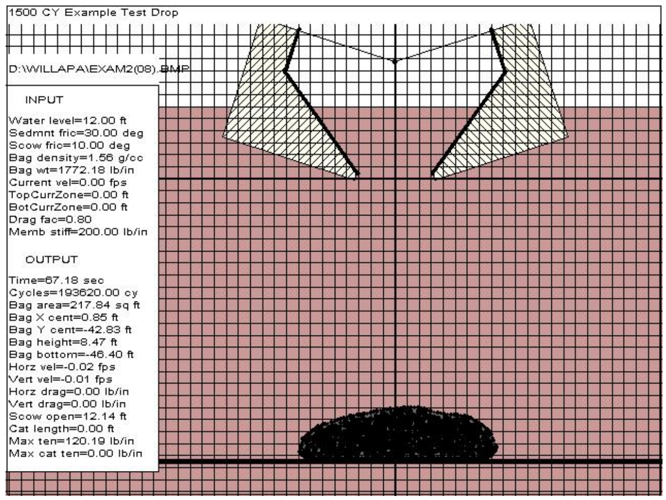
131

Split-Hull Scow Container Drop Simulations

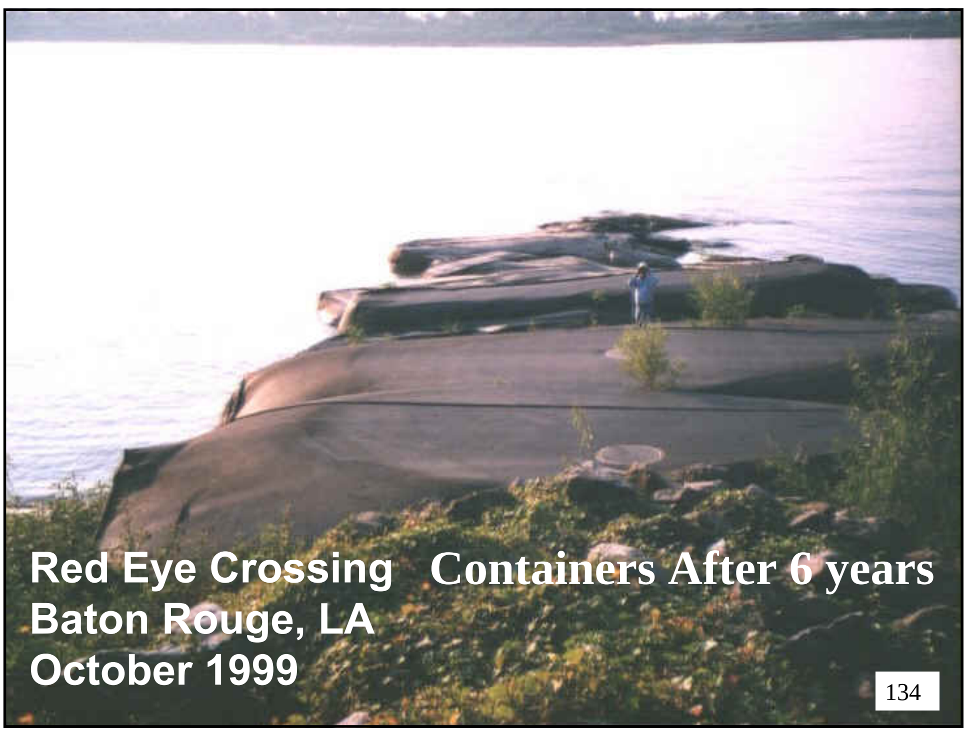


132

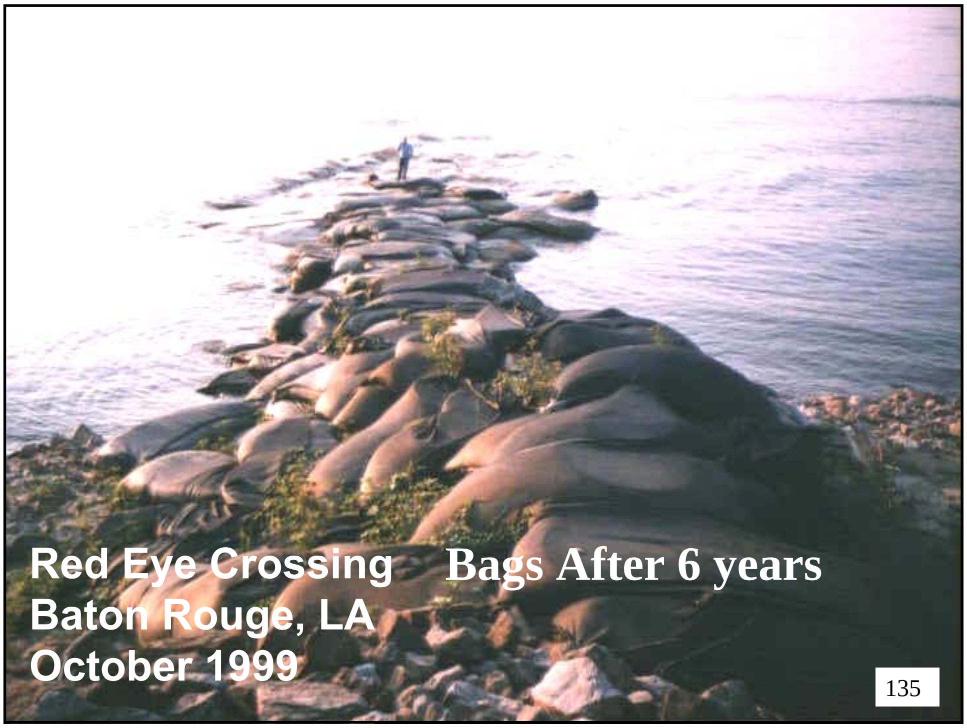
Split-Hull Scow Container Drop Simulations

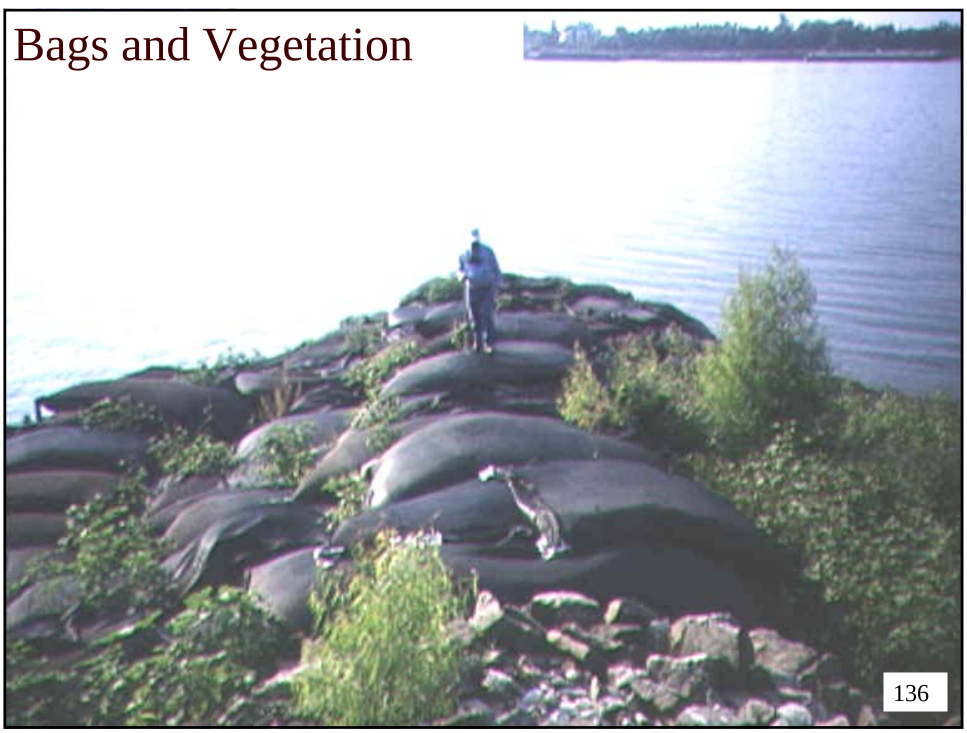


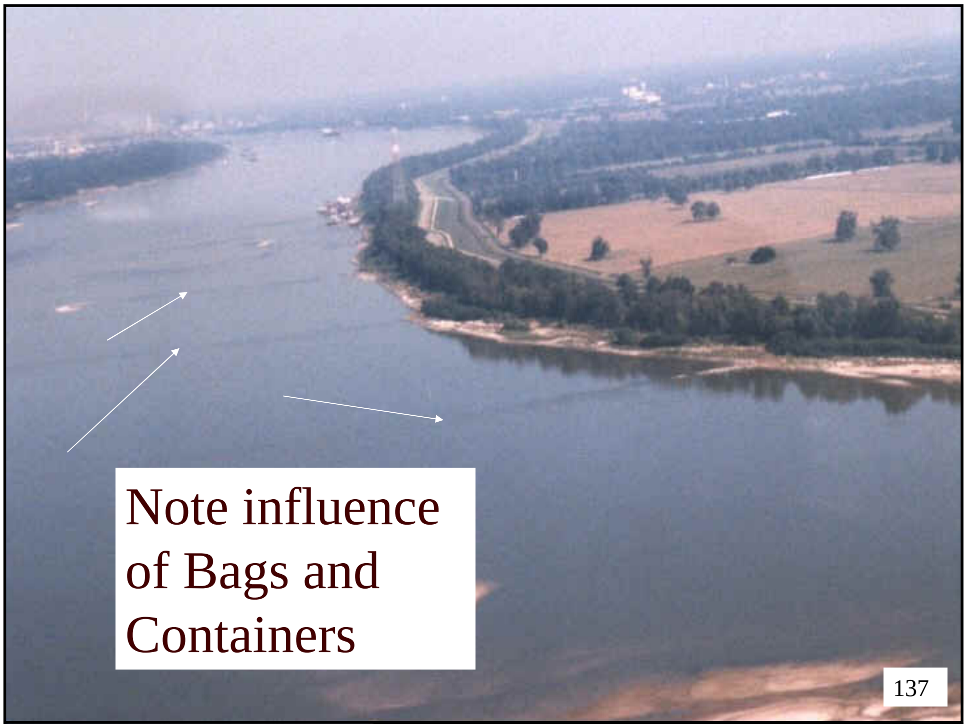
133



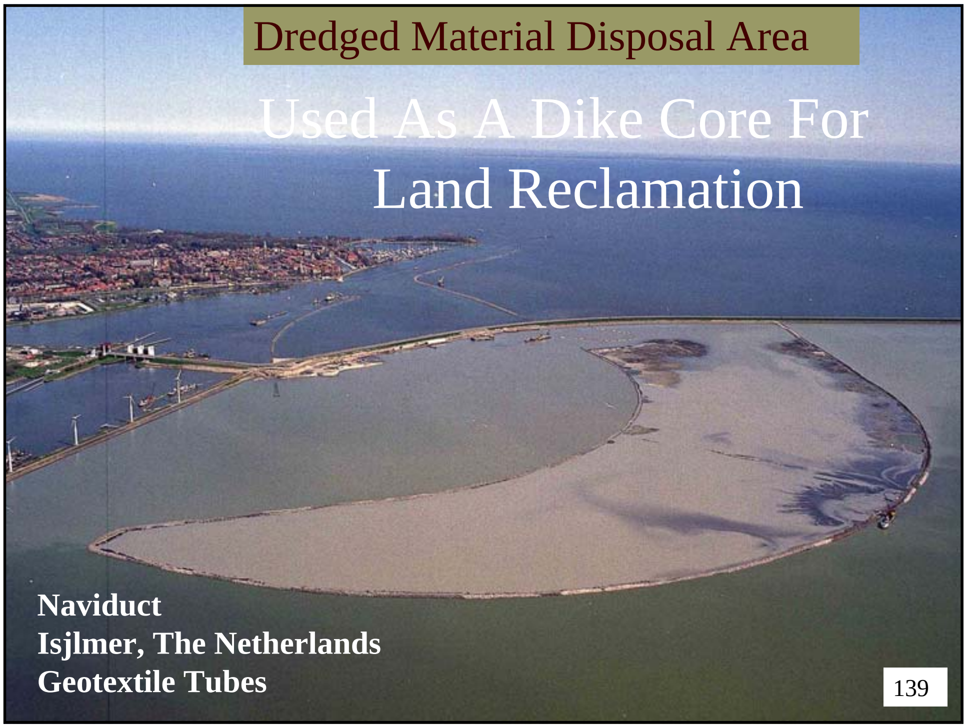
134


Red Eye Crossing
Baton Rouge, LA
October 1999
Bags After 6 years
135


Bags and Vegetation
136


Note influence of Bags and Containers
137


Note influence of Soft Dikes
138



The Naviduct Project

Large scale Rip Rap test covering Tubes

140

Woven Polyester Geotextile Tube Failures in a Coastal Erosion Application Installed in Dec 1997 and Completed in June 1998

141

Considerable amount of fill material has escaped from failed polyester tube

142

Close up view of polyester tube failed area near a fill port - MD yarns failed due to UV and hydrolysis degradation

143

2008 Geotextile Tubes Workshop was conducted as part of a research project funded by the US Department of Homeland Security (DHS) through UT Battelle at Oak Ridge National Laboratory under the Southeast Region Research Initiative (SERRI).

MISSISSIPPI STATE UNIVERSITY SERVICE LEARNING RESEARCH 1878

SERRI Southeast Region Research Initiative

ERDC US Army Engineer Research and Development Center

ORED OFFICE OF RESEARCH AND ECONOMIC DEVELOPMENT MISSISSIPPI STATE UNIVERSITY

End of *Geotextile Tubes, Design, Applications and Case Histories* by Jack Fowler, PhD, PE.

Section 6.5

2008 Geotextile Tubes Workshop

Nov 17-19 2008, Starkville MS

- ***Presentation Title:***

  Stability of Geotubes and Research Needs

- ***Authors:***

  Mohammed A. Gabr(Presenter)[1], Mahdi Khalilzad[1], Margery F. Overton[1], and Billy Edge[2]

- ***Affiliation and Contact Information:***

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  [2] Director, Reta and Bill Haynes '46 Coastal Engineering Laboratory, Department of Civil Engineering, Texas A&M University, Email: b-edge@tamu.edu

Jointly Sponsored by:

•Mississippi State University Civil and Environmental Engineering Department

•Mississippi State University Office of Research

•US Army Corps of Engineers Research and Development Center Coastal and Hydraulics Laboratory

Outline

1. Introduction
2. Approaches in literature
3. Analysis of Geotubes at Galveston
4. Behavior of Geotubes at Galveston
5. Summary

1

Recent Storms

Severe beach and dune erosion along the Gulf shoreline of the southeast Texas coast → Geotubes Performance

Tropical Storm Frances, September 1998

Tropical Storm Allison , June 2001

Not significant storms to assess geotube performance

Tropical Storm Fay, September 2002

Significant damage to the geotubes along the west Galveston beachfront

Hurricane Claudette, July 2003

Reference:

• Gibeaut, J. C., Hepner, Tiffany, Waldinger, R. L., Andrews, J. R., Smyth, R. C., and Gutiérrez, Roberto, 2003, Geotextile tubes along the upper Texas Gulf coast: May 2000 to March 2003: The University of Texas at Austin, Bureau of Economic Geology, final report prepared for Texas Coastal Coordination Council pursuant to National Oceanic and Atmospheric Administration Award No. NA07OZ0134, under GLO contract number 02-493 R, 37 p. + apps.

2

Notable Storms (1996-2006)

Storm	Date	Peak Surge at Galveston Pleasure Pier, m (NAVD88)
TS* Josephine	October 1996	+1.3
TS Charley	August 1998	+0.9
TS Frances	September 1998	+1.6
TS Allison	June 2001	+1.1
TS Fay	September 2002	+1.3
HU Isidore	September 2002	+1.0
HU Lili	October 2002	+1.0
HU Claudette	July 2003	+2.1
TS Grace	September 2003	+0.9
TS Ivan	September 2004	+1.1
HU Dennis	July 2005	+0.8
HU Katrina	August 2005	+0.8
HU Rita	September 2005	+1.2
Unnamed Storm	October 2006	+1.4

* NOTE: TS denotes tropical storm; HU denotes hurricane.

Reference:

• *Daniel J. Heilman, et al. (2008),* Interaction of Shore-Parallel Geotextile Tubes and Beaches along the Upper Texas Coast, US ARMY CORPS OF ENGINEERS, ERDC/CHL CHETN-II-51

3

Recent Storms

Peak Surge : 3.54 m

September 2008
IKE Storm

Reference:

- Website of National Weather Service Forecast Office

4

Geotubes at southeast Texas coast :

- Oval cross section of 12 ft made of geotextile fabric
- Rest on a fabric scour apron that has sediment-filled anchor tubes along each edge
- Placed in a trench parallel to shore along the back beach or foredunes
- Nine geotube projects cover a total of 7.6 mi of shoreline

Reference:

- Gibeaut, J. C., Hepner, Tiffany, Waldinger, R. L., Andrews, J. R., Smyth, R. C., and Gutiérrez, Roberto, 2003, Geotextile tubes along the upper Texas Gulf coast: May 2000 to March 2003: The University of Texas at Austin, Bureau of Economic Geology, final report prepared for Texas Coastal Coordination Council pursuant to National Oceanic and Atmospheric Administration Award No. NA07OZ0134, under GLO contract number 02-493 R, 37 p. + apps.
- Webpage of Bureau of Economic Geology, Coastal Studies Group

5

Geotubes at Bolivar Peninsula:

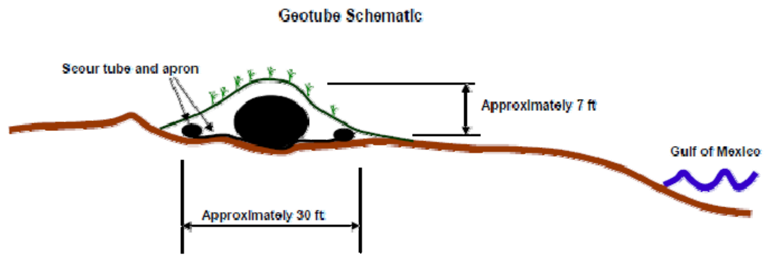
- 30 ft Circumference, 250 ft long geotextile tubes
- Main body: Mirafi® GT 1000
- Placed on a scour apron with anchor tubes made of Mirafi® GT 500
- Mirafi® 1120 N at the top of the geotube as a shroud for UV protection

Reference:

- TencateWebpage

6

Cross section of a geotube installation:



Reference:

- Gibeaut, J. C., Hepner, Tiffany, Waldinger, R. L., Andrews, J. R., Smyth, R. C., and Gutiérrez, Roberto, 2003, Geotextile tubes along the upper Texas Gulf coast: May 2000 to March 2003: The University of Texas at Austin, Bureau of Economic Geology, final report prepared for Texas Coastal Coordination Council pursuant to National Oceanic and Atmospheric Administration Award No. NA07OZ0134, under GLO contract number 02-493 R, 37 p. + apps.

7

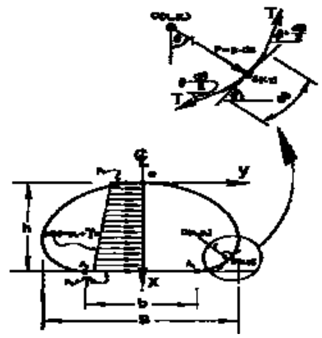
Parameters should be considered:

- Physical properties of filling materials and geotextile
- Internal stability: mechanical properties of geotextile, shape, and tension force
  - During filling
  - During performance
- Durability
- External hydrodynamical stability

8

Internal Stability: Tension in membrane (Leshchinsky et al., 1996)

- Assumptions:
  - Plain Strain State (Long Tube)
  - Thin, flexible shell with negligible unit weight
  - Hydrostatic state of stress inside the tube
  - No shear stress between geosynthetic and slurry



- Numerical solution of differential equations yields the relationship between T, P_0, h and y(x)
- Computer program GeoCoPS (Leshchinsky and Leshchinsky, 1996) was developed to compute geometry of tube y(x) and two of three parameters (T, h,and P_0)

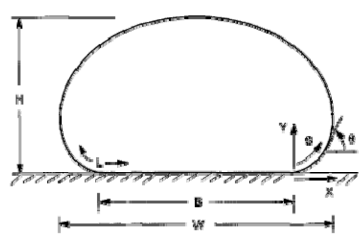
Reference:

- Leshchinsky, D., Leshchinsky, O., Ling, H. I., and Gilbert, P. A. (1996). "Geosynthetic tubes for confining pressurized slurry: some design aspects." *Journal of Geotechnical Engineering*, 122(8), 682-690.

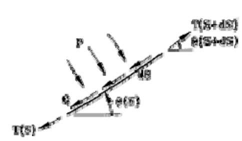
9

Tension in membrane (Plaut et al., 1998)

- Assumptions:
  - Two Dimensional solution (Plain Strain)
  - Inextensible membrane with negligible weight
  - Rest on a rigid, horizontal foundation
  - Incompressible fluid inside the tube



- Solution for 3 cases:
  - Geotube on the rigid foundation
  - Geotube on the deformable foundation
  - Geotube with water on one side



Reference:

- Plaut, R. H., & Suherman, S. (1998). Two-dimensional analysis of geosynthetic tubes. Acta Mechanica, 129(3-4), 207-218. 82-690.

10

Types of Wave Breaking

Hurricane IKE :

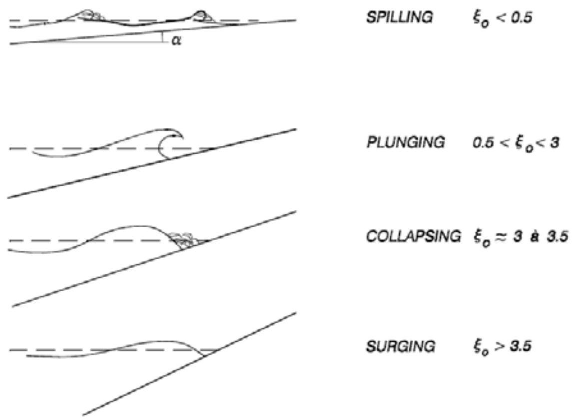
For pleasure pier:

Assuming:

Average Period: 8.2 sec

Hs= 3.54 m

Slope angle	ξ
α=5°	ξ =0.47
α=10°	ξ=0.96
α=20°	ξ=1.98



Reference:

- **US Army engineers, Coastal Engineering Manual, Report EM 1110-2-1100**
- **Website of NOAA**

External Stability; Hydrodynamic Pressure (P_w):

Hiroi (1920)

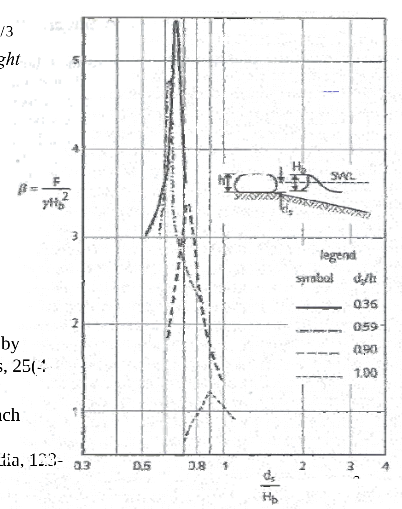
$$P_w = 1.5 \times \gamma_0 \times H_{1/3}$$

γ_0 = Unit weight of sea water *$H_{1/3}$=Significant wave height*

Liu (1981)

$$\beta = \frac{F}{\gamma H_b^{\,2}} \text{ in terms of } \frac{d_s}{H_b} \text{ and } \frac{d_s}{h}$$

β = Impact force coefficient



Reference:

- Shin, E. C., & Oh, Y. I. (2007). Coastal erosion prevention by geotextile tube technology. Geotextiles and Geomembranes, 25(4-5), 264-277
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Galveston Geotube

Circumference= 9.9 m

Peak water level= 3.8m NAVD

MSL=NAVD+0.15 m

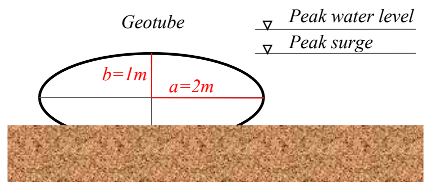
Bottom of Geotube at 1.5 m

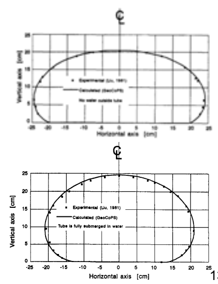
Water Head on Geotube=2.15 m

Break Wave Height = 1.67 m

Assumptions:

- a=2b
- Contact width is 80% of the long diameter.





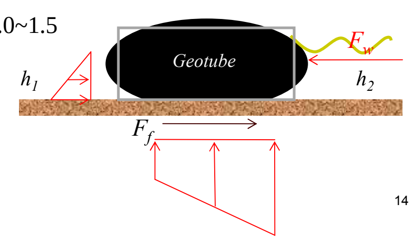
(Leshchinsky et al., 1996)

Reference:

- Website of National Weather Service Forecast Office

External Stability

- Sliding S.F.~0.8
- Overturning S.F.~1.5
- Bearing capacity
  - Normal to High Water Condition: S.F.=3.0~1.5
  - Seepage and Quick Conditions
  - Note: Not accounting the drag forces



COPRI: :Ike Field Investigation to Document Perishable Data: October 3, 2008

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Garry Gregory, Gregory Geotechnical - ASCE Geo Institute Liaison
Donald Stauble, USACE/ERDC/CHL
Jeffrey Waters, USACE/ERDC/CHL
Eddie Wiggins, USACE/JALBTCX
Marie Horgan Garrett, Coastal Solutions, Inc.

15

Consequences:

Damage to the coastal structure

Shoreline recession due to erosion

- Surge and flooding also from the bay side
- Elevation of shore protection Measures
- Geotube barriers: overtopped, rolled
- Some flattened and buried fully or partly

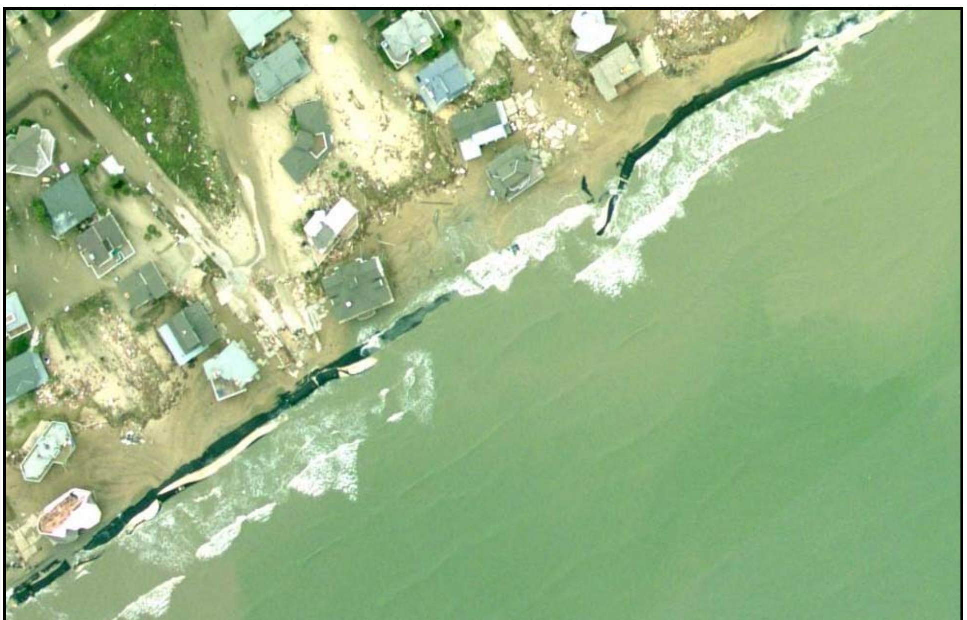
http://content.coprinstitute.org/HurricaneIketeam.html

16

Reference:

- http://ngs.woc.noaa.gov/ike/IMAGES/ike_c25882150.htm

17



Reference:

- http://ngs.woc.noaa.gov/ike/IMAGES/ike_c25882224.htm

18

19

Photo by Kojiro Suzuki, Port and Airport Research Institute, Japan

20

21

22

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Summary

- Geotubes provided protection for the landward infrastructures
- Lack of a well documented design process for Geotubes including characterization of storm loading
- Consider internal and external stability
- Consider the relative flexibility of the Geotube and underlying foundation in external and internal stability
- Consider possible Scour on landside due to trapping and scour at base
- Consider system approach for engineered “fuses” to minimize landside scour

24

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End of *Stability of Geotubes and Research Needs* presented by *Mohammed A. Gabr, PhD.*

Section 6.6

2008 Geotextile Tubes Workshop

Nov 17-19 2008, Starkville MS

- ***Presentation Title:***

  Use of Poor Quality Geo-Material in Geotextile Tubes for Structural Applications

- ***Author:***

Douglas A. Gaffney, P.E.

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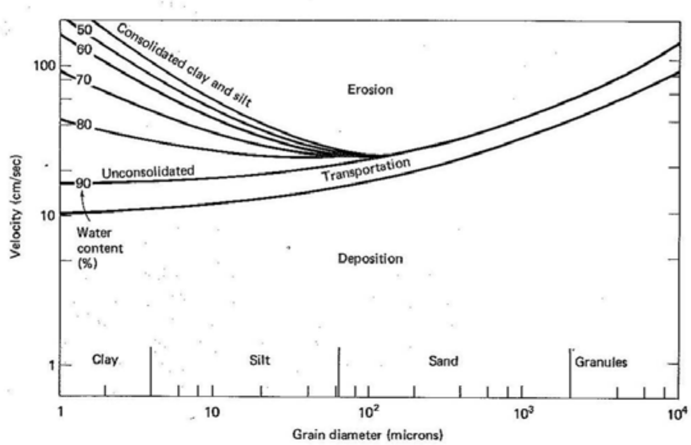
•US Army Corps of Engineers Research and Development Center Coastal and Hydraulics Laboratory

Poor Quality Geo-Materials

- Fine-grained (silts and clays)
- Often cohesive
- Low bearing capacity
- Critical Shear Velocity
  - Related to % Water content and grain size

1

Velocity to Grain Size Relationship



Source: Kennett, 1982

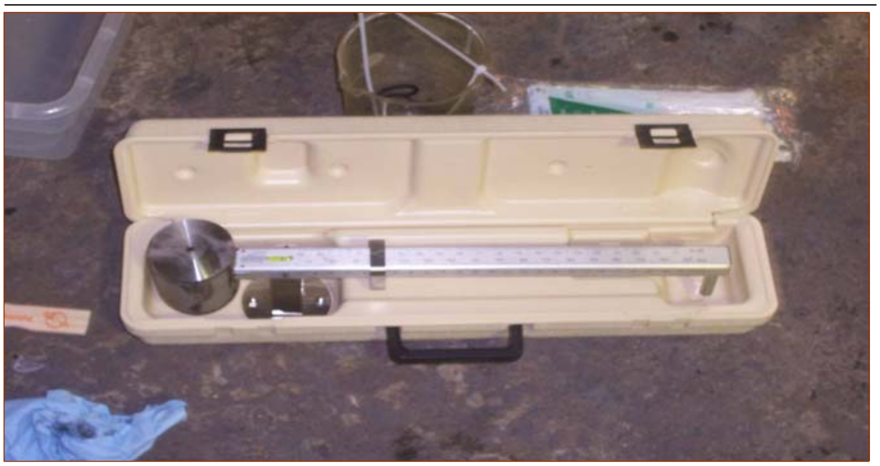
2

Geotextile Tubes

- Testing
  - Bench Scale (mud balance - % solids by weight)
  - Hanging Bag (decant flow rate, TSS, vane shear)
- Structures to prevent erosion
  - Scour aprons
  - Tubes
- Shear Stress
  - Waves - loss of material due to piping
  - Currents

3

Mud Balance



4

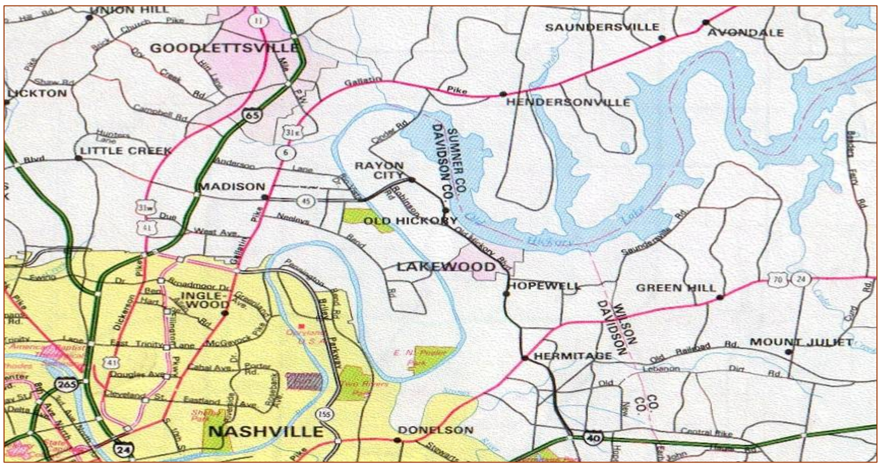
Hanging Bag

5

Erosion Control

6

USACE Drakes Creek Ecosystem Restoration Project, Hendersonville, TN



Source: USACE, 1999

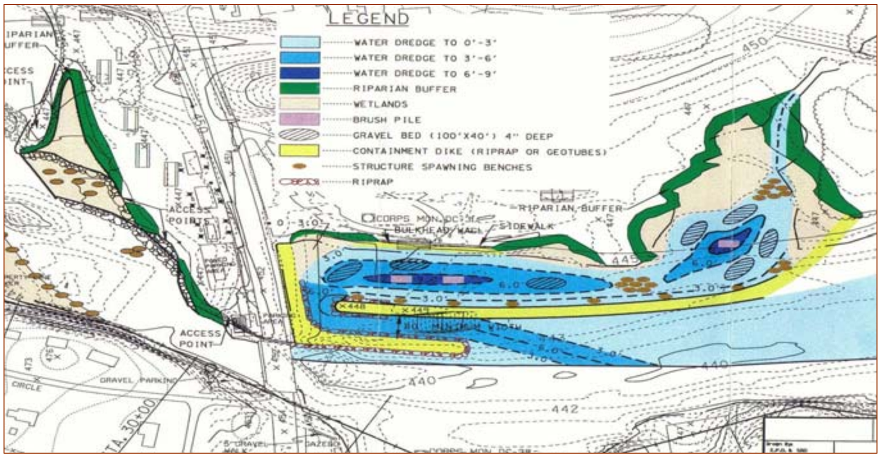
7

Drakes Creek Ecosystem Restoration Project

- Environmental Benefits
  - Cooler, deeper water
  - Discourage waterfowl at riverbank
  - Wetland habitat
  - Upland habitat
  - Minimize soil erosion
  - Gravel beds (fish habitat)
  - Return native species

8

USACE Drakes Creek Ecosystem Restoration Project, Hendersonville, TN



Source: USACE, 1999

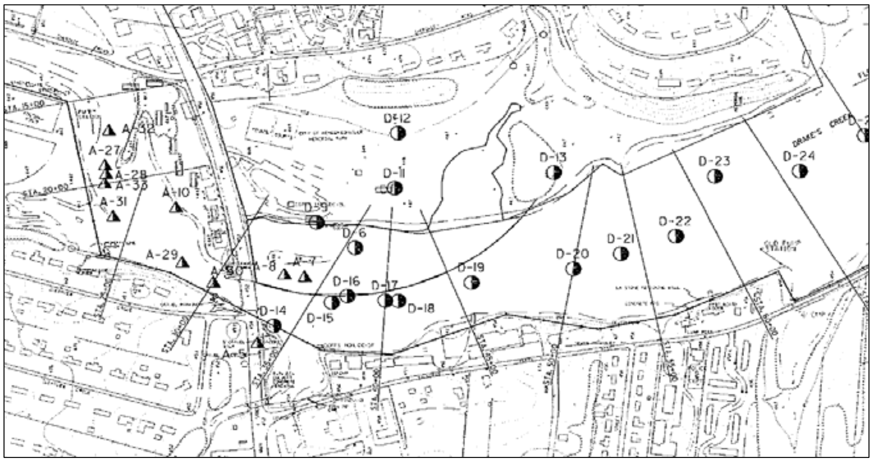
9

Drakes Creek Ecosystem Restoration Project

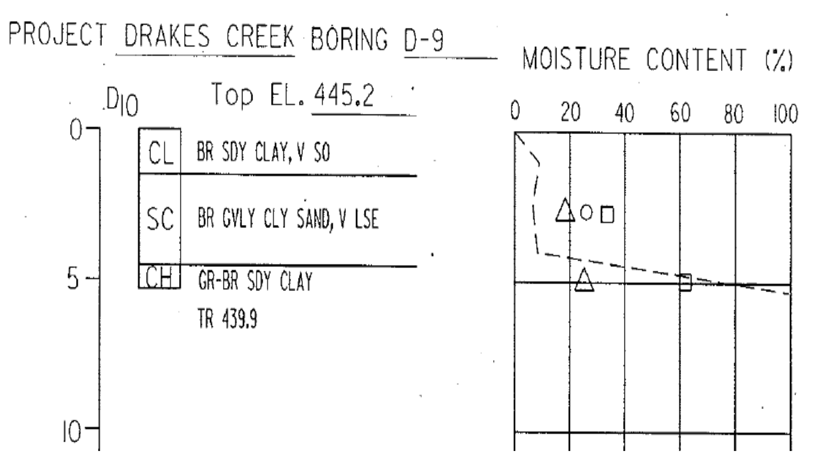
- 22,000 cubic yards dredged material
  - Sandy silts and clays
  - Required dewatering area
- 2,100 linear feet dike
  - 13 acre sub-embayment
  - 8,000 cubic yards of stone required
  - Shallow water depths

10

Geotechnical Borings



Typical Geotechnical Results



Drakes Creek Ecosystem Restoration Project

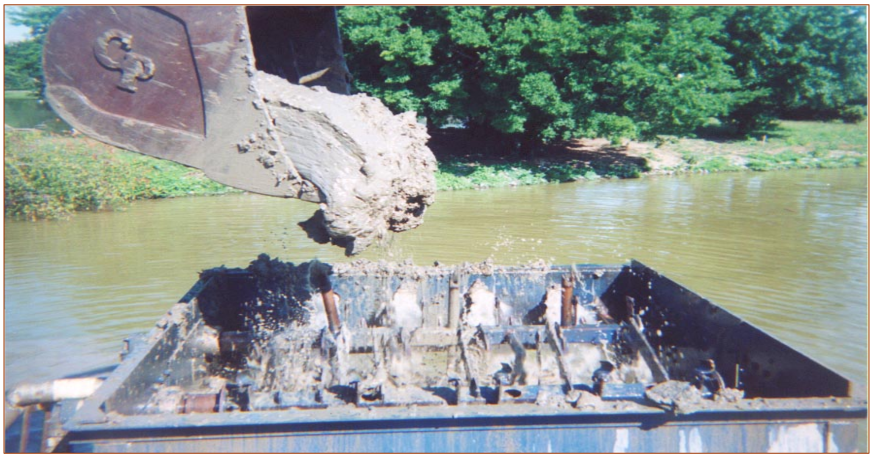
- Tubes
  - 45-ft circumference, woven polyester
  - Woven polypropylene scour aprons
  - Nonwoven UV shroud
  - Filled with poor quality sandy clay, organics and gravel.

13

Dredged Material

14

Dredged Material



15

Mechanical Dredge

16

Construction Equipment

17

Geotextile Dispenser

18

Scour Apron

19

Installation 2000

20

Butt Joints

21

Installation 2000

22

Installation 2000

23

Installation 2000

24

Dredged Material

25

Dredged Material

26

Installation 2000

27

Installation 2000

28

Connection to Upland

29

Wildlife

30

Dike

31

Vegetation

32

Phase II

- Continued dredging and placement into the containment area
- Proposed planting of the tube dike

33

Drakes Creek Project 2008

Source: Live Search Maps

34

Nyack Municipal Marina

Western Bank of the Hudson River

35

Dredging Project Goals

- Remove 1,800 CY of fine-grained, Hudson River sediment
- Quickly and Cost-effectively
- Populated setting
- Dewater the slurry - alternatives considered
  - Open air disposal
  - Filter presses
  - Geotextile tubes

36

Dredging

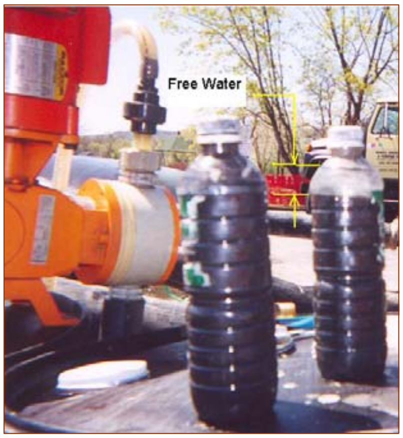
37

Tube Filling

38

Polymeric Conditioning

- Chemical feed pump
- Polydialymethyl / ammonium chloride
- Cationic Polymer
- Initial dosage rate 20 gallons per hour (approximately 167 ppm)
- Static mixer



39

Enhanced Settling

40

TESTING

- Percent Solids
  - Initial – 10 –15% solids
  - After 1 week – 25 -30% solids
  - After 2 months – 50% solids
- Specific Gravity of dry solids – 2.45
- Classification
  - MH elastic silt

41

Testing

- Paint Filter Test
  - EPA method 9095a
  - Determines whether a landfill considers the material to be dry

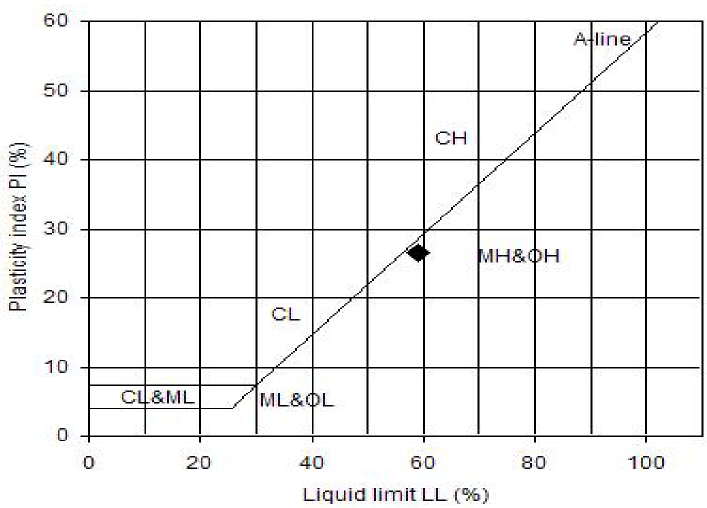
42

Dewatering Results

Sample	Paint Filter Test (June 30, 2003)	Percent Solids (April 30, 2003)	Percent Solids (June 30, 2003)
Tube 1	Passed		56
Tube 2	Passed		47
Tube 3	Passed		54
Tube 4	Passed	29.8	55
Tube 5	Passed		49
Tube 6	Passed	27.5 - lower 24.9 - upper	49

43

Dredged Material Properties



44

Dredged material is dry, now what?

- Truck to a landfill
  - Costly tipping fees and transportation
- Beneficial Use
  - Poor geotechnical properties
    - CBR – 3.43
    - Quick lime amendment
      - Hydrating excess moisture
      - Make soil more compactable
      - Increase shear strength

45

Lime Amendment

- Moisture content in September – 96.8%
- Optimum moisture content – 42%

46

Lime Amendment

- After two hours curing, 10% lime addition resulted in 67% increase in shear strength
- After two hours curing, 15% lime addition resulted in doubling of shear strength
- Quick lime or masonry lime

47

Parking Lot Design

- Parking Lot in town needed to be regraded for better water flow
- Requires fill material
- Dredged material would be sufficient quantity for subbase fill
- Requires approximately 146,000 pounds of lime (approximately $17,000)

48

Conclusions

- Geotextile tubes used as the main structural component for ecosystem restoration
  - Beneficial use of poor quality dredged material
  - Dramatically decrease erodability
- Geotextile tubes provide cost effective and rapid dewatering of poor quality material
  - With or without polymers

49

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50

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End of *Use of Poor Quality Geo-Material in Geotextile Tubes for Structural Applications by* Douglas A. Gaffney, P.E.

Section 6.7

2008 Geotextile Tubes Workshop

Nov 17-19 2008, Starkville MS

- ***Presentation Title:***

  Chemical Treatment of Dredged Solids

- ***Author:***

  Dewey W. Hunter

- ***Affiliation and Contact Information:***

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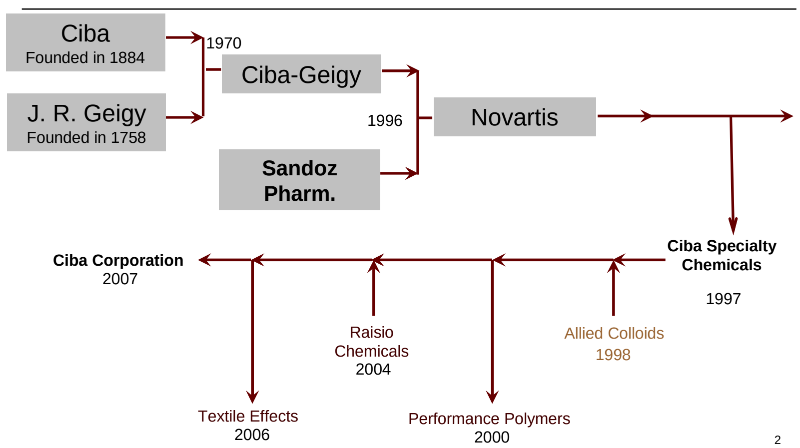
•US Army Corps of Engineers Research and Development Center Coastal and Hydraulics Laboratory

Ciba Corporation – Key Facts

- Corp. HQ in Basel, Switzerland
- U.S. Corp. HQ in Tarrytown, New York
- Our products and services are sold in over 120 countries on all continents.
- We employ 14,000 people
- 60 production sites in 23 countries.
- 22 R&D centers in 11 countries.
- Sales 6.0+ billion CHF (5.0 billion USD) in three major market areas: Europe, the Americas and Asia-Pacific.
- The company‘s roots go back to 1758 when J.R. Geigy founded the first chemical company in Basel, trading in chemicals and dyes.

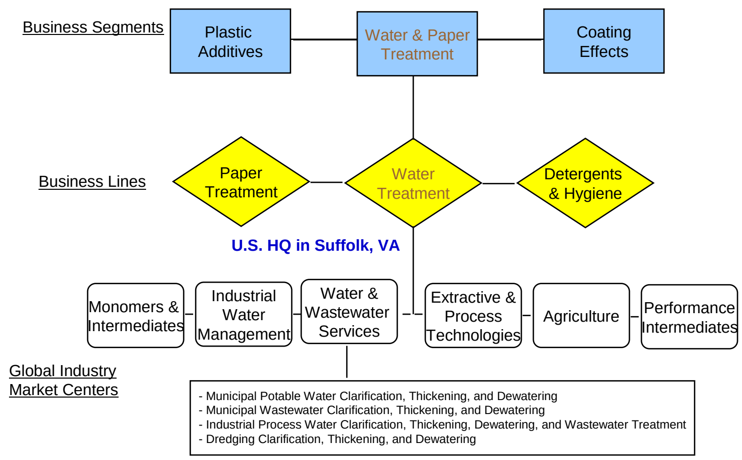
1

Ciba History



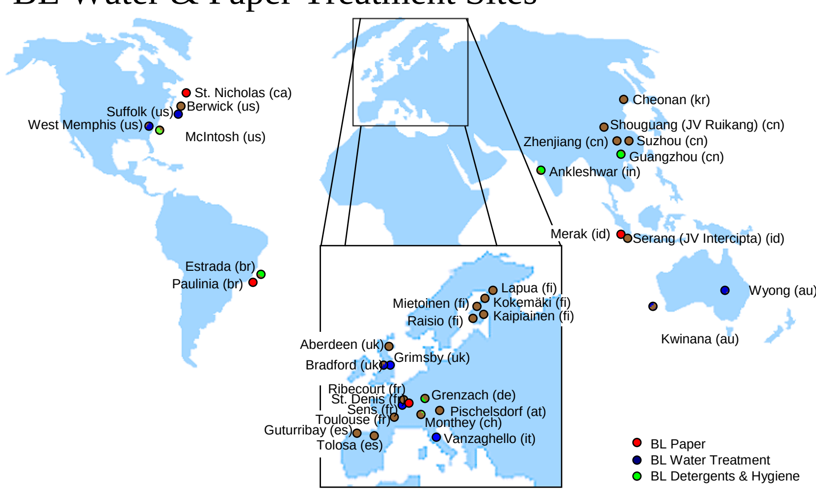
2

Ciba Corporation Business Structure



3

BL Water & Paper Treatment Sites



4

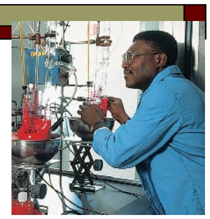
PIANC Classification of Soils

Soil Type	Particle Size – microns (10^{-6} meters)	Sieve Size
Boulders	> 200,000	6 in
Cobbles	60,000 – 200,000	3 – 6 in
Gravels - Coarse	20,000 – 60,000	¾ - 3 in
- Medium	6,000 – 20,000	¼ - ¾ in
- Fine	2,000 – 6,000	# 7 Sieve – ¼ in
Sands - Coarse	600 – 2,000	# 25 - # 7
- Medium	200 – 600	# 72 - # 25
- Fine	60 – 200	# 200 - # 72
Silts - Coarse	**20 – 60**	**Passing # 200**
- Medium	**6 – 20**	**"**
- Fine	**2 – 6**	**"**
Clays	**< 2**	**"**

Dredging "Fines" < 75 microns ; particles passing thru 200 mesh sieve
Cohesive Sediments < 62.5 microns
Suspended Solids < 45 microns
Colloidal Particles 0.001 – 1.0 microns

5

Why Use Chemical Treatment?



- **To Treat Problematic Sediments**
  - **Particles < 75 microns ("fines")**
  - **Contaminated sediments**
- **To Enhance Volume Reduction**
- **To Improve Process Efficiencies**
  - Higher solids loading (wt. of solids/unit time)
  - Improved solids-liquid separation in less time
    - Consolidate
    - Thicken
    - Dewater
  - **Higher hydraulic loading (gall./unit time)**
  - Create cleaner discharge water
    - Supernatant
    - Filtrate
    - Centrate
  - Higher solids removal efficiency (capture rate)
    - [(solids in – solids out)/solids in] x 100%

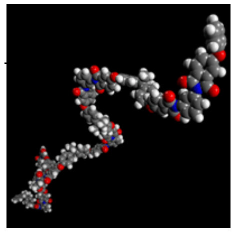
- **To Provide Overall Project Economy**
  - Cost-benefit analysis

Proven Technology for Water/Wastewater Treatment

6

Chemical Polymer Types (Organic)

NATURAL
- Proteins
- Gums
- Starch
- Cellulose



SYNTHETIC
- Plastics
  Polyethylene
  PVC
- Rubbers
  Polybutadiene
- Water Soluble
  Polyacrylamide
  PolyDMDAAC
  Polyamine

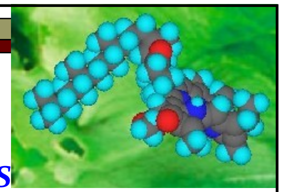
7

What are Polymers?

- Synthetic (man made) chemicals
- Organic (carbon based)
  - Long chains (macromolecules) of single monomer units via polymerization; longer chain ~ higher relative molecular weight
- Water soluble
- Polyelectrolytes
- Used extensively
  - Sold in U.S. since 1950’s
  - Municipal potable H2O and wastewater, industrial process and wastewater, mineral tailings, oil recovery, aggregate washing, soil conditioning

8

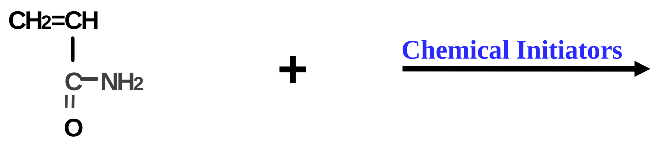
What Are Polymers Made Of?



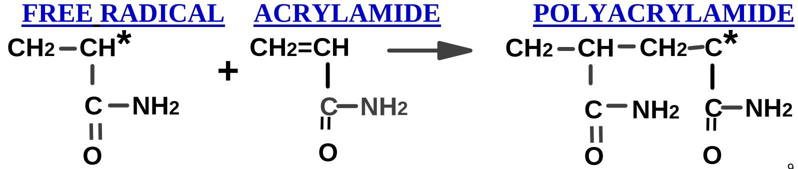
Greek	English
POLY MEROS	*MANY PARTS*

Large Molecule Made Up Of Simple Repeating Chemical Units of Carbon (Monomers)

ACRYLAMIDE (Monomer)



FREE RADICAL **ACRYLAMIDE** **POLYACRYLAMIDE**



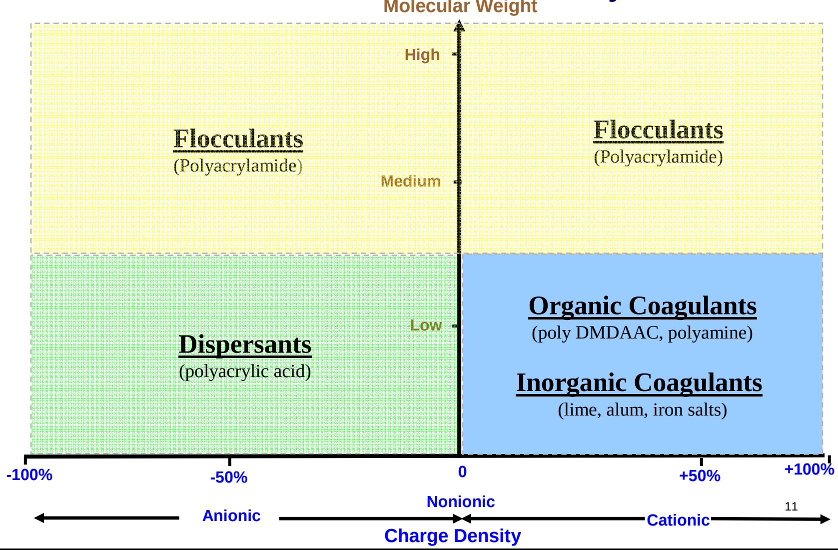
9

Polymers in Dredging

- Used in U.S. dredging more than 30 years
  - USACE tech. reports and engineering manuals
- Low usage vs. total cubic yardage
- Upland disposal/treatment/dewatering
- Fine grained sediments
  - Silts and clays (organic or inorganic)
  - High surface area-to-mass ratio
    - Particles attract and exhibit electrical charge
    - Colloidal suspensions
- Highly organic soils or substrates
- Contaminated sediments

10

Chemical Characteristics of Polymers



11

Chemical Treatment Options - Examples

Addition #1	Addition #2	Addition #3
Cationic Organic Coagulant	N/A	N/A
Cationic Inorganic Coagulant	N/A	N/A
Cationic Flocculant	N/A	N/A
Anionic Flocculant	N/A	N/A
Cationic Organic Coagulant	Anionic Flocculant	N/A
Cationic Inorganic Coagulant	Anionic Flocculant	N/A
Anionic Flocculant	Cationic Flocculant	N/A
Cationic Inorganic Coagulant	Cationic Organic Coagulant	Anionic Flocculant

12

STEP 1: COAGULATION

Coagulants (Organic and Inorganic)

- Low molecular weight
- Very high cationic (+) charge density

Coagulation

- Destabilize repulsion between particles
- Allow particles to agglomerate
- Produce small “floc” that may settle

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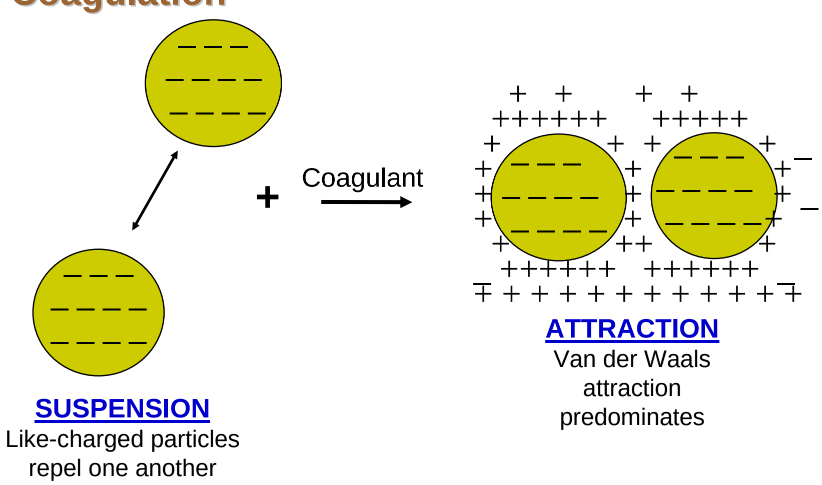
Coagulation



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STEP 2: FLOCCULATION

Flocculants (Anionic, Cationic, Nonionic)

- Wide molecular weight range; higher than coagulants
- Wide charge density range
- Destabilize repulsion between particles; not as well as coagulants

Flocculation

- Allows agglomeration to occur; more effective than coagulants
- Size of molecule allows for “netting” action
- Produces large “floc” that tends to readily separate from water and settle

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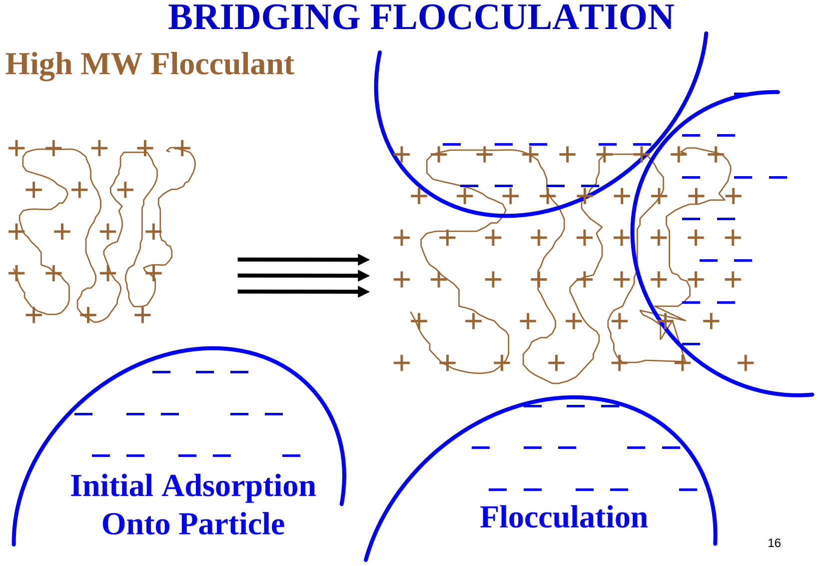
BRIDGING FLOCCULATION



16

Chemical Usage Considerations for Dredging:

- **Project Scope**
  - In-situ cubic yards (volume), % Total Solids (by weight), Dry Tons Solids (weight)
  - Project duration and hrs/day operation
  - Discharge water back into waterway?
  - Seasonal effects?
- **Aquatic Toxicity**
  - Ecotox and/or NSF data for all chemicals (MSDS)
  - Contact state or local agencies for requirements
  - Permits
- **Substrate Testing**
  - Representative core sampling data (In-situ % Total Solids)
  - Historical test or project data
  - Chemical(s) selection (charge & mol. wt. demand)
  - Dosage requirement (ppm = mg/L, or in lbs. chemical/dry ton solids)
- **Physical Form of Chemical**
  - Dry, oil-based liquid, water-based solution
  - Dictates safety, handling, storage, and makedown

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Chemical Usage Considerations for Dredging:

- **Associated Equipment**
  - Chemical handling, storage, makedown, metering, monitoring
  - Electrical and water supply
- **Applications Knowledge and Expertise**
  - In-house consultant or chemical supplier with experience
- **Cost-Benefit Analysis**
  - Costs of chemical usage vs. benefits
  - Overall operating costs
  - Costs of various options
- **Project Budgeting**
  - Consider and include all costs up front, not as an add-on later

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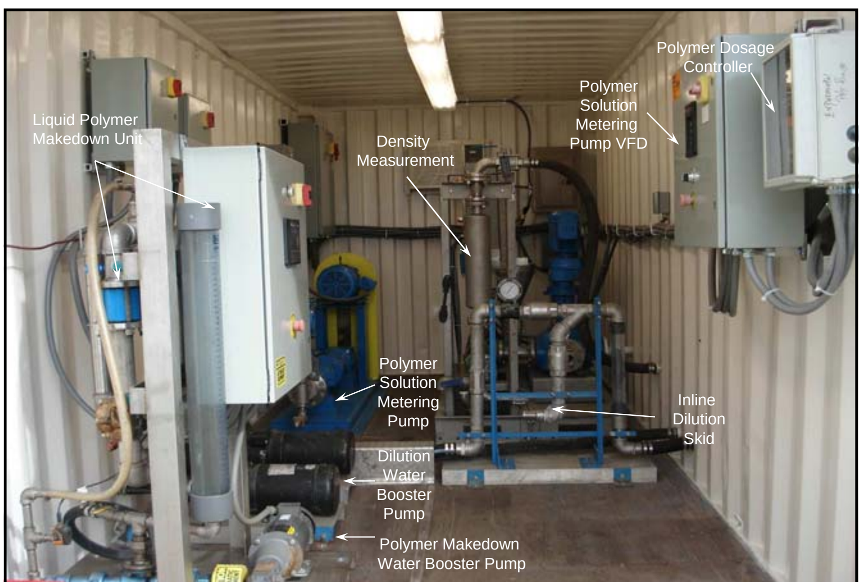
Containerized Liquid Polymer Makedown System

Dimensions: 20’x8’x8’

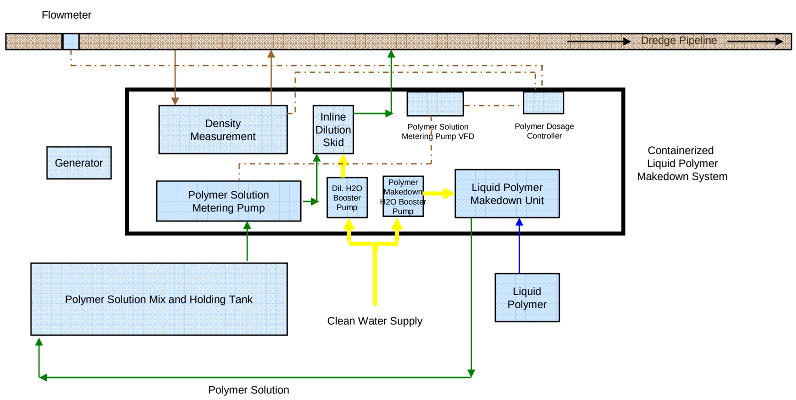
Gross Weight: 8,000 lbs.

Water Needs: 100 gpm @ 40 psi

Power Needs: 100 kW generator



System Layout - Example



Not Drawn to Scale

Challenges for the SERRI-DHS Application

- Following a disaster:
  - Clean water supply for polymer makedown
  - Availability of containerized polymer makedown system(s)
  - Availability of sufficient polymer supply
  - Correct polymer selection and dosage levels required
    - Salt water vs. freshwater inundation
  - Transport/placement into target area
  - Regulatory or ecotox issues

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CHARACTERISTIC	RESULT
Sample Type	Organic Clay in Rainwater
pH	7.5
Physical Characteristics	Dark Brown Color
Dry Solids	9.16%
Specific Gravity (of slurry)	1.079
Particle Size	
- d_{10}	4.54um
- d_{50}	19.87um
- d_{90}	104.2um
Mean	14.51um
Surface Area	10317cm²/ml
Organics & Volatiles	14.62%

Polymer Treatment Demonstration

- Substrate: Organic clay sample
- Location: New Orleans, LA
- Slurry Solids: ~ 6.2% Total Solids (wt/wt)
- Polymer Dosage:~ 3.0 lbs. polymer / dry ton solids

Polymer Dosage relates to approximately:
1.0 lb. of polymer for every 1,227.90 gallons of 6.2% T.S. slurry
1.0 lb. of polymer for every 6.08 cubic yards of 6.2% T.S. slurry

GDT Pillow Test Results – Oct. 27, 2008

- Substrate: Organic clay sample
- Location: New Orleans, LA
- Slurry Solids: 11.51 % Total Solids (wt/wt)
- Polymer Dosage: 3.0 lbs. polymer / dry ton solids

Results Obtained After 2 Hours

Sample	Cake Depth* (cm)	Dry Solids (%)	Yield Stress (Pa) After plunging		
			20	50	100
Corner 1	2.5	36.48	2694	2681	2674
Corner 2	3	38.23	2744	2738	2739
Center	5	40.53	2834	2834	2837
Corner 3	4	39.57	2795	2788	2784
Corner 4	4.5	40.14	2829	2829	2825

2008 Geotextile Tubes Workshop was conducted as part of a research project funded by the US Department of Homeland Security (DHS) through UT Battelle at Oak Ridge National Laboratory under the Southeast Region Research Initiative (SERRI).

SERRI
Southeast Region Research Initiative

ERDC
US Army Engineer Research and Development Center

ORED OFFICE OF RESEARCH AND ECONOMIC DEVELOPMENT
MISSISSIPPI STATE UNIVERSITY

End *of Chemical Treatment of Dredged Solids*

by Dewey W. Hunter

Section 6.8

2008 Geotextile Tubes Workshop

Nov 17-19 2008, Starkville MS

- ***Presentation Title:***

  Specification and Testing of

  Geotextile Tubes

- ***Author:***

  George R. Koerner, Ph.D., PE &CQA

- ***Affiliation and Contact Information:***

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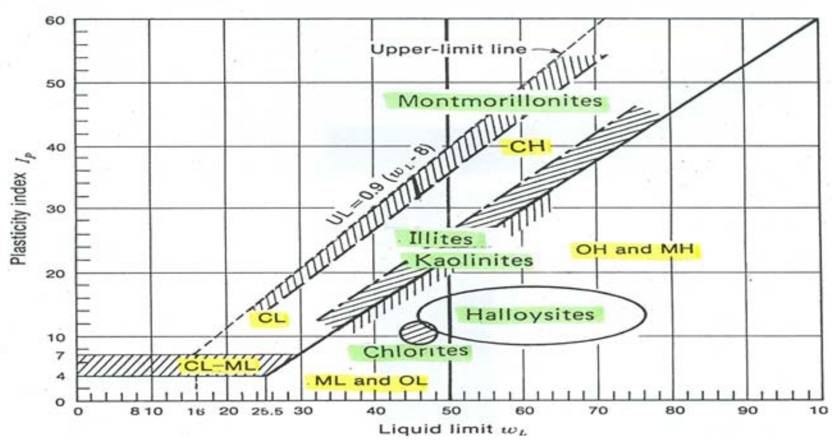
Jointly Sponsored by:
•Mississippi State University Civil and Environmental Engineering Department
•Mississippi State University Office of Research
•US Army Corps of Engineers Research and Development Center Coastal and Hydraulics Laboratory

Presentation Outline

- Background
- Manufacturing
- Specification
- Discussion Items

1

Liquid Limit



2

GS and soft soils

Walls, slopes and embankments

MESL

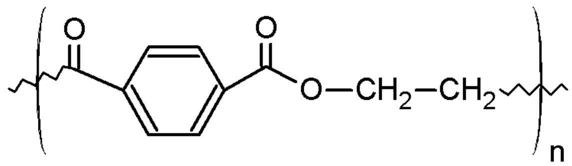
3

Polymeric Materials

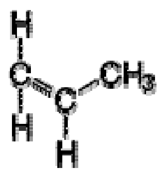
- polymer = poly (“many”) & mero (“parts”)
- characterized by high molecular weight, M_w = 10,000 to 100,000
- there are thousands of polymers
- Geotextiles use only a few

4

Common Geotextile Polymers



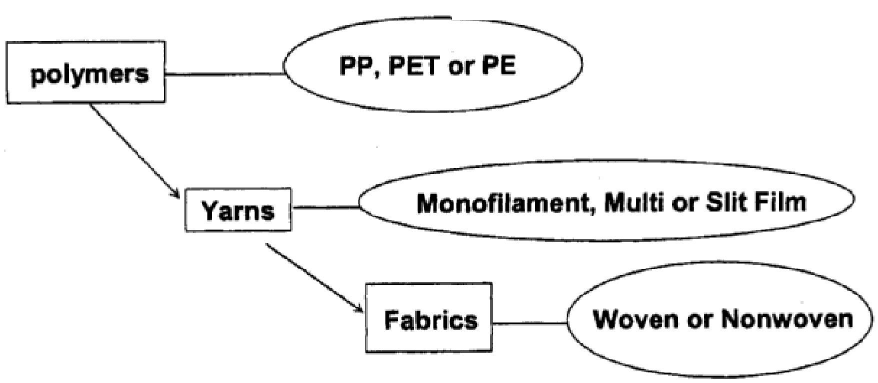
Polyethylene terephthalate (PET)



Polypropylene (PP)

5

Geotextile Manufacturing



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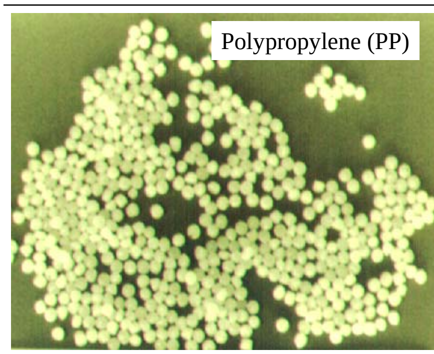
PP and PET Manufacturing

Polypropylene

Polyester

7

Polypropylene and Polyester



Polypropylene (PP)

Polyester (PET)

Type	Resin	Plasticizer	Fillers	C.B.	Additives*
PP	95-98	0	0	2-3	1-2
PET	97-98	0	0	1	1-2

***Additives are various antioxidants**

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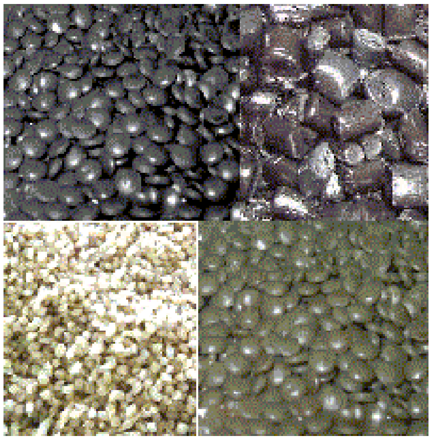
Carbon Black and Additives



Concentrate Let-Down

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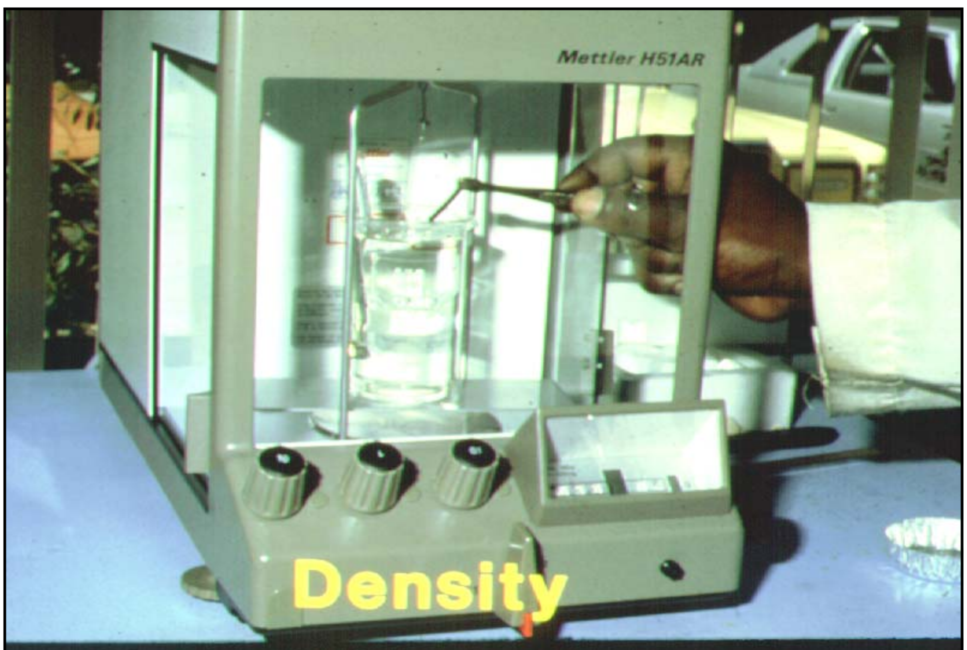

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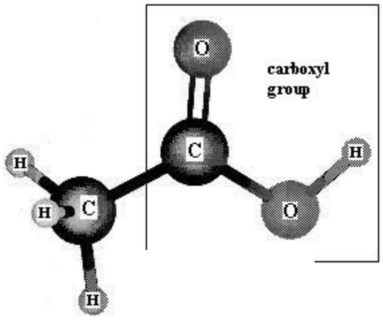
PET Durability requirements

- Minimum M_w = 25,000
- Max CEG = 30



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MFI

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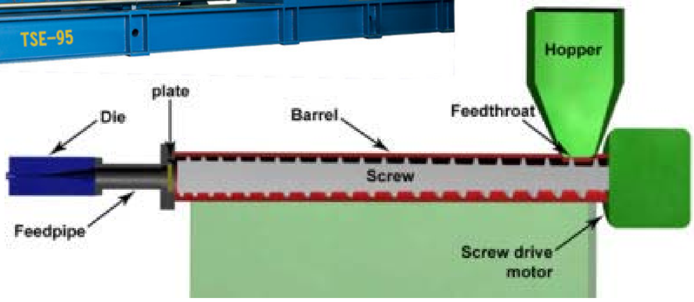
Extruder



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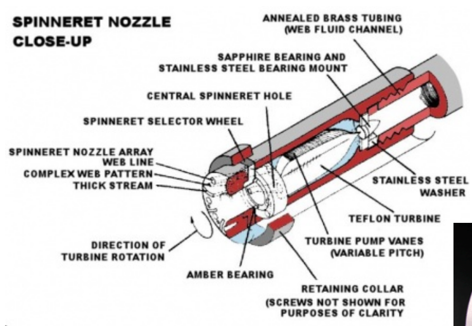
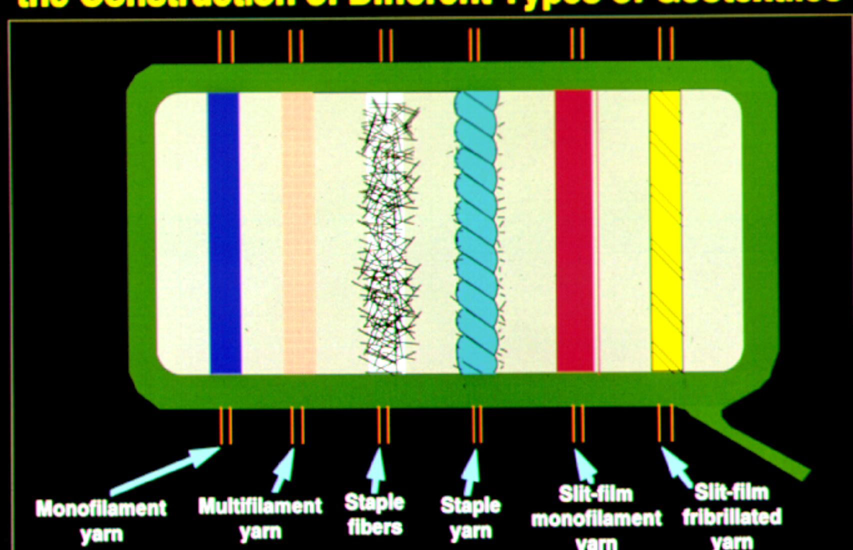
Extruding Yarns



15

Types of Polymeric Fibers or Yarns Used in the Construction of Different Types of Geotextiles



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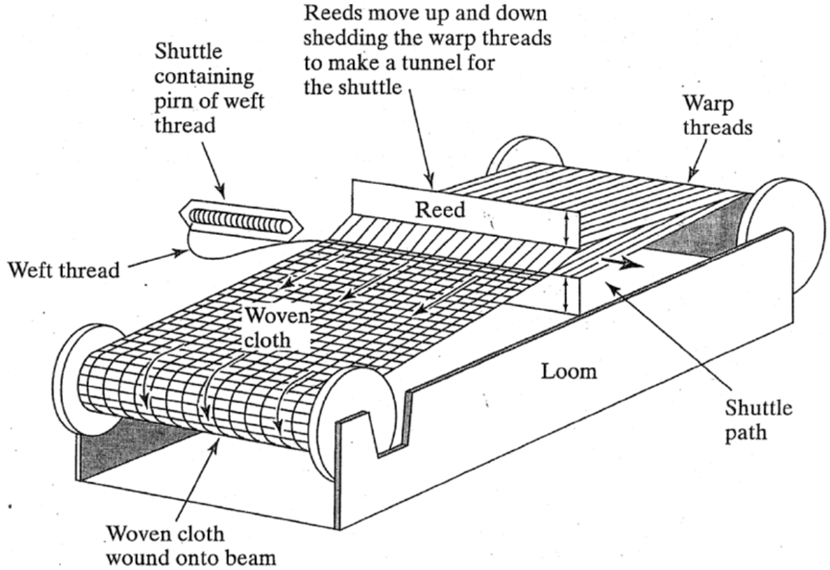
Manufacturing Wovens Geotextile



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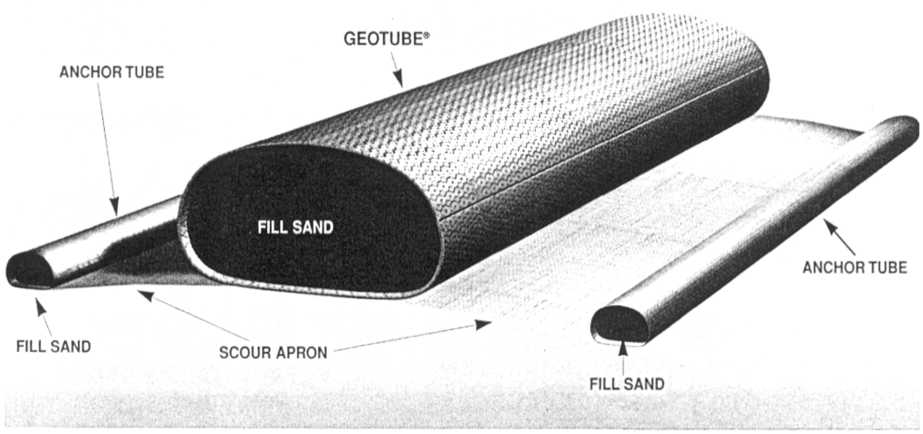
Anchor Tubes on Both Sides of Main Tube



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Geotextile Tube Specification

- Need existed for generic MQC specifications
- GSI assembled three main manufacturers at the time (1997)
- Several meetings of ad-hoc committee
- GRI-GT10, Application specific specification for “Coastal and Riverine structures.”
- Original approved by GSI membership on September 27, 1999
- Specification addresses
  - Properties
  - Test Methods
  - Units
  - Limiting test values
  - Frequencies

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Main Tube Circumference

- factory manufactured in six circumferences, maximum size is 5.7 m (19 ft.)
- Typical lengths include but are not limited to, 2.3; 4.6; 6.8; 9.1; 14 and 18 m (7.5; 15; 22.5; 30; 45 and 60 ft.)

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Anchor Tube Circumference

- 0.9 or 1.8 m (3 or 6 ft.) circumference
- connected to main tube by a fabric scour apron
- some designs call for two anchors

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Wide Width and Seam Properties

(a) Main Tube Properties

Property	ASTM	Aggressive	Typical
strength	D4595	175 × 175 kN/m (1000 × 1000 lb/in.)	70 × 95 kN/m (400 × 550 lb/in.)
elongation	D4595	15 × 15%	20 × 20%
seam	D4884	105 kN/m (600 lb/in.)	60 kN/m (350 lb/in.)

(b) Anchor Tube Properties

Property	ASTM	Aggressive	Typical
strength	D4595	70 × 95 kN/m (400 × 550 lb/in.)	70 × 95 kN/m (400 × 550 lb/in.)
elongation	D4595	20 × 20%	20 × 20%
seam	D4884	60 kN/m (350 lb/in.)	35 kN/m (200 lb/in.)

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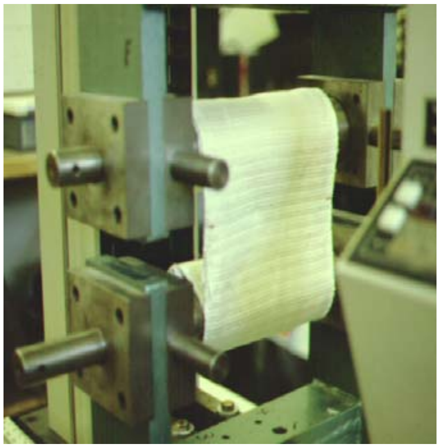
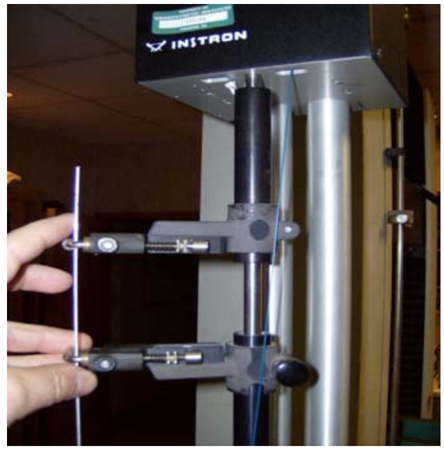
Tensile Strength ASTM D4595





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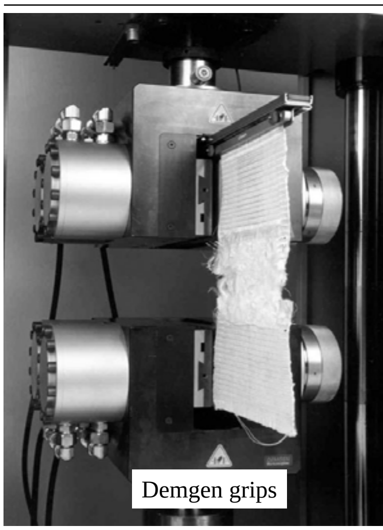
Tensile Strength ASTM D4595



Demgen grips

Non-contact extensometer

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Commentary on WWT:

- Important property which is hotly contested
- Grips can not initiate failure and break must occur within the gage length
- 2, 5, 10% Modulus often used for design
- 1.25% preload of expected breaking force is allowed in method
- Good specimen preparation is critical

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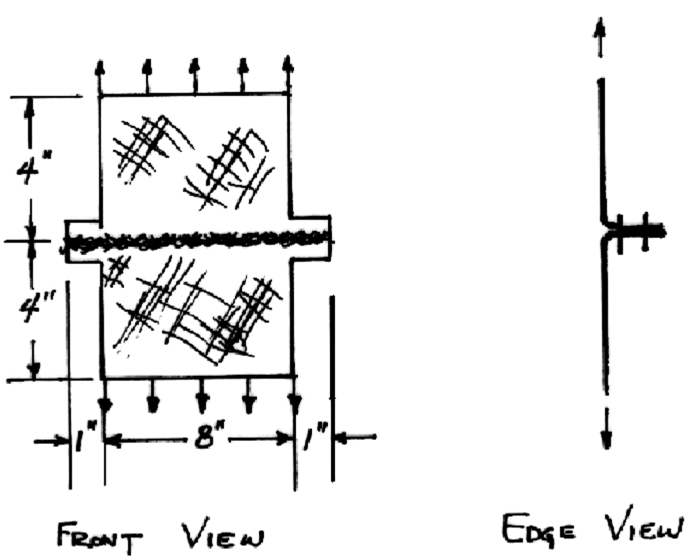
ASTM D4884 SEAM STRENGTH



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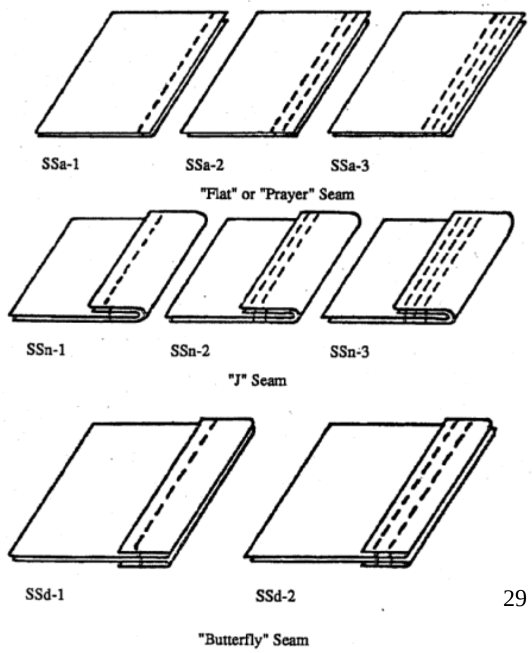
Types of Geotextile Seams

Sew
Thermal bond
Glue

Use thread of contrasting color to geotextile for CQA continuity check



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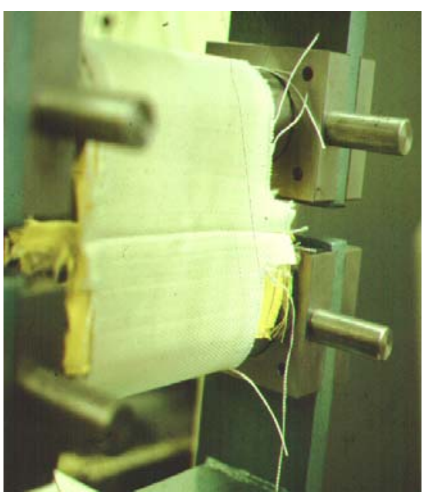
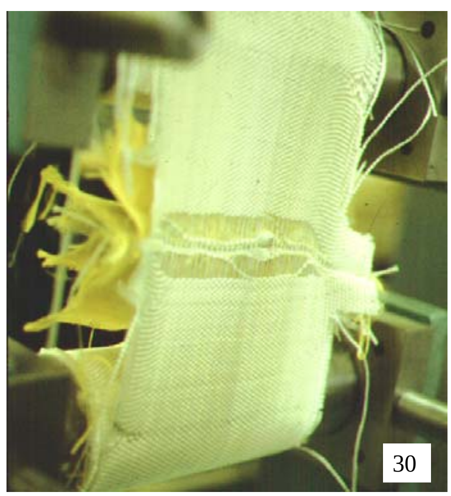
Sewn Seam Test ASTM D4884





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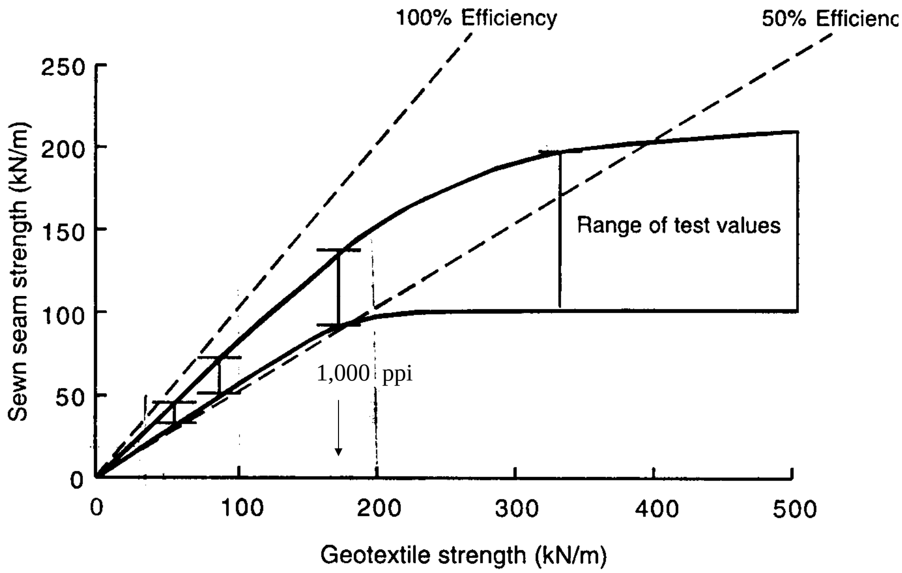

$$\text{Efficiency (\%)} = \frac{\text{Seam Strength}}{\text{Fabric Strength}}(100)$$

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Trapezoidal Tear Strength

- **Follows ASTM D4533**

location	aggressive	typical
main tube	2.7 × 2.7 kN (600 × 600 lb)	0.8 × 1.2 kN (180 × 270 lb)
anchor tube	0.8 × 1.2 kN (180 × 270 lb)	0.8 × 1.2 kN (180 × 270 lb)

- **Frequency is every 7500 m^2 (10,000 yd^2)**

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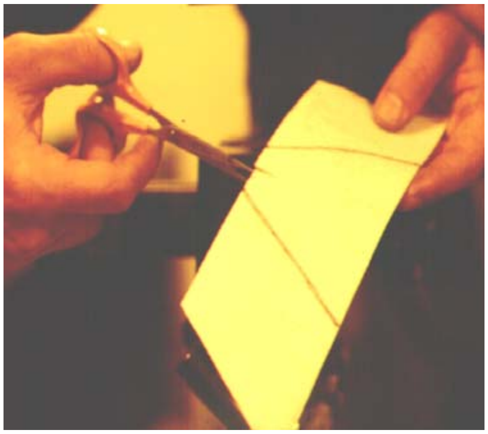
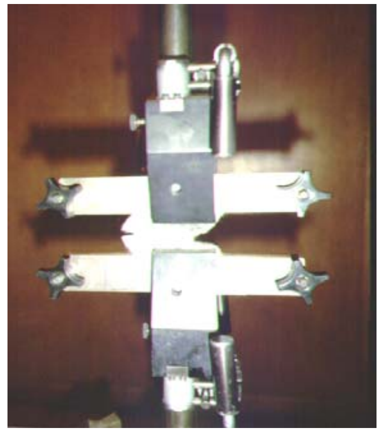
Trap Tear ASTM D4533





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Puncture Strength

- **follows ASTM D4833**
- **its called “pin” puncture**
- **uses a 8.0 mm (5/16 in.) probe**

location	aggressive	typical
main tube	1.8 kN (400 lb)	1.2 kN (260 lb)
anchor tube	1.2 kN (260 lb)	0.7 kN (160 lb)

- **frequency is every 10,000 yd^2 (7500 m^2)**

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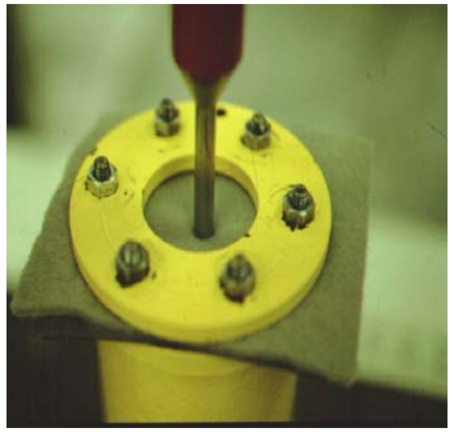
Puncture ASTM D4833



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Apparent Opening Size

- its dry bead sieving, per ASTM D4751
- AOS is often called EOS
- it's a maximum value, i.e., "max. ave."
- either 0_{95} in mm, or equivalent U. S. sieve size

location	aggressive	typical
main tube	0.425 mm (No. 40)	0.425 mm (No. 40)
anchor tube	0.425 mm (No. 40)	0.60 mm (No. 30)

- frequency is every 40,000 m^2 (50,000 yd^2)

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Apparent Opening Size ASTM D4751

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Water Flow Rate

- uses ASTM D4491
- measures flow rate/unit area

location	aggressive	typical
main tube	240 l/min-m^2 (6.0 gal/min-ft^2)	240 l/min-m^2 (6.0 gal/min-ft^2)
anchor tube	240 l/min-m^2 (6.0 gal/min-ft^2)	240 l/min-m^2 (6.0 gal/min-ft^2)

- frequency is every 40,000 m^2 (50,000 yd^2)

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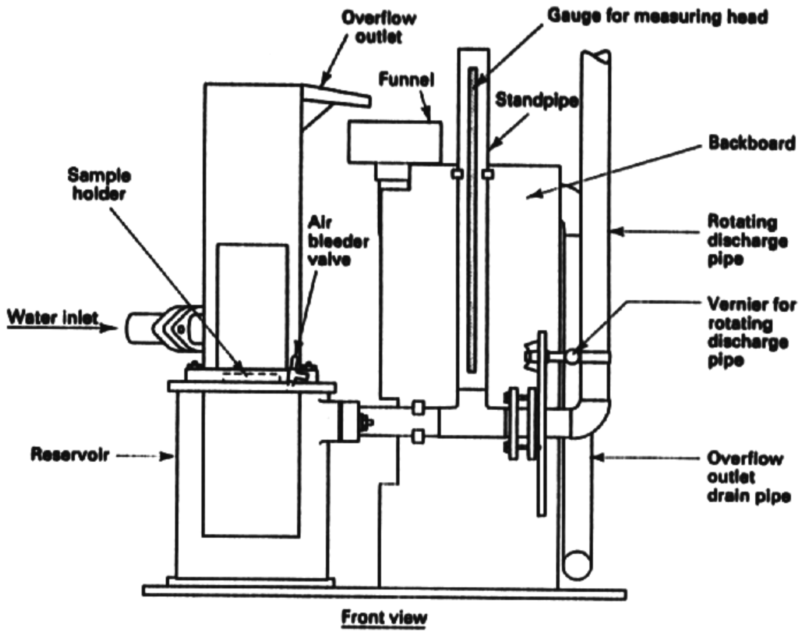

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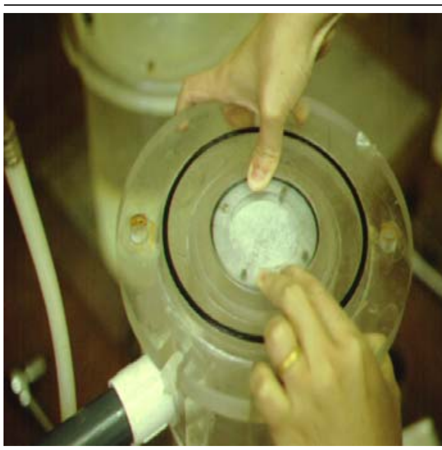
ASTM D4491 – Water Flow Rate (Permittivity) Device

Permittivity ASTM D4991



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Ultraviolet Resistance

- follows ASTM D4355
- it's the Xenon Arc device
- measures strength retained after 150 hrs. exposure
- must be ≥ 65% of original
- frequency is every year

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Typical Xenon Arc Weatherometer

Interior Chamber of Xenon Arc Weatherometer

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The Basic Tables follow

Main and Anchor Tubes – Aggressive

Main and Anchor Tubes – Typical

Note: The most recent version of this specification (text and tables) is available on the GSI Web Site

www.geosynthetic-institute.org

Table 1(a): Class 1 Tubes - Aggressive Conditions
(all are minimum average values unless noted otherwise)

Property	Test Method ASTM	English Units		Metric Units	
		Property	Frequency	Property	Frequency
<u>Physical</u>					
Tube Circumference	Measured	7.5/15/22.5/30/45/60-ft.	n/a	2.3/4.6/6.8/9.1/14/18 m	n/a
Fill Port (diameter)	Measured	12 or 18 in.	n/a	30 or 45 cm	n/a
<u>Mechanical</u>					
Wide Width Tensile Strength	D4595	1000 x 1000 lb/in.	10,000 yd²	175 x 175 kN/m	7500 m²
Wide Width Elongation (max.)	D4595	15 x 15%	10,000 yd²	15 x 15%	7500 m²
Trapezoidal Tear Strength	D4533	600 x 600 lb	10,000 yd²	2.7 x 2.7 kN	7500 m²
Puncture Strength	D4833	400 lb	10,000 yd²	1.8 kN	7500 m²
Seam Strength (factory)	D4884	600 lb./in.	50,000 yd²	105 kN/m	40,000 m²
<u>Hydraulic</u>					
Apparent Opening Size (AOS)	D4751	No. 40 Sieve (min.)	50,000 yd²	0.425 mm (max)	40,000 m²
Water Flow Rate	D4491	6 gpm/ft²	50,000 yd²	240 l/min/m²	40,000 m²
<u>Endurance</u>					
Accelerated UV Resistance (% retained after 150 hr)	D4355	65%	year	65%	year

Table 1(b): Class 1 Scour Aprons - Aggressive Conditions
(all are minimum average values unless noted otherwise)

Property	Test Method ASTM	English Units		Metric Units	
		Property	Frequency	Property	Frequency
<u>Physical</u>					
Anchor Tube Circumference	Measured	3-6 ft.	n/a	0.9 - 1.8 m	n/a
<u>Mechanical</u>					
Wide Width Tensile Strength	D4595	400 x 550 lb/in.	10,000 yd²	70 x 95 kN/m	7500 m²
Wide Width Elongation (max.)	D4595	20 x 20%	10,000 yd²	20 x 20%	7500 m²
Trapezoidal Tear Strength	D4533	180 x 270 lb	10,000 yd²	0.8 x1.2 kN	7500 m²
Puncture Strength	D4833	260 lb	10,000 yd²	1.2 kN	7500 m²
Seam Strength (factory)	D4884	350 lb/in.	50,000 yd²	60 kN/m	40,000 m²
<u>Hydraulic</u>					
Apparent Opening Size (AOS)	D4751	No. 40 Sieve (min.)	50,000 yd²	0.425 mm (max)	40,000 m²
Water Flow Rate	D4491	6 gpm/ft²	50,000 yd²	240 l/min/m²	40,000 m²
<u>Endurance</u>					
Accelerated UV Resistance (% retained after 150 hr)	D4355	65%	year	65%	year

Table 2(a): Class 2 Tubes - Typical Conditions
(all are minimum average values unless noted otherwise)

Property	Test Method ASTM	English Units		Metric Units	
		Property	Frequency	Property	Frequency
<u>Physical</u>					
Tube Circumference	Measured	7.5/15/22.5/30/45-ft	n/a	2.3/4.6/6.8/9.1/14 m	n/a
Fill Port (diameter)	Measured	12 or 18 in.	n/a	30 or 45 cm	n/a
<u>Mechanical</u>					
Wide Width Tensile Strength	D4595	400 x 550 lb/in.	10,000 yd^2	70 x 95 kN/m	7500 m^2
Wide Width Elongation (max.)	D4595	20 x 20%	10,000 yd^2	20 x 20%	7500 m^2
Trapezoidal Tear Strength	D4533	180 x 270 lb	10,000 yd^2	0.80 x 1.2 kN	7500 m^2
Puncture Strength	D4833	260 lb	10,000 yd^2	1.2 kN	7500 m^2
Seam Strength (factory)	D4884	350 lb./in.	50,000 yd^2	60 kN/m	40,000 m^2
<u>Hydraulic</u>					
Apparent Opening Size (AOS)	D4751	No. 40 Sieve (min.)	50,000 yd^2	0.425 mm (max)	40,000 m^2
Water Flow Rate	D4491	6 gpm/ft^2	50,000 yd^2	240 l/min/m^2	40,000 m^2
<u>Endurance</u>					
Accelerated UV Resistance (% retained after 150 hr)	D4355	65%	year	65%	year

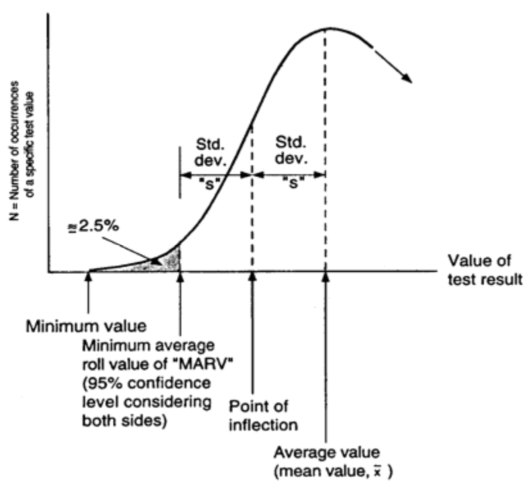
Table 2(b): Class 2 Scour Aprons - Typical Conditions
(all are minimum average values unless noted otherwise)

Property	Test Method ASTM	English Units		Metric Units	
		Property	Frequency	Property	Frequency
<u>Physical</u>					
Anchor Tube Circumference	Measured	3-6 ft	n/a	0.9-1.8 m	n/a
<u>Mechanical</u>					
Wide Width Tensile Strength	D4595	400 x 400 lb/in.	10,000 yd^2	70 x 70 kN/m	7500 m^2
Wide Width Elongation (max.)	D4595	20 x 20%	10,000 yd^2	20 x 20%	7500 m^2
Trapezoidal Tear Strength	D4533	180 x 270 lb	10,000 yd^2	0.80 x 1.2 kN	7500 m^2
Puncture Strength	D4833	160 lb	10,000 yd^2	0.70 kN	7500 m^2
Seam Strength (factory)	D4884	200 lb./in.	50,000 yd^2	35 kN/m	40,000 m^2
<u>Hydraulic</u>					
Apparent Opening Size (AOS)	D4751	No. 30 Sieve (min.)	50,000 yd^2	0.60 mm (max)	40,000 m^2
Water Flow Rate	D4491	6 gpm/ft^2	50,000 yd^2	240 l/min/m^2	40,000 m^2
<u>Endurance</u>					
Accelerated UV Resistance (% retained after 150 hr)	D4355	65%	year	65%	year

45

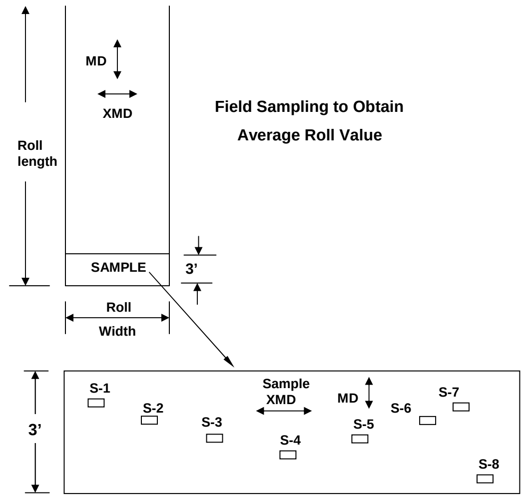
Regarding MARV

- <u>m</u>inimum <u>a</u>verage <u>r</u>oll <u>v</u>alue
- accommodates variation in GT properties
- statistically it's the "μ-2σ" value
- Shown in following slides



46

Field Sampling to Obtain Average Roll Value



Take Specimens from above Sample and Test as Required

47

125-216-343

Test Number	Roll Number					
	1	2	3	4	5	6
1	643N	627N	637N	642N	652N	637N
2	627	615	643	646	641	624
3	652	621	628	658	639	631
4	629	616	662	641	657	620
5	632	619	646	635	642	618
6	641	621	633	642	651	633
7	662	622	619	658	641	641
8	635	628	636	662	645	625
Average =	640	621	638	648	646	629

Thus, MARV = 621 N

48

Workshop Discussion Items (WDI)

- Purposely Omitted Tests
  - Mass per unit area (weight)
  - Thickness
- Performance testing: HBT **per GRI-GT14,** FFF **per GRI-GT8** and PF **per GRI-GT15** tests
- Endurance testing of coatings
- Connections and repair testing
- Installation Storage and Handling **per GRI-GT11**
- Geotexile tubes manufacturered on circular loom
- Accreditation

49

Koerner, G. R. and Koerner, R. M. (2006), "Geotextile Tube Assessment Using a Hanging Bag Test," Jour. Geotextiles and Geomembranes, Vol. 24, No. 2, April, 2006, pp. 129-137.

Hanging Bag Test (per GRI-GT12)

50

51

52

53

54

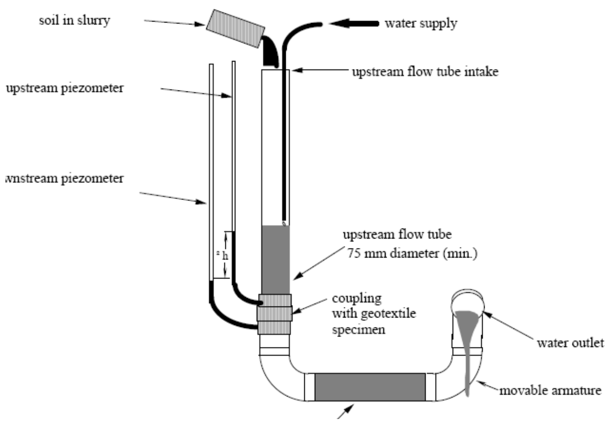
55

Commentary on HBT:

- AOS and permittivity are poor predictors of behavior for these GT as tubes
- this pertains to both water flow rate and passing soil/sediment gradation
- fine sediment/sludges are the most challenging w/r to filtration design
- HBT is reasonable from a qualitative “go/no go” perspective; with or without coagulant
- Need to standardize pass fail criteria
- This is a CQA rather than a MQC test

56

Other Performance Tests



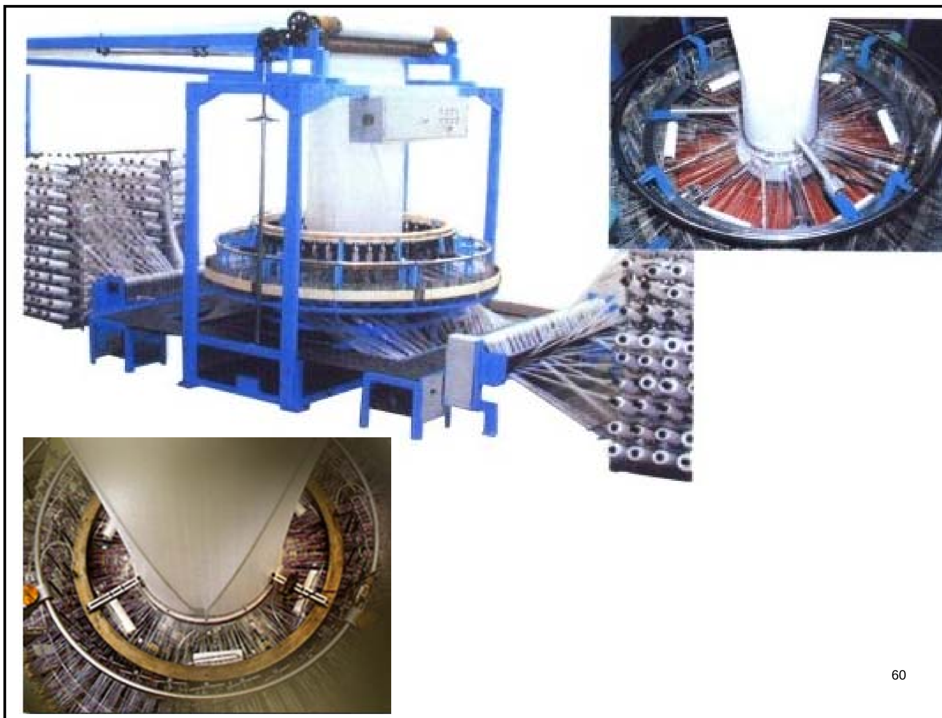
57

58

Coatings: GT is susceptible to UV and Temperature degradation

Koerner, G. R., Hsuan, Y. G. and Koerner, R. M. (1998), "Photo-Initiated Degradation of Geotextiles," Jour. Geotechnical and Geoenvironmental Engineering, ASCE, 124(12), 1159-1166.

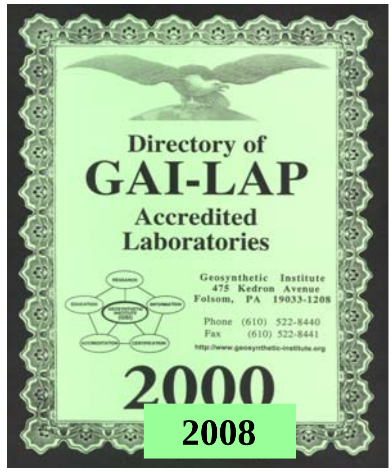
59



60

GAI-LAP Accreditation

- Lab needs to be accredited
- Model program after ISO 17025
- On-site audits
- Annual proficiency tests
- Pass/Fail based on proper equipment, documentation & good test results



61

GRI-GT11 Installation, Handling and Storage

- GT is susceptible to installation damage
- Rolls are heavy and require special construction equipment to lift and fill
- Do NOT push, slide or drag Geotextile tubes
- Storage for longer than 6 months requires special precautions
- Geoxtextiles cannot be trafficked

62

Concluding Comments

- MQC specification for GT tube was presented
- focuses on geotubes for coastal and river structures; however sludge dewatering is a large application area for geotextile tubes
- main tubes can be enormous
- hydraulic filled with sand to prevent erosion however, many other infills possible
- aggressive vs. typical conditions are listed, but subjective
- Hopefully WDI were provocative

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2008 Geotextile Tubes Workshop was conducted as part of a research project funded by the US Department of Homeland Security (DHS) through UT Battelle at Oak Ridge National Laboratory under the Southeast Region Research Initiative (SERRI).

End of *Specification and Testing of Geotextile Tubes* by George R. Koerner, Ph.D., PE &CQA.

Section 6.9

2008 Geotextile Tubes Workshop

Nov 17-19 2008, Starkville MS

- **Presentation Title:** *Analysis and Design of Geotextile Tubes*
- **Author:** *Dov Leshchinsky, PhD*
- **Affiliation and Contact Information:**
University of Delaware
Ph: (302) 831-2446
Fax: (302) 831-3640
Email:dov@ce.udel.edu

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•Mississippi State University Civil and Environmental Engineering Department
•Mississippi State University Office of Research
•US Army Corps of Engineers Research and Development Center Coastal and Hydraulics Laboratory

References

- Leshchinsky, D., Leshchinsky, O., Ling, H.I. and Gilbert, P.A., "Geosynthetic Tubes for Confining Pressurized Slurry: Some Design Aspects," Journal of Geotechnical Engineering, ASCE, 122(8),1996, pp. 682-690.
- Leshchinsky, D., "Issues in Geosynthetic-Reinforced Soil,“ Keynote paper, International Symposium *on Earth Reinforcement Practice, Kyushu, Japan,* Vol. II, 1993, pp. 871-897.
- Leshchinsky, D. and Leshchinsky, O., "Geosynthetic Confined Pressurized Slurry (GeoCoPS): Supplemental Notes for Version 1.0," Report TR CPAR-GL-96-1, 1996, USACOE, Waterways Experiment Station, Vicksburg, MS.

1

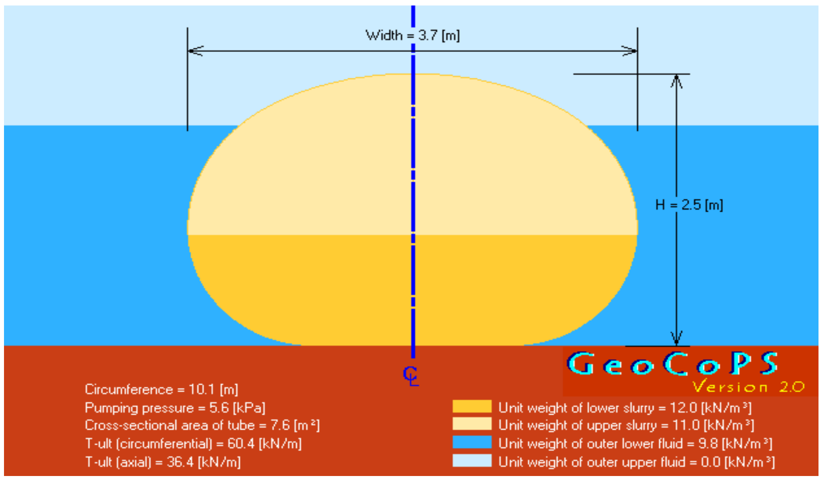
Structure of Tubes

Tubes are made of geotextile sheets sewn together to form a shell capable of confining pressurized slurry

➔ Critical: construction stage/seam strength

2

Objectives: Find sectional geometry and geotextile stresses



3

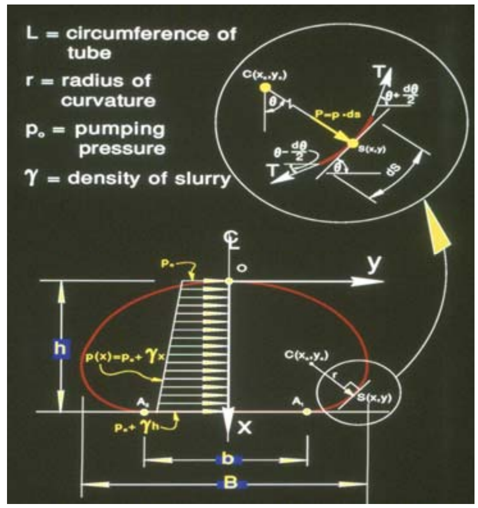
Idealization for simple analysis:

- Problem is 2-D
- Geotextile shell is flexible, thin and weightless
- Elongation of geotextile is negligible
- Slurry in tube produces hydrostatic stresses
- Shear between geotextile and slurry is negligible
- Foundation is leveled and relatively stiff

4

Formulation: Notation

- Equilibrium in direction of r along dS:
- $r(x) = T / p(x)$



5

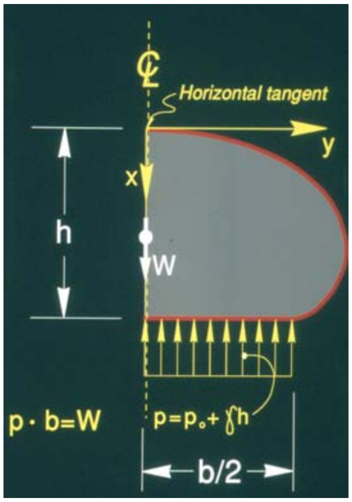
Formulation

- Radius of curvature = Differential equation :
- $r(x) = [1+(y')2]3/2 / y''$
- Combine equations of r(x):
- $T\, y'' - (p0+ \gamma x)\, [1+(y')2]3/2 = 0$
- Nature of numerical solution:
- $y = f(x|T, p0, h, \gamma)$

6

Impose Physical Constraints

- *$y = f(x|T, p0, h, \gamma)$ ➔ γ is known ➔ Unknowns: function y(x) and design parameters T, p0, h ➔ Specify one parameter ➔ Impose two physical constraints to solve:*
- *$p \cdot b = W \;\Rightarrow\; b = W / (p0 + \gamma h)$*
- *Replace b with L (L is meaningful physical constraint)*
- *Because of symmetry, tangent at (0,0) must be horizontal*



7

Solve:

$y = f(x|T, p_0, h, \gamma)$

For given

(L, γ) and p_0

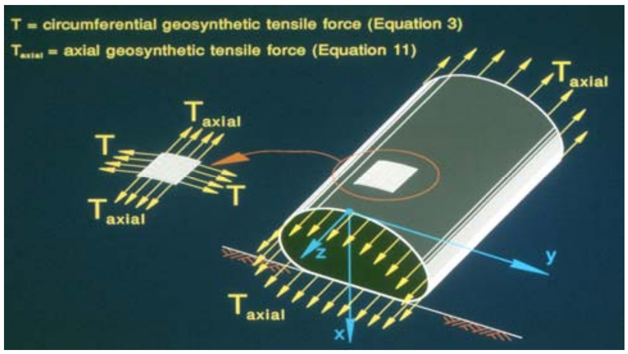
or (L, γ) and T

or (L, γ) and h

8

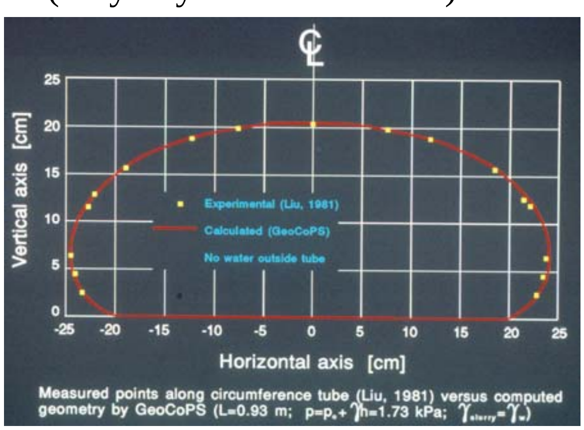
Axial Load

- *2-D section yields resultant force in the longitudinal direction ➔ Reaction force is evenly distributed along the geotextile circumference.*



Experimental Verification

- Liu (1981) used mortar-filled 2.5 m long tubes (Polyvinyl Chloride Tubes)

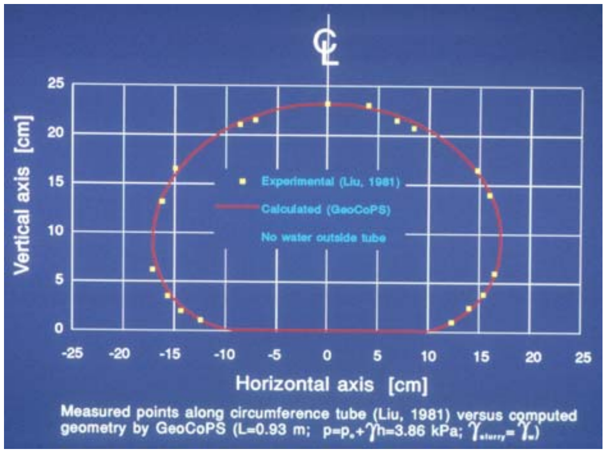


p at bottom:

1.73 kPa

Experimental Verification

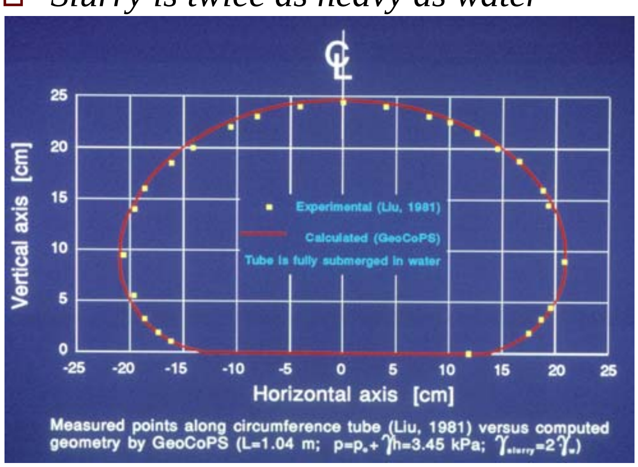
- *p at bottom:3.86 kPa*



11

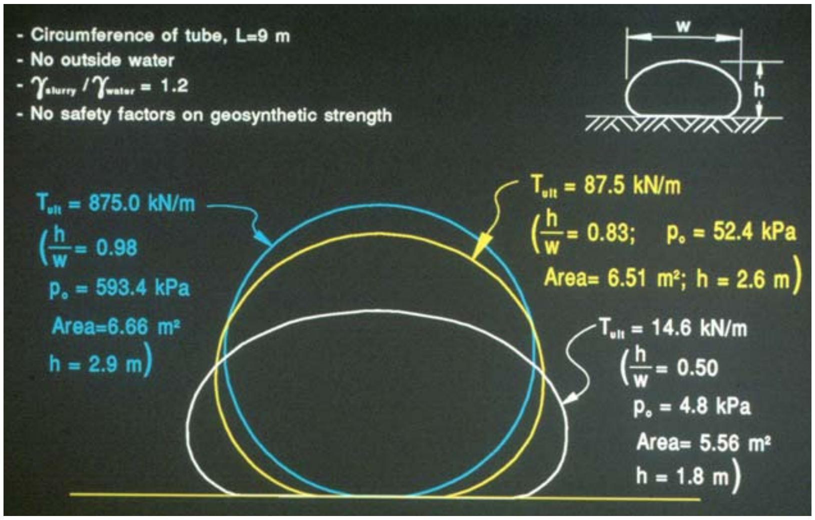
Experimental Verification

- *Slurry is twice as heavy as water*



12

Sensitivity to Pumping Pressure



13

Geotextile Strength

$$T_{ult} = T_{work} \left(F_{id} \bullet F_{cr} \bullet F_{bd} \bullet F_{cd} \bullet F_{ss}\right)$$

- T_{ult} = short-term strength of geotextile
- T_{work} = calculated tensile force during pumping in circumferential or axial direction
- F_{id} = reduction for installation damage
- F_{cr} = reduction for creep
- F_{bd} = reduction for biological degradation
- F_{cd} = reduction for chemical degradation
- F_{ss} = reduction for seam strength

14

Geotextile AOS: AASHTO, TF 25 (just an example as it is outdated; use relevant ASTM test procedure)

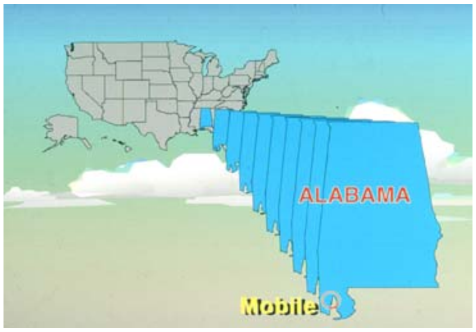
- For soil with 50%>+#200, use AOS>#30 (O_{95}<0.59 mm)
- For soil with 50%>+#200, use AOS>#30 (O_{95}<0.59 mm)
- Is this filtration criterion universally valid? Will it guarantee that the geotextile will not clog? Will it guarantee acceptable retention of particles? When in question, use real fill material for evaluation.

15

Selecting AOS with hydrodynamics can be challenging

16

Case History



17

Gaillard Island Experiment

- Pumping through 20 cm branch pipe
- Tubes attained asymmetrical elliptical shape, about 1.5 m high and 3.5 m wide
- Pumping pressure never exceeded 30 kPa

18

Gaillard Island Experiment

- Four tubes, each 150 m long
- Tubes fabricated from two 4.2 m wide sewn woven sheets
- Strength: 70 kN/m in warp and 45 kN/m in fill direction
- EOS for two was #70 and for the other two #100
- Clay fill: LL=120, PL=32, PI=88
- Two tubes lined with inner nonwoven geotextile

19

Grading Before Tube Deployment

20

Base Ready to Receive Tube

21

Deployment of First Tube

22

Connecting Pipe to Inlet

23

Pipe Connected to Inlet

24

Start of Pumping

25

One Hour Later…

26

Even the Birds Were Amazed…

27

Consistency of Pumped Material

28

Small Amount of Fines Washing Out Immediately After Pumping

29

Small Amount of Fines Washing Out Immediately After Pumping

30

Small Amount of Fines Washing Out Immediately After Pumping

31

Blocked Inlet Immediately After Pumping

32

Crest is Graded to Receive 3rd Tube

33

Pumping into Tube on Crest

34

Twisting and Sliding of Tube

35

Sample for Water Content Shortly After Pumping

36

Clean Water Seeping Due to Filtration (1 Hour After Pumping)

37

Water Content Along Tube

Time [days]	*Location [m]*	*Unit Weight [kN/m^3]*	*Water Content [%]*
0	***0***	***12.3***	***214***
0	***70***	***11.7***	***284***
0	***140***	***11.5***	***308***
30	***0***	***13.2***	***127***
30	***70***	***12.7***	***153***
30	***140***	***11.7***	***286***

38

About One Month After Pumping

39

About One Month After Pumping

40

About 6 Months After Pumping

41

Local Rupture of Seam…

42

2008 Geotextile Tubes Workshop was conducted as part of a research project funded by the US Department of Homeland Security (DHS) through UT Battelle at Oak Ridge National Laboratory under the Southeast Region Research Initiative (SERRI).

End of *Analysis and Design of Geotextile Tubes* presentation by Dov Leshchinsky, PhD

Section 6.10

2008 Geotextile Tubes Workshop

Nov 17-19 2008, Starkville MS

- ***Presentation Title:***

  Installation and Performance of Geotextile Tubes

- ***Author:***

  Nate Lovelace (Presenter) and Ed Herman

- ***Affiliation and Contact Information:***

  Corps of Engineers, Mobile District

Jointly Sponsored by:

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•Mississippi State University Office of Research

•US Army Corps of Engineers Research and Development Center Coastal and Hydraulics Laboratory

Covering Your Bases

- ✓ PERMITS
- ✓ BORROW SOURCE
- ✓ FOUNDATION
- ✓ ALIGNMENT
- ✓ TOLERANCES
- ✓ EQUIPMENT
- ✓ SCHEDULE

1

Getting Started

- Practice Tube (if possible)
- First Tube is the WORST
- Trench or cradle
- Plenty of Straps
- Plan for run-off
- Always order extra bags

2

3

4

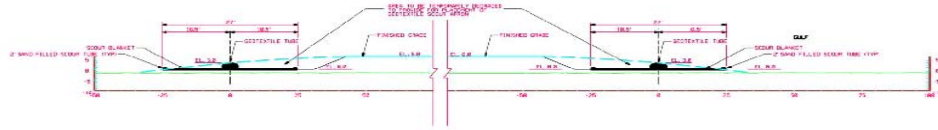
5

6

7

8

9


GEOTEXTILE TUBE
FINISHED GRADE
SCOUR BLANKET
GULF
TYPICAL SECTION

10

11

12

13

14

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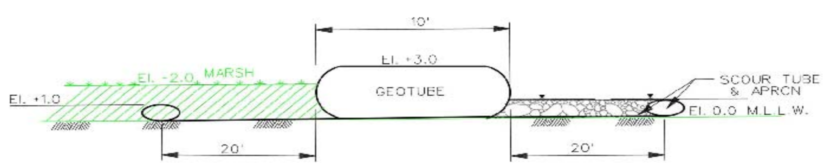

TYPICAL GEOTUBE SECTION
N.T.S.

24

Problems

- Fill Port Patches
- High Wind
- Constant Elevation
- Joints
- Terminating the Ends
- Curious People

25

26

27

2008 Geotextile Tubes Workshop was conducted as part of a research project funded by the US Department of Homeland Security (DHS) through UT Battelle at Oak Ridge National Laboratory under the Southeast Region Research Initiative (SERRI).

End of *Installation and Performance of Geotextile Tubes* by Nate Lovelace and Ed Herman.

Section 6.11

2008 Geotextile Tubes Workshop

Nov 17-19 2008, Starkville MS

- ***Presentation Title:***

  HSARPA - SERRI Water-Filled Technologies for Rapid Repair of Levee Breaches

- ***Author:*** *Don Resio, PhD*

- ***Affiliation and Contact Information:***

  Senior Research Scientist

  US Army Corps of Engineers Engineer Research and Development Center (ERDC)

  Ph: (601) 642-2018

  Fax: (601) 634-2055

  Email: Donald.T.Resio@usace.army.mil

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•Mississippi State University Civil and Environmental Engineering Department

•Mississippi State University Office of Research

•US Army Corps of Engineers Research and Development Center Coastal and Hydraulics Laboratory

Potential Levee and Dam Breaches Represent a Major Problem in Many Areas of the US

- New Orleans area
- Sacramento area
- Lake Okeechobee
- Rivers in Midwest
- Etc.

1

Breaching of large earthen levees typically develops quickly. Effective levee repair must be emplaced within a few hours of the initial breach.

2

Logistics Limitations:

Little or no access by land or water

Staging areas are almost nonexistent

Often only helicopter airdrops are possible

3

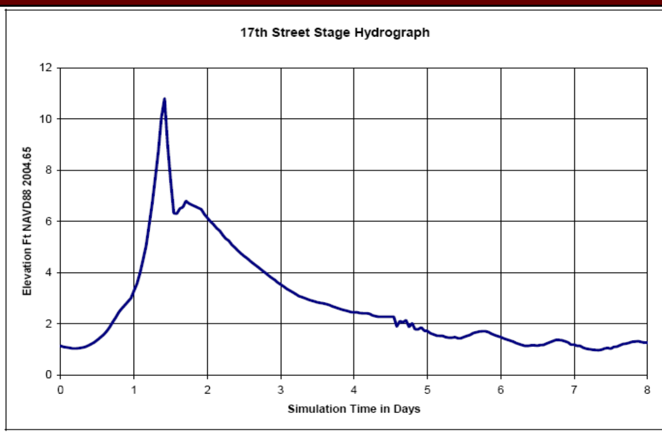


Figure 6. ADCIRC stage-hydrograph for 17th Street Canal at Lake Pontchartrain.

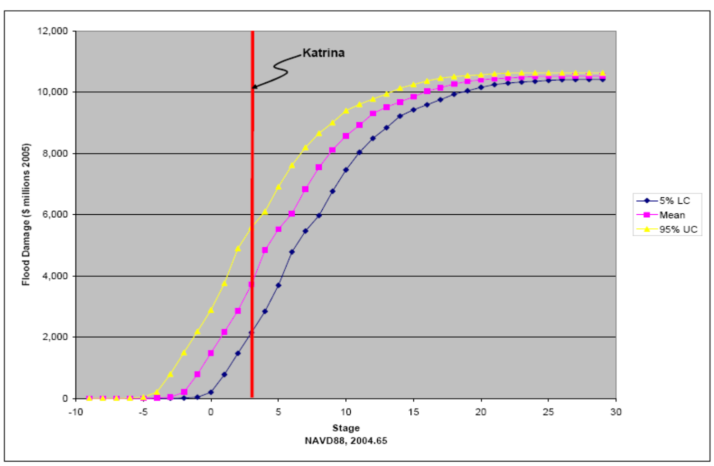
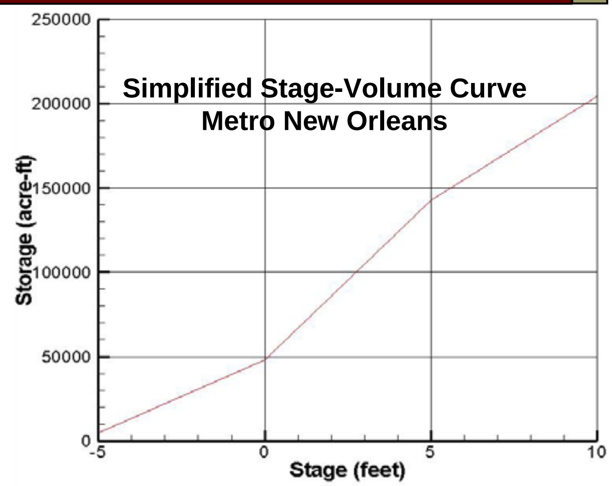


Figure 6. Relationship of stage and flood damage with uncertainty for Orleans Metro 5 (OM5) drainage subbasin—pre-Katrina conditions.



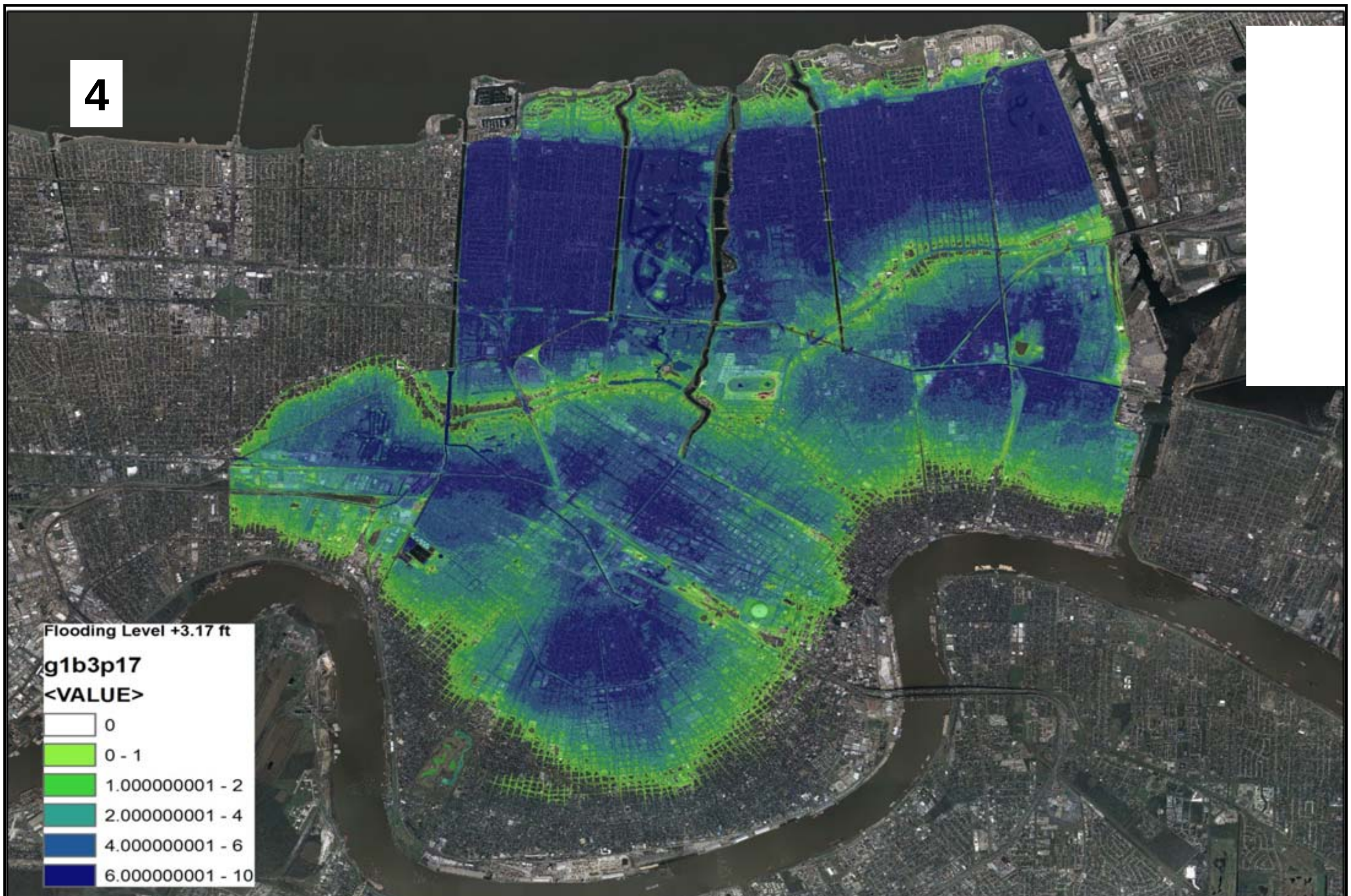
Bottom Line Time is Money!

At least 1.5 feet of the flood level in Metro New Orleans was due to water entering the city after 1300 CDT on the 29th

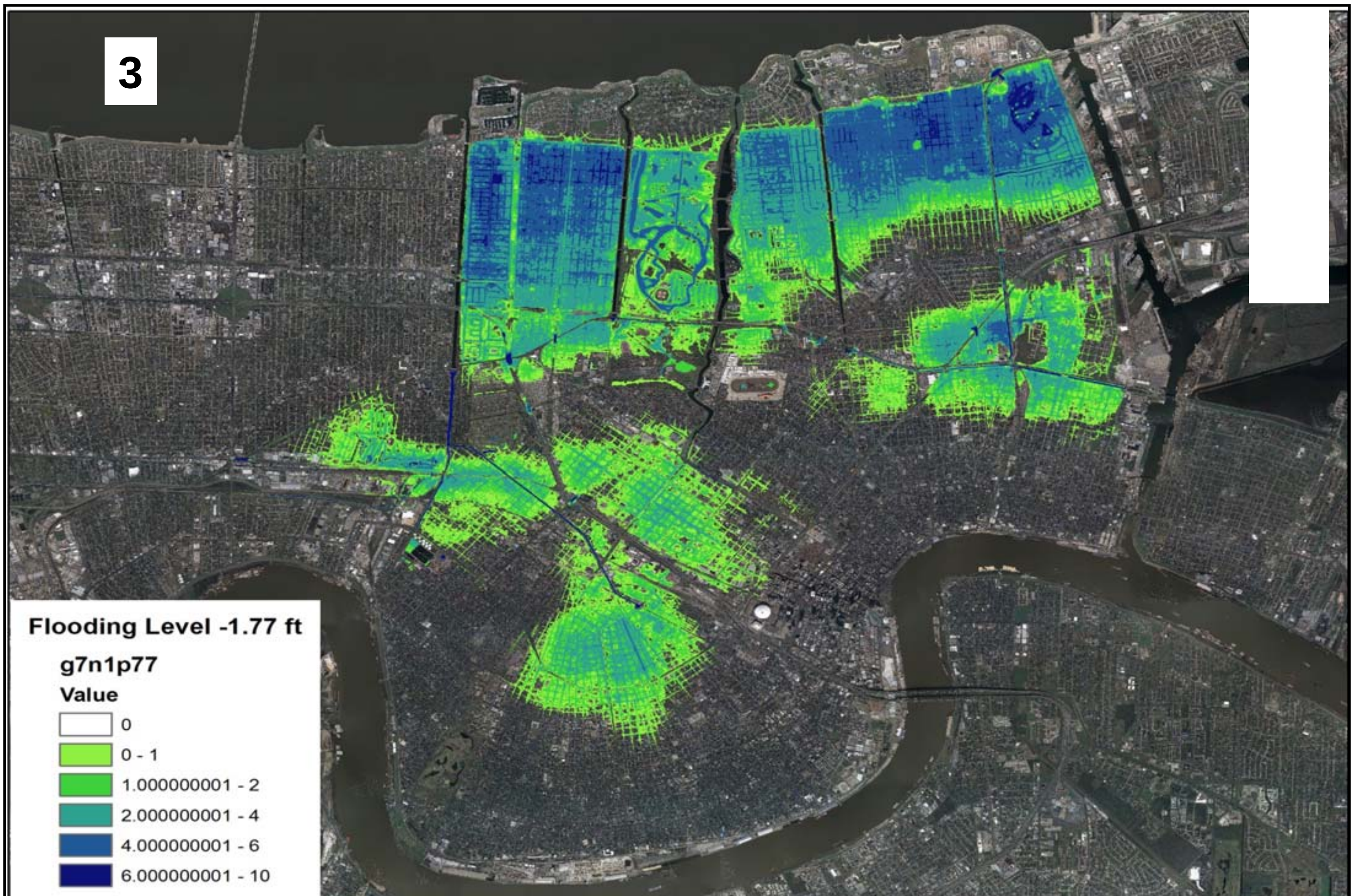
The increased cost due to this 1.5 feet of water was

$1.5 BILLION

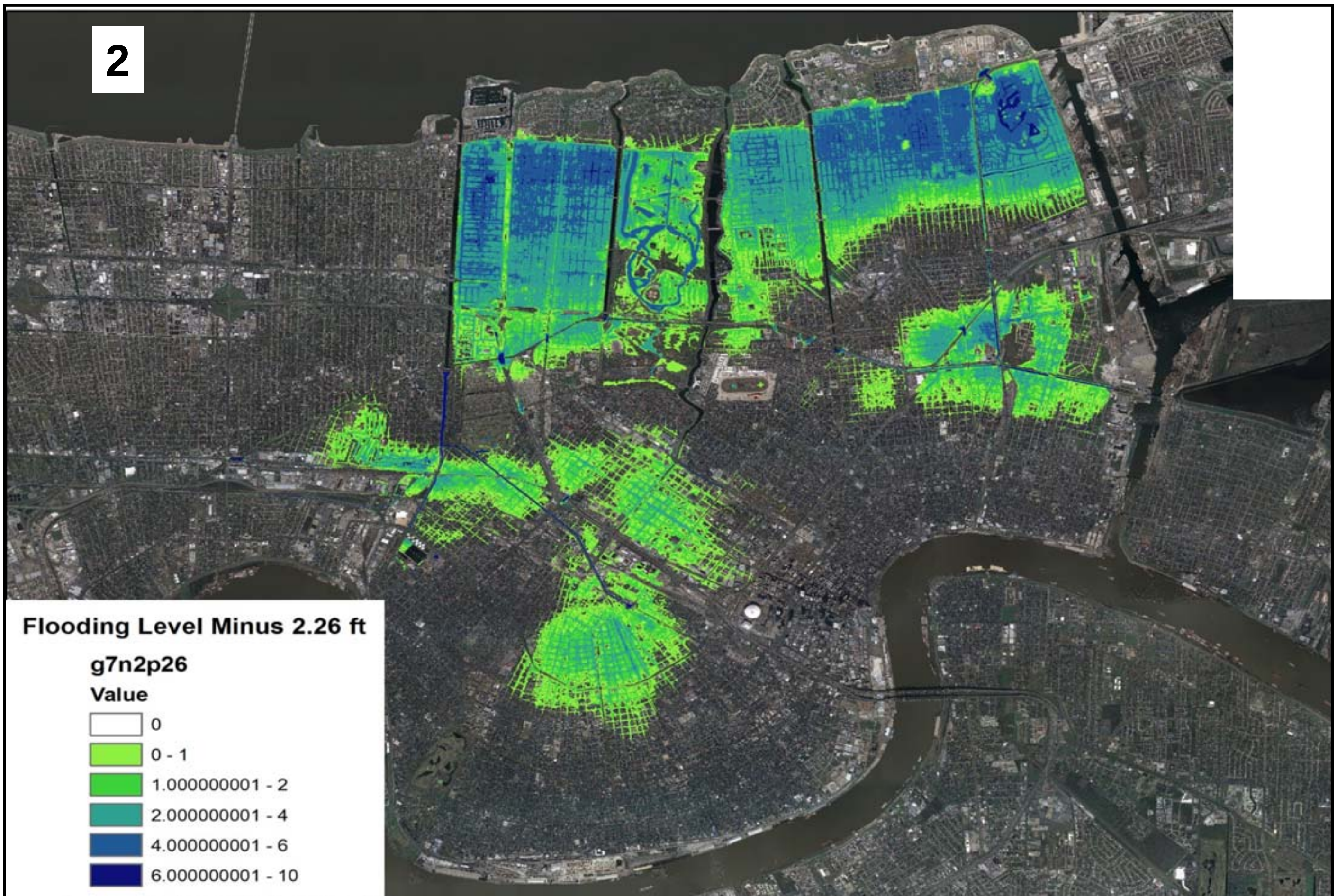
4


4
Flooding Level +3.17 ft
g1b3p17
<VALUE>
0
0 - 1
1.000000001 - 2
2.000000001 - 4
4.000000001 - 6
6.000000001 - 10

5


3
Flooding Level -1.77 ft
g7n1p77
Value
0
0 - 1
1.000000001 - 2
2.000000001 - 4
4.000000001 - 6
6.000000001 - 10

6


2
Flooding Level Minus 2.26 ft
g7n2p26
Value
0
0 - 1
1.000000001 - 2
2.000000001 - 4
4.000000001 - 6
6.000000001 - 10

7

FY 07 start for a new DHS innovation project:

Rapid Repair of Levee Breach

Homeland Security

8

Just because a problem is important does not mean that it can be solved. This problem has been around for a long time and has been viewed by many as intractable.

Major Complications Include:

1. Time for effective solution can be very short;
2. Little or no site access and logistics support;
3. Forces required to stop flow are huge;
4. Breach shape can be very irregular;
5. Anchoring forces can be extremely large; and
6. Stability of adjacent levees can be suspect.

Many innovative ideas were investigated

- rapid construction methods
- large gated structures
- special high-tech materials (unobtainium?)

However, Given the time/logistics constraints on this project we began to recognize that most of these could not presently meet our needs

And We began to focus on an area that we have been a leader in for many years – marine construction with fabrics

9

Figure X. RIB System used during ATD in Dec 2002.

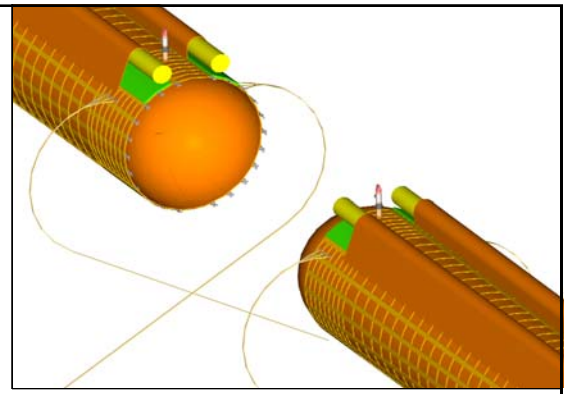
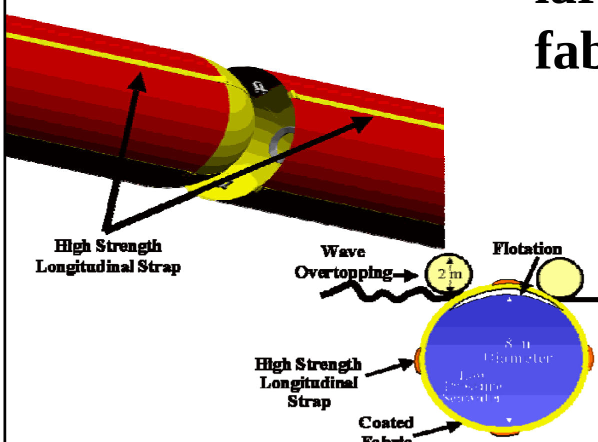


Figure . Final design drawing for ATD RIB.

The world's largest marine fabric structure



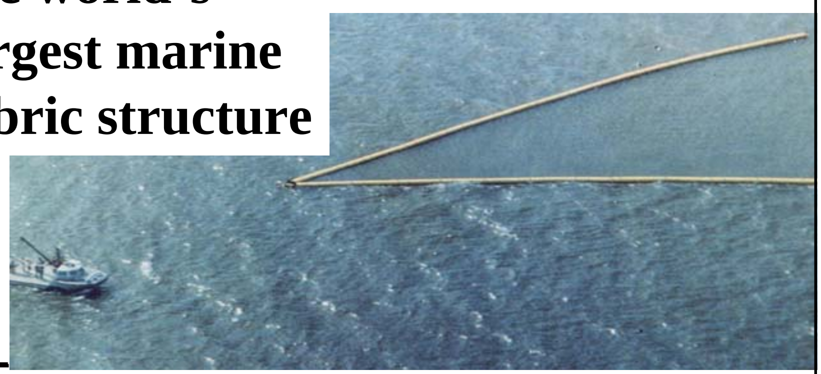
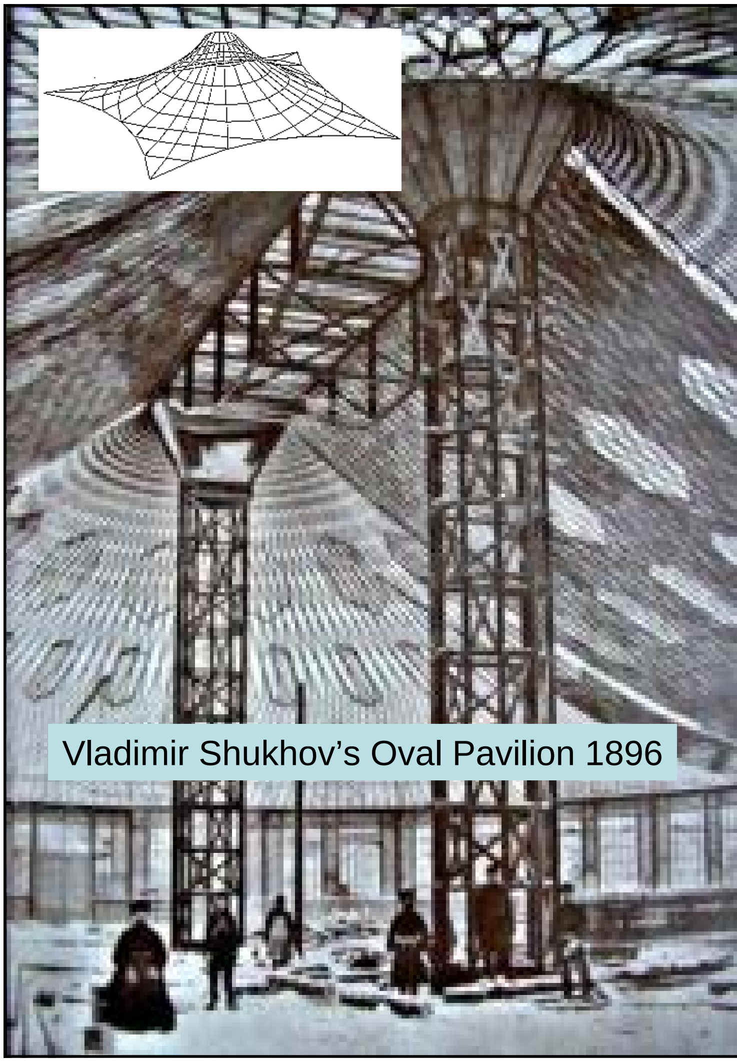


Figure X. RIB used in FY 96 field study.

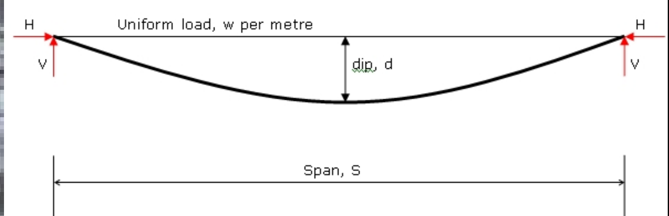
10



Vladimir Shukhov’s Oval Pavilion 1896

Fabrics have been used in structures since the late 19th century –

primarily in a simple “tension” mode.



11

Typical fabric use in construction:

In tension (e.g. roofs, bridges, etc.)
Under pressure (e.g. tires, domes, etc.)
To create beams that can carry moments.

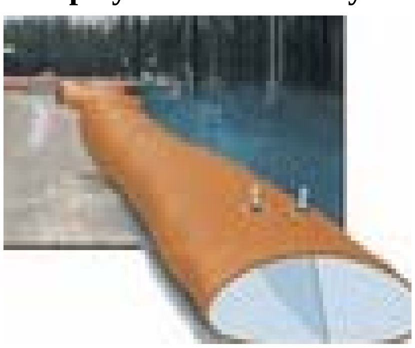
Air-beam structure at US Army Natick Lab in Natick, Massachusetts

Each of these modes of application had shortcomings for RRLB

12

In addition to the 3 modes of application already mentioned, water is frequently used today to create "ballast" inside of fabric tubes.

In this case, the tubes contain internal baffles to prevent them from rolling, since they are typically deployed over relatively flat terrain.



This is effective on flat surfaces but not in levee-breach situations.

Ballast comes only from the portion of contained water above the adjacent water surface and would be very difficult to deploy while over-topping is occurring.

Over a 13 month interval :

- Assembled an expert team of innovative engineers and scientists from within our laboratory and the private sector (Oceaneering & Kepner Plastics).
- Developed fundamentals for understanding the problem - hydrodynamics, geomorphology, geo-technical properties, structural requirements, etc.
- Examined a wide range of solution concepts
- Down-selected the best concepts
- Tested through a cycle of smaller scales (1:50&1:16)
- Designed large-scale (1:4) tests
- Constructed and demonstrated at ARS, Stillwater

14

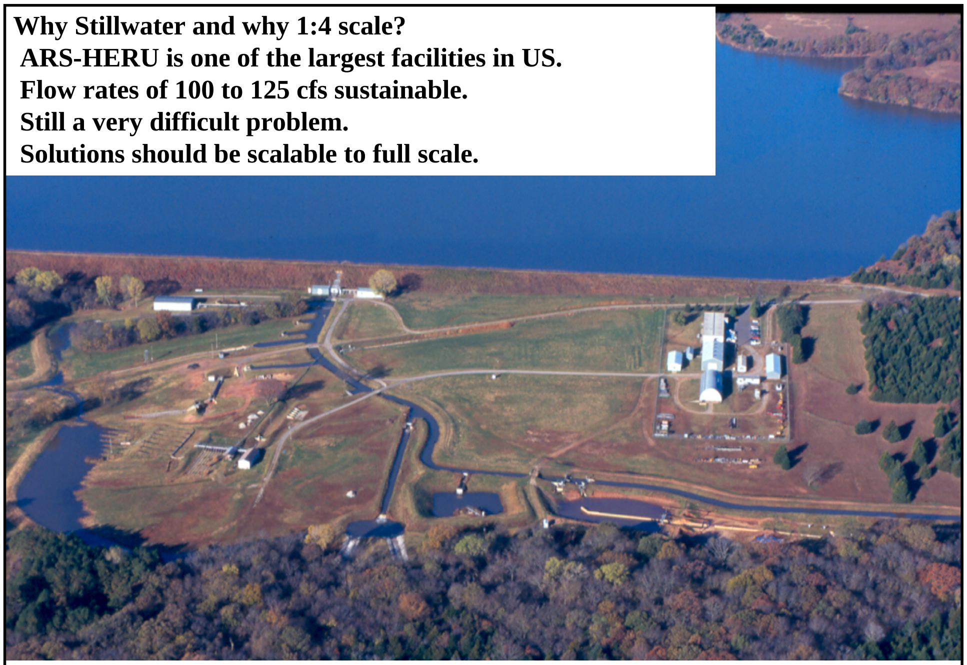
Why Stillwater and why 1:4 scale?

ARS-HERU is one of the largest facilities in US.

Flow rates of 100 to 125 cfs sustainable.

Still a very difficult problem.

Solutions should be scalable to full scale.



15

Three different types of water-filled fabric concepts were tested:

Rapid Spillway/Earthen Dam Protection:
Protect earthen section from breaching during high flow, while allowing overtopping (uses a simple lightweight ballasting concept)
Long Shallow Breach:
Seal a very long breach either before or during interval of water flow through it (does not depend on breach side support)
Deep/Steep Breaches (two times):
Seal a significant breach while water is moving through it at high velocity (uses sections near breach for support)

16

Even in a1:4 scale test forces can be very large –

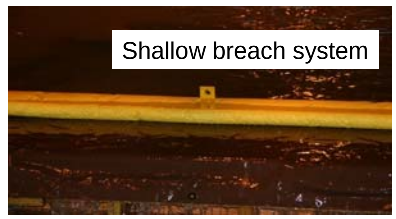
- **Only about 5200 pounds of water is held back; but shutting down the flow in 1 second results in a force that is 100 times greater!!**
- **Even this test would require a 32-inch to 40-inch "I-beam" with a steel plate to block the flow. This would weigh about 5000 pounds**
- **And for conventional moment-bearing materials it gets much worse at full scale (approximately a factor of 256 times heavier) for a breach that is 4 times larger than the test breach today.**
- **And you would still have to figure out how to seal the edges**

17

Once, we began to examine what was gained by having a levee or portion of a levee in place, we recognized we could utilize the levee or remnant levee as part of the solution.

In this case, we discovered that a fundamental property of water – its incompressibility – could be used to make a fabric system that resisted deformation past some threshold.

Constrained horizontal deformation **Constrained vertical deformation**



18

Demonstration - Stillwater, OK 28 Sep 2008

19

Movie-Still Photo 1 of 12

20

Movie-Still Photo 2 of 12

21

Movie-Still Photo 3 of 12

22

Movie-Still Photo 4 of 12

23

Movie-Still Photo 5 of 12

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Movie-Still Photo 6 of 12

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Movie-Still Photo 7 of 12

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Movie-Still Photo 8 of 12

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Movie-Still Photo 9 of 12

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Movie-Still Photo 11 of 12

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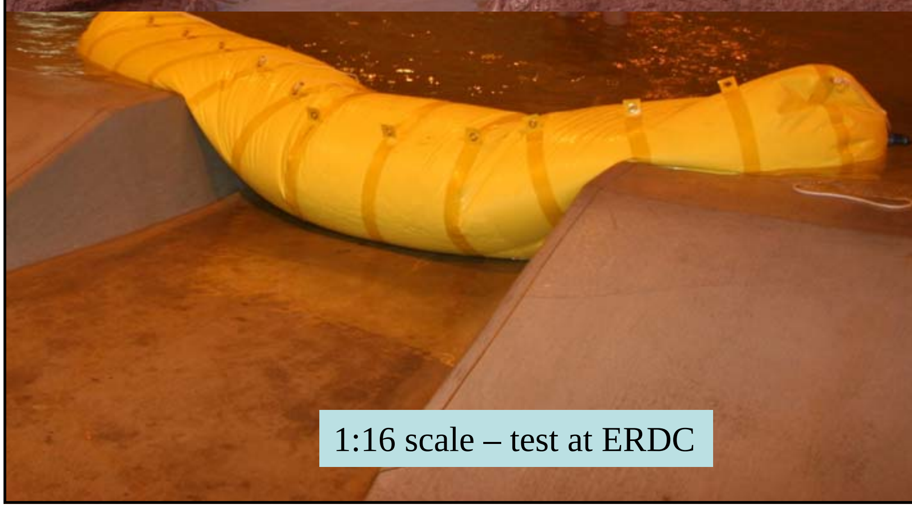
Movie-Still Photo 12 of 12

31



No "scale effects" are apparent in testing to date -

which suggests this new approach should work well at full scale.

Requirements for fabrics scale with the depth of the breach and the tube diameter

Path Ahead

- Plan a demonstration of a PLUG capable of stopping a rupture the size seen in Hurricane Katrina
  - Locate suitable location
  - Conduct demonstration
- Investigate Fabric improvements
  - Durability
  - Reparability
  - Scalability
- CONOPs development
  - Deployment requirements
  - Storage requirements

33

34

2008 Geotextile Tubes Workshop was conducted as part of a research project funded by the US Department of Homeland Security (DHS) through UT Battelle at Oak Ridge National Laboratory under the Southeast Region Research Initiative (SERRI).

End of *HSARPA - SERRI Water-Filled Technologies for Rapid Repair of Levee Breaches* by Dr. Don Resio

Section 6.12

2008 Geotextile Tubes Workshop

Nov 17-19 2008, Starkville MS

- ***Presentation Title:***

  Geotubes for Structural Applications

- ***Author:***

  Ed Trainer

- ***Affiliation and Contact Information:***

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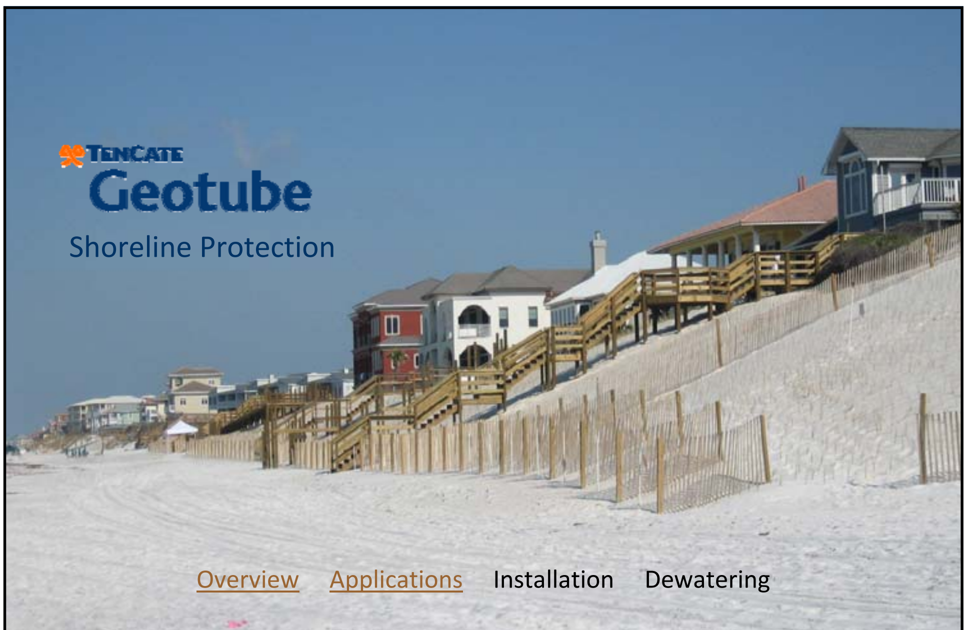
•Mississippi State University Civil and Environmental Engineering Department

•Mississippi State University Office of Research

•US Army Corps of Engineers Research and Development Center Coastal and Hydraulics Laboratory

Marine Structural Applications

1



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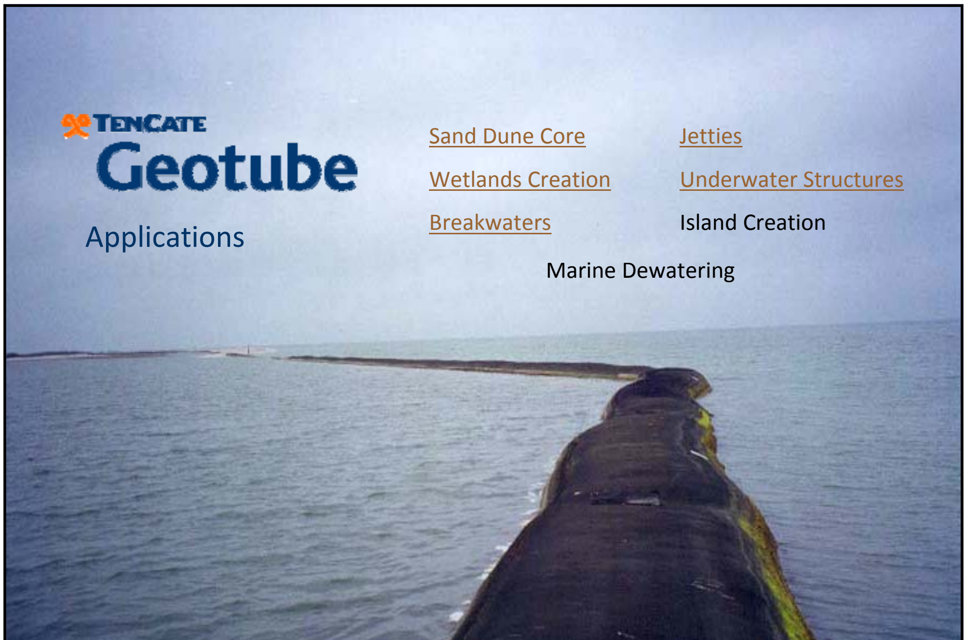


TENCATE

Geotube

Applications

Sand Dune Core

Wetlands Creation

Breakwaters

Jetties

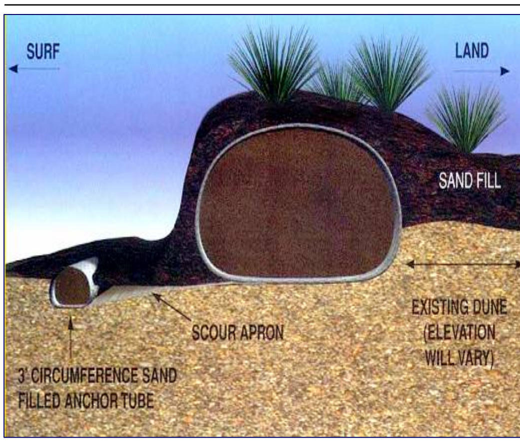
Underwater Structures

Island Creation

Marine Dewatering

3

Geotube® Marine Applications



Typical Sand Dune Reinforcement Design

SAND DUNE CORE

Projects:

- Atlantic City, New Jersey
- Sea Isle City, New Jersey
- NASA Wallops Isl., VA
- Bolivar Peninsula, Texas
- UnoCal, California

4

Atlantic City, NJ

5,000 lin. feet of Geotube® containers installed to protect the Boardwalk and billions of dollars in real estate.

Installed 1994

5

Atlantic City, NJ

Geotube® unit filled to a height of 6 feet with beach sand.

6

Atlantic City, NJ

Geotube® unit covered with sand and vegetated with dune grass to give the appearance of a natural dune.

7

Atlantic City, NJ

Following heavy storm activity in 1995, sand was washed from the ocean side of the Geotube® unit with no damage to the Boardwalk or adjacent property.

8

Atlantic City, NJ

After the storm, the sand over the Geotube® units was replaced. The units continue to protect the shoreline today.

9

Atlantic City, NJ

"Countless dollars in reconstruction were saved by the timely installation of Geotube® [units]," *The Press of Atlantic City*, Aug.11,1995.

End Of Section
Return to
Case Studies

10

Sea Isle City, NJ

4,000 lin. feet of Geotube® containers protect the shoreline and the highway behind it.

Installed 1997

11

Sea Isle City, NJ

Geotube® container being filled by hopper method with imported sand.

12

Sea Isle City, NJ

Sand being placed in hopper with backhoe. Note that hopper discharges directly into the tube.

13

Sea Isle City, NJ

Geotube® unit filled to a height of 6 feet.

14

Sea Isle City, NJ

Offshore storm generating heavy wave activity as the tide rolls in.

15

Sea Isle City, NJ

Geotube® unit withstands heavy wave impact at high tide.

16

Sea Isle City, NJ

Geotube® unit and scour apron intact after extreme high tide and heavy wave attack.

End Of Section
Return to
Case Studies

17

NASA Wallace Flight Center, Wallops Isl., VA

Hurricane Ernesto and tropical storms badly eroded the beach and adjacent launch pad at NASA Wallace Flight Center in the Fall of 2006.

18

NASA Wallace Flight Center, Wallops Isl., VA

Beach was graded, a scour apron was placed, and anchor tubes filled with sand. 34'C x 200'L tubes were rolled out and pumped with sand slurry.

19

NASA Wallace Flight Center, Wallops Isl., VA

Imported sand and water from the surf were mixed together in a slurry pit and pumped to the Geotube® units.

20

NASA Wallace Flight Center, Wallops Isl., VA

A header system with multiple flexible lines fed the sand slurry into the geoports.

21

Geotube® Marine Applications

ISLAND CREATION

Projects:

Amwaj Islands, Bahrain

Buena Ventura, Colombia

Naviduct, The Netherlands

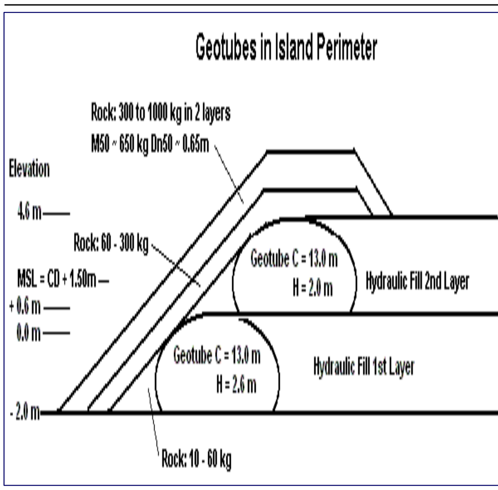
22

Amwaj Islands

Located in the Arabian Gulf off the coast of Bahrain, the project will use more than 30 kilometers of 13m circumference Geotube® containers to create the perimeter for the 2.79 million meter square island.

23

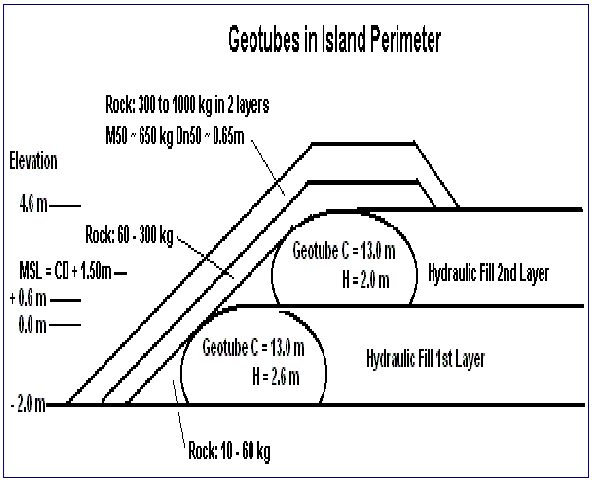
Amwaj Islands



The perimeter was created by filling two layers of Geotube® containers to a total height of 4.6 meters.

24

Amwaj Islands



The Geotube® containers are typically covered in sand, but in some areas, rip rap was used.

25

Amwaj Islands

The first Geotube® container layer is installed to a height of 2.6 meters using a .4 meter diameter cutter head dredge.

26

Amwaj Islands

The second layer of Geotube® containers is filled by the hopper method, or with a sand induction pump to a height of 2.0 meters.

27

Amwaj Islands

The combined height is 4.6 meters.

When the islands are completed, most of the tubes will be covered with sand and a beach will be created in front for the private residences.

28

Amwaj Islands

The island is being created by filling inside the Geotube® container perimeter with sand that is being dredged from the surrounding area.

29

Amwaj Islands

The $1.5 billion development includes 2 marinas, 3 five-star hotels, 30 commercial office buildings, and more than 1,350 private residences with beach front locations.

End Of Section
Return to
Case Studies

30

Buena Ventura, Colombia

City required a dredge spoil disposal site within San Antonia Bay to contain 600,000 m^3 dredged from navigation channel.

31

Buena Ventura, Colombia

1,100 lin. meters of 20 meter circumference by 3 meter high Geotube® containers were installed to create the perimeter containment for the dredge disposal island.

32

Buena Ventura, Colombia

The Geotube® containment project as it nears completion.

End Of Section
Return to
Case Studies

33

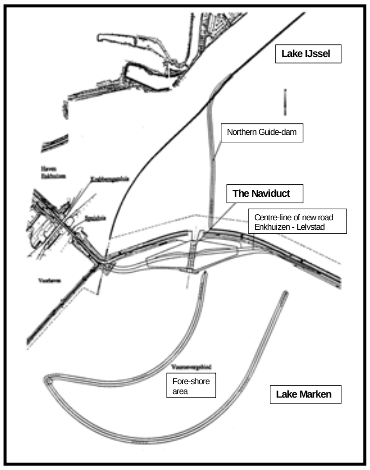
Naviduct Geotube® Project, The Netherlands

Geotube® units formed the perimeter for dredge spoil area during lock construction.

Installed 1999-2000

34

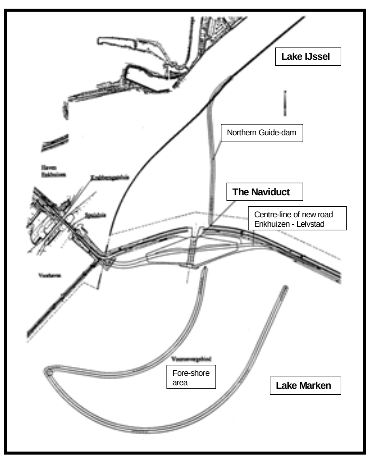
Naviduct Geotube® Project



- Dredging of 900,000 m^3 of peat and sand for the lock
- 7,500 linear meters of tubes with a diameter of 3.92 meters.

35

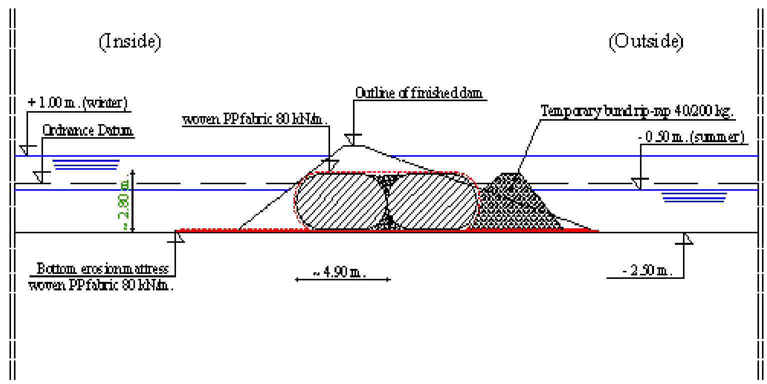
Naviduct Geotube® Project



60,250 m^2 of woven PP fabric 80 kN/m for the protection of the Geotube® units (against damage caused by dumping rock on top of them).

36

Revised design of Guide-dam



37

Naviduct Geotube® Project

Geotube® units installed before rip rap placement.

38

Naviduct Geotube® Project

Rip rap over Geotube® unit as final erosion protection.

(note geotextile protection layer)

39

Edwin Zengerink
Date: 29 May 2006

Temporary dam in Morocco near Rabat

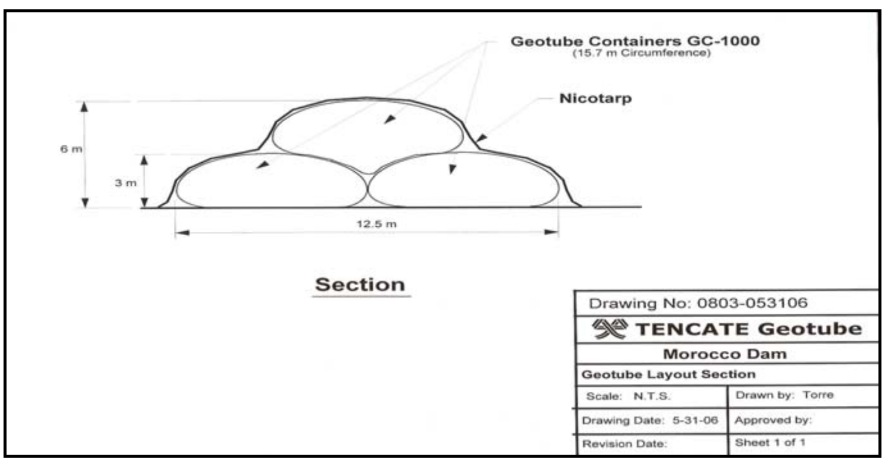
Temporary Dam in Morocco

- Final Dam height 6 meter
- 2 – 1 Geotube® Pyramid Structure
- Geotube® units , 15.7m circumference, fill height 3 m.
- Geotube length approximately 70 meter.
- Material used Geolon® PP 200 S, seam strength 160 kN/m1.
- Finally covered with Nicoflex, impermeable liner.

41

Geotube®

Geotube Dam Cross Section



42

Geotube®

Building a temporary dam in Morocco

43

Geotube®

Building a temporary dam in Morocco

44

Geotube®

Building a temporary dam in Morocco

45

Geotube®

Building a temporary dam in Morocco

46

Geotube®

Building a temporary dam in Morocco

47

Incheon Grand Bridge

48

Geotube® brief

- **Geotube® solution** – **as dykes for reclamation of temporary island for construction of bridge**
- **More than 14km of tubes**
- **3m, 4m & 5m diameter**
- **Mostly 50m & 60m long but some down to 15m to match profiling**

49

Equipment

- Sand supply barge – 1,800 m^3
- Work barge
  - Crane
  - Mixing tank
  - Water pumps
  - Excavators

50

Equipment

- Booster pump at 450HP
- Pumps 150 to 180 m^3/hr

Mixing tank

Pumps

Filling hose

51

Sand

- Key qualities: flowability, settling time, permeability
- Coarse sand, low fines, maximum gravel size
- Settling time of silica particles:
  - Gravel (10mm) – 1 sec
  - Coarse sand (1mm) – 10 sec
  - Fine sand (0.1mm) – 125 sec
  - Silt (0.01mm) – 108 min
- Quality of sand for fill at site very good

52

Filling

- Hydro-shaping: only water is pumped
- This will ensure good top level finish and even cross-section profile
- Quality achievable at site good

53

2nd layer

- Sand mattress placed over 2 bottom tubes

54

2nd layer

- 2nd layer tube placed above sand mattress

55

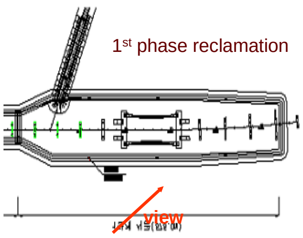
2nd layer

- Filled 2nd layer geotube

56

2nd layer

- Completed 2nd layer on nearside of island



Geotube® Protion of the Project completed

2008 Geotextile Tubes Workshop was conducted as part of a research project funded by the US Department of Homeland Security (DHS) through UT Battelle at Oak Ridge National Laboratory under the Southeast Region Research Initiative (SERRI).

End of *Geotubes for Structural Applications* by Ed Trainer.

Section 6.13

2008 Geotextile Tubes Workshop

Nov 17-19 2008, Starkville MS

- ***Presentation Title:***

  Geotubes for Dewatering Applications

- ***Author:***

  Ed Trainer

- ***Affiliation and Contact Information:***

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•Mississippi State University Office of Research

•US Army Corps of Engineers Research and Development Center Coastal and Hydraulics Laboratory

Dewatering Applications

1

Geotube® Marine Dewatering Applications

Advantages:

- Low cost
- High volume
- Custom sizing
- Flexibility.

2

Geotube® Marine Dewatering Applications

MARINE DEWATERING

Projects:

- Fox River
- Badger Ammunition
- Conner Creek
- <u>ConEdison</u>

3

Fox River Cleanup

Wisconsin

Challenge: Removal of 750,000-1 million yd^3 of PCB contaminated river and lake sediments that were generated from a concentration of paper mills along the entire length of the lower Fox River.

Installed 2004-2006

4

Fox River Cleanup

Solution: In the initial trial, 60’ circumference GT500 Geotube® Dewatering Containers were used to contain, dewater and remove the first 20,000 yd^3 of contaminated sediments from Little Lake Butte des Morts.

5

Fox River Cleanup

Solution: The Geotube® dewatering process was so effective in PCB removal and dewatering (achieving >50% solids) that it was selected for the full-scale project.

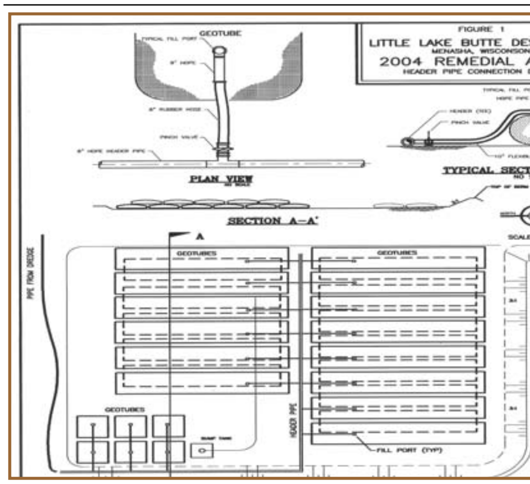
6

Fox River Cleanup

A special 8” swinging ladder cutter head dredge without cables was used to dredge sediments to allow for pleasure boat traffic during operations.

7

Fox River Cleanup



A HDPE lined dewatering cell with an 18” aggregate drainage layer was installed to collect all of the effluent water from the Geotube® containers.

8

Fox River Cleanup

Lay down area during installation.

9

Fox River Cleanup

Geotube® containers were stacked three and four layers high within the dewatering cell.

10

Fox River Cleanup

- To date, successfully dewatered and treated 250,000 yards^3 of PCB contaminated material for removal
- Geotube® units kept pace with the dredge pumping >2,000 gpm.

11

Fox River Cleanup

- Dewatered sediments averaged 50% total solids
- Considerable savings over traditional methods of dewatering (ex. $100 less per cubic yard during pilot phase).

12

Badger Army Ammunition Plant

Challenge: Clean up contaminated sediments from harbor caused by run-off from munitions production.

Installed 2001

13

Badger Army Ammunition Plant

Solution: 28,200 linear feet of 45' circumference (2001) and 10,650 linear feet of 60' circumference (2006) GT 500 Geotube® containers were installed to dewater over 145,000 cubic yards of contaminated sediments.

14

Badger Army Ammunition Plant

U.S. Army Corps of Engineers specified Geotube® technology as the best practice for dewatering contaminated marine dredge materials.

15

Badger Army Ammunition Plant

The 25 acre harbor was dredged to remove contaminated sediment.

Containments included mercury, lead and copper.

16

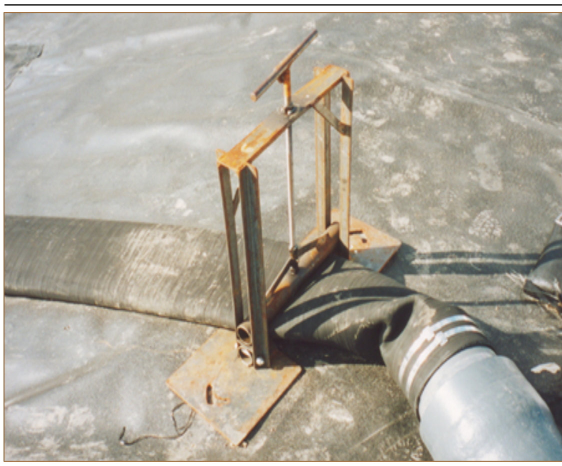
Badger Army Ammunition Plant

A manifold method of filling the containers was designed for the project.

Each branch could be individually adjusted to control sediment flow.

17

Badger Army Ammunition Plant



Each pipe that leads to a Geotube® bag was fitted with a pinch valve to control flow.

18

Badger Army Ammunition Plant

To aid in dewatering and consolidation, polymer was injected into the dredge spoil discharge line.

19

Badger Army Ammunition Plant

Geotube® units were installed side by side. Each was able to dewater an average of 750 cubic yards of contaminated sediments.

20

Badger Army Ammunition Plant

To maximize the allotted space for the dewatering project, three layers of Geotube® containers were added.

21

Badger Army Ammunition Plant

The effluent was collected in a temporary lagoon which will eventually become a wetlands area.

22

Badger Army Ammunition Plant

The clean lagoon water was used for irrigation.

23

Badger Army Ammunition Plant

The Geotube® containers remain in the dewatering basin and were covered with 3' of soil in 2002.

24

Badger Army Ammunition Plant

In 2006, a new layer of Geotube® containers was installed over the top of the previous containers in the basin.

Badger Army Ammunition Plant

The second phase will dewater 50,000 cubic yards.

End Of Section
Return to
Case Studies

Conner Creek

Challenge: Removal of 75,000 cubic yards of biosolids, PCBs, heavy metals, and carbon fuel contaminated sediments from the combined storm sewer and sewage overflow canal.

Installed 2004

27

Conner Creek

Solution: 14,000 lin. ft. of 60' circumference GT500 Geotube® dewatering containers were used to contain, dewater and remove the contaminants from the dredged sediments.

28

Conner Creek

Geotube® containers were placed in a dewatering cell alongside Conner Creek.

29

Conner Creek

Clean effluent was returned to Conner Creek.

30

Conner Creek

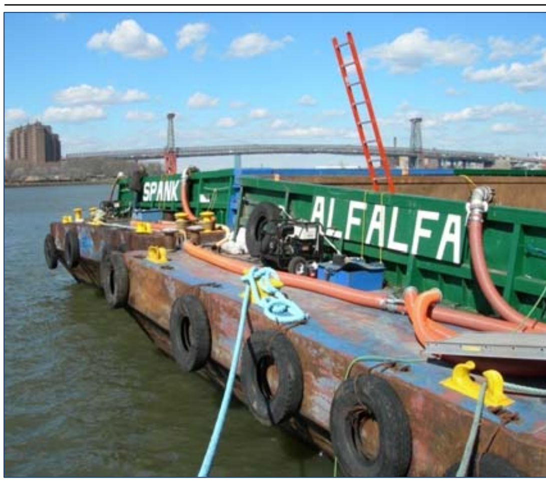
Dewatered sediments were removed with a hydraulic excavator and taken to a local landfill.

Solids exceeded 47%.

End Of Section
Return to
Case Studies

31

ConEdison



New York City

Challenge: Remove and dewater contaminated (PCB, hydrocarbons, etc.) sediments that collected in the cooling water intake tunnel for a power plant, while meeting strict EPA standards for effluent quality.

There was no available land for dewatering equipment of any type.

Installed 2006

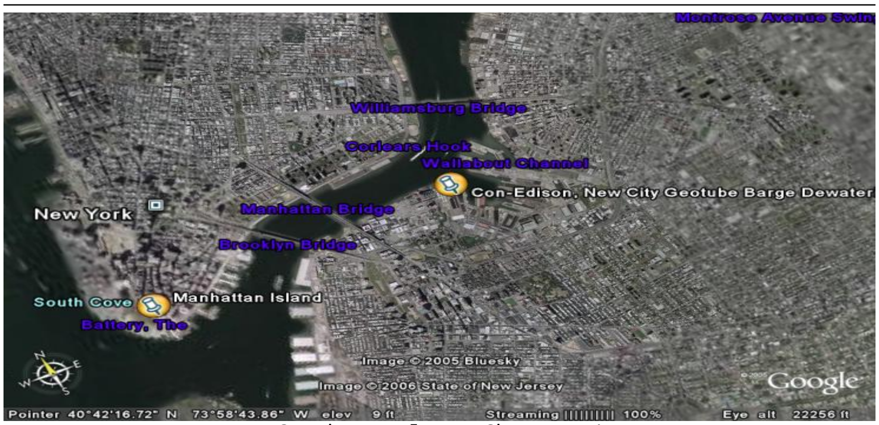
32

ConEdison

New York City

Solution: Geotube® dewatering technology, adapted to be operated completely on barges in the East River, adjacent to the site.

ConEdison



Google Maps Images Show Location

ConEdison

35

ConEdison

36

ConEdison

Geotube® units were custom sized to fit the barges. Two layers of Geotube® units were stacked in each barge.

37

ConEdison

The Smartfeed™ patented mobile chemical feed system provided automated polymer mixing and injection for the project.

Solids and flow were constantly changing, from 4% to 11% solids, and from 400 gpm to 1,500 gpm.

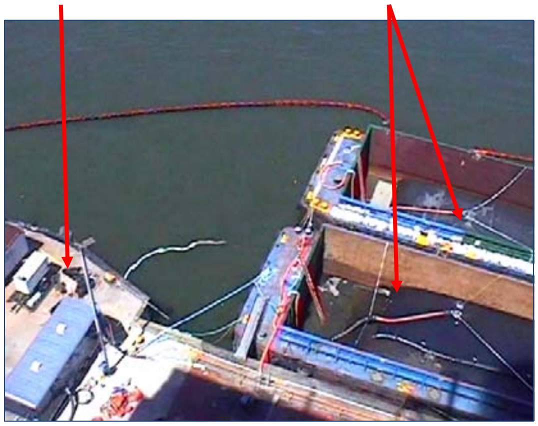
SmartFeed™ is a trademark of Mineral Processing Services, S. Portland, ME

38

ConEdison

Smartfeed™ Trailer

Geotube® units in barges



The Smartfeed™ system tracked changes in solids and flow, adjusting polymer injection to optimum level every five seconds.

39

ConEdison

Effluent was clean enough for direct discharge without additional treatment.

40

ConEdison

In 45 days, 67% dry solids were achieved. Solids were removed from the barge and hauled to an EPA approved landfill in NJ.

41

ConEdison

Results: “Environmental concerns evaporated when it became clear the water retrieved from the silt and captured by the Geotube® containers was much cleaner than the natural water of the East River.”

42

ConEdison

Results: Silt volume was reduced from an estimated 52 barges (non-dewatered) to less than 1 barge of dewatered solids. The project was so successful that the same method was used for another facility upriver and approved for future applications.

End Of Section
Return to
Case Studies

2008 Geotextile Tubes Workshop was conducted as part of a research project funded by the US Department of Homeland Security (DHS) through UT Battelle at Oak Ridge National Laboratory under the Southeast Region Research Initiative (SERRI).

End of *Geotubes for Dewatering Applications*
by Ed Trainer.

Section 6.14

2008 Geotextile Tubes Workshop

Nov 17-19 2008, Starkville MS

- ***Presentation Title:***

  Disposal of Coal Mine Slurry Using Geosynthetic Containers at North River Mine in Berry, Alabama

- ***Author:***

  Ed Trainer[1] (Presenter) and Mike Watts[2]

- ***Affiliation and Contact Information:***

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  2:Private Consultant

Jointly Sponsored by:

- Mississippi State University Civil and Environmental Engineering Department
- Mississippi State University Office of Research
- US Army Corps of Engineers Research and Development Center Coastal and Hydraulics Laboratory

Abstract:

- The processing of raw coal to a saleable, clean coal requires many mine operators to wash the run of mine product using a preparation plant. The fine rock particles leave the preparation plant suspended in water to form slurry. This waste slurry is normally disposed of via surface impoundments or injected into abandoned underground mine workings.

- When these primary methods of disposal are not available, the use of large geosynthetic containers for dewatering the slurry waste provides another means of waste processing. The use of geosynthetic containers for slurry dewatering is new to the industry and has successfully been implemented at Chevron Mining Inc. After testing was conducted and the necessary permits obtained, the North River Mine began using this unique and successful method to dispose of slurry.

- This presentation will explain the process and steps necessary for implementation.

1

Steps:

- Preliminary Testing
- Design and Permitting
- Bag Field Construction
- Filling the Bags
- Reclamation

2

Preliminary Testing

August 2007

Two - 100 foot Geotube® test bags were utilized

Polymer mixing tanks and injection pump setup

5

Test was performed by pumping slurry directly from Preparation Plant Thickener to the test bags

Solids at 25 – 35% Over 80% minus 400 mesh

6

7

"Making Sausages"

8

9

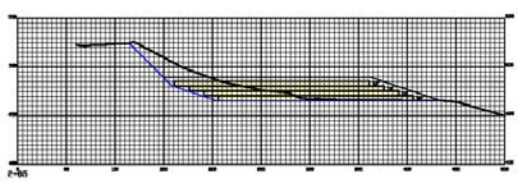
Results: Solids captured and water filtered

10

Design and Permitting

11

Bag Field Cut and Fill Design



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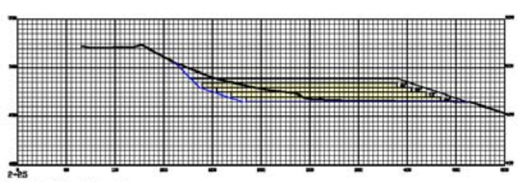

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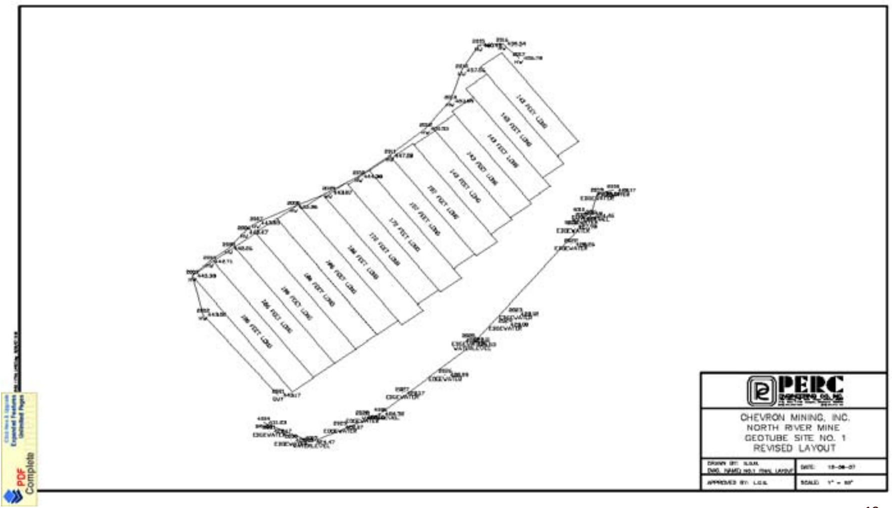
12

Bag Field Plan View



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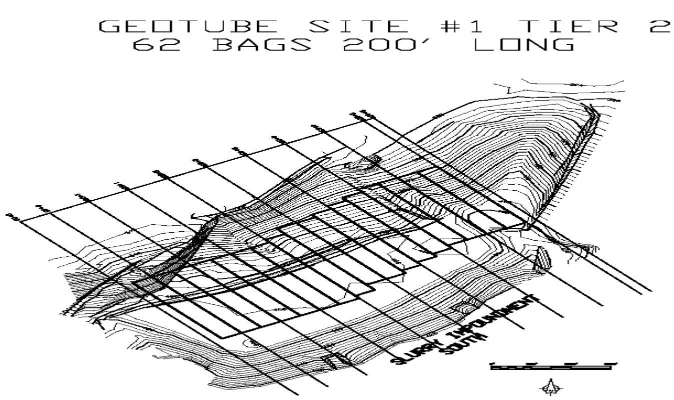
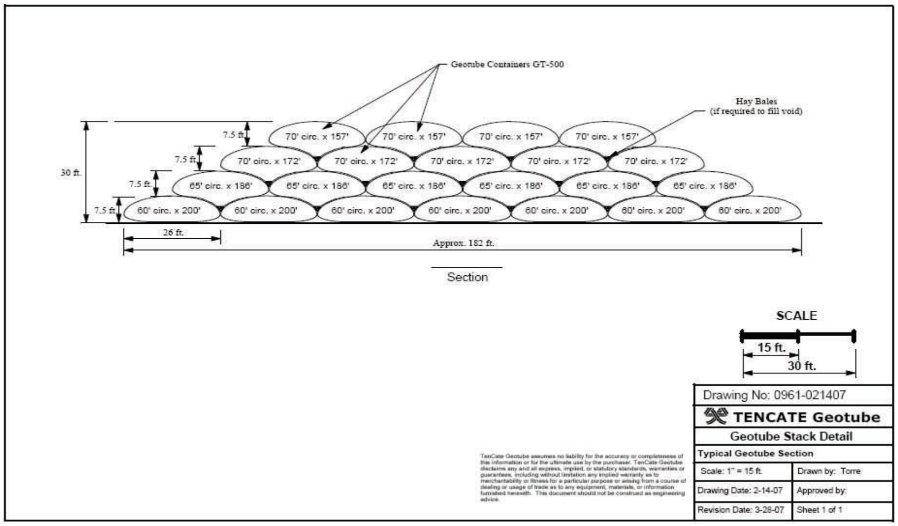


14

Stacking Plan



15

Bag Field Construction

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17

Crushed Rock was placed over the lay down areas to act as a drainage medium beneath the containers:

- 6" of crushed sandstone blend
- 3" crushed sandstone (# 57)

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20

Final Grade to 1% slope draining to existing slurry pond

21

Filling the Bags

22

North River Mine
GeoTube Filling Project

Response Plan for Rupture or Leak of GeoTube Bag

Action Steps:

- Move all workmen to a position of safety
- Contain Material
- Determine extent of rupture or leak
- Continue to operate in unaffected area
- Mitigate problem by repair, removal, or replacement as needed.
- Investigate cause
- Clean up area if needed
- Report incident to Project Manager

Notes:

Leaks rarely occur (maybe 1%). Care in handling bags is foremost.

The safety factor of the bags at maximum pressure is over 4.0.

All bag fields and work areas drain to the large pond effectively containing possible spills.

23

The Geotube® Containers used were 60 - 70 Feet in circumference and in various lengths

24

An 8-inch Cutterhead Dredge was used to pump the slurry from the surface impoundment to the Geotube® Containers

25

Polymer Mixing and Injection Station

26

A Manifold System was used to allow the filling of more than one tube at a time

27

Bags Dewatering

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In order to utilize a smaller foot print for larger volumes of material, the Geotube® Containers were stacked four layers high in pyramid fashion

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31

The construction schedule of bag fields overlapped so that there was no lost time in moving from one area to the next

32

Bag Field II

Bag Field I

33

Bag Field III

34

Retired Bag Field II Tier II

Ready for reclamation

Covering Bags

Reclamation

Once retired the fields were immediately covered and reclaimed

37

When the material inside the Geotube® Containers reach a moisture content of 35%, they could be covered and buried in place

38

A layer of sand and a layer of rock was placed around the edges of the bag field for drainage

39

40

Bags were then covered with material using low ground pressure equipment

41

42

Reclaimed Bag Field III

43

Ready for seed and mulch

44

Project Statistics:

- January – August 2008
- 1750 cubic yards per day
- 240 Geotube® Containers
- 42,000 combined linear feet of bags
- 5 cubic yards of slurry per linear foot of bag
- Moisture 30 – 35% after dewatering
- Very stable

45

Results:

- Over 200,000 yards of slurry waste disposal
- No Safety Incidents
- No Environmental Incidents

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OAK RIDGE
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