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A Study on Performance of Locally Available Marine Clay as Landfill Liner

Abishek Kumar A.A
Assistant Professor
Civil Engineering Department
Adi Shankara Institute of engineering & Technology
Kalady, Ernakulam, Kerala, India

Haritha R Nair
B.Tech Student,
Civil Engineering Department
Adi Shankara Institute of engineering & Technology
Kalady, Ernakulam, Kerala, India

Megha Mohanan
B.Tech Student,
Civil Engineering Department
Adi Shankara Institute of engineering & Technology
Kalady, Ernakulam, Kerala, India

Revathy Daskuttan
B.Tech Student,
Civil Engineering Department
Adi Shankara Institute of engineering & Technology
Kalady, Ernakulam, Kerala, India

Rosmin K Jose
B.Tech Student,
Civil Engineering Department
Adi Shankara Institute of engineering & Technology
Kalady, Ernakulam, Kerala, India

***Abstract*— A large amount of Municipal Solid Waste is produced due to rapid urbanization and industrialisation. There for there is an urgent necessity of improve planning and implementation of comprehensive MSW management. Landfilling is the efficient and economical method of solid waste management. The main components of engineered landfills are Liner system at the base and sides of the landfill. Which prevent migration of leachate or gas to the surrounding soil. Usually the liner system is made of locally available clayey soil. Natural clay is often fractured and cracked. Hence it is necessary to improve it's properties. Thus we conduct study to analyse the performance of marine clay treated with fly ash and GGBS. The infuence of fly ash and GGBS on the permeability, strength and dispersion characterstics were analysed and a best proportion for fly ash and GGBS is selected.**

Keywords—Municipal solid waste; Leachate; Permeability.

I. INTRODUCTION

One of the major problems facing urban communities is the efficient and long term disposal of Municipal Solid Waste (MSW). Consequences of interaction of waste with the ecosystem include health hazards such as viral, bacterial, and protozoan infections, infectious diarrhea, salmonellosis and shigellosis. Fat and oil components of waste may produce polycyclic aromatic hydrocarbons these may be washed into the soil by rain thereby contaminating the surface and groundwater source. The interactions of humic acids with soils may weaken their strength and suitability as engineering construction materials. Waste management methods such as burning, recycling, reuse, reduction, incineration, composting etc. have been practiced to curtail menace of waste generation. Despite advancements in these modern technologies to increase employment of energy and materials recovery, effective method for the safe disposal of municipal solid waste is an environmental challenge.

Landfills the more attractive method of disposal of MSW due to it's less investment, if a suitable disposal area can be found. The basic philosophy of this method is that the waste which will not become stable with time will be treated as "Stored" and not "Disposed". Waste containment can be effected through engineered design in which a basal lining system and a cover system isolate the waste dump from the hydrological cycle. Leachate collection system and gas collection system collects the products of reactions inside a waste dump. A waste containment facility so designed and constructed is termed as an "Engineered Landfill". At high temperatures complex biochemical reactions takes place with waste decomposition that may lead to increased pH releasing products of decomposition in both liquid and gaseous form. Landfill gas consists of Methane, Carbon Dioxide with presence of Hydrogen. It's travelling through the ground should be control within a landfill site using interceptor and collector drains. The leachate needs to be contained and collected to prevent pollution of the ground and groundwater. To avoid this suitable liner system has to be provided so that these liners can prevent the percolation of the leachate to the surrounding soil.

A landfill liner is a low permeable barrier, which is laid down under engineered landfill sites. Until it deteriorates, the liner retards migration of leachate, and its toxic constituents, into underlying aquifers or nearby rivers, causing spoliation of the local water. Generally the linear consists of a layer of compacted clay with a minimum required thickness and a maximum allowable hydraulic conductivity, overlaid by a high density polythelene geomembrane. Geotextile, Geosynthetic clay linear and Geonet are also in use.

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In this study, soil from Vyttilla is used. Here the study deals with the potential use of Marine clay as landfill liner. The marine clay is mixed with Fly ash and GGBSto improve its geotechnical characteristics and that character of the mix is checked to use as a landfill liner. Also the feasibility of the liner soil against the leachate water is checked and the effect of leachate on soil properties is studied. Also the dispersion characteristics of the liner soil are checked. The infuence of flyash and ggbs on the permeability, strength and dispersion characterstics were analysed and a best proportion for fly ash and GGBS is selected.

II. MATERIALS AND PROPERTIES

A. *Marine Clay*

Clay samples are collected from a construction site at Vyttilla, from a depth of 0.5m to 2m. Soil in this region is black coloured highly compressible soil with high organic content. The soil was dried and sieved. Marine soil found to be greenish or bluish in colour with fine stripes of organic matter.

TABLE I. PROPERTIES OF MARINE CLAY

Properties	Values
Specific gravity	2.19
Liquid lmit (%)	43
Maximum dry density	1.467 g/cc
Optimum moisture content	24%
Permeability (m/sec)	2.414 X 10^{-6}
Unconfined Compressive Strength (kN/m2)	38.753
Uniformity Co-efficient	7.38
Co-efficient of Curvature Free Swell Index	0.54 20%
Degree of Expensiveness	Low

B. *Fly Ash (FA)*

Fly ash used was collected from a Ready Mix Plant, Edayar. Fly ash is a waste produced from coal-fired power generating stations and is readily available inexpensive, compared with cement and lime and need to be safely disposed. In this study class F Fly ash is used.

TABLE 2. PROPERTIES OF FLYASH

Properties	Values
Specific gravity	2.26
Liquid limit (%)	26.5
Uniformity coefficient	2.78
Co-efficient of curvature	0.93

C. *GGBS*

Ground Granulated Blast Furnace Slag was collected from a Ready Mix Plant, Edayar. Blast furnace slag is produced as a by-product during the manufacture of iron in a blast furnace. Blast furnace slag has a glassy, disordered, crystalline structure, which is responsible for producing a cementing effect.

TABLE 3. PROPERTIES OF GGBS

Properties	Values
Specific gravity	2.88
Liquid limit (%)	49
Uniformity coefficient	1.45
Co-efficient of curvature	0.766

III. EXPERIMENTAL PROGRAM

A. *Preparation of Samples*

Samples are prepared by mixing Marine clay with fly ash and GGBS .Firstly Marine clay is mixed with the fly ash, where the fly ash content is 0%, 10%, 20%, &30% by the weight of the soil. Then Optimum fly ash content is fixed based on strength and permeability test results. After selecting Optimum fly ash content, 0-12.5%GGBS is added to the above Optimum fly ash mix and optimum GGBS percentage is found out using strength and permeability test values. Dispersion characterstics for the selected soil- FA – GGBS mix are tested.Tests are conducted for normal and synthetic leachate water prepared.

The sample preparations and conducting experiments are done according to ASTM and IS specifications

- Standard Proctor Tests
- Unconfined Compression Test
- Hydraulic conductivity Test
- Crumb Test
- Double Hydrometer Test

IV. RESULTS AND DISCUSSIONS

A. *Effect of Fly ash*

a) *Effect of Fly ash In Compaction Characteristics of Marine clay*

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TABLE 4. EFFECT OF FLY ASH IN COMPACTION CHARACTERISTICS OF MARINE

Flyash Content	OMC (%)	MDD (g/cc)
0	24	1.467
10	21	1.47
20	18	1.482
30	20	1.469

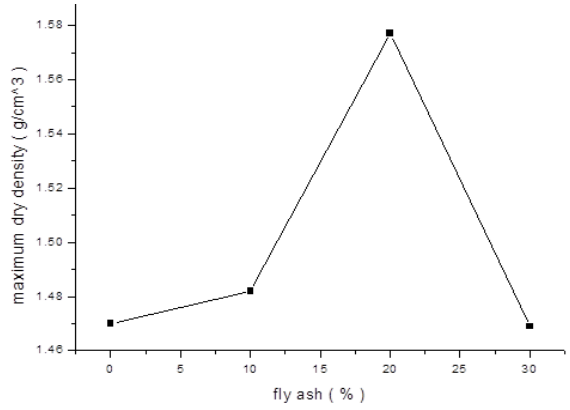

Fig.1 Variation of MDD on different Fly ash Content

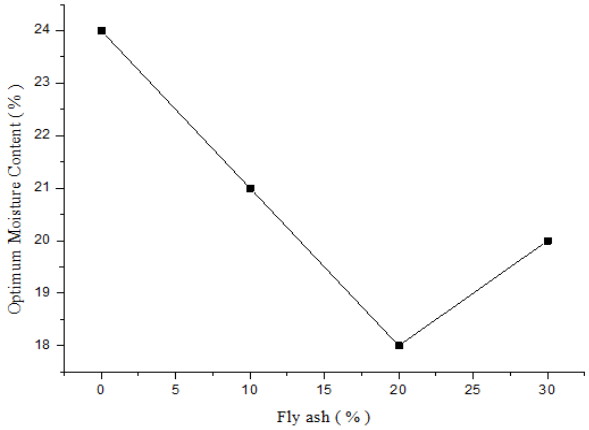

Fig.2 Variation of OMC on different Fly ash Content

Maximum Dry Density increases with increase in flyash content and Optimum Moisture Content reduces on addition of fly ash upto 20% FA content .

b) Effect of Flyash on the unconfined compressive strength of Marine Soil

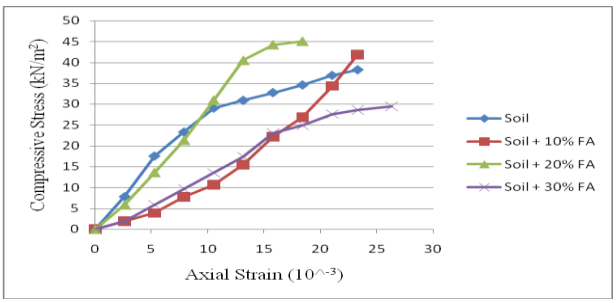

Fig.3 Stress Strain Curve for soil with different Fly ash Content

TABLE 5. VARIATION OF UCC ON DIFFERENT FLYASH CONTENT

Flyash Content (%)	UCC (kn/m^2)
0	38.153
10	41.88
20	45.087
30	29.508

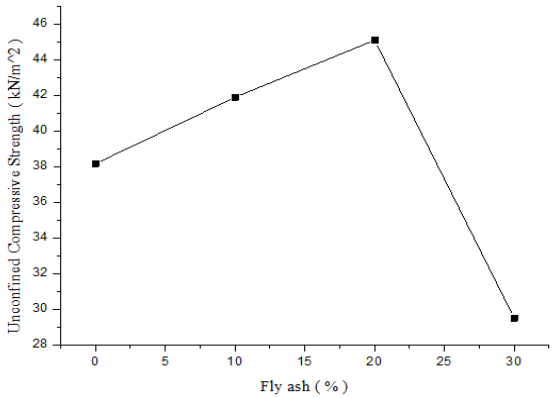

Fig.4 Variation Of UCC On Different Fly Ash Content

The unconfined compressive strength of marine soil increases with increase in flyash content up to 20% FA content and then decreases.

c) Effect of flyash on the hydraulic conductivity of marine soil

TABLE 6. EFFECT OF FLYASH ON THE HYDRAULIC CONDUCTIVITY OF COCHIN MARINE SOIL

Flyash content	K value (m/sec)
0	2.414*10^-6
10	1.057*10^-7
20	5.141*10^-8
30	4.925*10^-7

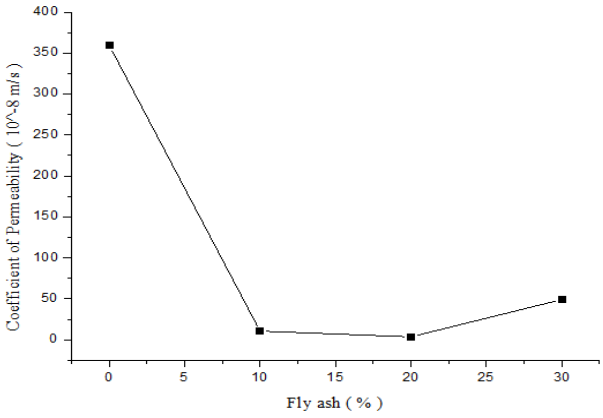

Fig.5 Effect of flyash on the hydraulic conductivity of marine clay

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Fly ash content of 20 % is able to reduce K value to 5.141*10^-8m/sec, whereas for plain soil it is 2.414*10^-6m/sec.

B. Effect of GGBS

Optimum value of fly ash was found to be 20%. So samples of soil + 20% flyash is taken and different percentage of ggbs was added and samples are prepared. Then strength and permeability test was conducted and optimum percentage of GGBS is found out.

a) Effect of GGBS in Compaction Characteristics of marine soil + 20% FA mix

TABLE 7. VARIATION OF OMC AND MDD ON DIFFERENT GGBS CONTENT

GGBS CONTENT (%)	OMC (%)	MDD (g/cc)
0	18	1.577
2.5	21	1.575
5	23	1.551
7.5	27	1.508
10	29	1.502
12.5	24	1.504

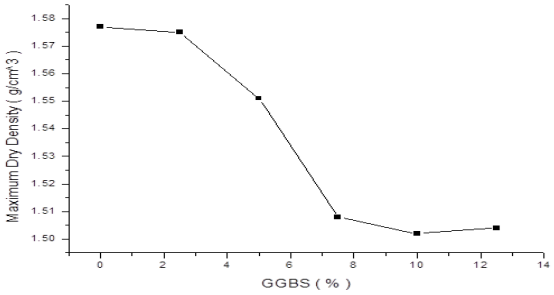

Fig.6 Variation of MDD on different GGBS Content

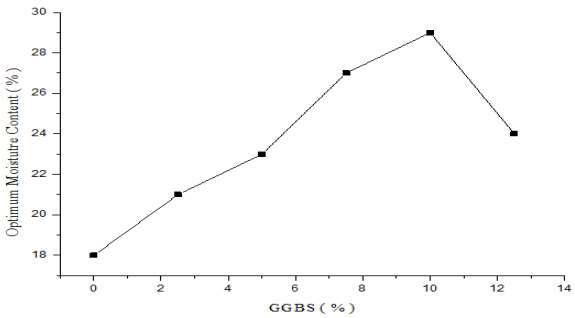

Fig.7 Variation of OMD on different GGBS Content

Soil amendment with GGBS also resulted in changes in both the optimum water content and the maximum dry density. It is marginal quite evident from inclusion of GGBS in the soil does not have any significant effect on the maximum dry density as well as on the optimum moisture content. Inclusion of GGBS in the clay reduce the maximum dry density and increase optimum moisture content.

b) Effect of GGBS on the unconfined compressive strength of marine soil

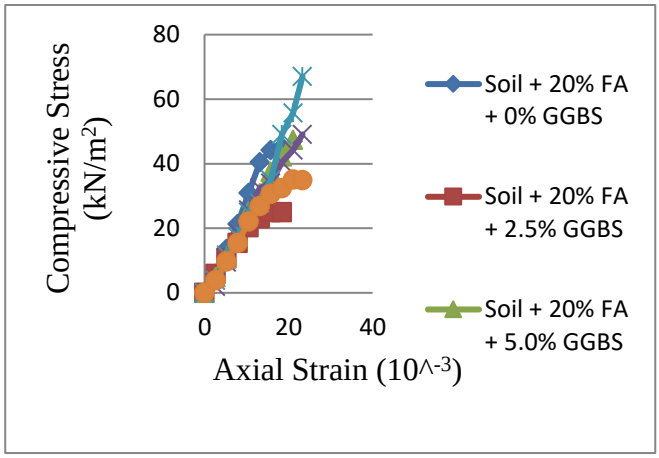

Fig.8 Stress Strain Curve for soil +20% FA with different GGBS Content

TABLE 8.VARIATION OF UCC ON DIFFERENT GGBS CONTENT

GGBS CONTENT (%)	UCC (kN/m²)
0	45.087
2.5	55.068
5	25.901
7.5	49.094
10	67.044
12.5	34.911

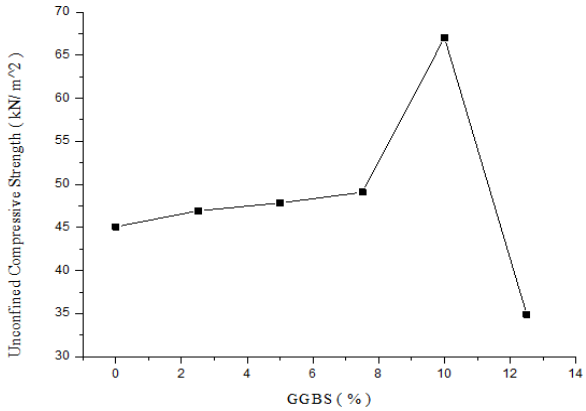

Fig.9Variation of UCS on different GGBS Content

GGBS content of 10% is able to give a strength of 67.044 kN/m2. From the figures, it can be observed that the unconfined compressive strength of Marine clay increases with increase in GGBS content. After reaching the peak stress, marine soil amended with 20% flyash and GGBSshows a sudden and drastic reduction in strength.

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c) Effect of GGBS inclusion on the hydraulic conductivity of marine soil + 20% Flyash

TABLE 9VARIATION OF K VALUE ON DIFFERENT GGBS CONTENT

GGBS CONTENT (%)	k VALUE (m/sec)
0	5.141*10^-8
2.5	3.967*10^-7
5	2.616*10^-7
7.5	7.642*10^-8
10	4.451*10^-8
12.5	9.651*10^-8

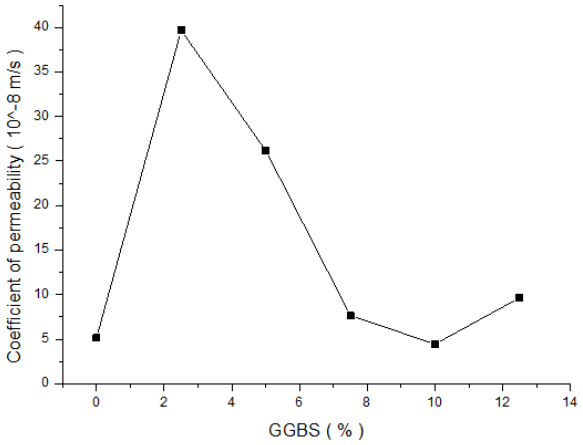

Fig.10 Variation of k value on different GGBS Content

K value of marine soil amended with 20% FA decreases with increase in GGBS content up to 10% and then increases.GGBS content of 10% is able to reduce the K value to 4.451*10^-8 m/sec.

C. Effects of Leachate Water on Properties of Liner

The landfill leachate is one kind of wastewater with high concentration of organic compounds, in-organic compounds and sometimes non-trivial level of toxic contaminants such as arsenic and chlorinated organic compounds.composition of the leachate generated depends on many factors namely type of waste, precipitation rates, temperature, food habits of general population etc.A synthetic Leachate with chemical composition as in table 10 is prepared and used.

TABLE 10: CHEMICAL COMPOUNDS USED IN SYNTHETIC LEACHATE

Chemical Compounds	Unit	Quantity Used
Copper Nitrate	mg/l	231
Ferric Chloride	mg/l	66864
Ammonia	mg/l	2100
Acetic Acid	Ml	49
Calcium Chloride	mg/l	20174
Magnesium Sulphate	mg/l	1092
Sodium Chloride	mg/l	10080

a) *Effect of Leachate Water on the Unconfined Compressive Strength of Soil.*

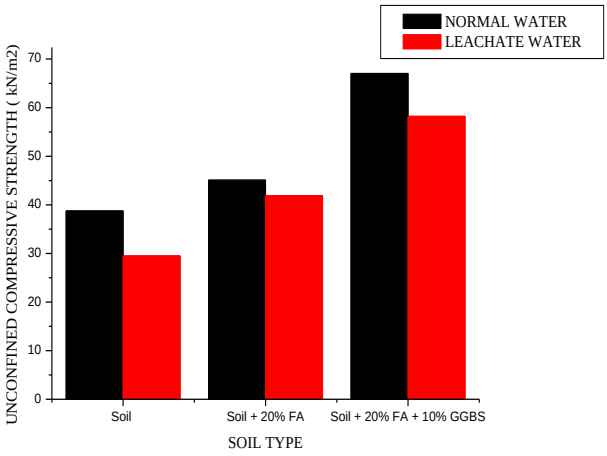

Fig..11 Effect of Leachate Water on the Unconfined Compressive Strength of Soil

b) Effect of Leachate Water on the hydraulic conductivity of Soil

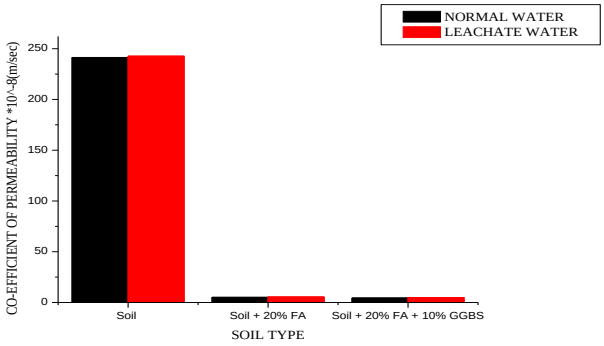

Fig..12 Effect of Leachate Water on the hydraulic conductivity of Soil

D. Dispersion Test

a) Dispersion Characteristics Based On Double Hydrometer Test

The Double hydrometer test was carried out as per ASTM standards. Test was carried out for soil,soil+20%FA and soil+20%FA+10%GGBS.

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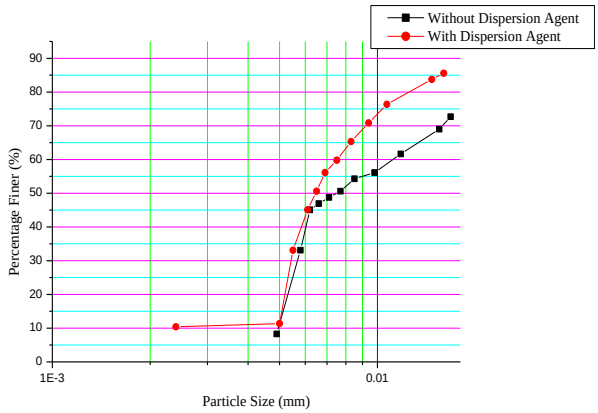

Fig..13 Double Hydrometer Test Results for Soil

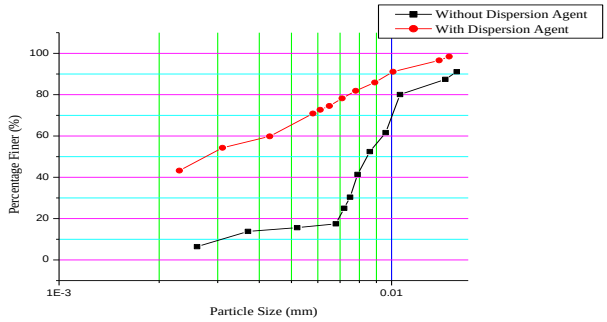

Fig..14 Double Hydrometer Test Results for Soil- 20% FA mix

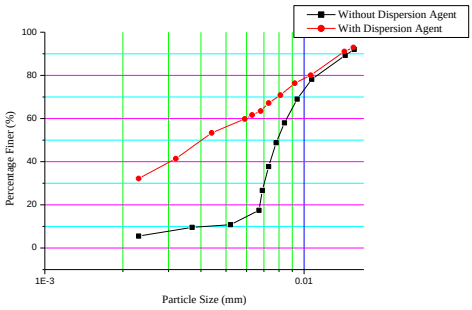

Fig..15Double Hydrometer Test Results for Soil- 20% FA + GGBS 10%

TABLE .11VARIATION IN DISPERSIVITY OF VARIOUS MIXES

Mix	Dispersivity (%)	Classification
Soil	75.4	Dispersive
Soil + 20% FA	23.7	Non Dispersive
Soil + 20% FA + 10% GGBS	19.3	Non Dispersive

b) Dispersion Characteristics Based On Crumb Test

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

TABLE .11VARIATION IN DISPERSIVITY OF VARIOUS MIXES

Sample Type	Time	Grade	Dispersivity
Soil	2min	2	Intermediate
	1hr	3	Dispersive
	6hr	3	Dispersive
Soil + 20% FA	2min	1	Non Dispersive
	1hr	2	Intermediate
	6hr	2	Intermediate
Soil + 20% FA + 10% GGBS	2min	1	Non Dispersive
	1hr	1	Non Dispersive
	6hr	1	Non Dispersive

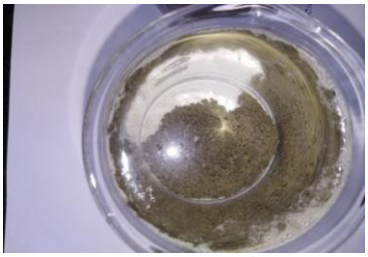

Fig.16Visual observations of Soil at 6hrs

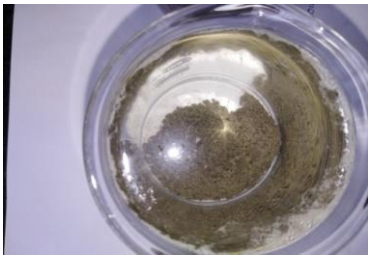

Fig..17Visual observations of Soil + 20% FA at 6hrs

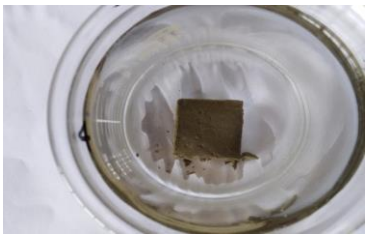

Fig..18Visual observations of Soil + 20% FA +10% GGBS at 6hrs

The addition of 20% flyash and 10%GGBS reduce dispersivity of soil and it is changed to non dispesive nature.

V. CONCLUSIONS

The strength, permeability, compaction and dispersion characteristics of soil amended with fly ash and GGBS was studied. The major conclusions drawn from the present study may be summarized as follows.

- The optimum percentage of Flyash was found to be 20% and that of GGBS to be 10%, based on strength and permeability characteristics.
- The addition of fly ash and GGBS cause significant decrease in the dispersion and permeability and increase in strength characteristics.
- Leachate water reduced the strength and increases the permeability characters of the soil.

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- Dispersivity of soil greatly reduced by the addition of flyash. Further it was reduced with the addition of GGBS.
- Crumb test result show that the dispersion of soil can be reduced by the addition of fly ash and GGBS.

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