Effect of Pore Fluids on Some Geotechnical Properties of Soil-Rice Husk Ash Mixture as Barriers

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Abstract— **This paper presents the effect of pore fluids on some geotechnical properties of treated kaolinite soil to be used as a liner or hydraulic barrier in Muncipal solid waste containment system. The kaolinite soil is modified with the addition of agricultural waste like rice husk ash. The variations in properties such as dry density, optimum moisture content, Atterbergs limit, Unconfined compressive strength, permeability were studied. The result of this study shows that for soil-rice husk ash mixtures, 9% rice husk ash addition satisfies the requirements for the preparation of liner. The UCS of mixture increased to a value greater than 200kN/m^2. The plasticity index and the hydraulic conductivity values falls within the range of liner material.**

Pore fluids used in this study are $CaCl_2$ and Acetic acid of different concentration. The effect of these pore fluids on Atterbergs limit and Unconfined compressive strength of kaolinite soil treated with 9% rice husk ash is studied. Results indicated that all of these pore fluids have a considerable effect on the geotechnical properties of the mixtures. When the salt is added to the soil-rice husk ash liner material, the liquid limit and plasticity index increases and unconfined compressive strength slightly increases at concentration of 0.5M. Addition of acetic acid also gives the positive changes in liner material up to 0.5M concentration.

Keywords—Kaolinite soil, Rice husk ash, Calcium chloride, Acetic acid, Liner, compaction, Atterbergs limit, Unconfined compressive strength test

I. INTRODUCTION

Many developing countries depend on surface water and groundwater as a primary source for drinking and many other activities in day today life. Rapid industrial development and urbanization has increased hazardous waste generation in developing countries which creates threats to the existing water sources. Heavy metals, organic and inorganic compounds and other toxic effluents are continuously released into the environment through manufacturing, mining, textile and oil firms. These wastes result in high pH of the land, fibrous materials, chemicals and heavy metals causing soil pollution which ultimately lead to ground water pollution.

One good method of preventing or controlling groundwater contamination is to place the waste material in an engineered containment facility with a liner and cover. The primary purpose of the liner system is to prevent or minimize the migration of leachate into the underlying soil during both the active disposal period as well as the inactive period. The cover system prevents the generation of leachate by minimizing the amount of precipitation percolating through the waste during the inactive period provides containment and prevent physical dispersion by wind and water. A barrier system usually includes one or more of the following; liners, covers and slurry cut-off walls. Liners and covers are two main engineered components of a waste disposal system. The objective of placing each component of the landfill is to prevent pollution of ground water with water containing contaminants leached from waste (leachate). Rice husk is an agricultural waste obtained from milling of rice. About 108 tons of rice husks are generated annually in the world. During milling of paddy about 78 % of weight is received as rice, rest 22 % of the weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for the boiling process. Rice husk contains about 75% organic volatile matter. The remaining 25% of the weight of this husk is converted into ash during the firing process, known as Rice Husk Ash.

In India, Central Board of Pollution Control and Ministry of Central Board of Pollution control and the Ministry of Urban Development, India have suggested liner requirements as

- Plasticity Index should be greater than or equal to 7 to 10% and liquid limit between 25 and 30%.
- Hydraulic conductivity less than or equal to 1x10^{-9}cm/s
- Minimum unconfined compressive strength should be 200kPa

The better understanding of the behavior and changes of clayey soil in various environment is very necessary nowadays. Because, increasing use of clays in soil engineering practices. Clays in which the surface forces or interparticle electrical repulsive and attractive forces are predominant exhibit a wide range of mechanical behavior. Hence modification of the properties of these soils becomes inevitable. Secondly with growing industrialization, generate and dispose a lot of industrial wastes on land. This will results in modification of soil properties. So it is necessary to evaluate the soil behavior in different environmental conditions. one of the important environmental factors that affect soil behavior is pore fluids.

This study is basically aimed at the evaluation of effect of inorganic pore fluids on some geotechnical properties of kaolinite soil treated with rice husk ash to be used as a liner material in waste containment systems

II. MATERIALS AND METHODS

A series of laboratory tests were conducted on kaolinite soil blended with Rice Husk Ash in various percentages i.e. 0%, 3%, 6%, 9%, 12% and 15% by weight of dry soil. Tests such as compaction test, unconfined compressive strength test, Atterberg's limits and hydraulic conductivity tests were conducted on Kaolinite soil and Rice husk ash mixes, as per relevant IS Code and to find out the optimum soil-rice husk ash mix suitable for a liner. Then to evaluate the effect of pore fluids in this optimum mix of liner material using some laboratory tests.

A. *Soil*

The study was conducted on Processed kaolinite clay which was collected from English India clay limited, Trivandrum. The physical properties of soil determined as per IS procedure and are shown in Table 1.

B. *Rice husk ash*

RHA collected from rani rice mill, arpookkara, Kottayam, passing through 75 micron IS sieve is used for treatment of soil.

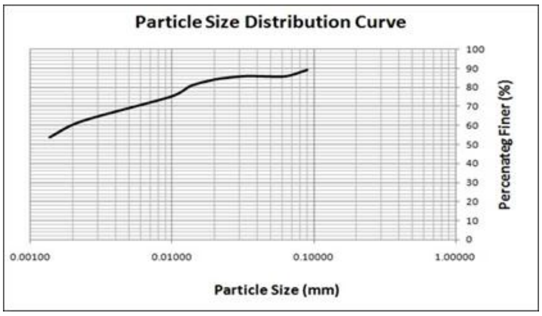

Fig.1 Particle size distribution curve of soil

Table 1. Properties of kaolinite soil

Sl No	Properties	Values
1.	Specific Gravity	2.62
2.	Liquid limit(%)	34.8
3.	Plastic limit(%)	23.4
4.	Plasticity index(%)	11.4
5.	IS classification	CL
6.	OMC(%)	24
7.	Dry density(g/cm^3)	1.43
8.	% clay	60
9.	% silt	26
10.	% sand	14
11.	UCS (kN/m^2)	68.52
12.	Permeability	6.65 x10^{-7}m/s

Table 2. Properties of rice husk ash

Sl No	Properties	Values
1.	Specific gravity	1.92
2.	Plastic limit	Non plastic
3.	Liquid limit (%)	40.2
4.	Maximum dry density(g/cm^3)	1.92
5.	OMC (%)	31.8

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Table 3 Chemical composition of rice husk ash

Sl No	Components	Percentage
1.	SiO_2	86
2.	Al_2O_3	2.6
3.	Fe_2O_3	1.8
4.	CaO	3.6
5.	MgO	.27
6.	Loss in ignition	4.2

C. *Pore fluids*

Pore fluids used in the study include calcium chloride ($CaCl_2$) and acetic acid (CH_3COOH) with varying concentration 0.25, 0.5, 1, 2 molarity.

III. RESULTS AND DISCUSSION

A. *Variation in properties on addition rice husk ash to kaolinite*

Varying percentage of rice husk ash was added to kaolinite and variation in geotechnical properties was found out. From the tests conducted It was observed that 9% addition of rice husk ash to kaolinite soil was found as the optimum which satisfied the liner requirements. Variation in properties of optimum mix is given in table 4.

Table 4. Properties of kaolinite + 9% rice husk ash

Sl No	Properties	Values
1.	Maximum dry density(g/cm^3)	1.92
2.	OMC (%)	31.8
3.	Plastic limit	25
4.	Liquid limit (%)	33.3
5.	Plasticity index	8.3
6.	Unconfined compressive strength (kPa)	375.15
7.	Permeability (cm/s)	2.12x10^{-9}
8.	Shrinkage limit (%)	27.205

B.Variation in properties on addition of pore fluids to amended liner

1) Atterbergs limit test

Atterbergs limit test was conducted as per IS 2720 (part 5) of the acid contaminated and base contaminated soil and the results are shown in figure 2 and 3. Test was performed on the optimum mix of rice husk ash and kaolinite soil with varying concentration of solutions from 0.25, 0.5, 1, 2 molarity

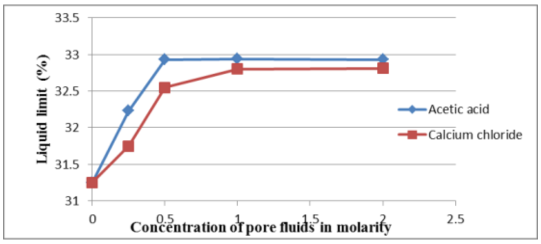

Fig 2. Variation in liquid limit with concentration of solution

From the graph we can observe that liquid limit increases with increase in concentration of pore fluids in case of both acetic acid and calcium chloride. Study is conducted only up to 2.5 M concentration because after that the variation is almost negligible.

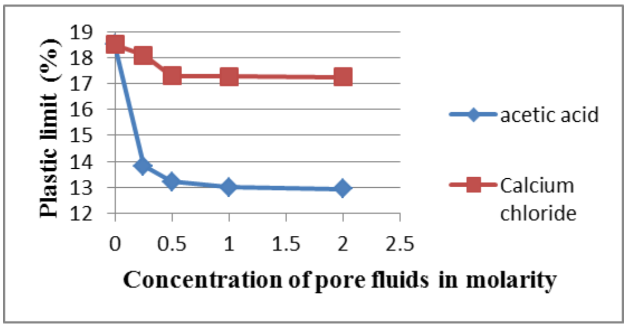

Fig 3. Variation in plastic limit with concentration of solution

From the graph we can observe that plastic limit decreases with increase in concentration of pore fluids in both the case of acetic acid and calcium chloride

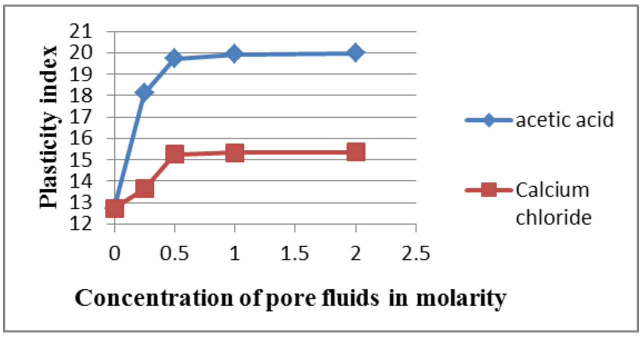

Fig 4. Variation in plasticity index with concentration of solution

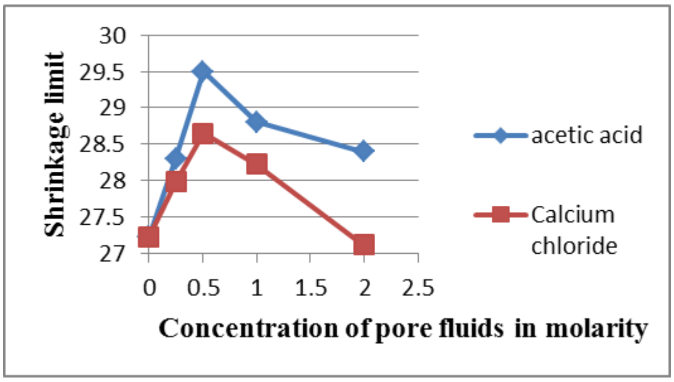

Fig 5.Variation shrinkage limit with concentration of solution

From graphs 2, 3, 4 and 5 we can see that liquid limit and plasticity index increases and plastic limit decreases and shrinkage limit increases with increase in concentration of acetic acid and calcium chloride solution. This increase is due to decrease in dielectric constant of the pore fluid. Clays tend to flocculate and behave almost as if they were silt soil in presence of these fluids which have lower dielectric constant than that of water.

2) Unconfined Compression Test

The unconfined compression strength was determined in the laboratory by conducting unconfined compression test. The test was carried as per IS: 2720 (Part 10)- 1991 in the contaminated samples and the unconfined compression strength of the acid contaminated and base contaminated samples are shown in fig 6.

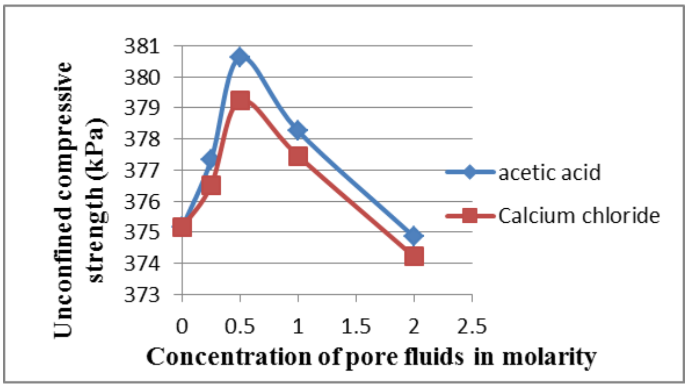

Fig 6 Variation in UCC strength with concentration of solution

From fig 6, we can see that UCC strength is found to increase with increase in concentration of pore fluids. The UCC strength increased from 375.15kPa to 380.62 and 379.23kPa with the addition of acid and base respectively at 0.5 M concentration. There after strength decreased. Because the dielectric constant decreases, the net forces between the clay particles will be an attractive force. In this study, the dielectric constant of the pore fluids decreased with increase in concentrations of the solutions both acetic acid and calcium chloride. So the net attractive force between the clay particles increased with decrease in dielectric constant of the pore fluid thereby the structure changed into a flocculated one.

IV. CONCLUSION

The following conclusions have been made from present experimental studies

Rice husk ash when mixed with kaolinite proves to be a better material for a landfill liner than kaolinite soil alone.

This amended liner material has low hydraulic conductivity, high compressive strength, and less susceptibility to cracking.

A mixture of 9% rice husk ash to the kaolinite soil is the suitable proportion that can be used as a landfill barrier material.

With the addition of pore fluids to the optimum rice husk ash – kaolinite mix it was observed, that

a. Liquid limit and plasticity index increased and plastic limit decreased as the dielectric constant of pore fluid decreased.

b.Shrinkage limit increased with the addition of pore fluids up to 0.5 M concentration of both acid and base

c. Unconfined compressive strength increased with increase in concentration of acids and bases up to 0.5M concentration.

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