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A Study on the Effects of Chemicals on the Geotechnical Properties of Bentonite and Zeolite Mixture as Clay Liner

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***Abstract*: One of the main problems in the geo environmental field is the intrusion of toxic contaminants from waste disposal and other sources into the underlying ground water supply. The liners are affected by the leachate from decomposition of waste materials. Due to high swelling and adsorption capability, bentonite is commonly used material for liners. The natural zeolites and the commercial powdered bentonite were used in various experiments, such as compaction, hydraulic conductivity, and strength. Various ratios of bentonite and zeolites compacted at the optimum water content were tested to determine the strength parameters. The laboratory samples compacted under optimum water content and slightly higher water contents were tested for hydraulic conductivity (k). Cation exchange capacity, an important chemical property of a liner material, of bentonite and natural zeolite were found to be 60 and 95 meq/100g, respectively. Ideal landfill liner material should have low hydraulic conductivity and high cation exchange capacity. This study aims at investigating certain features of a novel material proposed to serve as an impervious liner in sanitary landfills**

***Keywords*: Bentonite, liner, Hydraulic conductivity**

1. Introduction

A compacted clay liner or landfill liner comprises, compacted cohesive soil having no seepage. The main goal is to decrease porosity and soil permeability. Landfills are the most popular municipal solid waste disposal system. The design of liner is made so as to isolate the waste from the environment minimizing the passage of leachate into the groundwater. To ensure this the important characteristics for compacted landfill liners are selection of materials, hydraulic conductivity, strength, compressibility and contaminant retention capacity. Usually soil rich in clay minerals are used as compacted liner materials for their low hydraulic conductivity which is required to be less than1×10^ -7 cm/s [Daniel, 1987; 1990; Benson and Trast, 1995]. Instead of clay, mixture of expansive soil such as bentonite with zeolite mixture can be used as compacted barriers. Continuously increasing awareness in preserving the groundwater supplies from contaminants generated from waste sites has given rise to the design of well-isolated containment structures. The transport of leachates eliminating from surface water impoundments is of great importance to engineers because of the pollution problems these leachates cause in groundwater supplies. The use of liner systems is common in preventing transport of contaminants to the surrounding pollution-prone environment. These measures generally involve the application of low permeability natural clays, bentonite mixtures or synthetic materials [1]. Compacted natural clays are often used in constructing hydraulic barriers underneath waste containment systems. The usual thickness for such liners is between at least a few decimeters to greater than one meter. Typically, the hydraulic conductivity must be less than or equal to 1 x 10 -7 cm s -1 for soil liners and covers used to contain hazardous waste, industrial waste, and municipal waste. In the absence of impervious natural soils, compacted mixtures of bentonite and sand have been used to form barriers to fluids. A voluminous amount of literature could be found on the hydraulic conductivity and other properties of such mixtures. Sand bentonite mixtures are one of the lowest cost technologies available for constructing an impervious liner for waste water ponds and sanitary landfills. The imperviousness of these liners can be influenced by many factors such as: the matrix material grain size distribution of sand; and the fines contents. One important aspect of the hydraulic barriers is the cation exchange capacity (CEC) of the liner material. The most abundant clay minerals such as illite and chlorite have CEC values between 10 and 40meq/100g (Grim, 1968), whereas the natural zeolites have CEC values between 200 and 400meq/100 g. The objective of this paper is to present landfill liner material composed of natural zeolite and bentonite. Bentonite serves as a pore sealant yielding low hydraulic conductivity, whereas the high CEC ability of zeolite content is utilized in purifying the contaminants in the leachate. Various ratios of bentonite to zeolite (B/Z) are tested to obtain the most desirable mixture ratio of this ideal liner material for waste containment structures

2. Objectives of the study

- To study the liner properties of bentonite –zeolite mixture.
- To determine the geotechnical properties of bentonite with varying percentage of zeolite.

3. Materials and methodology

A. Materials

1) Soil

Bentonite for the present study was collected from Associate Chemicals; Kochi. Sodium bentonite was taken from there. Various tests were conducted for determining the index properties of sodium bentonite.

Fig. 1. Bentonite Clay

Table 1
Properties of Sodium bentonite

Properties	**Values**
Specific gravity	2.59
Liquid limit (%) (IS 2720 PART 51985)	332
Plastic limit (%) (IS 2720 PART 51985)	50
Plastic index (%) (IS 2720 PART 51985)	282
Shrinkage limit (%) (IS 2720 PART 51985)	15.6
IS Classification	CH
Natural moisture content (%)	40
Optimum moisture content (%) (IS 2720 PART 7)	38
Maximum dry density (g/cc) (IS 2720 PART 7)	1.29
Percentage of clay (IS 2720 PART 4)	80
Percentage of silt (IS 2720 PART 4)	11.8
Percentage of sand (IS 2720 PART 4)	8.2
UCC strength (kg/cm^2) (IS 2720 PART 10)	0.88

2) Zeolite

Natural zeolites in Turkey are found in acidic tufts. Two levels of acidic tufts, of about 60m thickness each, are observed in a volcano-sedimentary sequence of Miocene age about 1000m thick. The acidic tuff levels are located near the bottom and upper sections of the volcano-sedimentary sequence, respectively. Zeolite-bearing tufts in the vicinity of are white in colour and stratified. These tufts were formed in a lacustrine environment in Neogene time, fed by volcanic activity in the form of ash flow. Tufts of acidic and rhyolitic composition are thought zeolitized by alteration of the basic lacustrine environment. Mineralogical compositions of these tuff sections are dominated by clinoptinolite (70-90%). Minor amounts of quartz, biotite, and volcanic glass are associated with clinoptinolite. Also, very little iron oxide mineral (hematite) is present.

Fig. 2. Zeolite

Table 2
Properties of Zeolite

Properties	Values
Specific gravity	2.22
OMC (%)	11.4
Dry density	1.2

B. Methodology

1) Liner specification

As per Boyton and Daniel the specification suitable for liner construction is,

Table 3
Liner specification

Percentage of fines	≥ 20 -30%
Percentage of gravel	≤ 30%
Plasticity Index	≥ 7 – 10%
Coefficient of permeability	< 1 x 10^{-7}cm/s

4. Results

A. Compaction for various proportion of zeolite

Compaction of different proportions of the zeolite and bentonite mixtures was tested and results were obtained are shown below.

Table 4
Compaction for various proportions of zeolite

% of zeolite	0	0.1	0.2	0.3	0.4	0.5	0.6
MDD(g/cc)	1.229	1.3	1.34	1.34	1.35	1.3	1.32
OMC (%)	38	36	35	35	34	36	37

The results obtained shows that increase in the percentage of zeolite to the bentonite increases maximum dry density and decrease the optimum moisture content.

5. Conclusion

- Suitability of bentonite as a liner is evaluated by conducting various test such as permeability, atterbergs limit, and hydrometer.
- Bentonite can be used as liner as per the liner specification of Boyton and Daniel
- Addition of zeolite to the clay reduced optimum moisture contents of clay and increased the maximum dry density of the clay.

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