International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 06, June-2019

Effect of Bagasse Ash on Strength Characteristics and Index Properties of Kaolinite Clay

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Abstract— **Soil stabilization is the process of improving the soil by adding different types of additives. Soil stabilization may be achieved by mechanically mixing the natural soil and stabilizing material together into a homogenous mixture or by adding stabilizing material to an undisturbed soil deposit and obtaining interaction by letting it permeate through soil voids. Commonly used stabilizers are lime, cement, fly ash, bitumen, gypsum and so on. In this paper bagasse ash, an agricultural waste is used as a stabilizer for improving the strength and index properties of kaolinite clay. Bagasse ash is a locally available agricultural waste which possesses disposal problems. The improvement in strength and index properties of kaolinite clay mixed with bagasse ash is studied by conducting Standard Proctor test, California bearing Ratio test and Atterberg Limits test. Percentages of bagasse ash used are 1.5%, 3%, 4.5% and 6%.**

Keywords— Kaolinite clay; bagasse ash; california bearing ratio; attergerg's limits

I. INTRODUCTION

Soil stabilization is the alteration of the soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. Soil stabilization can be utilized on roadways, parking areas, site development projects, airports and many other situations where sub-grades are not suitable for construction. Stabilization can be used to treat a wide range of sub-grade materials, varying from expansive clays to granular materials. Sugarcane bagasse ash is a byproduct of sugar factories after burning sugarcane bagasse itself after the extraction of all economical sugarcane. Bagasse is generally used as a fuel to fire furnaces in the same sugar mill that yields about 8-10% ashes containing high amount of unburnt matter, silicon, aluminium, iron and calcium oxides. The ash therefore becomes industrial waste and poses disposal problems.

In this study, bagasse ash is used as a stabilizer for the stabilization of the kaolinite clay and the optimum percentage of bagasse ash for index properties and CBR value is determined.

A. Literature Review

Soil stabilization is the process of improving the engineering properties of soil and to make it perform the indended use. Several materials have been used as stabilizers including lime, fly ash, rice husk ash etc.

II. MATERIALS

A. Kaolinite Soil

Kaolinite is a clay mineral with a soft consistency and earthly texture. It is easily broken and can be molded and shaped, especially when wet. The soil for this study was collected from English India Company Limited, Kochuveli of Thiruvananthapuram district which belongs to kaolinite category.

B. Sugarcane bagasse ash

Bagasse ash is a fibrous material obtained from sugar cane plant after the extraction of sugar cane juice. Sugar factory waste bagasse is used as bio fuel and in manufacturing of paper. Sugar industry produces 30% bagasse for each of crushed sugar cane, when this bagasse is burnt the resultant ash is known as bagasse ash. Bagasse shows the presence of amorphous silica, which is an indication of pozzolonic properties, responsible in holding the soil grains together for better shear strength. The chemical properties of bagasse ash are shown in Table 1.

Table 1. Chemical properties of bagasse ash

Sl. No	Component	% by mass
1.	Silica (SiO_2)	70.87
2.	Aluminium oxide (Al_2O_3)	6.86
3.	Iron oxide (Fe_2O_3)	4.87
4.	Calcium oxide(CaO)	3.41
5.	Magnesia (MgO)	3.25

III. EXPERIMENTAL PROGRAMME AND RESULTS

All engineering properties of the soil sample were determined. The soil was classified as clay of high compressibility (CH). The main aim of this study is to determine the effect of bagasse ash on strength characteristics and index properties of kaolinite soil. Various geotechnical properties of the kaolinite soil were determined as per Indian Standards (IS 2720) and are shown in Table 2.

Table 2. Properties of kaolinite clay

Sl. No	Properties	Values
1.	% Clay	67%
2.	% Silt	34%
3.	Liquid Limit	72%
4.	Plastic Limit	25%
5.	Plasticity index	47%
6.	Shrinkage Limit	18%
7.	OMC	34%
8.	MDD	1.4g/cc
9.	UCS	103kN/m^2
10.	CBR	3.8%
11.	Specific gravity	2.58

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A. Standard proctor test

As the proportion of bagasse ash increased, the maximum dry density decreased whereas optimum moisture content increased. The compaction curve of kaolinite clay treated with different percentage of bagasse ash is shown in Fig. 1.

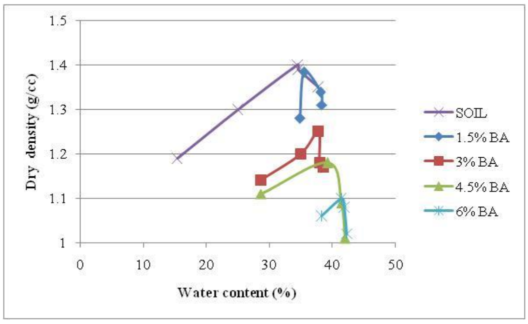

Fig. 1 Compaction curve for kaolinite clay treated with different percentage of bagasse ash

B. California bearing ratio test

The percentages of bagasse ash selected were mixed with the kaolinite clay to conduct unsoaked CBR test to determine the optimum content of bagasse ash. CBR value first increases and then decreases as the percentage of bagasse ash increases. The optimum percentage of CBR value was obtained at 3%. The Load-penetration curve is plotted in Fig.2. CBR value of kaolinite clay treated with various percentage of bagasse ash is shown in Table 3.

Table 3. Percentages of bagasse ash and CBR value

% BA	CBR (%)
0	3.80
1.5	4.20
3	5.85
4.5	4.58
6	4.11

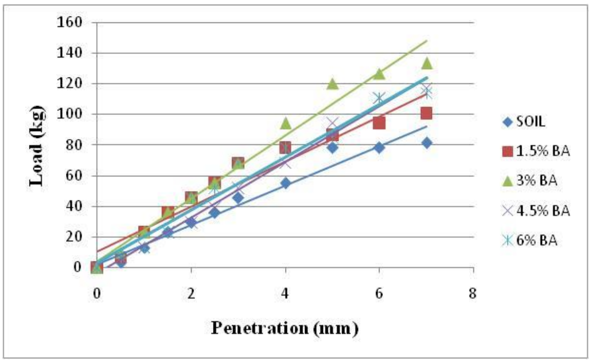

Fig. 2 Load-penetration curve of kaolinite clay treated with different % of BA

C. Liquid Limit test

The bagasse ash in different percentages was mixed with kaolinite clay to determine the liquid limit using cone penetration test. The cone penetration – water content curve is shown in Fig.3. The liquid limit decreases with increase in percentage of bagasse ash.

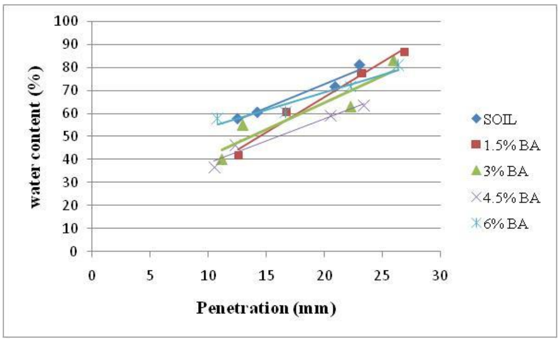

Fig. 3 Water content-cone penetration graph for kaolinite clay treated with different % of BA

D. Plastic Limit test

Different percentages of bagasse ash were mixed with kaolinite clay in order to determine the plastic limit. Plastic limit increases with increase in percentage of bagasse ash. The variation of plastic limit for different soil-ash mix is shown in Fig.4.

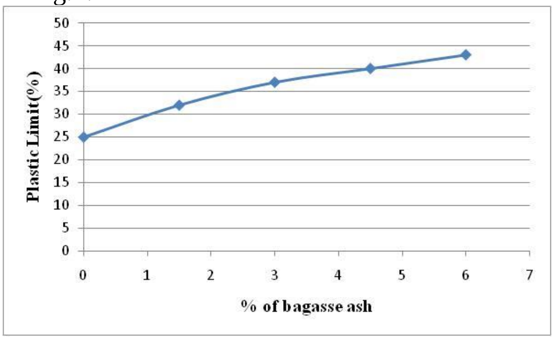

Fig. 4 Variation of PL for different % of BA

The variation of plasticity index with increase in percentage of bagasse ash is shown in Fig.5. Plasticity index decreases with increase in percentage of baasse ash.

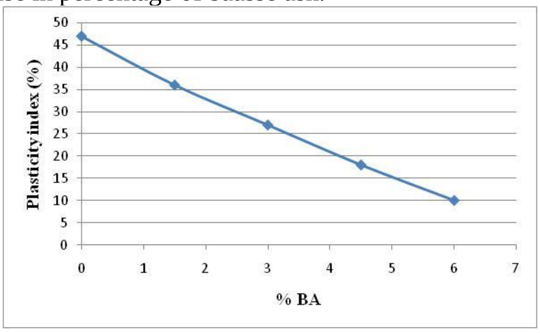

Fig.5 Variation of PI for different % of BA

Liquid limit, plastic limit and plasticity index of kaolinite clay treated with various percentages of bagasse ash is shown in Table 4.

Table 4. LL, PL and PI for different % of BA

% BA	LL	PL	PI
0	47	25	72
1.5	36	32	68
3	27	37	64
4.5	18	40	58
6	10	43	53

IV. CONCLUSIONS

- With the addition of bagasse ash LL decreases, PL increases and therefore PI decreases.
- Liquid limit decreases by 26%, plastic limit increases by 72% and plasticity decreases by 79%.
- With the addition of bagasse ash, optimum moisture content increases whereas maximum dry density decreases.
- The CBR value increases with increase in bagasse ash.
- The optimum percentage of bagasse ash is obtained as 3% and the CBR value at optimum percentage is 5.85%.
- There is an increase of 54% CBR value for kaolinite clay when treated with bagasse ash.
- Bagasse ash can be effectively used for improvement of clayey soil.
- Since bagasse ash is an agricultural waste, usage of this also reduces its disposal problem.

ACKNOWLEDGMENT

The author wishes to express an acknowledgement to Assistant Professor Sini T for valuable guidance and support. The author also wishes to acknowledge technical and economical support from Civil Engineering Department, College of Engineering Trivandrum.

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