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Influence of Bagasse Ash and Lime on Mechanical and Chemical Stabilization of Black Cotton Soil

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ABSTRACT
Black cottons soil (BCS) has unimaginable ability to expand and shrink when it absorbs water. This expansive nature made it unacceptable for use as construction material. Bagasse ash (BA) and lime are good admixtures that can be used to improve the shear strength of stabilized BCS. This research is aim at investigating the influence of BA and lime on mechanical and chemical stabilization of BCS. Soil test on the geotechnical properties of BCS obtained from Eket classified it as an A-2-7 soil. Mechanical and chemical method of stabilization was used to investigate the influence of the admixtures on CBR value of the soil. Result obtained showed that BA and lime has so much influence on mechanical and chemical stabilization of BCS. The CBR value of Eket's stabilized BCS increases with simultaneous increase in varying percentage of partial replacement of BA and lime. Conclusively, increased quantity of Lime and BA admixture when used to stabilize BCS, will increase the CBR value and strength of the soil. Lime admixture produced tremendous increase compared to BA. Federal ministry of works should support the use of bagasse ash and lime for mechanical stabilization of road pavement, since it will help to eradicate incessant road pavement and building failures and satisfies ISO 9001:2018 requirements.

Keyword: Bagasse ash, lime, mechanical stabilization, chemical stabilization, black cotton soil

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I. INTRODUCTION

The unstable nature of BCS makes it notorious, uncertain, and highly problematic (Fondjo, Theron, and Ray., 2021). It is clayish in nature, characterized with enormous volume changes and large shear failure when in contact with water (Bhujbal, and Gaikwad, 2022). BCS has a swelling-shrinkage potential phenomenon which is greatly influenced by clay mineralogy constituent, environmental, stress condition and soil properties factors which describe the functional relationship of the swell-shrinkage potential of the study area (Merouane, and Mamoune, 2018).The unstable nature of the swell potential of BCS need to be determine to prevent incessant collapse of civil engineering structures (Kshatriya, Sathe, and Kankarej, 2022; Darikandeh, and Phanikumar , 2021; Akinwande, and Aderinola, 2020; Khan,Wang, and Patterson, 2017) and increase the service life of infrastructural facilities(Diome, and Biaye L, 2022).

BA is an industrial waste material of sugar manufacturing industry (Singh, and Siddique,2022; Siddique, and Cachim, 2018; and Patel 2022). Sugarcane (Saccharum Officinarum) is the largest crop by production quantity in the world, a large amount of wet bagasse is yielded and the management of this residue is of great importance from environmental point of view. The views of Ouedraogo, Sawadogo, Sanou, Barro, Nassio, Seynou, and Zerbo (2022) showed that BA is produced by calcinations of sugar cane bagasse at temperatures ranging from 550^0C to 750^0C with a heating stage of 2 to 3 hours, resulting to the production of pozzolanic ashes, and cementious materials for production of cement.

Improving the properties of BCS requires soil stabilization technique (Rehman, 2020). Several types of stabilization materials have been used for BCS stabilization. BCS can be stabilized using fly ash (FA) (Nanda, 2021; Chethan, and Ravi Shankar, 2021). Prudhvi , and Chellaiah, (2022), stabilized soil using salts. (Majeed, and Tangri,2021, stabilized soil with industrial waste. Garg, Biswas, Kumar, Siddharth, and Singh, 2021), carried out stabilization with coal bottom ash (Navagire,

Sharma, and Rambabu.2021). Mai-Bade, Chinade, Batari, and Saeed, (2021) and Premkumar, Subha, Sandhiya, and Narayanan, (2021), utilizes lime, cement, E-waste, groundnut shell ash, bagasse ash and plantain peel powder, reclaimed asphalt pavement, E-waste, and still mill ore for BCS stabilization.

This research is seeks to investigate the influence of BA and lime on mechanical stabilized BCS (Kiran, Muhamed, and Jaya, 2019) with specific objective of observing the influence of BA on the California bearing capacity(CBR) of stabilized BA-BCS.

II. MATERIALS AND METHODS

The materials used for this research include all laboratory equipments required for Atterberg limit, moisture content and compressive test, disturbed soil collector, and BCS obtained from Eket senatorial district of Akwa-Ibom state, having coordinates of $4^{o}27'57''N$ $7^{o}37'45''E$. The BCS was collected at a depth not less than 150mm from 8 different trial pits of about 4m apart, each using the method of disturbed sampling technique. The scope of this research study includes stabilization of BCS with BA and lime to determine the consistency limit, Atterberg limit, and CBR value of the soil, investigate the influence of BA and lime admixtures on CBR value of stabilized BCS obtained from Eket. Varying percentages of partially replaced Lime and BA were carried out based on the work of Kollu, Nagarajan, Rajarajachozhan,.Sriaadith, and Saravanan, (2021).

Sample preparation of BCS, BA, Sieve analysis, Atterberg limit, and CBR value were carried out based on the thoughts of Kollu, Nagarajan, Rajarajachozhan, Sriaadith, and Saravanan (2021), and Premkumar, Subha, Sandhiya, and Narayanan, (2021). CBR test result of BCS obtained from Eket locations is presented in table 3.1 below. Aerial map of the geographical location of Eket in Akwa Ibom state of Nigeria and sample preparation of the tests conducted are presented in appendix I and II respectively.

III. RESULTS AND DISCUSSION

The sieve analysis, Atterberg limit tt, specific gravity test results of BCS obtained from Eket are presented below.

3.1 Geotechnical properties of BCS obtained from Eket.

Table 3.1. Sieve analysis, Atterberg limit, specific gravity.

Parameter	Value
Sand content (grain size 2 to 75 µ mm), %	-
Sand content (grain size 75to 2 µ mm), %	21
Clay content (grain size <2 µ mm), %	82
Liquid limit, LL, %	59
Plastic limit, PL, %	30
Plasticity index, PI, %	29
Specific gravity of solids	2.7

Discussion of findings in table.3.1

i. Table 3.1 is the average geotechnical properties of the BCS obtained from Eket
ii. The soil is classified as an A-2-7 soil which has some percentages of silt, sand and clay based on AASHTO classification method.

3.2 California bearing ratio of stabilized BCS with lime and BA.

The results of CBR test conducted on the obtained samples from Eket senatorial district are presented below.

Table 3.2. Variation of CBR ratio with increases BA and lime contents BCS from Eket location

BAGASSE ASH % CONTENT	CALIFORNIA BEARING RATIO					
	2%Lime	4%Lime	6%Lime	8%Lime	10%Lime	12%Lime
0	23.30	59.89	87.34	149.26	167.38	257.38
2	23.57	84.44	93.70	175.12	207.26	245.34
4	25.42	85.29	104.94	196.37	235.22	273.30
6	26.48	93.40	117.07	209.09	263.18	301.26
8	25.13	109.13	123.68	221.03	291.14	329.22
10	25.11	121. 03	135.59	230. 24	319.10	357.18
12	24.98	135.19	176.12	242.05	347.06	385.14

Discussion of findings in table.3.2

i. Table 3.2 presents the CBR values of Eket'sstabilized BCS with varying percentage of partially replaced BA and lime.
ii. The result showed that increase in partial percentage replacement of BA and lime results in simultaneous increase in the CBR value of Eket's stabilized BCS.
iii. The result equally showed that rate of increase in the CBR values of stabilized BCS with lime are higher compared to BA.

IV. CONCLUSION

The soil is classified as an A-2-7 soil which has some percentages of silt, sand and clay based on AASHTO Classification method. BA and lime has so much influence in the mechanical and chemical stabilization of BCS. Result showed that the CBR value of the Eket's stabilized BCS increases with simultaneous increase in varying partial percentage replacement of BA and lime. Lime admixture gave tremendous increase compared to BA. It is advisable to add lime admixture to BA in other to achieve optimal strength when ever BA is to be used to stabilize BCS.

V. RECOMMENDATION

Federal ministry of works should support the use of bagasse ash and lime for mechanical stabilization of road pavement, since it will help fulfill the requirements of ISO 9001:2018 standards.

CONTRIBUTION TO KNOWLEDGE

The use of BA and lime will help engineers to properly analyze and design sub grades road pavements in locations where black cotton soil exist.

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APPENDICES I

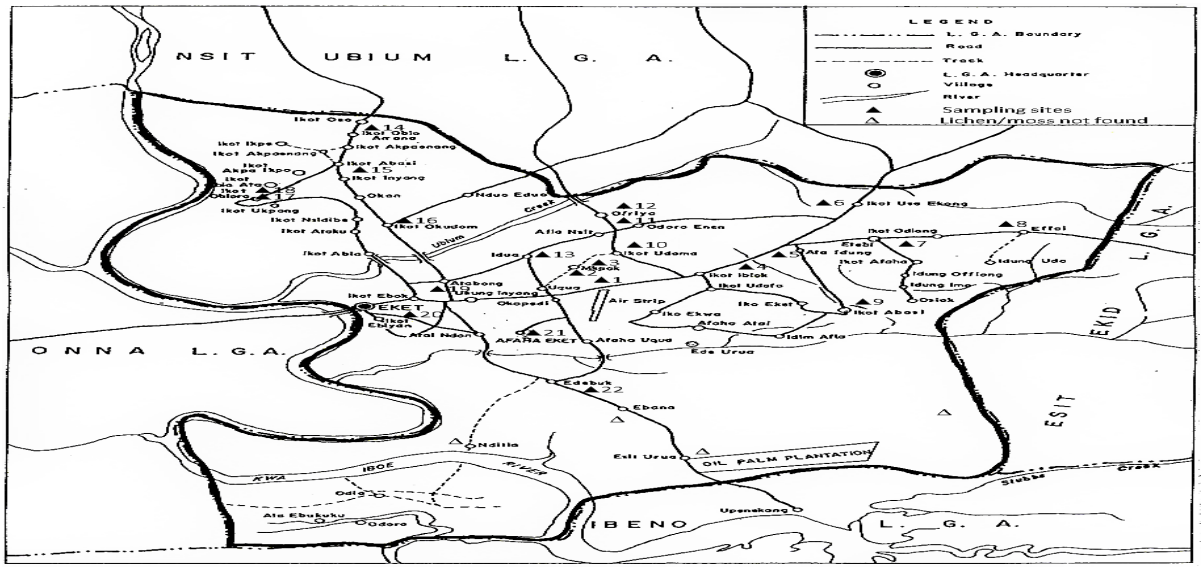

Plate 1.1 showing the study area of Eket senatorial district of Akwa Ibom state

APPENDIX II

Plate 1.2.1 Processing stage of bagasse fibrous

Plate 1.3. bagasse refining

Plate 1.5 Raw sugar cane plant processed to bagasse

Plate 1.4 refined bagasse fibrous

Plate1.6 Incinerated bagasse fibrous cotton soil

Plate 3.3 liquid limit testing of black

Plate 3.1 stacked arranged sieve