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Evaluation of Fly Ash as Amended Liner and the Effect of Pore Fluids

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Abstract - ***Major energy production in India is achieved by the thermal power plants. By- product from these plants mainly include fly ash and bottom ash. Effective utilization of fly ash is being mainly concentrated on in this paper. Fly ash even though have so many advantages in using as a liner it can't be used alone since it is having high hydraulic conductivity and low cation exchange capacity. To overcome this, fly ash is mixed with bentonite. Amending fly ash with bentonite improves cation exchange capacity, shrinkage and volume change behavior. It also poses good strength to be used as a liner. When the liner is encountered with waste materials its properties get altered. This paper also studies the variation in geotechnical properties on addition of pore fluids with variation in concentration.***

Key Words**:** ***fly ash, liquid limit, plasticity index, UCC***

1. INTRODUCTION

In India major energy consumption is achieved by the Thermal power plants. The environmental impact of these power plants include issues such as land use, waste management, water and air pollution caused by the coal mining, processing and the use of its products. Major b-product released from the thermal power plants are the fly ash and the bottom ash. Main focus on this paper is the effective utilization of fly ash. About 110 million tones of coal ash is being generated every year which leads to degradation of land. As per a survey conducted by the National Power Corporation about 20000 hectares of the land is occupied by the ash ponds. It became very necessary to find out alternative routes for the disposal of fly ash and that due to its pozzolanic nature its use in geotechnical engineering field increased.

Landfills are required to effectively dispose of waste. If not properly planned landfill can lead to pollution of environment, ground water, soil contamination etc. to avoid this suitable liner system have to be provided so that these liners can prevent the percolation of the leachate to the surrounding soil. Fly ash when used alone meets some of the requirements of a liner but the most important disadvantage of using it alone is its high hydraulic conductivity and low cation exchange capacity. Therefore amending fly ash with bentonite improves cation exchange capapcity, shrinkage and volume change behavior. Also fly ash- bentonite mix poses suitable strength to be used a liner system for landfill.

2. MATERIALS AND METHODS

2.1 SOIL

Soil used in the study is Calcium bentonite. It was collected from Coimbatore. Engineering properties of it is listed in table 1. The scanning electron microscopic image of calcium bentonite is shown in fig 1.

Table 1: Properties of calcium bentonite

PROPERTIES	VALUES
Specific gravity	2.67
Liquid limit (%)	276
Plastic limit(%)	52
Plasticity index(%)	224
Shrinkage limit	12.54
Max dry density (g/cc)	1.463
OMC(%)	19.12
UCC(kPa)	94.16
Permeability(cm/s)	2.79×10^{-5}

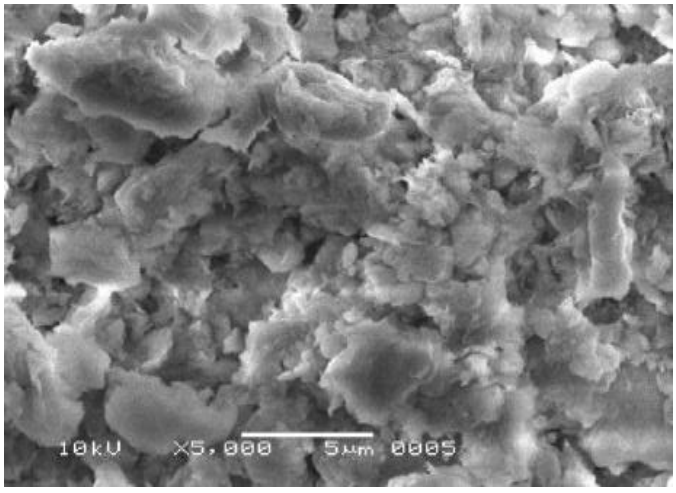


Fig- 1: SEM image of Calcium Bentonite

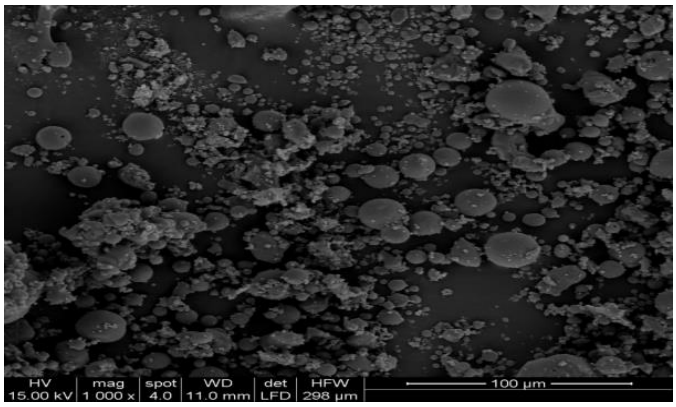
2.2 FLY ASH

Fly ash was collected from Thoothukudi Thermal Power Plant. Physical properties of fly ash are shown in table 2.

Table- 2: Properties of fly ash

PROPERTIES	VALUES
Specific gravity	2.18
Liquid limit(%)	28
% sand	46
% silt	29.75
% clay	16.25
Uniformity coefficient(Cu)	6.13
Coefficient of curvature (Cc)	1.383
Free swell index	0.75
OMC(%)	31.3
MDD(g/cc)	1.16
Permeability(cm/s)	2.79×10^{-5}
UCC(kPa)	92.23
Class of fly ash	F

Fig- 2: SEM image of fly ash



The chemical composition of fly ash is shown in table 3.

Table- 3: Chemical composition of fly ash

COMPOSITION	PERCENTAGES
SiO_2	57.5
Al_2O_3	33
Fe_2O_3	4.8
TiO_2	1.4
CaO	0.5
MgO	0.2
MnO	Bd
K_2O	0.4
Na_2O	0.2
LOI	1.5

1.3 Pore fluids

Pore fluids used in the study includes acetic acid (CH_3COOH) and sodium hydroxides (NaOH) with varying molarities of 0.1, 0.2, 0.3, 0.4 and 0.5.

2.4 PREPARATION OF FLY ASH- BENTONITE MIXTURE

The soil sample was dried in an oven at approximately 105 ºC. Then the fly ash and bentonite were blended to prepare the mixture under dry condition. The amount of bentonite taken was to be 10%, 15%, 20%, 30% and 40% of the dry weight of fly ash. The dry mixtures were mixed with the required amount of water content to give the optimum Proctor moisture content.

3. RESULTS AND DISCUSSIONS

3.1 VARIATION IN PROPERTIES ON ADDITION OF BENTONITE TO FLY ASH

Varying percentage of bentonite was added to fly ash and variation in geotechnical properties found out. From the tests conducted it was observed that 40% addition of bentonite to fly ash 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 fly ash+ 40% bentonite

Properties	Values
Liquid limit(%)	68
Plastic limit(%)	44
Plasticity index (%)	23.56
MDD(g/cc)	1.208
OMC(%)	23
UCC(kPa)	110
Permeability(cm/s)	1.83×10^{-9}

3.2 VARIATION IN PROPERTIES ON ADDING PORE FLUIDS TO AMENDED FLY ASH LINER

1) Atterberg Limit Test

Atterberg limit test was conducted as per IS 2720 (part 5) of the acid contaminated and base contaminated soil and the results are shown in chart 1 and 2. Test was performed on the optimum mix of fly ash and bentonite by varying the concentration of solutions from 0.1 M to 0.5 M.

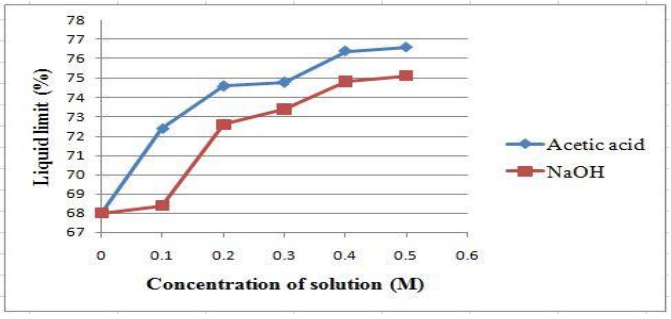


Chart-1: Variation in liquid limit with concentration of solution

From the chart we can observe that liquid limit increases with increase in concentration of solution in case of both acetic acid and sodium hydroxide. Study is conducted only upto 0.5 M concentration because after that the variation is almost negligible.

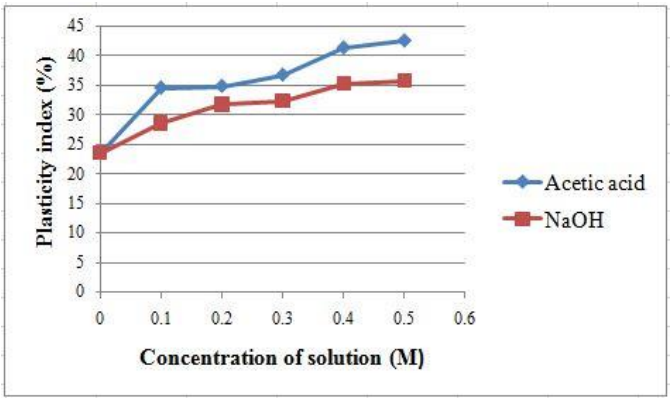


Chart -2: Variation in plasticity index with concentration of solution

From charts 1 and 2 we can see that liquid limit and plasticity index increases with increase in concentration of acetic acid and NaOH 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 chart 3.

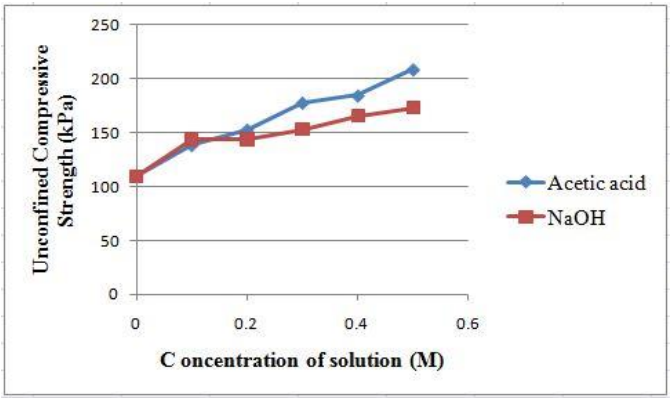


Chart-3: Variation in UCC strength with concentration of solution

From chart 3, we can see that UCC strength is found to increase with increase in concentration of solutions. The reason behind the increase in UCC strength is that as 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 concentration of the solutions both acetic acid and sodium hydroxide. Therefore the net attractive forces between the clay particles increased with decrease in dielectric constant of the pore fluid thereby the structure changed into a flocculated one.

(3) pH Test

The soil pH is a measure of acidity or basicity in soils. pH is defined as the negative logarithm of hydrogen ions. The pH test was conducted using pH meter as per IS 2720: (Part 26)-1987 in order to determine the pH value. Variation in pH value with increase in concentrations is shown in chart 4.

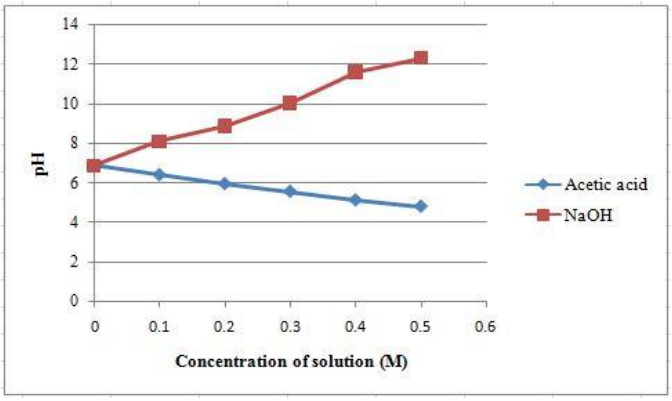


Chart-4: Variation in pH strength with concentration of solution

4. CONCLUSION

Fly ash when mixed with bentonite proves to be a better material for a landfill liner than fly ash or bentonite alone. This material has low hydraulic conductivity, high compressive strength, some flexibility and less susceptibility to cracking. Mixtures of fly ash and bentonite in suitable proportions can be used as a landfill barrier material.

With the addition of pore fluids to the optimum fly ash-bentonite mix it was observed:
a. Liquid limit and plasticity index increased as the dielectric constant decreased.
b. UCC strength increased with increase in concentration of acids and bases.

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