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Project Summary

Quick Indicator Tests to Characterize Bentonite Type

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Ten commercially available bentonite products representing unaltered, polymer protected, and chemically treated sodium bentonites were used in laboratory testing. The purpose of the tests was to identify a quick, reliable, cost-effective and field indicator test procedure to permit:

- **identification of bentonite type;**
- **prediction of the hydraulic conductivity performance of the bentonite under chemical or leachate attack, both in pure form and when admixed with other soils for use as slurry trench backfill.**

Eighteen test procedures were applied in either slurry or powdered form to several bentonite concentrations, several acetone concentrations, and three general hydration cases. Results demonstrate that gel strength and apparent viscosity tests may be used to distinguish between the specific unaltered, polymer protected or extended, and chemically treated bentonites tested.

A total of ninety-five hydraulic conductivity tests were performed on various soil-bentonites and bentonite filter cakes. Results indicate that the hydraulic conductivity of bentonite filter cakes permeated by a mixture of 25% acetone in water was not significantly different from baseline (0% acetone) results. Moreover, there was no performance distinction to be made on the basis of bentonite type.

Selected indicator parameters were measured on the same slurries used to prepare filter cakes for hydraulic conductivity testing. Results for the 10-minute gel strength test suggested an apparent qualitative correlation with hydraulic conductivity as a function of acetone concentration.

This Project Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The Land Pollution Control Division, Containment Branch, of the Hazardous Waste Engineering Research Laboratory (now the Risk Reduction Engineering Laboratory), is conducting research to evaluate the effectiveness of earthern barriers to prevent the movement of contaminated groundwater from hazardous waste sites. Of particular interest are the immediate and long-term performance characteristics of these barriers under the influence of organic contaminants.

Various soil-bentonite mixtures are utilized as barriers in the form of slurry cutoff walls. The selection and specification of a particular bentonite for use in slurry wall construction is often an application-dependent decision involving cost and subjective performance considerations. Sodium bentonites are classified by vendors as unaltered, polymer protected or extended, and chemically treated. Currently, there is no test protocol to distinguish between these bentonite type classifications or to evaluate relative in-service hydraulic conductivity performance under chemical or leachate attack.

The purpose of this research was to identify a quick, reliable, cost-effective and field-practical indicator test procedure.

Procedures

The research was performed in three consecutive phases from June 1, 1984 to September 30, 1986. A total of ten different vendor-supplied bentonite products were studied utilizing eighteen test procedures, three different bentonite hydration procedures and eight test liquids including deionized water, acetone in various concentrations, and 100% methanol and xylene. The project involved almost 2000 separate indicator test runs and a total of 95 hydraulic conductivity tests.

Phase I involved the application of ten indicator tests using two hydration procedures and three test liquids (deionized water, 25% acetone, 75% acetone) to determine the rationale for and scope of subsequent research.

Phase II involved four additional test procedures, one additional bentonite hydration condition, three additional concentrations of acetone (5%, 15%, 50%), and 100% methanol and xylene. About 64% of all indicator test data reported were generated during Phase II in an effort to establish a statistically viable data base for evaluation.

The focus of Phase III was threefold: to further examine the most promising test procedures; to perform a statistical analysis to determine which tests, if any, could be used to distinguish between unaltered, polymer protected or extended, and chemically treated bentonites; and to determine the relationships, if any, between indicator test parameters and hydraulic conductivity. Phase III testing involved nine test procedures, two of the three bentonite hydration procedures previously used, and selected test liquids (deionized water, 25%, 50%, and 75% acetone, and 100% methanol).

The ten sodium bentonite products used in this study were classified as unaltered, polymer protected/extended, or chemically treated. The term "unaltered" indicates a naturally occurring sodium bentonite or a blend of different grades of naturally occurring sodium bentonite that has not been subjected to chemical or physical alteration or modification. The term "polymer protected or extended" indicates a naturally occurring sodium bentonite that has been polymer "amended" either to enhance its resistance to chemical degradation or to improve its yield for economic reasons. The category termed "chemically treated" represents products that are designed to resist in situ degradation under chemical or leachate attack.

The majority of indicator tests used in the course of this study involved the testing of a bentonite/water slurry or a bentonite/water/chemical slurry and may be termed "slurry characterization" tests. These tests are generally employed in bentonite manufacture and by consumers of bentonite products to monitor key slurry properties such as viscosity and gel strength. The scope of testing also included several tests that are generally associated with either geotechnical engineering or environmental science. In addition, a few new test procedures were developed in-house or adopted from other consultants and researchers evaluating special bentonite testing methods. These tests and the Phase in which they were used are shown in Table 1.

The particular procedure used to prepare samples for testing depended primarily upon the type of test and whether or not the bentonite was to be tested in slurry form. Tests such as free swell and liquid limit were performed on powdered bentonite samples as supplied from the vendor. Other tests, such as the modified swell test, involved chemical modification of bentonite prior to testing in powdered form.

The procedure involving powdered bentonite was used to prepare both standard "baseline" (0% chemical) slurries and chemically "hydrated" water/chemical solutions. Data for baseline slurries generally reflect the normal level of response of the parameter of interest in typical slurry applications. Data for the chemically "hydrated" case were not intended to reflect a normal slurry application, but rather, served to represent a different hydration case purely for type-distinction purposes.

The procedure involving a water hydrated bentonite was employed both to provide a third slurry test case for type-distinction/characterization purposes and to reflect the more typical situation of chemical impact after full water hydration of the bentonite. This procedure involved the preparation of a standard paste for each bentonite which was allowed to hydrate for several days. This paste was then mixed in the design proportion with the various water/acetone solutions to achieve the desired fi slurry for testing.

All slurries were cured in airti containers in a high humidi environment for a period of 24 ho prior to testing. This curing time w maintained in order to standardi bentonite hydration time and achieve nearly full bentonite hydration state.

Conclusions and Recommendations

Within the scope of this study it possible to distinguish betwe unaltered, polymer protected/extend and chemically treated bentonite typ on the basis of results from select indicator tests. Based upon a one-w analysis of variance of all results selected tests, the 10-second strength test, the 10-minute gel stren test, and the apparent viscosity test m be used to distinguish between the th bentonite types by use of a chemica "hydrated" 25% acetone slurry havin bentonite concentration of 5%. Wh fully water-hydrated prior to exposure acetone concentrations in the range 0% to 50%, the behavior of the bentor types is not sufficiently different to per type-distinction. Although seve indicator test procedures permit limi type-distinction, those employing rotational viscometer to measure vari bentonite slurry parameters are the m useful for type-distinction purposes.

Initial bentonite concentration of slurry has little, if any, measurable eff on the equilibrium hydraulic conducti of filter cakes formed via slurry filtrat regardless of the acetone concentrat of the permeant liquid (up to 50%) bentonite type. The greatest reduction hydraulic conductivity of filter ca relative to baseline (0% acetone) res is at an acetone concentration of 25 with little or no additional reduction w increasing acetone concentration up 50%. For the range of aceto concentrations tested herein, bentor concentration has a greater effect on hydraulic conductivity of a benton amended soil than bentonite type. T maximum observed difference hydraulic conductivity between differ soil-bentonites due to bentonite type about one order of magnitude.

A quantitative correlation betwe indicator test parameters studied and hydraulic conductivity of pure benton and soil-bentonites permeated varying concentrations of acetone can be demonstrated; however, qualitat correlation between hydrau

Table 1. *Indicator Tests*

	Indicator Test	Research Phase I	II	III
1	Marsh Funnel Viscosity	x	x	x
2.	10-second Gel Strength	x	x	x
3.	10-minute Gel Strength		x	x
4.	Apparent Viscosity	x	x	x
5.	Yield Point	x	x	x
6.	Plastic Viscosity	x	x	x
7.	API Filtrate Loss	x	x	x
8.	Unit Filtrate Loss	x	x	x
9.	Modified Swell		x	x
10	Free Swell (2-hr)		x	
11.	Free Swell (24-hr)	x	x	
12	Mud Weight		x	
13	Specific Conductance		x	
14	pH	x	x	
15	% retained, #200 Sieve	x		
16	Turbidity	x		
17	Cracking Pattern	x		
18	Liquid Limit	x		

conductivity and 10-minute gel strength was observed for filter cake samples representing each of the three bentonite types This apparent correlation has no practical utility since acetone was observed to have an insignificant effect on the hydraulic conductivity of bentonite filter cakes. A similar qualitative correlation was not observed for soil-bentonites under any set of test conditions

Although a type-distinction capability was demonstrated for the specific unaltered, polymer protected/extended, and chemically treated bentonites tested herein, utilization of such should not be initiated until substantial verification testing is completed on a much wider sampling of the population of commercial bentonite products The question of which bentonite type yields the best long-term bentonite-amended clay barrier for different contaminant therefore remains unanswered Any future research effort to resolve this question should focus on long-term chemical exposure of the barrier and should employ several priority pollutants as permeant liquids instead of an "artificial" chemical permeant which produces data of highly limited utility

A qualitative correlation between the 10-minute gel strength test and the hydraulic conductivity of filter cakes permeated by acetone can be demonstrated, however, such a demonstration is not possible in the case of soil-bentonites Apparently there is no substitute for long-term multiple pore volume hydraulic conductivity testing; therefore, the concept of a "quick indicator," especially in the case of bentonite-amended clays, may be tenuous

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Walter E. Grube, Jr. *is the EPA Project Officer (see below).*
The complete report, entitled "Quick Indicator Tests to Characterize Bentonite Type," (Order No. PB 88-244 033/AS; Cost: $32.95, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
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