(IJRST) 2016, Vol. No. 6, Issue No. I, Jan-Mar e-ISSN: 2249-0604; p-ISSN: 2454-180X

ANALYSIS OF STRENGTH CHARACTERISITCS OF BLACK COTTON SOIL USING WOOD ASH AS STABILIZER

***M.Usha Rani, **J.Martina Jenifer**
**Professor, Department of Civil Engineering,*
R.M.K.Engineering College,
Chennai, Tamilnadu
***Assistant Professor, Department of Civil Engineering,*
R.M.K.Engineering College
Chennai, Tamilnadu

ABSTRACT

Black Cotton soils are highly clayey soils (Montmorillonite clay mineral). The bearing capacity of Black cotton soil is extremely low. Due to this reason, the roads require periodic maintenance to take-up repeated application of wheel loads and also the thickness of the pavement is more than the other grade soils. Soil stabilization is the alteration of one or more soil properties by mechanical or chemical means to create an improved strength of existing soil. Soil stabilization and the thickness of pavement can be controlled using different additives. Wood Ash which is a waste material from industrial power plants can be used for soil stabilization which solves the problem of environment pollution. In this study the behaviour of black cotton soil is studied by using wood ash as stabilizing agent. Different quantities of wooden ash (% by weight) are added to the BC soil. Atterberg limits, Differential free swell, Standard Proctor Compaction and CBR tests are the experiments were conducted on these soil mixes. The results concluded that the use of wooden ash increases the strength of soil to a great extent.

Keywords: *Black Cotton Soil, Wood Ash, CBR value*

1 INTRODUCTION

In many situations, soils cannot be used directly as road service layers, foundation layers and as a construction material. The properties of the soil changed when it comes to contact with water. Expansive soils are one of those kinds of soils whose volume change takes place while it comes in contact with water The expansive soils occur all over the world. India has large tracks of expansive soil known as Black Cotton soil (BC soil), covering an area of 0.8 million square kilometer, which is about 20% of total land area. The major areas of their occurrence are states of Maharashtra, Gujarat, southern parts of Uttar Pradesh, eastern parts of Madhya Pradesh, parts of Andhra Pradesh and Karnataka. This type of soil is available up to a depth of 3.7 meters on an average in the above parts of India. Expansive soils occurring above water table undergo volumetric changes with change in moisture content. Increase

in water content causes the swelling of the soils and loss of strength and decrease in moisture content brings about soil shrinkage. Swelling and shrinkage of expansive soil cause differential settlements resulting in severe damage to the foundations, buildings, roads, retaining structures, canal linings, etc. The construction of foundation for structure on black cotton soils poses a challenge to the civil engineers. Chemical stabilization is one of the oldest methods of stabilization of problematic soil. Various research works have been undertaken for improving the expansive nature of the black cotton soil using materials like wooden ash, as admixture. Wooden ash is a locally available material residue powder left after the combustion of wood, such as burning wooden in a home fireplace or an industrial power plant.

1.1 *Objectives of the Study*

- To evaluate the properties of black cotton soil before and after stabilization with wood ash.
- To evaluate the suitable blend that can be used in the stabilization of black cotton soil.
- To evaluate the strength characteristics of the black cotton soil for different blends with ash with different percentage variations (5% and 10%).

1.2 *Scope of the Study*

In remote rural villages, the development of road network is of vital importance in the socioeconomic development. Especially the rural villages having black cotton soil as subgrade is very difficult to lay the pavementThe bearing capacity of Black cotton soil is extremely low. Due to this reason, the roads require periodic maintenance to take-up repeated application of wheel loads and also the thickness of the pavement is more than the other grade soils. This proves to be costly, and at the same time, conditions of roads during monsoon seasons are extremely poor. Soil stabilization and the thickness of pavement can be controlled using different additives, but use of Wood Ash which is a waste material from industrial power plants will be much significant. This project is focused on stabilizing black cotton soil mixed with various percentage of Wood Ash (0%, 5%, and 10% by dry weight of soil) .

2.LITERATURE REVIEW

Stabilization, in a broad sense, incorporates method employed for modifying the properties of soil to improve its engineering performances. Stabilization is being used for variety of engineering works, the most common application being in the construction of roads and air-field pavements, where the main objective is to increase the strength or stability of soil and to reduce the construction cost by making best use of locally available materials. There are many attempts made in stabilizing soils with the use of wastes and additives, here are some of the research works carried on stabilizing soil with use of wastes. Cokca[1] (2001) studied the effect of ash on the expansive soil. He found that the free swelling potential of the samples decreased with increasing percentage of stabilizer. Phanikumar and Sharma[2] (2004) investigated the effect of ash on the volume change of a highly plastic expansive clay and non expansive clay with low plasticity. The effect of ash on free swell index, swell potential, and swelling pressure of expansive clays were evaluated. Their study reported that the strength increased with an increase in ash content. Kumar and Sharma (2008) presented a study of the efficacy of ash in

improving the engineering characteristics of expansive soils. An experimental program evaluated the effect of the ash on the free swell index, swell potential, swelling pressure, plasticity, compaction, strength, and hydraulic conductivity characteristics of expansive soil. The results showed that the plasticity, hydraulic conductivity and swelling properties of the blends decreased and the dry unit weight and strength increased with an increase in ash content. Kumar and Prasanna[2] (2012) studied the effect of silica and calcium extracted from rice husk ash on geo technical properties of expansive soils. They concluded that the characteristics of such soils are improved remarkably. Similarly many researchers Osman Sivrikaya[5] (2013), Kumar Sabat[4] (2012), Qian Guoping[7] et al. (2011), Phanikumar[6] et al. (2004), Rezende[8], et al. (2003), Yorimichi[9] et al. (1999) Kamon[3] et al. (1994) have investigated the use of industrial wastes like ash, granite mill tailings, marble dusts, other stone wastes to improve the properties of weak expansive soils. They concluded that these industrial wastes can increase the strength and decrease the swelling behaviour of expansive soils if used individually or as an admixture to such soils. Furthermore, maximum dry unit weight increased and optimum moisture content decreased with increasing ash content.

3 MATERIALS USED

3.1 *Black Cotton Soil*

Black cotton soil (BC soil) is a highly clayey soil. The black colour in Black cotton soil (BC soil) is due to the presence of titanium oxide in small concentration. Expansive soils are the soils which expand when the moisture content of the soils is increased. The clay mineral montmorillonite is mainly responsible for expansive characteristics of the soil. The expansive soils are also called swelling soils or black cotton soils. Black soils are highly retentive of moisture, extremely compact and tenacious when wet, considerably contracted developing deep wide cracks on drying and self-ploughing. Black soils are credited with high fertility. These are well suited to leguminous crops like cotton, turn and citrus fruits. Other crops include wheat, jowar, millets, linseed, castor, tobacco, sugarcane, safflower, vegetables etc.

3.2 *Wood Ash*

Wood ash is the waste by - product produced from the incineration of wood wastes, like bark and knots used as fuel in these systems. Until recently land filling has been the only available disposal option for wood ash. However, the nutrient content and alkaline pH of wood ash make it useful as a nutrient supplement and an agricultural lime alternative. Utilization of industrial and agricultural waste products in the construction of roads has been the focus of research for economical and environmental reasons. In this experiment the wood ash is collected from pulp mill from Chennai. The chemical composition of wood ash are shown in Table1.

4 METHODOLOGY

4.1 *Experimental Programme*

Basic laboratory tests (Attenbergs limit, compaction, CBR,) were carried out on black cotton soil sample to determine the basic properties of soil sample.

- The black cotton soil which is determined for the basic properties are classified according to IS and HRB classification using the Attenberg‟s limit and sieve analysis.

- Then the stabilization of black cotton soil with wood ash is carried out by blending the soil with different percentages of ash 5%, & 10%)
- To determine the strength behavior of black cotton soil with ash , the laboratory tests (compaction, California bearing ratio, Free swell test) were carried.
- The strength tests are carried out on each percentage of blends. By getting the results of all these blends the comparison of the best suitable additive mix will be carried out.
- With the suitable blend mix the design for the flexible pavement according to the IRC-37 had carried out and the pavement layer thickness with and without stabilization for black cotton soil will be compared.
- The results are concluded suitably.

4.2 *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 dryed. Using the sample the basic laboratory tests are conducted as specified. Further for the blend mix the sample was prepared as follows

Firstly black cotton soil was kept in oven for removing moisture content and drying at 110°C temperature for 24hrs is done.

- Then the ash is also kept in oven for maintaining the dry form .
- For different blend mixes the ash content was taken according to certain percentages by weight of soil and it is mixed with soil in dry form itself. Then the test procedure is conducted.

5 RESULTS AND DISCUSSIONS

Basic Properties of Black Cotton Soil which are determined by conducting laboratory tests as per IS code specification are tabulated in the Table 2.

5.1 *Effect of wood ash on Atterberg limits*

The tests on the liquid limit (LL), plastic limit (PL), and plasticity index (PI) of the soil-ash mixture were conducted according to I.S. 2720 (Part v)-1970. The liquid limit value for 5% and 10% addition of ash were compared with soil without ash. The decrease in value of 52% was observed in 5% addition of wood ash and 58% was noted in 10 % addition of wood ash. The decrease in percentage between 5% and 10 % of addition of wood ash was found as 14%. The plastic limit value for 5 % and 10% addition of ash were compared with soil without ash. The decrease in value of 10% was observed in 5% addition of wood ash and 22% was noted in 10 % addition of wood ash. The decrease in percentage between 5% and 10 % of addition of wood ash was found as 13%. Fig,1.shows the plasticity index for 5 % and 10% addition of ash were compared with Soil without ash. The decrease in value of 86% was observed in 5% addition of wood ash and 88% was noted in 10 % addition of wood ash. The decrease in percentage between 5% and 10 % of addition of wood ash was found as 20%.As Increased addition of ash with BC soil, the amount of soil to be flocculated decreases and the

finer particles of ash may be incorporated in the voids of flocculated soil ; thereby decreasing the water held in the pores leading to the decrease in the plastic limit.

5.2 *Effect of wood ash on free swell index*

The measured values of differential free swell of soil and ash mixture contents are shown Table. The differential free swell of black cotton soil decreases with an increase in percentages of ash. Fig.3. shows the free swell for 5 % and 10% addition of ash were compared with soil without ash. The decrease in value of 20% was observed in 5% addition of wood ash and 33% was noted in 10 % addition of wood ash. The decrease in percentage between 5% and 10 % of addition of wood ash was found as 10%.

5.3 Effect of wood ash on percentage of clay

Sieve analysis

The Grain size analysis on natural soil and the soil additive mixture were conducted according to I.S. 2720 (Part IV)-1975. The percentage of gravel, sand and clay are in black cotton soil as 3.55%, 46.56% and 48.89 % respectively, whereas those noted 5% addition of wood ash as 3.18%, 54.052% and 42.768 % and 10 % addition of wood ash 5.876%, 57% and 37.124%. Fig.2 shows the percentage of clay content in for 5 % and 10% addition of ash were compared with soil without ash

5.4 Effect of wood ash on Optimum Moisture Content(OMC)

The compaction tests to obtain the moisture-density relationship of the soil-additive mixtures were conducted according to I.S. 2720 (Part viii)-1965. Fig.4 shows the variation of maximum dry density and Fig.5 shows the Optimum moisture content for 5 % and 10% addition of ash were compared with Soil without ash. The increase in value of 9% was observed in 5% addition of wood ash and 9.21% was noted in 10 % addition of wood ash. The decrease in percentage between 5% and 10 % of addition of wood ash was found as 18%.

5.5 Effect of wood ash on CBR

The CBR tests were conducted according to I.S. code. A standard CBR mold with a detachable collar was used. Fig,6 shows the CBR value for 5 % and 10% addition of ash were compared with Soil without ash. The increase in value of 40% was observed in 5% addition of wood ash and 65% was noted in 10 % addition of wood ash. The increase in percentage between 5% and 10 % of addition of wood ash was found as 10%.

5.6 Flexible pavement design as per IRC-37-2001

The thickness of flexible pavement for 5 % and 10% addition of ash were compared with only Black Cotton Soil. The decrease in value of 20% was observed in 5% addition of wood ash and 31% was noted in 10 % addition of wood ash. The decrease in percentage between 5% and 10 % of addition of wood ash was found as 13%.

CONCLUSION

This experimental program evaluated the effect of ash on the some basic engineering properties of BC soil such as Liquid limit, plastic limit, compaction of BC soil and California bearing ratio (CBR) of BC Soil. The percentage of ash used in black cotton soil are 5% and 10%.

- The properties of soil sample such as plasticity index and free swell of the expansive soil decreases with the increase in percentage of wood ash.
- The maximum dry density of the soil increases with increase in percentage of wood ash. Irrespective of their percentages.
- The differential free swell of black cotton soil decreases with an increase in percentages of ash
- The soaked CBR of the soil increases with increase in percentage wood ash content.
- The thickness of flexible pavement thickness decreases with increase in percentage of wood ash

Acknowledgment: *The authors wishes to take this opportunity to express their sincere thanks to the management, principal for providing facilities to carryout the experimental work.*

About the Authors

Dr.M.Usharani working as a professor at RMK Engineering College, obtained her B.E. (Civil) M.E. (Structures) and Ph.D (Civil Engineering) all from CIT, Coimbatore. She has about **20** years of experience in teaching for B.E Civil engineering and M.E Strucutral Engineering (10years in Coimbatore, 8 years in Chennai and 2 years in St. Joseph University, Tanzania) research, consultancy activities and 9 years of experience in construction industry. She conducted and attended national conferences, workshops & technical seminars. She was the Principal Investigator for R& D Project Funded by Institution of Engineers, India (IIE) . Totally She has Published 30 Research Papers in International journals, National journals, International and National Conferences. Written one book on Structural Analysis I . She is a Life member of ISTE & ICI.

J.Martina Jenifer working as a Assistant professor at RMK Engineering College, obtained her her B.E. (Civil) I Class with Distinction from St.Peter, Chennai: M.E. (Structures) I Class with Distinction from Hindustan, Chennai ; She has about 3 years of experience in teaching. She has Published 3 Research Papers in International journals and International Conferences and attended FDP, Seminars and workshop. She takes responsibility in department activities like Industrial visit and placement. Written one book on Structural Analysis I. She has guided more than 5 UG projects. She is a Life member of ISTE & ACI.

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Table 1: Chemical Composition of Wood Ash

Constituent	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	NaO	L.O.I
Composition [%]	31.8	28	2.34	10.53	9.32	10.38	6.5	27

Table 2: Test Results

SL.NO	DESCRIPTION	BLACK COTTON SOIL	BLACK COTTON SOIL + 5 % ASH	BLACK COTTON SOIL + 10 % ASH
1	LIQUID LIMIT (%)	54.84	26.325	22.68
2	PLASTIC LIMIT (%)	24.515	21.985	19.21
3	PLASTICITY INDEX	30.325	4.34	3.47
4	FREE SWELL INDEX (%)	50	40	33.33
5	PERCENTAGE OF CLAY (%)	49.89	42.768	37.124
6	MAXIMUM DRY DENSITY (kg/m^3)	1.879	1.88	1.895
7	OPTIMUM MOISTURE CONTENT M_C (%)	10.2	11.25	9.26
8	CALIFORNIA BEARING RATIO	2.15	3.6	6.09
9	THICKNESS OF FLEXIBLE PAVEMENT (mm)	820	655	570

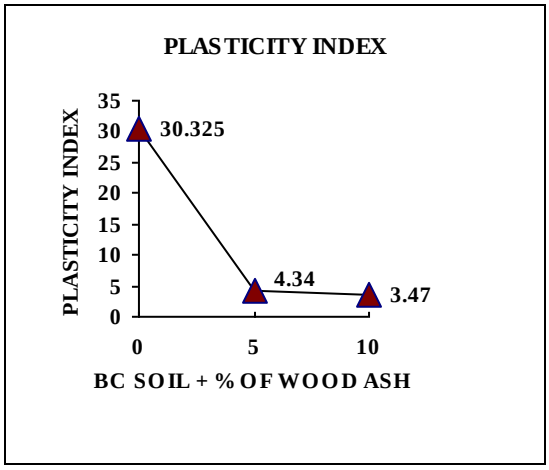

Fig. 1 Variation of Plasticity Index for Black Cotton Soil with 0%, 5% and 10% addition of Wood Ash

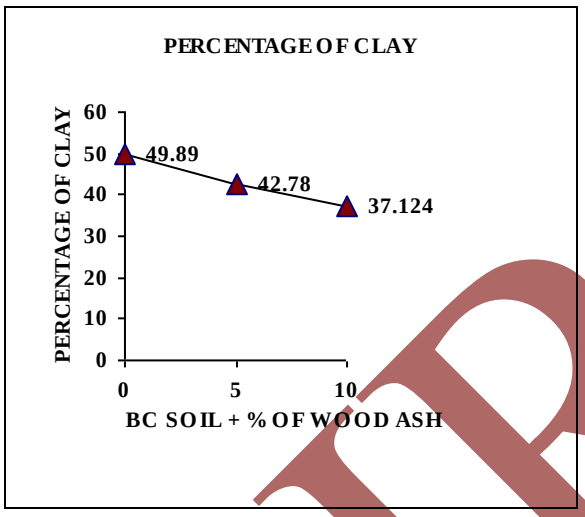

Fig. 3 Variation of Percentage of Clay for Black Cotton Soil with 0%, 5% and 10% addition of Wood Ash

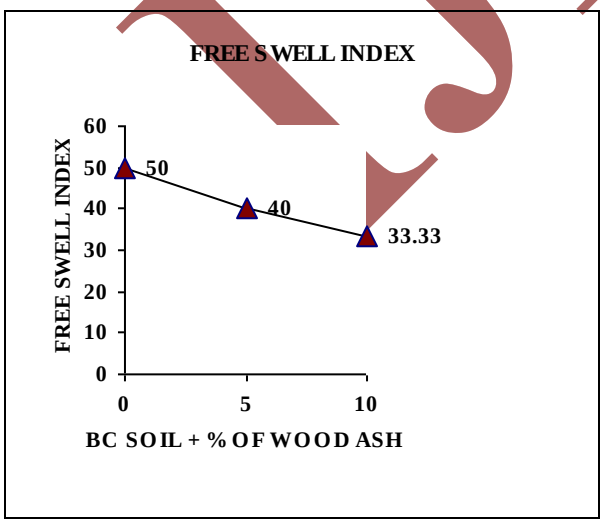

Fig. 2 Variation of Free Swell Index for Black Cotton Soil with 0%, 5% and 10% addition of Wood Ash

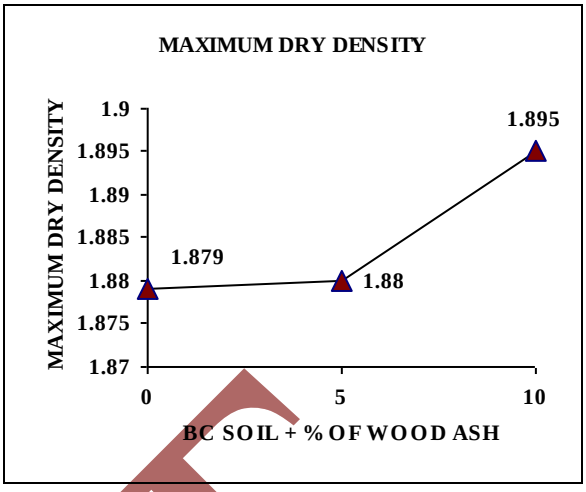

Fig. 4 Variation of Maximum Dry Density for Black Cotton Soil with 0%, 5% and 10% addition of Wood Ash

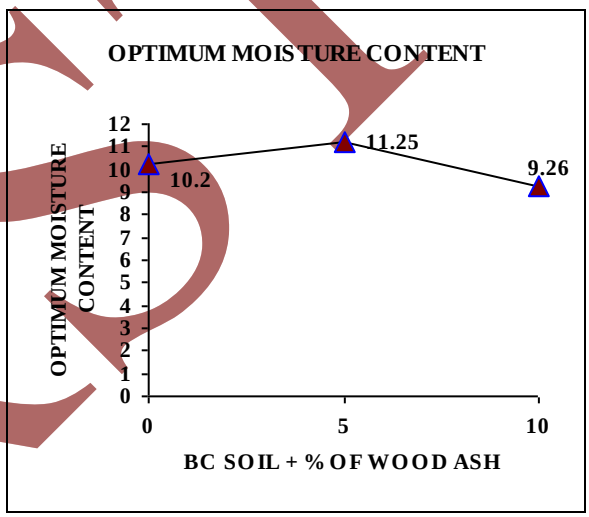

Fig. 5 Variation of Optimum Maximum Content for Black Cotton Soil with 0%, 5% and 10% addition of Wood Ash

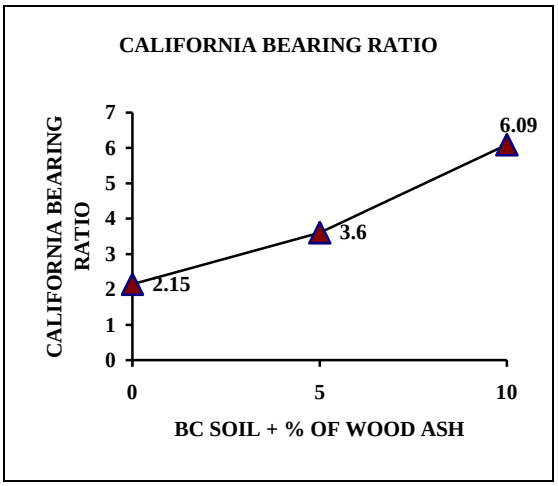

Fig. 6 Variation of CBR Value of Black Cotton Soil with 0%, 5% and 10% addition of Wood Ash