An Investigative Study on the Introduction of Waste Flex Fibers to Clay and Bentonite Mix used in Landfill Liners

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***Abstract*—'Waste management' is one of the serious problems that India faces now.The advancements in the field of geotechnics and the advent of geosynthetics, associated with growing environmental concern have enabled the switch from open dumps to landfills. The main task of the impermeable land fill liners is to reduce the migration of leachate to the ground water and reduce to reasonable amount. Compacted clays soils have traditionally been used as liners having hydraulic conductivity, typically in the range of 10^{-6} to 10^{7}. But,when temperature and moisture fluctuations are high, they form cracks that causes an increase in the hydraulic conductivity in the order of many folds. Because of low permeability and high adsorption capacity, bentonite is the material used in the clay liners to improve its properties.But as bentonite can not resist the swelling,it was added with waste flux fibers.In present study, suitability of clay and Bentonite and waste flux fibers as landfill barrier is tested. The characteristics are** determined **with 3%bentonite and 0.25%flex fibers of aspect ratio 6. This study points out to an effective remedy for serious environmental issues in India by landfills with the help of geotechnical engineering.**

Keywords* — *Landfill, Landfillliners, bentonite,compaction test,attertberg test, permeability test.

I. INTRODUCTION

The important of landfill throughout world increases and need of engineered waste dumps is necessary. But nowadays landfills become a serious environment pollution factor by the emission of toxic gases to atmosphere and migration of leachate produced from the decomposition of waste dumps. Landfills are lined on the bottom and sides with natural and synthetic barrier to contain and collect liquids (leachate) and prevent waste to escape to the environment. Compacted clays soils have traditionally been used as liners of hydraulic conductivity, typically in the range of 10^{-6}-10^{-7} cm/s. Clayey soil liners are suitable when temperature and moisture fluctuations are minimal, however; when temperature and moisture fluctuations are high, they form cracks .

Even though geomembranes have been point out as the best alternative for liners, they are out of reach of most underdeveloped countries for their high price and the need for trained personnel for installation. Then, for most underdeveloped countries there is a need for a landfill liner that is natural, locally available, and that can be installed in an inexpensive way, and in compliance with the environmental regulations. Because of low permeability and high adsorption capacity, bentonite can be used with clay as landfill liner material.This combination provides a natural ,easily available efficient and economical alternative to all landfill liners and it can be adopted by all developing countries like India.

Bentonite can increase the plasticity index of clayey soil . When liquid interact with clay minerals, the properties which are increased and hydraulic conductivity tend to decrease. The hydraulic conductivity of liner material is less than or equal to $1x10^{-7}$ cm/sec. The low conductivity will be gained adequate strength and minimum shrinkage.. In present study, suitability of clay and Bentonite as landfill barrier is tested.To, limit the sweeling of clay and bentonite, it was added with 0.25% waste flex fibers of aspect ratio 6. The characteristics of this combination is determined with different percentages of bentonites to clay.

II. SPECIFICATIONS FOR LINERS

Table1.Recommended specification for liners

PARAMETERS	REQUIREMENTS
Liquid limit	>30%.,50%
Plasticity index	12-30
Unconfined compressive strength	>=20KPa
Permeability	<1*10 $^{-7}$cm/s

III. MATERIALS

CLAY

Clayey soil with low hydraulic conductivity was collected from Payyoli.

Table 2. Properties of clay

PARAMETERS	VALUES
Liquid limit	30%
Plastic limit	20%
Plasticity index	10
Dry density	1.616 g/cc
Optimum moisture content	21%
Unconfined compressive strength	0.2475kg/cm^2
Permeability	1.95* 10 $^{-7}$cm/s

BENTONITE

Bentonite is montmorillonite type of clay having less pore space, relatively small pore spaces occupied by water. It leads to reduction of hydraulic conductivity of Montmorillonite. Bentonite can also increase the plasticity index of clayey soil in mm. Hence, it was preferred as blended soil. Different types bentonites are named after respective dominnat elements like sodium,potassium,calcium,and aluminium. Sodium bentonite is used for the study,collected from Kutch,Gujarat.

Table 3.Properties of bentonite

PROPERTY	VALUES
Liquid limit	350%
Plastic limit	66.67%
Plasicity index	283.3
Shrinkage limit	10%
Specific gravity	10
Maximium dry density	1.34 g/cc
Optimum moisture content	19%

IV. EXPERIMENTAL PROGRAMME

The required hydraulic conductivity could not be achieved from clayey soil alone,hence clay is blended with 3%,5%, and 7% bentonite .The dry density and optimum moisture content of three samples are found.

DRY DENSITY AND OPTIMUM MOISTURE CONTENT (OMC)

The maximum dry density and the optimum moisture content of the clay-bentonite samples were determined by using standard proctor test .While designing a landfill liner ,the strength and deformation behavior of the material is evaluated by testing the sample compacted to maximum dry density.

Table4. results of compaction test

% of bentonite added with clay	Maximum dry density (g/cc)	Optimum moisture content (%)
3%	1.6	22.5
5%	1.582	23.15
7%	1.57	23.37

CLAY BLENDED WITH 3% BENTONITE

Hydraulic conductivity

Table5. variation in hydraulic conductivity

Material	Dry density (g/cc)	OMC (%)	Permeability (cm/s)
Clay	1.616	21	$1.95* 10^{-7}$
Clay+3%bentonite	1.6	22.5	$2.79*10^{-10}$

The observed value of hydraulic conductivity of clay mixed with 3% bentonite was less than $1*10^{-7}$cm/s. Hence this mix satisfied required condition of hydraulic conductivity for the liners. So this clay +3% bentonite was preferred for further studies.

Atterberg's limit

Table 6. Results of Atterberg limit test

Liquid limit(%)	46
Plastic limit(%)	29.62
Plasticity index	16.37

The atterberg limit test conducted on 3%bentonite sample shows the increase in plasticity index to 16.37.It shows themix is medium plastic.

Unconfined Compressive Strength (UCC)test

Table 7.results of UCC test

Sample number	UCC strength(Kg/cm^2)
1	0.322
2	0.482

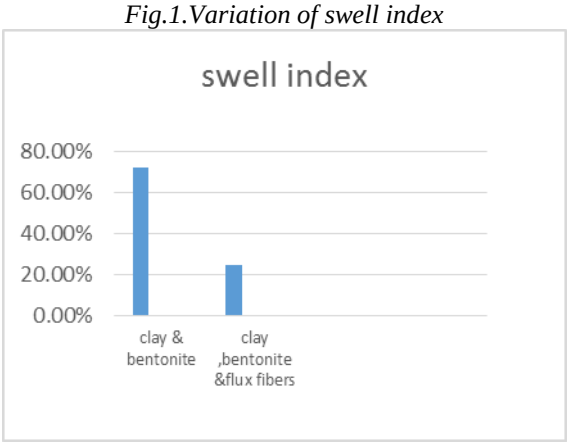
The test was done in 2 samples of clay and 3% bentonite.The average unconfined compressive strength was obtained as 0.402Kg/ cm^2.

Swell index

Swell index is the increase in volume of soil without any external constraint when subjected to submergence in water.As per the test, swell index was obtained as 72.72%, which shows the mix is highly swelling.

In order to limit the swelling that is acceptable for liners ,the mix of clay and bentonite was added with waste flux fibers at 0.25% with aspect ratio 6.

Fig.1.Variation of swell index



TEST RESULTS WHILE ADDING FLEX FIBERS

The test conducted on clay and bentonite are repeated using 0.25%waste flex fibers of aspect ratio 6.

Table 7.Properties of clay ,bentonite and flex fiber mix

Max.dry density	1.57g/ccc
Optimum moistutre content	24.5%
UCC strength	0.426kg/cm^2
Coefficient of consolidation	$9.380*10^{-5}$cm^2/s
Hydraulic conductivity	$8.46*10^{-11}$ cm/s
Swell index	25%

V. CONCLUSIONS

Based on the experiments , following are the conclusions obtained:

1. The hydraulic conductivity of clay was obtained as 1.95* 10 $^{-7}$cm/s, which is greater than the required value of hydraulic conductivity for liners.Hence it is blended with bentonite having low hydraulic conductivity.
2. The hydraulic conductivity of clay+3% bentonite sample was obtained as 2.79*$^{-10}$cm/s. It satisfies the criteria for liners.
3. The further experiments conducted on 3% bentonite sample showed that plasiticity index was increased at 63% and UCC strength was increased at the rate of 62%.
4. Even though the clay+3% bentonite mix satisfies hydraulic conductivity and UCC strength,it can not accept as liners due to it's high swelling.
5. Hence it is added with 0.25% waste flex fibers in the aspect ratio 6.
6. Then, swelling and permeability were reduced at the rate of 65%and the UCC strength improved by waste flex fibers.
7. Hence, the introduction of flex fibers into clay and bentonite can be taken as an effective method of preparation of landfill liners and waste management.

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