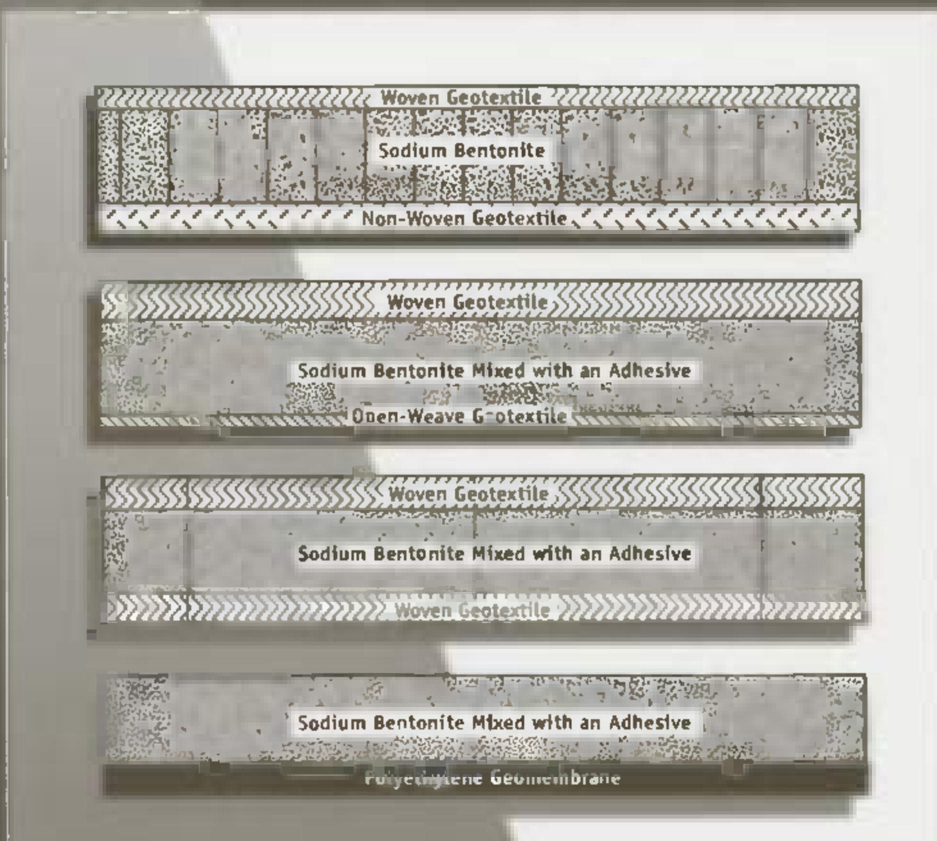
Testing and Acceptance Criteria for Geosynthetic Clay Liners



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Foreword

The Symposium on Testing and Acceptance Criteria for Geosynthetic Clay Liners was held 29 January 1996 in Atlanta, Georgia. ASTM Committee D35 on Geosynthetics through its Subcommittee D35.04 on Geosynthetic Clay Liners sponsored the symposium. Larry W. Well, CH2M Hill, Inc., presided as symposium chairman and Kent von Maubeuge, Naue Fasertechnik Gmbh and Company, presided as symposium cochairman. Larry W. Well is editor of this publication.

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Overview

A symposium sponsored ASTM Subcommittee D35.04 on Geosynthetic Clay Liners was held on 29 Jan. 1996 at the Hyatt Regency in Atlanta, Georgia. The intention of the program was to bring together the current knowledge and understanding about the use of this relatively new product currently being used in containment systems. The symposium had attendees from around the world and presenters from Canada, France, Germany, and the United States. The international flavor of the symposium and technical papers suggests the world has embraced this new product and its representatives are eager to share their experience and knowledge. This cooperation is a very positive signal that the development of single and composite containment systems using GCLs will continue well into the next millennium. There is no doubt that additional forums about GCLs will be held in the future to add to the knowledge base we currently have.

Background

Geosynthetic clay liners (GCLs) are developing as an important and accepted component in hydraulic barriers for containment systems. Used in conjunction with geomembranes they are becoming commonplace, working as partners to make reliable composite lining systems for landfill lining and capping systems. GCLs alone are also effective barrier linings for liquid impoundment. The fact that they are manufactured products made under comprehensive quality control and fabrication standards provides a performance reliability that compacted clay soil layers do not often achieve.

The mid-1980s saw the introduction of GCLs into the containment industry. Since that time there have been millions of square meters of GCLs installed. The designs for these innovative installations involve careful review of the basic soil mechanics and engineering principles to accomplish design goals. Design goals are related to hydraulic conductivity, chemical resistance, slope stability, uniformity of product, environmental influences, and installation cost. The careful application of the scientific and engineering principles in GCL applications has fortunately prevented many significant failures. A basic tool in the workshop of engineering is past experience to learn what works well and what is not successful. With over a decade of practice using GCLs the time was ripe to hold this symposium to examine where we have been, what we have to work with now, and chart our course for the future.

Organization

The Special Testing Publication (STP) No. 1308 "Testing and Acceptance Criteria for Geosynthetic Clay Liners" presents state-of-the-art review. A summary is provided of the types of products, special test procedures developed over the last several years, and results of studies of hydraulic, chemical compatibility and stability issues. Experiments with various chemicals, and case histories are also presented to inform the reader of the state of the practice. The STP is arranged to present a progression from special testing procedures, shear strength and creep testing results, hydraulic conductivity testing, chemical compatibility issues, and, finally, to specification suggestions for GCL applications. We hope the information contained herein provides insight, guidance, and confidence in proper applications of GCLs in containment systems for liquids, solid, and hazardous waste containment systems. We intended for the STP to be used as a reference in future work for designers, regulatory agencies, and professors as the topic of geosynthetic containment systems becomes more common place in college curricula. Currently there does not appear to be a host compendium for information about GCLs, and we intend this STP to be a beginning for a collection of pertinent technical information.

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Keynote Address

The Keynote Address **Perspectives of Geosynthetic Clay Liners** presents a neat and tidy overview that addresses a number of topics and issues pertaining to geosynthetic clay liners. The relevant physical, hydraulic, mechanical, and endurance properties, and their associated test methods are reviewed for the perspective of manufacturing quality control tests versus design oriented or performance tests. Current activity and recommendations are suggested for these relatively new and unique liquid barrier materials.

Special Testing Procedures

The paper that describes the **Effect of Moisture Content on Free Swell of the Clay Component of Geosynthetic Clay Liners** discusses the effect that initial moisture content has in causing the free swell to decrease linearly, in some GCLs, and nonlinearly in with other GCL products. A procedure for calculating the free swell from the initial moisture content is presented.

The **Effect of Swell Pressure on GCL Cover Stability** describes the importance of bentonite swell pressure in the stability of a soil cover system that incorporates a GCL. The typical one-dimensional swell test indicates greater swell pressure than typical overburden loading provides. Hence, slope stability may be compromised. The paper also presents an innovative suggestion for development of GCL products to increase cover stability.

A Comparison of Sample Preparation Methodology in the Evaluation of Geosynthetic Clay Liner (GCL) Hydraulic Conductivity presents the important procedures for taking testing specimens used for hydraulic conductivity testing from GCL samples. Different conditioning and trimming procedures are examined and rated for effectiveness.

Shear Strength and Long-Term Creep Testing

The **Effect of Normal Stress During Hydration and Shear on the Shear Strength of GCL/Textured Geomembrane Interfaces** used two pre-shear inundation methods designed to simulate field conditions in a laboratory testing program. The purpose is to evaluate the interface shear strength. The results of two different GCL materials and the two pre-shear conditions are compared.

A design case history examined one GCL product in **Strength and Conformance Testing of a GCL Used in a Solid Waste Landfill Lining System.** As part of a composite landfill lining system in Seismic Zone 4 area on a relatively steep slope required careful evaluation of both internal shear strength of the GCL and the interface friction between the GCL and textured HDPE liner. Stability analyses using stress-dependent interface and internal shear strengths for the GCL are discussed. Quality assurance and conformance testing for the project on the GCL are also discussed.

The **Short-Term and Creep Shear Characteristics of a Needlepunched Thermally Locked Geosynthetic Clay Liner** are explored by a series of constant-rate direct shear tests following procedures of ASTM D 5321. The test results demonstrate that the needlepunched thermally locked reinforcing fibers provide substantial short-term shear strength to a GCL. The long-term shear strength can be affected due to potential creep within the reinforcing fibers and this was examined in a newly developed constant-load (creep) shear testing device.

Another study on the **Long-Term Shear Strength Behavior of a Needlepunched Geosynthetic Clay Liner** describes two large scale constant-load (creep) shear testing devices that were developed to evaluate shearing behavior and interfaces between GCLs and other geosynthetics or soils. One device simulates loading conditions that typically occur in a cover system. The other device simulates loading conditions that may occur on a GCL deployed in a landfill lining system. Further testing is planned to more accurately define the time-dependent internal and interface shear behavior of the GCL.

In another paper guidelines are presented for **Shear Strength Testing for Geosynthetic Clay Liner** for measuring the internal and interface shear strengths in a direct shear test. Currently, there is a significant variability between laboratories in shear testing procedures in relation to specimen hydration and shear rate. The intent of the study is to present methods to provide measured strengths that are representative of typical field conditions.

Hydraulic Conductivity Testing Compatibility Issues

A design case history is used to describe the rationale used to evaluate the use of **Geosynthetic Clay Liners in Alkaline Environments.** Designers are faced with equivalency calculations for comparison of GCL performance with compacted clay liners. One important property is the ability of the hydraulic conductivity of the GCL to withstand degradation due to permeation of alkaline leachates rich in materials such as calcium. The paper discusses the concept of ion exchange and the resulting decrease in swell potential, and adsorption capacity and the increase in hydraulic conductivity. Conclusions suggest appropriate performance testing with the leachate in question must be performed during the design phase and confirmed by construction quality assurance testing.

Laboratory Simulation of Geosynthetic Clay Liner Application in Contaminated Liquids Evacuation evaluated the ability of a GCL in preventing leakage of mineral oil into ground water. A full-scale model was designed and constructed for the testing program that showed only one-percent of the precipitated water and leaked mineral oil was collected underneath the GCL. Further research is recommended on techniques of seaming GCLs; the minimum acceptance rate of hydration of GCLs for different liquids; the influence of the water content of adjacent soils in GCL hydration; and long-term hydraulic compatibility of GCLs with different liquids and leachates.

Experiments were conducted to investigate **First-Exposure Performance of the Bentonite Component of a GCL in a Low-pH Calcium-Enriched Environment** by testing the compatibility of the sodium-bentonite component subjected to acidic ground water. A second test was performed to learn the combined effects of acidic ground water enriched with calcium. The relationship between the ionic exchange and changes in hydraulic conductivity and electrical conductance are reported and discussed.

Hydraulic Conductivity Testing Issues and Methods

The **Influence of Initial Hydration Conditions on GCL Leachate Permeability** describes the climatic situations occurring between installation of the GCL and installation of waste in a landfill. The first incident of leachate exposure can correspond to various degrees of hydration of the GCL. The paper aims at analyzing the partially and totally hydrated GCLs behavior after a long-term exposure to leachate. Tests were performed on two needle-punched GCLs in three conditions of hydration that show an important variation of the permeability related the degree of initial hydration.

In the continuing evolution of testing procedures **Measurement of Hydraulic Properties of Geosynthetic Clay Liners Using a Flow Box** is described and evaluated. The GCL flow box offers several advantages over large tanks or flexible wall pemeameters. The conclusions of the testing programs on large-scale intact specimens, overlapped seams, and GCLs under environmental stresses such as freeze-thaw is that the tests may be performed more conveniently and reliably for verifying hydraulic conductivity of GCL panels.

The most important variables in hydraulic conductivity testing are addressed in **Laboratory Hydraulic Conductivity Testing of GCLs in Flexible-Wall Permeameters.** The paper describes the variables and the round-robin testing program conducted by 18 laboratories to independently measure the hydraulic conductivity of a GCL permeated with water. All test specimens came from the same sample. The coefficient of variability for the round-robin testing program, for experienced laboratories, and for a manufacturers 7-month quality control testing period are presented. The results of the round-water testing are encouraging, considering there was less variability than might be expected.

Specifications for GCL Applications

Geosynthetic clay liners are being used on increasingly steep and high landfill slopes, which requires careful determination of the appropriate shear strength to be used in design. **A Design Perspective on Shear Strength Testing of Geosynthetic Clay Liners** reviews shear strength testing of GCLs and the subsequent use of the strength data, from a design viewpoint. There are references to landfills in Hong Kong's mountainous terrain that has many steep-sided valleys or canyons with 25 to 40° natural slopes rising from near sea-level to a few hundred meters.

A discussion of **Manufacturing Quality Control and Specification Criteria for Geosynthetic Clay Liners** is aimed at state-of-the-art quality control and quality assurance testing to help maximize GCL performance. Newly developed ASTM standards for GCL testing and practice are described as they closely relate to quality control and development of useful specifications for construction projects.

A Study of the CBR Bearing Capacity Test for Hydrated Geosynthetic Clay Liners describes a modified version of the California Bearing Ratio (CBR) penetration test used to investigate hydrated GCL bearing capacity. Comparisons of various styles of GCL products are presented as influenced surcharge pressure, displacement rate, mold diameter, and test termination criteria based on lateral bentonite migration (squeezing). Recommendations for equipment and methodologies for the test are included in the paper.

Conclusion

Some very good work has been done in the last decade in developing, using, testing, and understanding geosynthetic clay liner materials. The geosynthetics industry is one of inno-

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