Journal of Engineering Science 06(1&2), 2015, 81-85

JES
an international Journal

IMPROVEMENT OF CLAY SOIL CHARACTERISTICS BY USING FLY ASH, BAMBOO LEAF ASH AND RICE HUSK ASH

M. R. Karim, M. H. Hasan and M. A. Alim*

Department of Civil Engineering, Rajshahi University of Engineering & Technology, Bangladesh

Received: 28 July 2015 Accepted: 27 December 2015

ABSTRACT

Some waste materials such Fly Ash, Rice husk ash, Bamboo Leaf ash may use to make the soil stable. The objective of this study was to evaluate the effect of Fly Ash, Rice Husk ash and Bamboo Leaf ash derived from combustion of sub-bituminous coal at electric power plant, burning of rice husk and bamboo leaf in improving of clay soils. Tests were conducted on untreated soils and treated soils with Fly Ash, Rice Husk ash and Bamboo Leaf ash. Addition of 15% Fly ash, Bamboo leaf ash and Rice husk ash increased dry density, unconfined compressive strength and California bearing ratio while addition of 20% admixtures decreased the above properties. So it can be concluded that for 15% addition of admixtures (fly ash, bamboo leaf ash and rice husk ash) soil quality improved because the voids of the soil is replaced by the admixtures. But 20% addition of admixture with soil the excess amount of ash reduced the geotechnical properties of soil.

Keywords: *Clayey soil, improvement, rice husk ash, bamboo leaf ash, fly ash, CBR, strength.*

1. INTRODUCTION

Soil improvement could either be by modification or stabilization or both. Soil modification is the addition of a modifier (cement, lime, fly ash, blast furnace slag, rice husk ash, bamboo leaf ash, brick dust etc.) to a soil to change its index properties, while soil stabilization is the treatment of soils to enable their strength and durability to be improved such that they become suitable for construction beyond their original condition. Cement and lime are usually used for stabilizing soils. But the price of these materials is increasing day by day. The dependency on the utilization of industrially manufactured soil improving additives (cement, lime etc.) has kept the cost of construction of stabilized subgrade soil financially high. For these reason alternative soil modifiers become more important to reduce construction cost. Now a days disposal of different wastes produced from different industries is a great problem. Those materials pose environmental pollution in the nearby locality because many of them are non- biodegradable. In recent years, applications of industrial wastes have been considered with great interest in many industrialized and developing countries. There are various problems generally occur in clay soil, such as high compressibility, swelling and shrinkage. Footing resting on clay soil consolidation settlement occurs. Soft soils show major volume changes due to change in moisture content. This causes major damage to property constructed on it. These soils contain minerals such as montmorillonite that are capable of absorbing water. When they absorb water, their volume increases and in dry season volume decreases. Due to this shrinkage cracks may form. Although mechanical compaction, dewatering and earth reinforcement have been found to improve the strength of soil. Other methods like stabilization using admixtures are more advantageous. The different admixtures available are lime, cement, fly ash, blast furnace slag, rice husk ash, bamboo leaf ash, chemicals etc. At present cement stabilization is not preferable because of the increasing cost of cement and environmental concerns related to its production. Lime is not suitable for soils which contain sulphates. Presence of sulphate can increase the swelling behavior of soil due to the formation of swelling material. Various researches have been done on bamboo leaf ash and rice husk ash. Such as (Olugbenga O. Amu, 2010) carried out the characteristics of bamboo leaf ash on soil stabilization in highway construction. Koteswara *et al.* (2011) used rice husk ash, lime and gypsum as additives to the expansive soil which resulted in considerable improvement of soil parameters. On the other hand fly ash also shows the similar behavior of rice husk ash and bamboo leaf ash. The utilization of waste material is not only the proportioning solution of disposal problem, but also saves construction cost. The main objective of this paper is to investigate the potential of using waste materials in the field of geotechnical engineering.

2. MATERIAL USED

Clay type soil is used in this study. Soil was collected from Rashahi University of Engineering & Technology (RUET) campus near Vodra Moore, Rajshahi. Then fly ash, bamboo leaf ash and rice husk ash are collected different available locations.

The Bamboo leaf ash and Rice husk ash had been collected from Bagatipara in Natore. Bamboo leaf as was obtained by burning the dried Bamboo leaf and the Rice husk ash was obtained by burning the Rice husk as

* Corresponding author: maalim@ruet.ac.bd

shown in Figure 1(a-d). Fly ash has been collected from nearby thermal power station at Baropukuria in Dinajpur district. Fly ash had been collected from nearby thermal power station at Barapukuria in Dinajpur district. Fly ash was produced from brunt crush from the coal fed power plant. It is available in Barapukuria coal based power plant. Annually 52000 MT fly ash is produced. Its disposal caused environmental pollution.

Figure 1: Materials used: (a) Soil sample; (b) bamboo leaf ash; (c) rice husk ash; (d) fly ash

3. METHODOLOGY

Collected soil sample was kept in laboratory for three weeks to reach it air dried condition. After that the soil sample was oven dried and grinded. The soil samples were prepared by adding the Fly ash, Bamboo leaf ash and Rice husk ash for 5%, 10%, 15% and 20% (by weight). The collected oven dried sample was passed through 4.75mm sieve so that the homogeneous sample can be prepared. For the preparation of each specimen, all the materials were mixed thoroughly by trawl and pass the mixture by 20mm sieve. After mixing of different percentage of admixtures different laboratory tests are required. Such as Atterberg's limits test, standard proctor test, unconfined compression strength test and California bearing ratio test. These tests were performed to evaluate liquid limit, plastic limit, shrinkage limit, maximum dry density, optimum moisture content, unconfined compression strength and CBR.

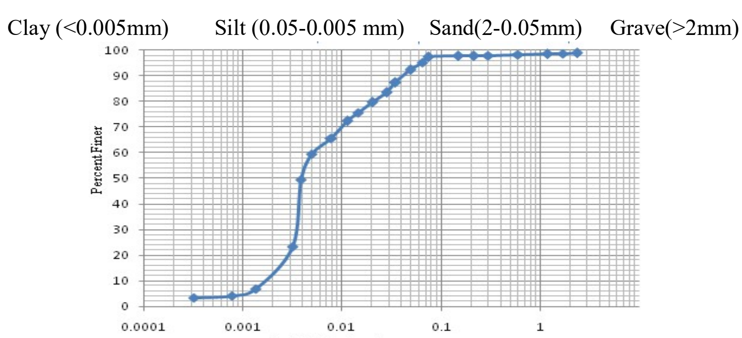

Figure 2: Grain size distribution of used soil

Table 1: Geotechnical properties of used soil

Index Property	Constituents	Index Property	Constituents
Liquid limit	42.80%	D_{60}	0.005 mm
Plastic limit	20.69%	Sand (%)	6.50
Specific gravity	2.66	Silt (%)	33.25
Optimum moisture content	19.43%	Clay (%)	60.25
Maximum dry density	1.671 gm/cm^3	Textural soil classification	Clay
Grain size distribution		Uniformity co-efficient	2.78
D_{10}	0.0019 mm	CBR value (%)	8.09
D_{30}	0.0035 mm		

4. RESULTS AND DISCUSSIONS

Effect on Atterberg's Limits

Liquid limit and plastic limit for original soil and treated soils with fly ash, bamboo leaf ash, rice husk ash at different percentages are shown in Figures 3 & 4. In general decrease in liquid limit of all treated soils with fly ash, bamboo leaf ash and rice husk ash due to admixture reaction which forms compounds possessing cementitious properties with soil particles. This trend conforms to findings of (Muntohar and Hantoro, 2000) who found that the liquid limit reduces with increasing lime and rice husk ash combinations. Plastic limits increase with the increase in percentages of fly ash, bamboo leaf ash and rice husk ash. For treated soils with different percentage of fly ash (FA), bamboo leaf ash (BLA) and rice husk ash (RHA), there is increase in plastic limit with increase in FA, BLA and RHA content. The results are agreed with (Muntohar and Hantoro, 2000) finding the plastic limit increases with increasing lime and rice husk ash content.

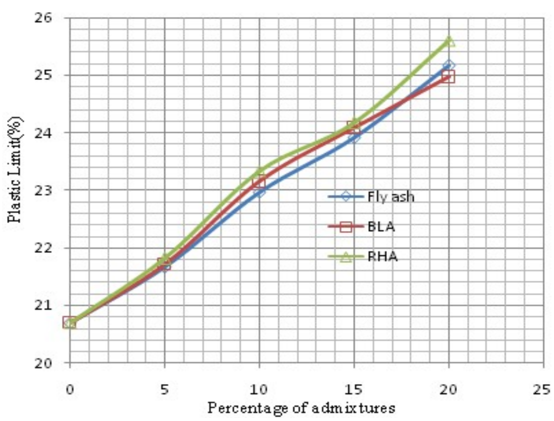

Figure 3: Variation of liquid limit with varying percentage of admixture

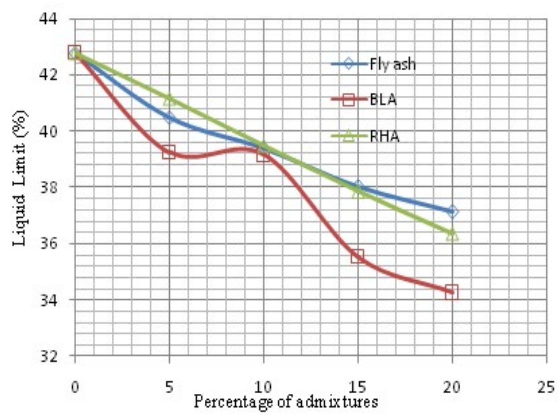

Figure 4: Variation of plastic limit with varying percentage of admixture

Effect on Compaction Characteristics

The variations of maximum dry density (MDD) and optimum moisture content (OMC) of treated soils with admixtures are shown in Figures 5 & 6. These figures indicate that the maximum dry density increases with increase in the FA, BLA and RHA content while the optimum moisture content decreases with increase in the FA, BLA and RHA content for adding up to 15% admixtures. On the other hand maximum dry density decreases and optimum moisture content increase for the addition of 20% of admixtures. The phenomenon is observed because of existing of excess fine particles (admixtures) in soil masses.

Effect on Unconfined Compressive Strength

The Unconfined Compressive Strength (UCS) values increase with subsequent addition of FA, BLA, and RHA to its maximum at 15% admixtures while it drops at 20% of admixtures as shown in Figure 7. The subsequent increase in the UCS is attributed to the formation of cementitious compounds between the $Ca(OH)_2$ present in the soil and RH and the pozzolans in the admixtures. This decrease in the UCS values after the addition of 20% admixtures may be due to the excess admixtures introduced to the soil and therefore forming weak bonds between the soil and the cementitious compounds formed. These results are compatible with the findings of Yadu *et al.* (2011) who studied stabilization of black cotton soil with fly ash and rice husk ash.

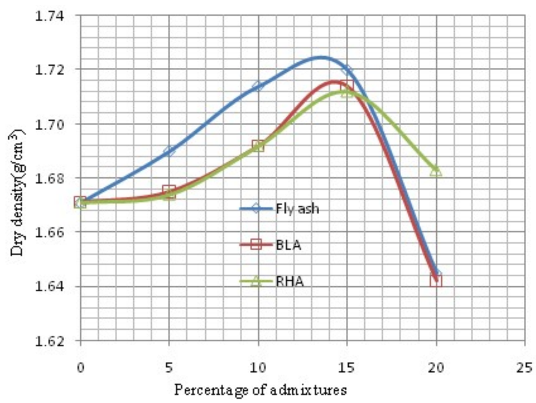

Figure 5: Variation of MDD with varying percentage of admixtures

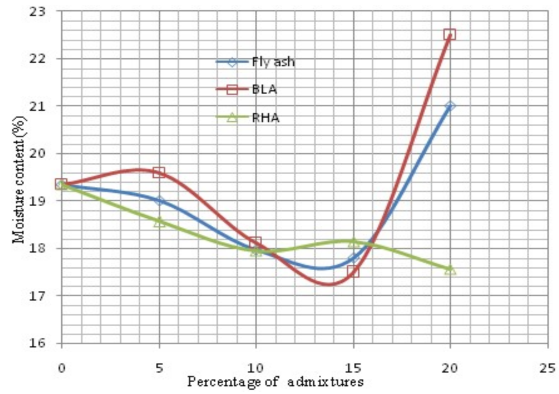

Figure 6: Variation of OMC with varying percentage of admixtures

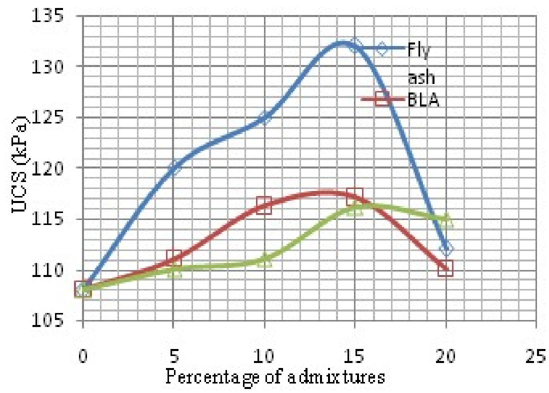

Figure 7: Variation of UCS with varying percentage of admixtures

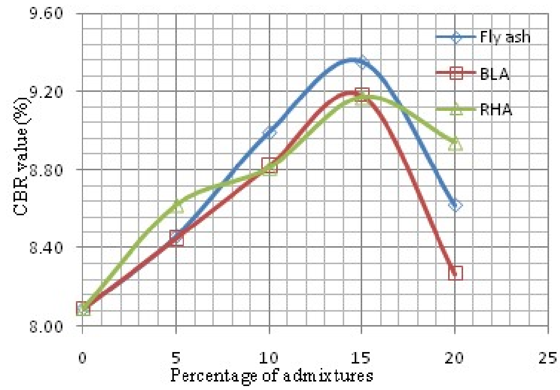

Figure 8: Variation of CBR with varying Percentage of admixtures

Effect on California Bearing Ratio (CBR)

Figure 8 shows that California bearing ratio (CBR) increases for the addition of fly ash, bamboo leaf ash and rice husk ash. CBR value increased due to addition of FA, BLA and RHA up to 15% admixtures. On the other hand CBR value decreased due to addition of FA, BLA and RHA up to 20% admixtures. This behavior is found because density increased for adding mixtures up to 15% and decreased for 20% (Figure 5).

Table 2: Comparative geotechnical properties of soil with 15% addition of admixture

15% Admixture	Liquid limit (%)	Plastic limit (%)	Maximum dry density(g/cm^3)	Optimum moisture content (%)	UCS (kPa)	CBR for 2.5mm penetration (%)
Fly ash	38.00	23.91	1.720	17.81	132	9.35
Bamboo leaf ash	35.51	24.08	1.714	17.51	117.1	9.18
Rice husk ash	37.85	24.58	1.712	18.15	116	9.17

5. CONCLUSIONS

The present study can serve as an effective method to utilize fly ash, bamboo leaf ash and rice husk ash in the stabilization of soil. The following conclusions could be drawn from the study:

i. The soil used in this study is clay which contains sand 6.55%, silt 33.25% and clay 60.2%. Other geotechnical properties are specific gravity 2.66, liquid limit 42.80%, plastic limit 20.69%, optimum moisture content 19.35%, maximum dry density 1.671 g/cm^3, unconfined compression strength 108 kPa and CBR value is 8.09%.

ii. It is found that by adding up to 20% admixtures (fly ash, bamboo leaf ash and rice husk ash) into the untreated soils, liquid limit decrease and plastic limit increases. Whereas maximum dry density, unconfined compression strength and CBR increase by adding upto15% admixtures, on the other hand decrease these parameters for further addition 20% of admixtures with untreated soil. It indicates that the untreated soil improved due to addition of 15% admixtures.

REFERENCES

Amu, O. O., and Babajide, S. S., 2011. Department of Civil Engineering, obafemiawolowouniversityile-ife, osun state, Nigeria.

Çokca, E., 2001. Use of class C fly ashes for the Stabilization – of an expansive soil, Journal of Geotechnical and Geoenvironmental Engineering, 127, 568-573.

Koteswara, R. D., Pranav, P. R. T., and Anusha, M., 2011. Stabilization of Expansive Soil with Rice Husk Ash, Lime and Gypsum – An Experimental Study, International Journal of Engineering Science and Technology, 3, 11, 8076 – 8085.

LaxmikantYadu, and Tripathi R. K., 2013. Stabilization of soft soil with granulated blast furnace slag and fly ash.

Musa Alhassan, 2007. Potentials of rice husk ash for soil stabilization.

Olugbenga O. Amu et al., 2010. Characteristics of bamboo leaf ash stabilization on lateritic soil in highway construction.

Braja M. Das, Principles of geotechnical engineering book, 4^{th} edition.

Robert M. B., 2009. Soil stabilization with fly ash and rice husk ash, Effects of bamboo leaf ash on lime stabilized lateritic soil for highway construction.

Sharma, A. K., and Sivapullaiah P.V., 2012. Improvement of Strength of Expansive Soil with Waste Granulated Blast Furnace Slag, Geo Congress.

Sharma A. K., and Shivapulliah P.V., 2011. Soil Stabilisation with Waste Materials Based Binder, Proceedings of Indian Geotechnical Conference December 15-17.

Punmia B. C., Soil mechanics and foundations book, 16^{th} edition.

Sridharan, A., Prashanth, J.P., and Sivapullaiah, P.V., 1997. Effect of fly ash on the unconfined strength of black cotton soil, Ground Improvement, 1, 169-175.

Yadu, L. K., Tripathi, R. K., and Singh, D. V., 2011. Laboratory Performance Evaluation of Stabilized Black Cotton Soil with Rice Husk Ash, Journal of Chhattisgarh Swami Vivekanand Technical University Bhilai, 4, 1, 50-55.