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A Study on Bagasse Ash Incorporated Site Soil as a Liner Material

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***Abstract*: Due to the increase in industrialization and population, large quantities of waste are generated in different forms. The wastes produced are of mainly solid type wastes such as mining waste, municipal waste, construction and demolition waste, sewage sludge waste, hazardous waste, coal ash, agricultural waste etc. When these types of wastes are dumped on the ground, it causes several environmental problems. Solid waste disposal facility is designed on the concept of contained waste by isolating them from the environment by providing an impermeable liner at the base and at the sides of the waste called a landfill. Soil liners are commonly used in the base of waste containment facilities and it has been used for many years. A low hydraulic conductivity is a key parameter in the design of liner to prevent the downward migration of contaminants into aquifers. The previous studies revealed that the soil liner should have a hydraulic conductivity lower than $1x10^{-9}$ m/s. Sugarcane bagasse ash is a by-product of sugar factories found after burning sugarcane bagasse which itself is found after the extraction of all economical sugar from sugarcane. The disposal of this material is already causing environmental problems around the sugar factories. This study deals with the potential use of sugarcane bagasse ash as an additive to improve the geotechnical properties of soil and thereby suitably using it as a liner material.**

***Keywords*: Bagasse ash, Compaction, Hydraulic conductivity, Liner material, Site soil, UCC.**

1. Introduction

Due to the increase in industrialization and population, large quantities of waste are generated in different forms. The wastes produced are of mainly solid type wastes such as mining waste, municipal waste, construction and demolition waste, sewage sludge waste, hazardous waste, coal ash, agricultural waste etc. When these types of wastes are dumped on the ground, it causes several environmental problems. Solid waste disposal facility is designed on the concept of contained waste by isolating them from the environment by providing an impermeable liner at the base and impermeable cover at the top of the waste is called a landfill.

The landfills are of various types such as engineered landfill, sanitary landfill and secured landfill. The engineered type of landfill is the environmentally acceptable disposal of waste on ground. Sanitary landfills are where non-hazardous waste is spread in layers, compacted and covered with earth at the end of each working day. Secure landfills are those where hazardous waste is disposed of by burial, in holes or trenches in ground lined with impervious plastic sheeting to prevent leakage or leaching of dangerous substances into soil and water supply.

Engineered containment systems are the modern landfills which have been designed to minimize the impact of solid waste on the environment and human health. The modern landfills are provided with a liner system for isolating the landfill contents from the environment and also for protecting the soil and ground water from pollution originating in the landfill. An important threat caused to the ground water posed by modern landfills is leachate. Leachate and landfill gases are the important constituents formed inside the landfill. Leachate is the liquid compound that formed as the reactions occurred inside the landfill. It varies widely in its composition regarding to the type of wastes that present in the landfill and age of the landfill. It mainly contains both suspended and dissolved material. Like leachate, the landfill gases are also formed due to chemical reactions produced by the wastes inside the landfill. The leachate may move from the landfill and contaminate the ground water and soil, which results in the risk to all living beings.

For retarding the entry of leachate liners are provided. The liners provided in the landfill are constructed to make as a barrier between the waste and environment. Also the movement of leachate to drain the leachate to the collection and treatment facilities. The important requirement for liner is the low hydraulic conductivity to remove the possibility of advective flow through liner. As per the environment protection agency (EPA) regulations, the hydraulic conductivity of liner should be below 1x 10-9 m/s. The hydraulic conductivity is depended upon the materials present in the liner. Along with the hydraulic conductivity, compaction density, volume change, compressibility etc. are some of the other important factors depend upon the effectiveness of the liner.

Osinubi et al., (1998) has done laboratory tests on a residual lateritic soil treated with quick lime about 8% in dry soil to evaluate the effect of lime content, curing period and compactive effort in the permeability of lateritic soil-lime mixtures at various maximum dry densities and optimum moisture contents corresponding to it. Permeability of specimens increased with 4% lime content to its maximum amount and decreased after 4%

A. Liner Specifications

As per Boyton and Daniel the specification suitable for liner construction are as follows:

Table 1
Liner Specification

Liner specification	
Percentage of fines	≥ 20 -30%
Percentage of gravel	≤ 30%
Plasticity Index	≥ 7 – 10%
Coefficient of permeability	< 1 x 10^{-7}cm/s

2. Objectives

The main objectives of the study include:

- Suitability of Bagasse Ash treated Site soil as a liner material.
- To determine engineering properties of bagasse ash added site soil by varying its percentage.
- To determine suitable amount of Bagasse ash added in the soil to perform as a good liner.
- Effectiveness of treated soil against the transport of leachate.

3. Methodology

A. Materials used

1) Site soil

The site soil used in this investigation was collected from Kunnuvila, Neyyattinkara, Thiruvananthapuram. Various laboratory tests were done on the soil to determine the properties of the soil considered. The soil is classified as CI as per Indian standards. The physical and compaction properties of soil are summarised in Table 2.

Table 2
Geotechnical properties of Site soil 1

S.No.	Property	Values
1	Specific gravity, G	2.62
2	Permeability, k (cm/s)	16.7 x 10^{-7}
3	Liquid limit (%)	39
4	Plastic limit (%)	29.67
5	Plasticity index (%)	9.33
6	U C C Strength(kN/m^2)	65.74
7	Optimum moisture content (%)	24
8	Maximum dry density (g/cc)	1.69
9	Percentage of clay (%)	57
10	Percentage of silt (%)	24
11	Percentage of sand (%)	19
12	IS Classification	CI

2) Bagasse ash

Sugarcane bagasse ash is a by-product of sugar factories found after burning sugarcane bagasse which itself is found after the extraction of all economical sugar from sugarcane. The disposal of this material is already causing environmental problems around the sugar factories. This study examined the potential use of sugarcane bagasse ash as an additive for reducing the permeability of the soil, by providing it proper binding properties. Bagasse ash was added in the soil as 0%, 2%, 4%,6% and 8%. So, as to obtain the required properties to the soil.

4. Results and Discussions

A. Compaction Characteristics

It is necessary to find the optimum dosage of Bagasse ash for the Site soil to be improved. For this, compaction test was conducted with various dosages of Bagasse ash such as 2%, 4%, 6% and 8%. Figure 1 shows the compaction curve for different dosages. In general, the compaction characteristics are affected by soil type and composition of soil particles.

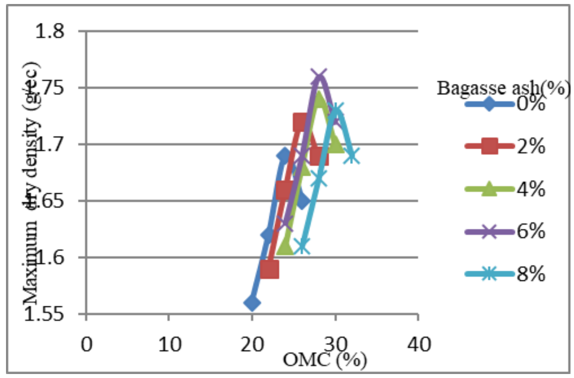

Fig. 1. Compaction curve for different dosage of bagasse ash

From the test results, optimum dosage of bagasse ash in Site soil was obtained as 6%. The variation of maximum dry density (MDD) and OMC with increase in bagasse ash dosage is illustrated in Table 3.

Table 3
Variation of OMC and MDD with respect to dosage of Bagasse ash

Percentage of Bagasse Ash	OMC (%)	Maximum Dry Density(g/cc)
0%	24	1.68
2%	26	1.72
4%	28	1.74
6%	28	1.76
8%	30	1.73

B. Unconfined compressive strength

For conducting unconfined compression test samples are prepared in optimum moisture content. Sample is filled in the mould at required maximum dry density and sample is taken out from the mould without any distortion at varying percentage of Bagasse ash corresponding to MDD values. Then the sample is tested in unconfined compressive strength apparatus.

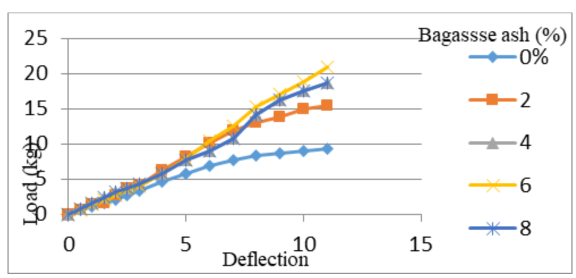

Fig. 2. Variation in UCC strength of the soil

Table 4
Variation in Unconfined Compressive Strength with Bagasse Ash addition

Percentage of Bagasse Ash	U C C Strength(kg/cm^2)
0%	9.0742
2%	15.054
4%	18.042
6%	20.567
8%	18.345

C. Hydraulic Conductivity

The hydraulic conductivity of soil mix was determined using 1-D consolidation apparatus. The soil is added with varying percentage of bagasse ash and is tested to determine the hydraulic conductivity of soil considered. The so obtained values are tabulated in Table 4.

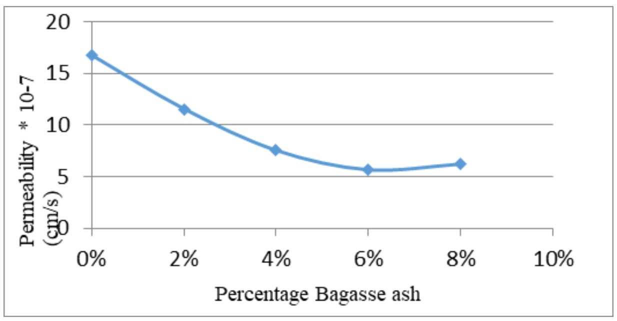

Fig. 3. Hydraulic conductivity of soil treated with Bagasse ash

Table 5
Variation in hydraulic conductivity with varying Bagasse ash percentage

Percentage of Bagasse Ash	Permeability (cm/s)
0%	16.7 x 10^{-7}
2%	11.54 x 10^{-7}
4%	7.54 x 10^{-7}
6%	5.67 x 10^{-7}
8%	6.22 x 10^{-7}

5. Conclusion

Following are the conclusions obtained from the study:

- Maximum dry density and U C C Strength were found to increase with increase in addition of bagasse ash.
- Permeability was found to decrease with increase in addition of bagasse ash.
- Liner has to carry the super imposed loads due to overlying loads. As U C C Strength increases, efficiency of liner also increases.
- Permeability of soil decreased and it indicates that it can prevent leaching out of contaminants and can further prevent contamination of ground water.

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