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Strength, Dispersion and Cracking Characteristics of Locally Available Marine Soil As A Landfill Liner

K Nanditha[1] , J Harikrishna Menon[2] ,
Muneeba Muhammed Iqbal[3] , Nazrin V A[4]
[1234] UG students, Dept. of Civil Engineering
Adi Shankara Institute of engineering and technology,
Kalady, India

Abishek Kumar A A
Assistant professor,
Dept of Civil Engineering
Adi Shankara institute of engineering and technology,
Kalady India

***Abstract*—In a developing country like India, a huge amount of waste is produced daily due to human activities. This waste needs to be properly disposed as it can cause high risk and can affect human life when it gets in contact with water and other such resources. Landfilling is a method used to dispose waste that requires only less investment unless a suitable area is found. In landfilling, liner is used on the bottom to prevent the leachate migration to the groundwater. Landfill liner can be constructed using different types of materials, using locally available materials would make it cost-effective. Locally available marine soil is used for liner construction. Marine soil is mixed with additives such as fly ash and polypropylene in different proportions to increase its liner properties and the best mixture of this proportion is found. The tests are done to find the strength, dispersion, and cracking characteristics of the liner material.**

Keywords*— *Landfill liner; Marine soil; Dispersion; Crack.

I. INTRODUCTION

Waste disposal is a difficulty faced by all. If it is not properly disposed, it can cause health issues to all living things. There are different methods of waste disposal, among them one is landfilling. Traditional ways of waste disposal are open dumping. But it leads to many environmental issues. So we need an effective method of waste disposal. Landfilling is a method that we commonly adopt nowadays in which wastes are buried. Since the wastes are being buried, there can be migration of chemicals to underground water which contaminates the water and makes it non-useful. Contamination of water leads to many health problems for both human beings and animals, it can also affect aquatic life. To prevent underground contamination liners are kept on the sides and the bottom side. A landfill liner is a low permeable barrier that can prevent the percolation of leachate water. A good liner should have less dispersion and cracking characteristics, strength, minimum gravel content, maximum fines content, and hydraulic conductivity of less than 10-7 cm/s. Liners can be created with different materials and they are high in cost. The commonly used landfill liner materials are compacted clay, geosynthetic clay, geomembrane, geo-textiles, geo-net, and geo-grid.

This study is to make a cost-effective liner by taking locally available soil as the liner material. The soil taken for this study is marine soil. To improve its strength characteristics additives such as fly ash and polypropylene fiber are added to it. Initial property testing is done on both fly ash and marine soil.

For strength property testing fly ash is taken in 0%, 10%, 20%, 30% and 40% and polypropylene fiber is taken in 0%, 0.25%, 0.50%, 0.75% and 1.00%. The best mix is found out using various tests. Using the best proportions both dispersion and crack have been analyzed

II. MATERIAL PROPERTIES

A. Marine soil

Marine soil samples are collected from the Cochin Shipyard. Dredging was carried out there for dry dock construction. Marine soil was collected from there at a depth of 25-30m. The soil in this region is black-colored highly compressible soil with high organic content. The soil was dried and sieved.

TABLE 1. PROPERTIES OF MARINE SOIL

PROPERTIES	VALUES
Specific Gravity	2.54
Liquid Limit (%)	46
Plastic Limit	22.1
Flow index	30.59
Optimum Moisture Content (%)	21
Maximum Dry Density (kN/m^3)	10.66
Coefficient of curvature	2.023
Uniformity coefficient	8.84
Unconfined Compressive strength(kN/m^2)	77.89
Permeability(cm/sec)	1.09x10^{-5}

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B. Fly ash

Fly ash used in this study was collected from ready mix plant Edayar, Ernakulam. Fly ash is a waste produced from coal-fired power generating stations and is readily available inexpensively. In this study class fly ash is used

TABLE 2. PROPERTIES OF FLY ASH

PROPERTIES	VALUES
Specific Gravity	2
Liquid Limit (%)	53.5
Flow index	45.55
Coefficient of curvature	1.36
Uniformity coefficient	4.7

C. Polypropylene

Polypropylene is the most common synthetic material used to stabilize soil and concrete. This material has a relatively low cost. By blending the fibers with mineral components, the strength and the applicable temperature range of the component are extended. For the study purpose, it is collected from an online source

III. EXPERIMENTAL PROGRAM

A. Sample Preparation

Samples are prepared by mixing Marine soil with fly ash and polypropylene. Firstly Marine soil is mixed with the fly ash, where the fly ash content is 0%, 10%, 20%, 30% & 40% by the weight of the soil. Then Optimum fly ash is fixed based on strength test results After selecting Optimum fly ash content, 0%, 0.25%, 0.50%, 0.75% & 1.0% polypropylene is added to the above Optimum fly ash mix and optimum polypropylene percentage is found out using strength test values. Dispersion characteristics for the selected soil- fly ash mix are tested. The sample preparations and conducting experiments are done according to ASTM and IS specifications.

- Unconfined Compressive strength
- Crumb Test
- Double Hydrometer Test
- Crack Analysis using ImageJ software

IV. RESULTS AND DISCUSSION

A. Unconfined compressive strength test

1) Effect of fly ash: Take a sample of soil and then addthe different percentages of fly ash and then strength tests are conducted. Effect of Fly ash on the unconfined compressivestrength of Marine Soil is as follows.

TABLE 3. VARIATION OF UCC ON FLY ASH CONTENT

FLY ASH CONTENT	UCS (kN/m^2)
0%	77.89
10%	96.65
20%	100.3
30%	92.9
40%	83.85

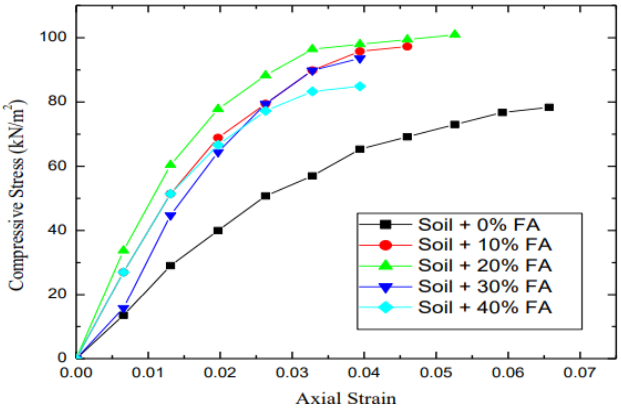

Fig. 1 Strain Curve for soil with different fly ash Content

The UCC value of marine soil increases with increase in fly ash content up to 20% fly ash content and then decreases.

2) Effect of polypropylene: The optimum content of fly ash was found as 20%. Take a sample of soil + 20% fly ash and add different percentages of polypropylene. Strength test was conducted and the optimum percentage of polypropylene was found.

TABLE 4. VARIATION OF UCC ON DIFFERENT POLYPROPYLENE CONTENT

PP FIBRE CONTENT	UCS (kN/m^2)
0%	100.3
0.25%	103.26
0.50%	130.08
0.75%	132.9
1.00%	119.12

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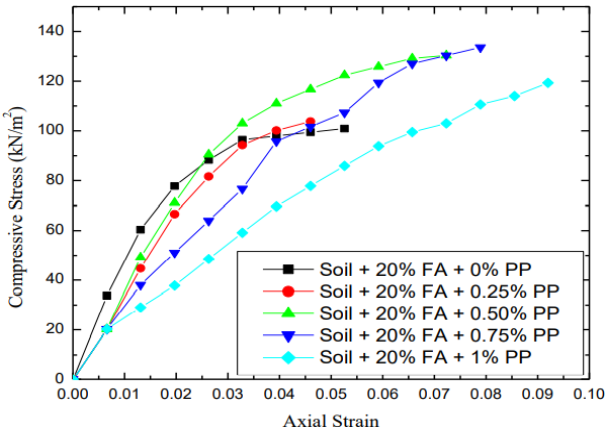

Fig. 2 Strain Curve for soil + 20% fly ash with differentpolypropylene content

B. *Dispersion test*

1) Dispersion Characteristics Based On Crumb Test:

The Crumb test gives a quick indication of the depressiveness of soil. The Crumb test was carried out as per ASTM standards. A sample of 15mm cubes was prepared. Sample compacted according to its maximum dry density and optimum moisture content. Visual observations are made at 2 minutes, 1 hour, and 6 hours.

Fig.3 Soil at 6hours

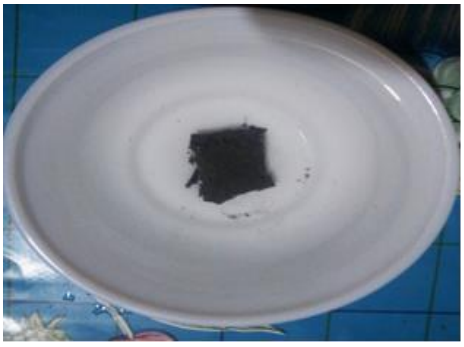

Fig. 4 Soil + 20% fly ash at 6hours

TABLE 5. DISPERSIVITY IF VARIOUS MIXES

Sample type	Time	Grade	Dispersivity
Soil	2 min	2	Intermediate
	1 hour	3	Dispersive
	6 hour	4	Highly dispersive
Soil + 20%fly ash	2min	1	Non dispersive
	1 hour	2	Intermediate
	6 hour	2	Intermediate

2) Dispersion Characteristics Based on doublehydrometer test:

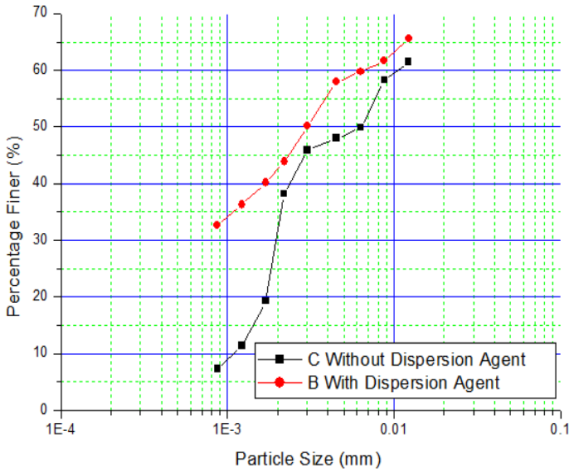

Fig. 5 Double hydrometer test result for soil

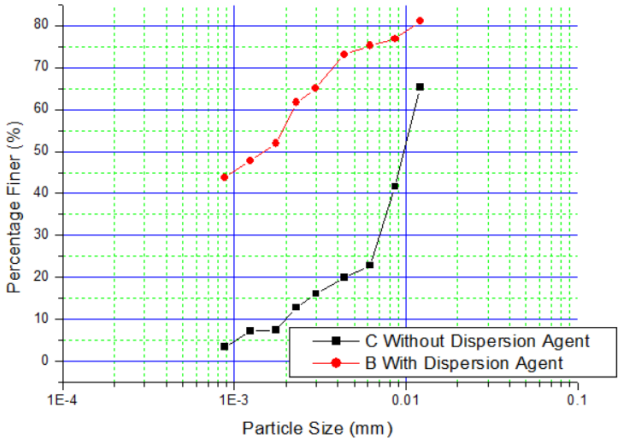

Fig. 6 Double hydrometer test result for soil + 20% fly ash

C. *Crack analysis*

Three moulds were taken in which one is filled with soil samples, the second is filled with soil + 20% fly ash and

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the last is filled with soil + 20% fly ash+ 0.75% polypropylene mix. Then the samples were kept at room temperature for 7 days. Pictures of crack formation in each sample were taken after these 7 days and analysis is done using ImageJ software.

TABLE 6. CRACK LENGTH, WIDTH AND CRACK INTENSITY FACTOR OF SOIL WITH VARIOUS PROPORTIONS OF FLY ASH ANDPOLYPROPYLENE

Sample	Crack length (mm)	Averagewidth (mm)	Crack intensity factor (%)
Soil	389	0.978	4.84
Soil + 20%fly ash	305	0.861	3.34
Soil + 20%fly ash + 0.75% polypropylene	89.384	0.588	0.67

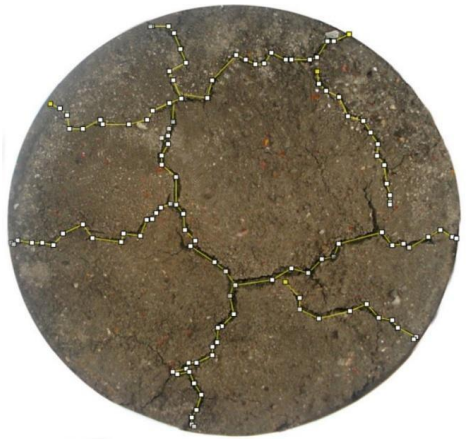

Fig. 7 Crack of normal soil

Fig. 8 Crack of soil + 20% fly ash

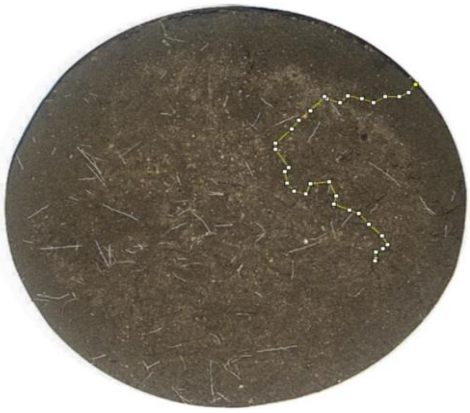

Fig. 9 Crack of soil + 20% fly ash + 0.75% polypropylene

Crack length and width get reduced by adding 20%fly ash and 0.75% polypropylene.

V. CONCLUSION

The strength, dispersion, and cracking characteristics of soil amended with fly ash and polypropylene fiber were studied. The major conclusions drawn from the present study may be summarized as follows.

- The optimum percentage of Fly ash was found to be 20% and that of polypropylene fibers to be 0.75%, based on strength characteristics.
- The addition of fly ash causes a significant decrease in the dispersion and increase in strength characteristics.
- Dispersivity of soil is greatly reduced by the addition of fly ash.
- Crumb test results show that the dispersion of soil can be reduced by the addition of fly ash.
- Crack when tested by ImageJ software, soil + 20% fly ash + 0.75% polypropylene showed reduced crack width.

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