Scope International Journal of Science, Humanities, Management and Technology. ISSN : 2455-068X
Vol.5 Issue 1 (2019) 18 - 25. Submitted 04/02/2019. Published 27/02/2019

AN EXPERIMENTAL INVESTIGATION ON STABILIZATION OF BLACK-COTTON SOIL USING WOOD ASH

Varnika.P & Balasubramanian.N
Assistant Professor & Professor, Dhanalakshmi Srinivasan College of Engineering,Coimbatore.

Abstract— The stability of the structures to be built on the soil depends totally on the soil at which it rests. There are several types of soils that may pose a threat to the stability of structures built on them. Black cotton soil is one such problematic soil, widely spread across the world. They become very sticky when wet and usually characterized by surface cracks when dry. In order to adjust the geotechnical parameters of black cotton soil to meet the requirements of technical specifications in construction industry, studying of soil stabilization is more emphasized. Soil stabilization is the permanent physical and chemical alteration of soils to enhance their physical properties. Due to the growing cost of stabilizers, industrial and agricultural wastes can be used for stabilization. In this project, the behavior of black cotton soil is experimentally studied by using wood ash as stabilizing agent. Wood ash is a gray material and it is the residue powder left after the combustion of wood, such as burning wood in a home fireplace or an industrial power plant. Wood ash is added to black cotton soil in multiples of two percentages and various tests such as Differential free swell, Standard Proctor Compaction, Atterberg limits, Unconfined Compressive Strength and California Bearing Ratio(CBR) tests were conducted. The tests results showed maximum strength of soil samples when treated with 8% of wood ash. The result of investigation shall provide the basic successful implementation of wood ash for soil stabilization in practice. ***Key words:*** Black Cotton Soil, Wood Ash, Compaction, California Bearing Ratio.

I. INTRODUCTION

It is hard to overstate the importance of soil in construction of structures and other aspect of civil engineering practices. The foundation of a building or road is an essential part for effective transmission of load to the subsoil present beneath it. The quality of soil has large impact on type of structure and its design. Each type of soil possess unique characteristics and plays a vital role in each distinct. Black cotton soils are weak soils possessing low shear strength. Black cotton soils occurs mostly in the central and western parts and covers approximately 20% of the total area of India. They are popularly known as “Black cotton soils” because of their dark brown color and suitability for growing cotton. Black cotton soils are very hard in dry state and possess high bearing capacity. Black cotton soils become very sticky when wet and usually are characterized by surface cracks when dry. To overcome these circumstances in the soil, it should be treated and stabilized in best way. Stabilization in a broad sense incorporates the various methods employed for modifying the properties of a soil to improve its engineering performance. Properties of soil may be altered in many ways, among which are included chemical, thermal, mechanical and other means. Wood ash is a gray material and it is the residue powder left after the combustion of wood which can be

used for soil stabilization.

A. Objectives of Study:

- To evaluate the properties of black cotton soil before and after stabilization with wood ash.
- To strengthen a weak soil and restrict the volume change potential of a highly plastic black cotton soil.
- To evaluate the strength characteristics of the black cotton soil for different blends with ash with different percentage variations (2%,4%,6%,8% and 10%).
- To evaluate the optimum value of percentage addition of wood ash to black cotton soil.

II. LITERATURE REVIEW

Stabilization can increase the shear strength of a soil and control the shrink-swell properties of a soil, thus improving the load-bearing capacity of a sub-grade to support pavements and foundations. For the past several years researchers have recognized the use of locally available materials which are cost effective and abundantly available as by products from industrial and agricultural activities to improve the properties of expansive soil with an aim to reduce stabilization costs. Here are some of the research works done on stabilization of soil using wood ash as stabilizer.

Arash Barazesh et al (2012) had studied about the effect of wood ash on clay soils in Atterberg test. In this regard, various laboratory experiments were carried out on soil specimens and different proportions of wood ash admixtures to examine the effect of wood ash on plasticity and liquid limits as well as plasticity range in specimens. They found that addition of wood ash to clay soils helps to reduce liquid limit and plasticity index to a desirable value suitable for using the soil for construction of any structure. Supanic et al (2012) had analyzed about utilization of wood ash as a stabilizer in road construction. They performed preliminary laboratory tests with 6 different wood ash samples in order to evaluate the chemical and mechanical suitability of the ash samples as a binder in road construction. They inferred that wood ash feature a significant amount of free CaO, which is the relevant reacting component in the soil stabilization process. Gandhi (2014) had carried out an experimental study on expansive soil modified using bagasse ash and wood ash in Surat region. He inferred that on increasing wood-ash content, free swell index decreases steadily to a lowest value, then it decreases slightly and same at 40%,60% and 80% wood ash content respectively. Usha Rani and Martina Jenifer (2016) had analyzed the strength characteristics of black cotton soil using wood ash as a stabilizer. They found an increase in CBR value of about 40% was observed in 5% addition of wood ash and 65% was noted in 10% addition of wood ash. Similarly many researchers such as Amu et al (2008), Anders Lagervist and Bo Lind (2013), Ayininnola (2013), Tanmay Jain et al (2015), Gyaneshwar Singh Uchariya et al (2016) had investigated about addition of wood ash as a stabilizing agent. Wood ashes have soil binding properties similar to burnt lime. The binding properties depend on particle size as well as on content of calcium-oxide (CaO) present in the ash. Wood ash in general has pozzolanic property and it works on coagulation of loose soil. The results also show that addition of wood ash could decrease the swelling behavior of expansive soils.

III. MATERIALS USED

A. Black Cotton Soil:

Black soil is dark, as its name suggests, and fertile with a clay- like consistency. It holds moisture well, becoming hard in dry conditions and sticky in wet conditions. The soil is composed of less than 30 percent clay, slickensides or wedge-shaped peds and cracks that open and close periodically. The mineralogy of this soil is dominated by the presence of montmorillonite which is characterized by large volume change from wet to dry seasons and vice versa. In this experiment, soil sample is collected from Puliyur village located in Karur district. Black cotton soils are well suited to grow crops like cotton, turn and citrus fruits.

B. Wood Ash:

Wood ash is the waste by - product produced from the incineration of wood wastes, like bark and knots. It is used traditionally by gardeners as a good source of potash for domestic gardens. Hardwoods usually produce more ash than softwoods and the bark and leaves generally produce more ash than the inner woody parts of the tree. Clean pure wood ash can be beneficial as a soil amendment replacing lime and providing many trace elements. In this experiment, wood ash is collected from paper industry located in Karur district. The chemical composition of wood ash are shown in Table 1.

Constituent	Composition (%)
Silicon Dioxide	19.30
Aluminium Oxide	10.04
Calcium Oxide	35.63
Potassium Oxide	9.21
Magnesium Oxide	7.30
Ferric Oxide	2.52
Sodium Oxide	3.60
Loss On Ignition	12.40

Table1:Chemical composition of wood ash

IV. METHODOLGY

A. Experimental Investigation:

- After preparing the soil samples, basic tests such as Atterberg's limit, compaction, Unconfined Compressive Strength(UCS) and California Bearing Ratio(CBR), were carried out to determine the engineering properties of black cotton soil samples.
- Then wood ash was added to black cotton soil sample in multiples of two percentages (2%,4%,6%,8% and 10%).
- Each percentage of blended mix was taken and laboratory tests (compaction, CBR, UCC) were carried out to determine the strength behavior of the mix.
- After comparing the results on each percentage of blend, optimum percentage of addition of wood ash to be added was determined.
- The results are concluded suitably.

B. Sample Preparation:

Soil sample as received from the field is dried in the air or in sun. The clods are broken with a wooden-mallet to hasten drying. The organic matter, like tree roots and pieces of bark were removed from the sample. They the sample is kept in oven for drying at 110°C temperature for 24hrs. For the tests like liquid limit, plastic limit, light compaction the sample was air dried. Then wood ash was also kept in oven for maintaining the dry form

of the ash. Wood ash was taken according to percentage specified and mixed with soil in dry form itself.

V. RESULTS AND DISCUSSIONS

A. Geotechnical Properties of Soil Sample:

Black cotton soil (BCS) was taken and basic laboratory experiments were carried out. Soil sample was prepared as stated above. These data are necessary to analyze the results after addition of wood ash. Results are listed in Table 2.

Soil Properties	Test Results
Specific Gravity	2.57
Liquid Limit (%)	45.27
Plastic Limit (%)	28.3
Plasticity Index (%)	18.97
Free Swell Index (%)	46.2
Is Classification	Ch (High Plasticity)
Maximum Dry Density (Kg/M^3)	1.85
Optimum Moisture Content (%)	11.58
California Bearing Ratio	2
Unconfined Compressive Strength (Kn/M^2)	215.76

Table 2: Geotechnical properties of soil sample

A.Blending with Wood Ash:

Wood ash (WA) was added to black cotton soil in following percentages: 2%, 4% ,6% ,8% and 10%. Laboratory tests were done on blended soil mix and results are tabulated in Table 3.

Particulars Of Test	Bcs + 2% Wa	Bcs + 4% Wa	Bcs + 6% Wa	Bcs + 8% Wa	Bcs + 10 % Wa
Liquid Limit (%)	44.15	43.54	41.12	39.23	40.34
Plastic Limit (%)	24.1	23.4	21.7	20.2	21.4
Plasticity Index (%)	20.05	20.14	19.42	19.03	18.94

Maximum Dry Density (Kg/M^3)	1.86	1.872	1.88	1.89	1.892
Optimum Moisture Content (%)	12.31	13.27	13.56	11.23	10.18
Free Swell Index (%)	41.2	37.14	33.7	30.56	28.3
Cbr Value	2	3	5	7	5

Table 3: Test results

B. *Effect of Wood Ash on Atterberg Limits:*

Wood ash was added in multiples of two percentages to black cotton soil sample and tests such as Liquid limit and Plastic limit were carried out as per IS 2720 (Part - 5) : 1985. Results are presented graphically in Fig.1 and Fig.2. Test results show that both liquid limit and plastic limit decreases with increase in percentage of wood ash added. The graph follows this trend up to 8% of wood ash and then show a slight increase in its value.

The reactions took place here are cation exchange, flocculation, agglomeration and pozzolanic reaction.

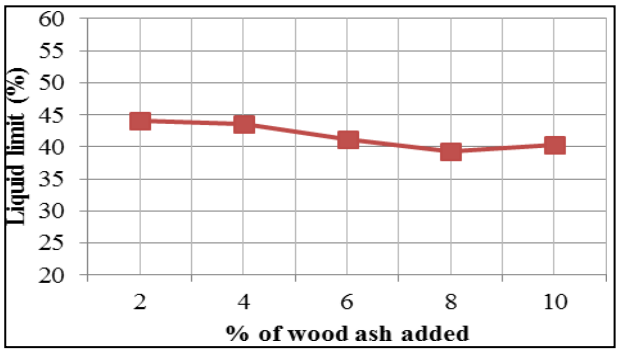

Fig. 1: Variation of Liquid limit with varying percentage of wood ash

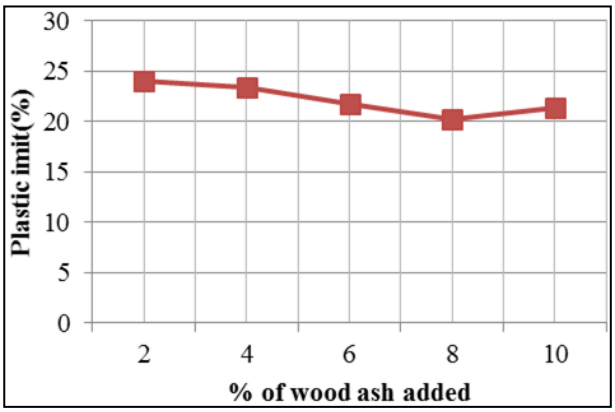

Fig. 2: Variation of Plastic limit with varying percentage of wood ash

C. Effect of Wood Ash on Free Swell Index:

Free swell index test was carried out according to IS.2720 (Part 40) : 1977. The Free swell index of the expansive soil is found to be high due to its cyclic swelling-shrinkage behavior. Free swell index value decreased with increase in percentage of wood ash added. It is presented graphically in Fig3

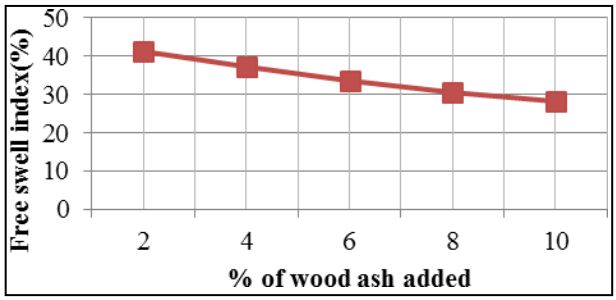

Fig. 3: Variation of free swell index with varying percentage of wood ash

D.Effect of Wood Ash on Compaction Characteristics:

Standard Proctor compaction test was carried out as per IS.2720 (PART - 7) : 1980. Addition of wood ash does not much have effect on density but it has increased slightly. These values are presented graphically in Fig 4.The graph (Fig 5) relating the values of optimum moisture content shows an initial increase in its value and then it is decreased. The moisture content of the soil is reduced due to hydrophilic nature of wood ash and thereby increases the bearing capacity of soil.

E.Effect of Wood Ash on Compressive Strength:

Unconfined Compressive Strength test was conducted as per IS.2720 (Part - 10) : 1991. Table 4 lists the values of compressive strength for every percentage increase in wood ash. Compressive strength increased with increase in percentage of wood ash added. UCS value of 452.13 KN/m2 is noted under 8% addition of wood ash after 28 days of curing. Fig 7 presents the compressive stress values graphically.

Percentage Of Wood Ash Added	Unconfined Compressive Strength (Kn/M^2)		
	Curing Period (Days)		
	7	14	28
2	232.12	261.67	317.14
4	256.25	285.21	349.52
6	270.53	305.34	395.86
8	302.95	356.85	452.13
10	289.37	329.17	425.27

Table 4: Unconfined Compressive Strength (UCS) test results

IV. CONCLUSION

Wood ash was added to black cotton soil in multiples of two percentages and tests such as liquid limit, plastic limit, compaction, California bearing ratio, Unconfined compressive strength test were carried out. Following results are inferred.

- The properties such as liquid limit and plastic limit decreases with increase in percentage of wood ash added.
- Maximum dry density shows a slight increase with increase in percentage of wood ash added.
- Differential free swell index decreases with increase in percentage of wood ash added.
- California bearing ratio of the soil attained its highest value at 8% addition of wood ash.

A curing period of 28 days is observed to yield maximum compressive strength of black cotton soil blocks reinforced with 8% of wood ash added. From the above laboratory investigation, it can be concluded that wood ash has a potential to modify the engineering behavior of black cotton soil and can be used as a cheap and good stabilizing agent.

REFERENCES

Amu.O.O, I.K.Adewumi, R.A.Mustapha and O.O.Ola, "Analysis of california bearing ratio values of black cotton soil stabilized with wood ash", Ife Journal of Science, vol.10, no.1, 2008.

[1] Anders Lagerkvist and Bo Lind , "Use of wood ash for road stabilization", Proceedings of 11th International Symposium on Environmental Issues and Waste Management in Energy and Mineral Production, 2013.

[2] Arash Barazesh, Hamidreza Saba, Moustafa Yousefi Rad and Mehdi Gharib, "Effect of wood ash admixture on clay soils in atterberg test", International Journal of Basic Sciences and Applied Research, Vol.1, Issue 4, 2012.

[3] Gbenga M.Ayininnola and Oluwatosin P.Oyedemi, "Impact of hardwood and softwood ashes on geotechnical properties of black cotton soil", Transnational Journal of Science and Technology, vol.3, No.10, 2013.

[4] Gyaneshwar Singh Uchariya, Rohit Arya and M.K.Trivedi,"Stabilization of clay soil using wood ash ", International Journal for Scientific Research and Development (IJSRD), Vol.4, Issue 04, 2016.

[5] Khushbu S.Gandhi, "Experimental study of surat region expansive soil modified using bagasse ash and wood ash", International Journal in IT and Engineering, vol.2, no.12, 2014.

[6] Supanic K. and Obernberger , "Wood ash utilization as a stabilizer in road construction - results of large scale tests", International Journal of Basic Sciences and Applied Research Vol.4, Issue 4, 2012.

[7] Tanmay Jain, Gulshan Yadhav, B.Chandra and C.H.Solanki, "Stabilization of black cotton soil using wood ash ", Proceedings of 50th Indian Geotechnical Conference, Pune, India, 2015.

[8] IS.2720 (Part 5) : 1985 - Methods of test for soil : Determination of liquid limit and plastic limit.

[9] IS.2720 (Part 40) : 1977 - Methods of test for soil : Determination of free swell index of soils.

[10] IS.2720 (Part 7) : 1980 - Methods of test for soil : Determination of water content and dry density using light compaction.

[11] IS.2720 (Part 10) : 1991 - Methods of test for soil : Determination of unconfined compressive strength.