ISSN (e): 2250 – 3005 || Volume, 08 || Issue, 01|| January – 2018 ||
International Journal of Computational Engineering Research (IJCER)

An Experimental Study on Stabilization of Black Cotton Soil by using sugarcane bagasse ash

SimantineeSamal[1], P.V.S. Vara Prasad[2]
[1]*Assistant Professor, Department of Civil Engineering, Gandhi Institute For Technology (GIFT), Bhubaneswar*
[2]*Assistant Professor, Department of Civil Engineering, Gandhi Engineering College, Bhubaneswar*

Abstract—*Expansive soils have the tendency to undergo volume change behaviour and cause huge uplift pressures and upheaval of structures based on it due to presence of moisture. In most of cases, practically it is not possible to avoid expansive soil and replacement of soil by any material or soil, in large area of expansive soil. The black cotton soil is type of expansive soil. For the treatment of black cotton soil, various materials add in black cotton soil. These materials work as admixture in black cotton soil and stabilize the soil. In this research work, black cotton soil (expansive soil) is stabilized by using sugarcane bagasse ash (SCBA) from 10% to 40% weight of black cotton soil. The liquid limit, plastic limit, plasticity index, differential free swell index, standard proctor test and California bearing ratio tests were performed in laboratory to study the behaviour of black cotton soil.*
Keywords— *Black Cotton Soil, California Bearing Ratio, Differential Free Swell Index, Sugarcane Bagasse Ash, Standard Proctor Test*

I. INTRODUCTION

Black cotton soils are inorganic soils from medium to high compressibility and frame a real soil gather in India. In rainy season black cotton soil absorbs water heavily which results into swelling and softening of soil. In summer season reduction in water content this shrinks and produces cracks. These soils possess weak properties due to presence of clay mineral known as Montmorillonite. Typical behaviour of soil results into failure of structure in the form of settlement cracks etc. so the construction is very difficult. Various scientist and research tried to improve the properties of black cotton soil by using different admixtures and waste materials. T. Sudesh Reddy et.al. performed experimental study on utilization of rural waste marginally enhances the properties of local soil; sugarcane bagasse ash remains can be utilized as substitution in neighbourhood soil up as far as possible. The accompanying conclusions are made in view of the laboratory tests did in their examination. They observed that 20% sugarcane bagasse ash improved the engineering properties of black cotton soil. They also added fibre percentage 0% to 1.5% at variation in mix of black cotton soil with 20% sugarcane bagasse ash. From test results it is concluded the CBR value is also increasing in both case of mix. Amruta P. Kulkarni et. al. performed experimental study on stabilization of black cotton soil using bagasse ash and lime. The performed experiment on black cotton soil and they observed that plasticity index is decreasing and CBR value increasing when optimum ratio of bagasse ash to lime was used. Similarly, Ashish Murariet. al. studied that sugarcane bagasse ash helps in improving the engineering properties of black cotton soil. From experimental study they concluded that dry density and CBR value are increased with increasing the percentage of SCBA. Same as S. A. Nalini et.al. Prepared 3 varieties of soil samples with altered percentage of bentonite on which CBR test were executed with or without geogrid reinforcement in one or multilayer. Results show that rise in plasticity index lower CBR value in both soaked and unsoaked condition. CBR can be considerably increased by using geogrid reinforcement in two layers in comparison to unreinforced but less value in comparison to single layers reinforcement. Hence, this experimental study is done for black cotton soil which is locally available in Bhopal region.

II. EXPERIMENTAL WORK

MATERIALS

Soil: The soil is collected from GIFT campus, Bhubaneswar, Odisha (INDIA). According to Unified Soil Classification system, the soil was classified as clayey sand with low plasticity and the properties of soil are given in Table 1.

Table 1: Properties of Soil Sample

S. No.	Parameters	Values
1.	Specific Gravity	2.65
2.	Optimum Moisture Content	14.10 %

3.	Maximum Dry Density	1.77 g/cc
4.	Liquid Limit 38.00 %	38.00 %
5.	Plastic Limit 18.97 %	18.97 %
6.	Plasticity Index 19.03 %	19.03 %
7.	Category of Soil	
	As per USC System (fines fraction)	Cu = 8.771 Cc = 0.740 Poorly graded sandy soil
	As per USC System (A-line chart)	Clayey Sand (SC) Low Plasticity (CL)

Cement Kiln Dust: As the name implies, Cement kiln dust is fine powder-like by-product of Portland cement production. They are collected from the stacks of high-temperature rotary kilns by the federally mandated dust collection systems (e.g., cyclones, electrostatic precipitators, and/or bag houses). Large quantities of cement kiln dust are produced during the manufacture of cement clinker by the dry process. Several factors influence the chemical and physical properties of CKD, because plant operations differ considerably with respect to raw feed, type of operation, dust collection facility, and type of fuel used. The dust from each plant can vary markedly in chemical, mineralogical and physical composition. The research described in this project work was conducted exclusively with pre-calciner CKD from Orissa Cement Limited, Bhubaneswar (INDIA) and all results and conclusions of the report are intended to refer to CKD from Orissa Cement Limited, Bhubaneswar (INDIA).

Table 2: Typical Chemical Composition of Cement Kiln Dust

Oxide	Concentration (%)
CaO	50.81
Al2O3	4.71
SiO2	17.18
Fe2O3	1.92
Mn2O3	0.002
Na2O	0.001
K2O	1.35
Loss of Ignition	24.03

METHODS:

To study about soil stabilization, soil is mixed with CKD and their engineering properties were determined. Laboratory tests have been planned in such a way that it takes into account all the related aspects, such as related percentages of CKD are mixed at calculated OMC and dry weight of soil. Following laboratory tests have been conducted as per IS2720-(1985) (Reaffirmed 1995):

- Soil Compaction Test (Light Compaction Test) as per IS-2720 (Part VII)
- Atterberg's Limit Test (Liquid limit & Plastic Limit) as per IS-2720(Part V)
- Unconfined Compression Test as per IS-2720 (Part X)
- CBR Test as per IS-2720 (Part 16), and
- Permeability Test (Falling head method)

III. RESULT AND DISCUSSION

Following laboratory test results are obtained for different percentages of CKD (0 % to 30 %) when mixed with dry weight of Soil is given in table 3.

Table 3: Laboratory Test Results

CKD (%)	0	5	10	15	20	25	30
OMC (%)	14.1	14.4	14.8	15.2	15.5	15.9	16.3
MDD (g/cc)	1.77	1.75	1.72	1.70	1.69	1.67	1.65
WL (%)	38.00	37.80	36.75	35.25	35.02	34.78	33.50
WP (%)	18.97	19.99	22.02	22.60	24.36	25.73	26.00
IP (%)	19.03	17.81	14.73	12.65	10.66	9.05	7.05
UCS (kg/cm^2)	0.949	1.073	1.441	1.816	2.383	2.629	2.833
Soaked CBR (%)	2.64	3.85	4.30	5.02	5.54	6.02	6.74
Unsoaked CBR (%)	3.40	3.96	4.29	4.98	5.27	5.85	6.35
Permeability (k) (cm/ sec)	2.661x10-5	2.275x10-5	1.785x10-5	1.644x10-5	1.392x10-5	5.825x10-6	2.565x10-6

Compaction Test Result:

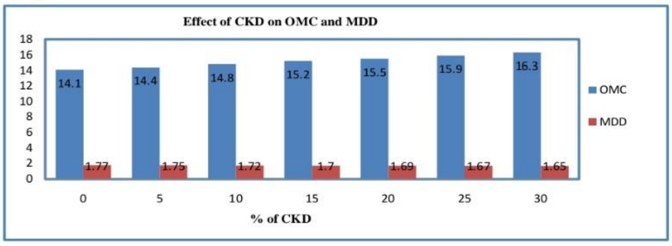

Fig 1: OMC and MDD at varying percentage of CKD

As per above Fig.1, OMC is increasing but MDD is decreasing gradually as finer particles of CKD are increasing. When CKD is used as soil stabilizing additive, Soil particles become large-sized clusters, resulting in texture change. This flocculation-agglomeration process results in flock formation. The enlarged particle size causes the void ratio to increase. This increase in void ratio reflects the decrease in MDD and increase of moisture content for the Soil-CKD mixture

Liquid Limit & Plastic Limit Test Result:

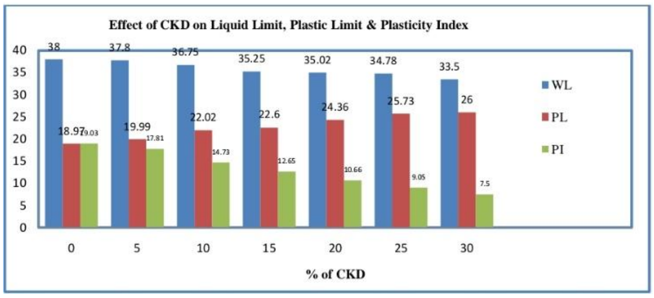

Fig.2: Liquid Limit, Plastic Limit & Plasticity Index at varying Percentages of CKD

Atterberg' s limit indices variation with CKD content is shown in figure 2. Liquid limit and Plastic limit increased with CKD content, while the Plasticity index decreased with CKD content. This is due to the presence of Ca2+, Si2+, and Al3+cations with increased CKD usage they react with soil particles. This reduction in the plasticity may be attributed to the chemical and cementation effect on structural composition of the soil. Since the modification of soil particles leading to increase the effective particle size (resulting from inter-particle cementation), consequently the amount of moisture that attracted to these particles decreased.The increase in Plastic limit may be attributed to the quantity of water used should be just sufficient to satisfy hydration requirements of the CKD and to make the mixture workable.

Unconfined Compression Test Result:

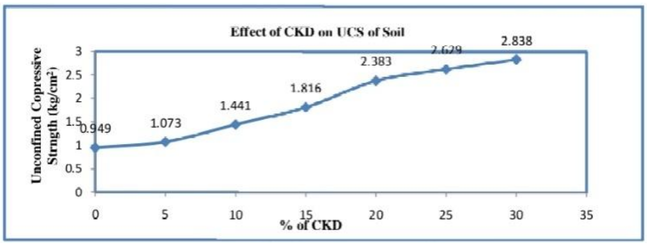

Fig.3: UCS of Soil at varying Percentages of CKD

From above fig.3, it can be seen that the Unconfined Compressive Strength of the Soil sample have increased as the percentage of CKD increases. The Unconfined Compressive Strength at 30% addition of CKD to the soil is 2.833 kg /cm^2. As compared to the untreated soil (at 0% CKD), the percentage increase at 30% addition of CKD to the soil is about 198.52%. This is due to the fact that addition of CKD make available additional amount of Silica and lime than that of present in natural soilonly.

CBR Test Result:

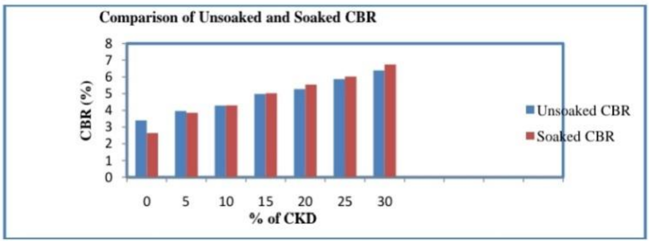

Fig.4: Unsoaked& Soaked CBR Variation of Soil-CKD

Mix. Here, as per above fig.4, Soaked CBR value is greater than Unsoaked CBR value at 10% addition of CKD and onward. This increment may be attributed to the chemical and cementation effect (the Oxides amount in the CKD is about 2/3rd of Oxide amounts found in Portland cement) on structural composition of the soil. Presence of Ca2+, Si2+, and Al3+cations in CKD, it react with water and resulting in the formation of Calcium-Silicate-hydrates (CSH) and Calcium-Aluminate- hydrates (CAH). CSH and CAH are cementation products similar to those formed in Portland cement. Time duration and sufficient water favours these reactions.

Permeability Test Result:

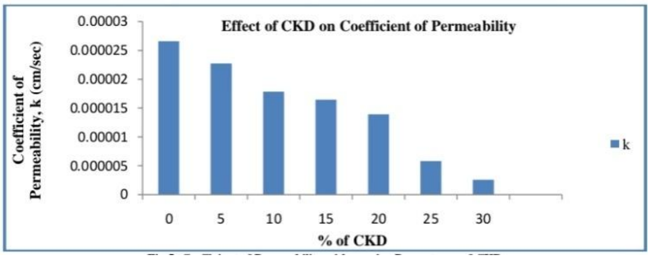

Fig.5: Coefficient of Permeability with varying Percentages of CKD

From above fig.5, it can be seen that the Permeability of the Soil Sample have decreased as the percentage of CKD increased. The Coefficient of Permeability at 30 % addition of CKD to the soil is 2.565x10-6 cm/sec. As compared to the Untreated Soil (at 0 % CKD), the percentage decrease at 30 % addition of CKD to the soil is 90.36 %. This is due to the increase in finer material as percentages of CKD increase in the Soil-CKD mixture. Permeability decreases even further because of the growing reaction products (CHS & CAH) and reduction in connected voids.

IV. CONCLUSION

Based on the obtained results and discussion thereof following conclusions can be made:

♦ The compaction characteristics of soils vary significantly with CKD content. The optimum moisture content increases and maximum dry density decreases with increased CKD content.

♦ As compared to untreated soil, the percentage increase in OMC at 30% addition of CKD to the soil is15.60%, and percentage decrease in MDD is 7.27%.

♦ Liquid limit decreases and Plastic limit of soil increases as the percentage of CKD increases. The Plasticity index of soil reduces with increased CKD content. Reduction in Plasticity index is 60.58%. Hence the soil samples become less plastic and compressible.

♦ With increases of CKD percentage compressive strength of soil increases. Percentage increase in compressive strength of soil is 203.79%.

♦ CBR value for soaked and unsoaked condition increases with increases in percentage of CKD. Percentage increase in CBR value for soaked and unsoaked is156.06% and 86.76% respectively. CBR values of soil are indicator of sub-grade soil strength and are often used for design of flexible pavement. The CBR value of CKD treated soil is 6.76% which can be used for the designing of flexible pavement for light and medium traffic.

♦ Coefficient of permeability i.e., Hydraulic conductivity of soil reduces with increased CKD percentages. Percentage reduction in Permeability of soil is 90.36%; hence stabilized soil may be used for the impervious core in embankment and, the treated soil could be used as a soil-based barrier layer for containment of hazardous waste.

This project work concluded that CKD is potentially useful in stabilizing of soil. However, the stabilizing effect is primarily a function of the chemical composition, fineness, and addition level of the CKD as well as the type of parent soil. CKD is an effective soil stabilization agent, based on the results observed and described in this thesis. It is recommended that it can be considered for use in the stabilization of soil.

REFERENCES

[1]. Khandaker M. Anwar Hossain.;" Stabilized Soils Incorporating Combinations of Rice Husk Ash and Cement Kiln Dust" 1320 / journal of materials in civil engineering © asce / September 2011
[2]. Amin EsmaeilRamaji.; "A Review on the Soil Stabilization Using Low-Cost Methods" Journal of Applied Sciences Research, 8(4): 2193-2196, 2012, ISSN 1819-544X
[3]. Wayne S. Adaska.; "Beneficial uses of cement kiln dust" Presented at 2008 IEEE/PCA 50th Cement Industry Technical Conf., Miami, FL, May 19-22, 2008
[4]. M. K. Rahman, S. Rehman& O. S. B. Al-Amoudi.;"literature review on cement kiln dust usage in soil and waste stabilization and experimental investigation"IJRRAS 7 (1) ● April 2011
[5]. Tara Sen and Umesh Mishra.;" Usage of Industrial Waste Products in Village Road Construction" International Journal of Environmental Science and Development, Vol. 1, No. 2, June 2010 ISSN:2010-0264
[6]. MohieEldin Mohamed AfifiyElmashad.;"Soil Improvement using Cement Dust Mixture" World Academy of Science, Engineering and Technology 58 2011
[7]. Mukesh A. Patel,Dr. H. S. Patel.;"A review on effects of stabilizing agents for stabilization of soil" Civil and Environmental Research ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online) Vol 2, No.6, 2012
[8]. Onyelowe Ken C. and Okoafor F. O.;" Geochemistry of soil stabilization" ISSN 2305-493X, vol. 1, no. 1, october 2012
[9]. Z. A. Baghdadi, Member, ASCE, M. N. Fatani, and N. A. Sabban.; "Soil modification by cement kiln dust" 2181 journal of materials in civil engineering / November 1995
[10]. F.O.P. Oriola and G. Moses.; "Compacted black cotton soil treated with cement kiln dust as hydraulic barrier material" AMERICAN JOURNAL OF SCIENTIFIC AND INDUSTRIAL RESEARCH © 2011, Science Huβ, http://www.scihub.org/AJSIR ISSN: 2153-649X doi:10.5251/ajsir.2011.2.4.521.530
[11]. Dr. Robert M. Brooks.; "Soil Stabilization with Flyash and Rice Husk Ash"International Journal of Research and Reviews in Applied Sciences ISSN: 2076-734X, EISSN: 2076-7366 Volume 1, Issue 3(December 2009)
[12]. Gyanen. Takhelmayum, Savitha.A.L, Krishna Gudi.; "Laboratory Study on Soil Stabilization Using Fly ash Mixtures" International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 2, Issue 1, January 2013
[13]. Musa Alhassan.;" Potentialsof Rice Husk Ash for Soil Stabilization" AU J.T. 11(4): 246-250 (Apr. 2008)
[14]. SulaphaPeethamparan and Jan Olek.; "Study of the Effectiveness of Cement Kiln Dusts in Stabilizing Na-Montmorillonite Clay" Journal of Materials in Civil Engineering © ASCE / February 2008 / 137
[15]. MahrousA.M.Ali and Huang-Sik Yang.; "Utilisation of cement kiln dustin industry cement bricks" Geosystem Engineering, 14(1), 29-34(March, 2011)