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Improvement of Geotechnical Properties of Black Cotton Soil by Ggbs and Metakaoline

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ABSTRACT

Black cotton soil is one of the major deposits of India. They exhibit height rate of swelling and shrinkage when exposed to change in moisture contentand hence have been found to be most troublesome from engineering consideration. These soils expand and become sticky during the dry season causing deep cracks into the soil. An objective of the project is to stabilize the BC soil and made the stable structures. For the stabilization process Ground Granulated Blast Furnace slag (GGBS) which is locally available industrial waste and metakaoline is used as admixtures. In this research, different amount of GGBS are added separately i.e. 4, 8, 12% by dry weight of soil and addition of 4%, 8% and 12% of Metakaolinare used for the stabilization of soil,The performance of stabilized soil are evaluated using physical and strength performance tests like specific gravity, Atterberg limits, standard proctor test and California Bearing Ratio (CBR) test at optimum moisture content. The result shows that the use of GGBS and metakaoline increases the soil stabilization.

KEYWORDS: Ground Granulated Blast Furnace slag (GGBS)**,** Black cotton soil (BC),California Bearing Ratio (CBR),Metakaoline.

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INTRODUCTION

India is a country of large dimensions with different climatic and geological conditions. Due to different geological conditions, it is having different verities of soil from one place to another. One among them is black cotton soil, which is also known as problematic soil. Because of the high degree of compressibility and instability, low compressive strength(less than 40kpa) and potential to swell with high water content as it contains minerals such as montmorillonite that are able to absorb water. Therefore, when this soil is encountered in location designated for civil engineering projects, the possible alternative solutions can be either abandon the site, or remove and replace the soil. However, these solutions are not always feasible and they can be expensive. Thus, the researchers have investigated improving the engineering properties of the native problem soil by several methods, most importantly soil stabilization.

Soil stabilization is the process of amending the physical properties and geotechnical characteristics of the soft soil such as strength, permeability, durability and compressibility either mechanically or by addition of chemical stabilizers to be suitable for construction and meet engineering design standards including permanency. Cement and lime are most important traditional stabilizers and have been investigated by many researches. However, cement production has many drawbacks such as carbon dioxide emission, energy consumption and natural resources exhausting. The negative environmental impact of cement manufacture in addition to the high cost has encouraged the researchers to find sustainable alternatives to replace cement partially or totally in soil stabilization. These materials are called supplementary cementations materials which are waste or by-products and process hydraulic or pozzolanic characteristics such as fly ash, rice husk and GGBS. The use of the waste and by-product materials for soil stabilization can help mitigate the issues of disposal and environmental pollution.

In this research GGBS and metakaoline is used as the admixture to stabilize the soil. By the laboratory test Liquid limit, Plastic limit, Specific gravity, Plastic index test, Standard proctor test, Unconfined confined test, California bearing ratio test. GGBS is taken in the different ratio i.e 4%, 8% and 12% and metakaoline is taken as 4%,8% and 12%. Analyze the properties of Black Cotton Soils for their index and shrinkage parameters. Compare the California bearing ratio of Black Cotton soils and without addition of GGBS and metakaoline.

AIM AND OBJECTIVES:

The aim of this research is to using GGBS and metakaoline as the stabilization of Black Cotton soil. The specific objectives of this study include:

- Determination of the properties which reflect engineering behavior of the back cotton soil as well as GGBS and metakaoline.
- Determination of the index properties and the properties relating to strength of the black cotton soil – GGBS and metakaoline mixtures;
- To evaluate the effect of optimum GGBS and metakaoline content on index properties and Atterberg limits that are LL, PL and PI of black cotton soil ,GGBS and metakaoline mixtures.
- Determination of the optimum GGBS and metakaoline content on strength characteristics of the black cotton soil – GGBS and metakaoline mixtures.

SCOPE:

- The effects of industrial waste on the strength characteristics of an expansive soil can be investigated.
- In future study testes can be carried on black cotton soil or on different types of soil.
- The problems like contraction, expansion, less bearingcapacity can be eliminated in the Research.

NEED FOR PROJECT:

To increase the black cotton soil compressive stress by adding the admixturesof Ground Granulated Blast Furnace and metakaoline. The properties of black cotton soil get effectively modified by varying proportions of GGBS and metakaoline. Due to administration many lands can be left unused that must be contain BC soil or clay. So it necessary to stabilize BC soil for increasing the use of that land.

SITE LOCATION:

- Site sample are collected from Kanchipuram.
- Soil sample collected are Black Cotton Soil.

Fig 1 Site Location

LITERATURE REVIEW

Ashish Kumar Pathak[1]investigated the effect of GGBS on the engineering property (optimum moisture content and maximum dry density, plastic limit, liquid limit, compaction, unconfined compressive strength, triaxial and California bearing ratio test) of the soil and determine the engineering properties of the stabilized. Laxmikantyadu and R. K. Tripathi[2]evaluated the performance of GBS with fly ash modified soil using compaction and California bearing ratio(CBR) test. Ormila& Preethi[3] studied the effect of adding GGBS to expensive soil collected from Palur, Tamil Nadu at various percentages (15%, 20%, and 25%). Sharma & Sivapullaiah[4]studied the use of fly ash and/ or GGBS with lime as a stabiliser added to a black cotton soil. Dr. H.V. Hajare and Er. Sanjay[5] soil stabilization by using Ground granulated blast furnace slag (GGBS).Manjunathetal6on the unconfined compressive strength properties of black cotton soil. Lime and GGBS were added in various combination with curing of 0, 7 & 28 days. The results showed that soil stabilized with GGBS and lime gave strength higher than that with lime only.

BLACK COTTON SOIL OR EXPANSIVE SOIL

Black cotton soils are generally reddish brown to black in color and occur from 0.5m to 10m deep and have high potential for shrinking or swelling as a result of changing moisture content. Due to intensive shrink-swell processes, surfaces cracks resulting in openings during dry seasons. Black cotton soil have low strength and are susceptible to excessive volume changes, making their use for construction purpose very difficult.

Fig 2 Black Cotton Soil

GROUND GRANULATED BLAST FURNACE (GGBS):

Ground Granulated Blast Furnace Slag is obtained by quenching Melton iron slag (a by-product of iron and steel making) from a blast furnace in water or stream, to produce glassy, granular product that is then dried and ground into a powder. These operate at a temperature of about 1500 degrees centigrade and are fed with a carefully controlled mixture of iron-ore, coke and lime stone. GGBS has cementations properties, which makes a suitable partial replacement additive to Portland cement. GGBS Slag is primarily made of silica, alumina, calcium oxide, and magnesia (95%) and other elements like manganese, iron, sculpture and trace amounts of other elements (5%) of slag. To

increase the strength when GGBS is added to the soil, it also reacts with water and produces silica hydrates from its available supply of calcium oxide and silica.

Fig 3 GGBS

Table 1: Chemical Properties Of GGBS

ITEMS	CaO	SiO	Al_2O_3	MgO	Fe_2O_3	SO_3	K_2O	TiO_2	pH
GGBS	40.13	37.73`	5.75	4.26	0.01	0.0	0.61	0.65	8.5

Metakaolin (MK)

Metakaolin is fine aluminosilicate having pozzolanic activity. It is manufactured by the calcinations process of Kaolinite clays at a temperature of 550□C-900□C. Metakaolin used in this study is shown in Figure 4 and it was acquired from Ashirwad Chemicals, Chennai, India. For improving the geotechnical properties of black cotton soil, Metakaolin is chosen as a Traditional stabilizer. It is white in colour and amorphous. It had specific gravity of 2.5. Narrow limits of chemical composition and minor amounts of impurity components are present in Metakaolin obtained from purest grades of Kaolinite.

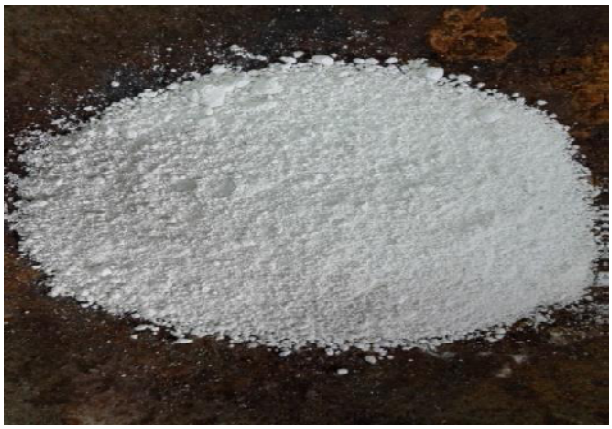

Fig 4: Metakaolin

Table 2: Physical Properties of Metakaolin

Colour	White
Shape	Oval and Flaky
Size	2-10µm
Physical form	Powder
Specific Gravity	2.5
Specific Surface Area	10-25 m2/g

Table 3: Chemical composition on Metakaolin

Composition	Percentage (%)
Silica (SiO2)	52.10
Alumina (Al2O3)	40.50
Ferric oxide (Fe2O3)	2.50
Calcium oxide (CaO)	1.00
Magnesium oxide (MgO)	0.19
Sodium oxide (Na2O)	0.12
Potassium oxide (K2O)	0.50
Loss on ignition (LOI)	0.68

EXPERIMENTAL INVESTIGATION

Influence of GGBS and Metakaolin on Atterberg Limits

In this study, the influence of GGBS and Metakaolin on the plasticity characteristics of Black cotton soil was determined by conducting Atterberg limits test as per IS: 2720 (Part 5) – 1985. An experimental investigation on Atterberg limits were conducted on the soil samples treated with 4%, 8% and 12% of GGBS and 4%, 8%, and 12% of Metakaoline . Atterberg limits test was conducted to determine the influence of three different stabilizers on Liquid Limit (LL), Plastic Limit (PL) and Plasticity Index (PI) and the rate of decrease in plasticity characteristics after varied curing periods. Tests also aimed to determine the optimum values of these materials.

Influence of GGBS and Metakaolin On CBR

In this study, the influence of GGBS and Metakaolinon California Bearing ratio value of Black cotton soil was determined by conducting CBR test.CBR test were conducted on the soil samples treated with 4%, 8% and 12% of GGBS and 4%, 8%, and 12% of Metakaoline. CRB test was conducted to determine the CBR value of the treated black cotton soil.

Influence of GGBS and Metakaolin On Unconfined compression Test

In this study, the influence of GGBS and Metakaolinon Unconfined compression test of Black cotton soil was determined by conducting unconfined compression test.Unconfined compression test were conducted on the soil samples treated with 4%, 8% and 12% of GGBS and 4%, 8%, and 12% of Metakaoline . Unconfined compression test was conducted to determine the stress –strain behavior of the treated black cotton soil.

RESULTS AND DISCUSSION

Specific Gravity

TABLE - 4

RATIO	SPECIFIC GRAVITY
BC SOIL	2.81
BC SOIL + 4% GGBS + 4% Metakaoline	2.11
BC SOIL + 8% GGBS + 8% Metakaoline	1.93
BC SOIL + 12% GGBS + 12% Metakaoline	1.85

GRAPHS FOR SPECIFIC GRAVITY:

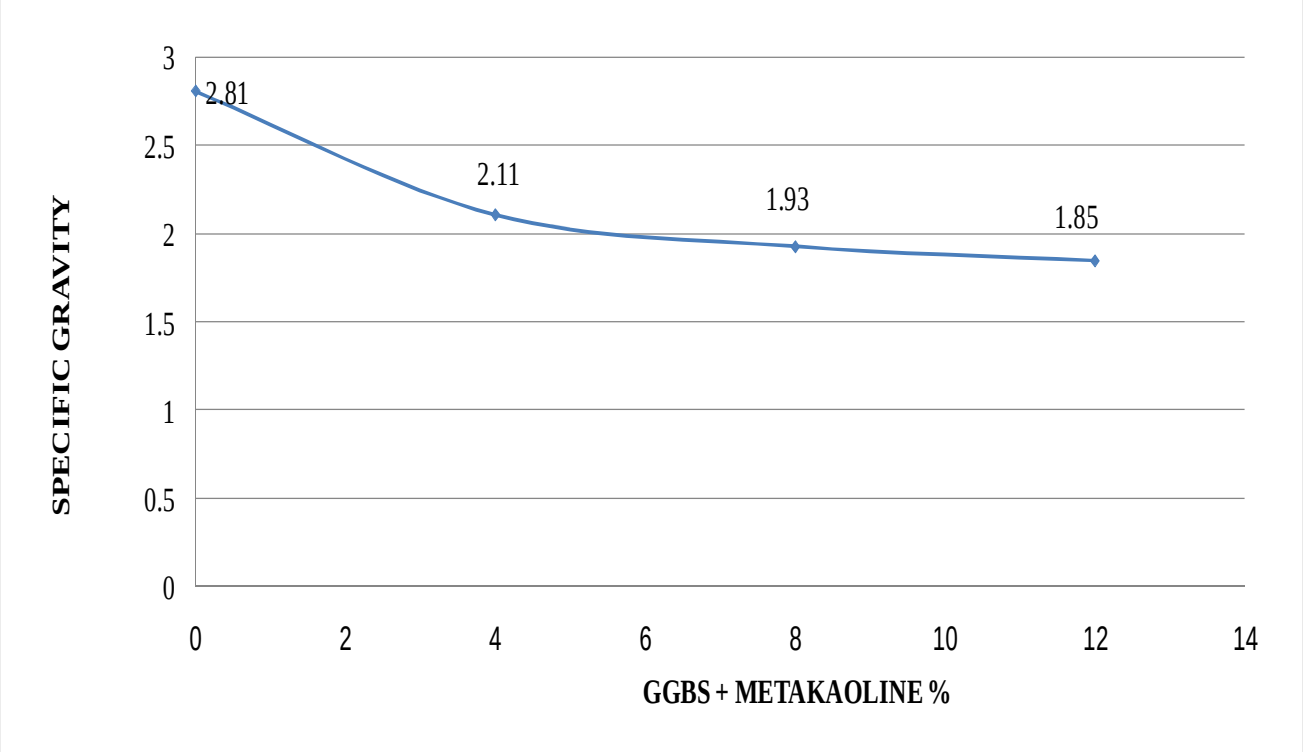

Fig 5 Graph For Specific Gravity

LIQUIDLIMITS

TABLE - 5

RATIO	**LIQUID LIMIT**
BC SOIL	11.1%
BC SOIL + 4% GGBS + 4% Metakaoline	10.46%
BC SOIL +8% GGBS + 8% Metakaoline	15.35%
BC SOIL + 12% GGBS + 12% Metakaoline	11.46%

PLASTIC LIMITS

TABLE - 6

RATIO	PLASTIC LIMIT
BC SOIL	26.46%
BC SOIL + 4% GGBS+ 4% Metakaoline	37.43%
BC SOIL + 8% GGBS + 8% Metakaoline	16.36%
BC SOIL + 12% GGBS+ 12% Metakaoline	25%

STANDARD PROCTOR COMPACTION

TABLE - 7

RATIO	MAXIMUM DRY DENSITY	OPTIMUM MOISTURE CONENT
BC SOIL	16.425	6.685
BC SOIL + 4% GGBS+4% Metakaoline	13.848	11.665
BC SOIL + 8% GGBS+ 8% Metakaoline	14.486	10.41
BC SOIL +12% GGBS+12% Metakaoline	14.610	6.823

CALIFORNIA BEARING RATIO

TABLE - 8

RATIO	CBR %
BC SOIL	4.64
BC SOIL + 4% GGBS +4% Metakaoline	10
BC SOIL + 8% GGBS+ 8% Metakaoline	16
BC SOIL + 12% GGBS+12% Metakaoline	12

GRAPHS FOR CBR:

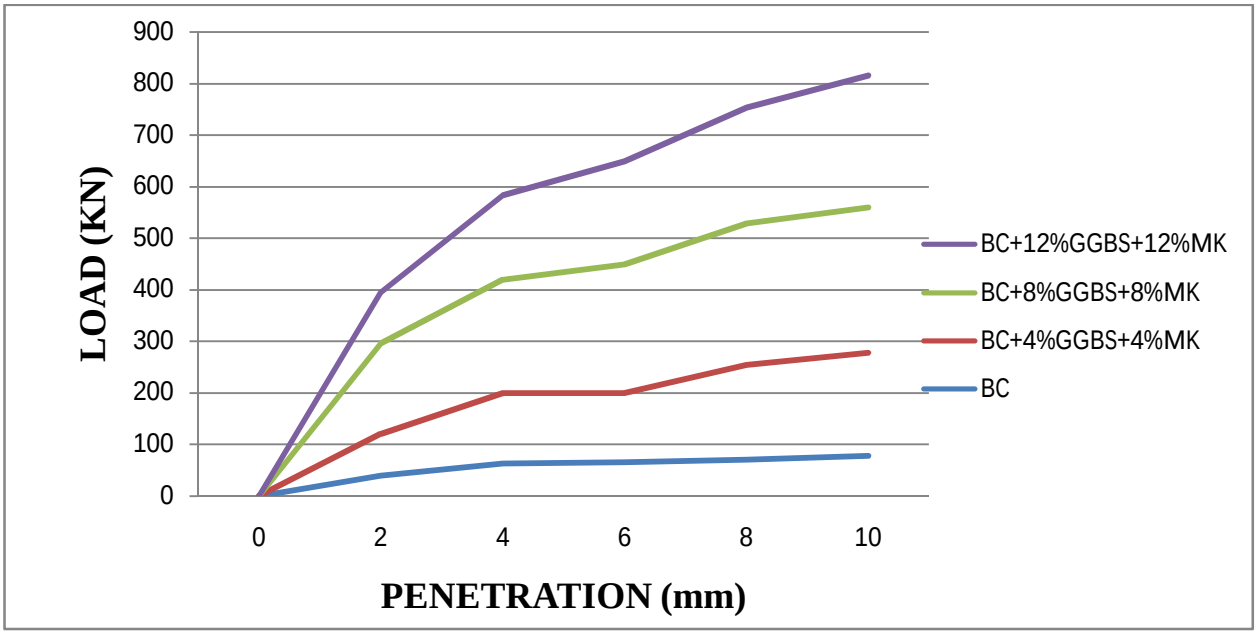

FIG 6: LOAD - PENETRATION CURVE

UNCONFINED COMPRESSION TEST:

TABLE -9

RATIO	CS (KN/m^2)
BC SOIL	260
BC SOIL + 4% GGBS+4% Metakaoline	284.5
BC SOIL + 8% GGBS+ 8% Metakaoline	245.5
BC SOIL + 12% GGBS+12% Metakaoline	308

GRAPHS FOR UNCONFINED COMPRESSION TEST:

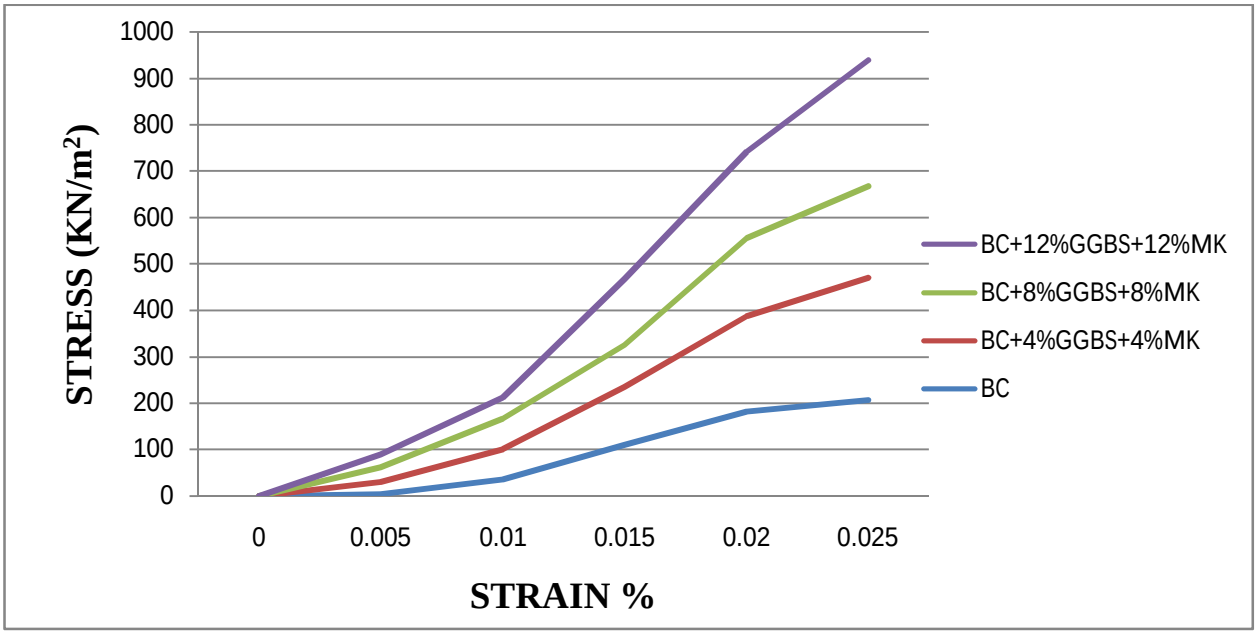

Fig 7 Stress - Strain Curve

CONCLUSION

- The study has been successfully conducted to assess the geotechnical properties of clay improved with GGBS slag and Metakaoline. The slag altered the clay soil by reducing the fine particles.
- The soft soil is identified to be organic clay with low compressibility(CL) according to the IS classification system. The soil is required to be stabilized before doing any construction work.
- Swelling potential of expansive soil diminished with the addition of admixtures. The compressibility of soil reduces with GGBS slag and Metakaoline.
- The specific gravity for an untreated BC soil is 2.81 and it is gradually decreased by 2.11, 1.93 and 1.85 by adding 4%, 8% and 12% of GGBS and Metakaoline respectively. So it is low density material.
- The liquid limit for untreated BC soil is 11.1 and it is increased to 15.35 in addition of 8% GGBS and Metakaoline.
- The plastic limit for untreated BC soil is 26.46%. it reaches its high value when 4% GGBS and Metakaoline is added.

- In this study black cotton soil is stabilized with addition of GGBS slag and Metakaoline. The optimum value of maximum dry density is achieved for black cotton soil mix of 4% by GGBS slag and Metakaoline.
- The CBR value of untreated BC soil was found to be 4.64, it reach its high value of 16 when 8% GGBS and Metakaoline is added.
- The Optimum Moisture Content of an untreated BC soil is found to be 6.685. It reaches its high value 11.665 when 4% GGBS and Metakaoline is added.
- Compressive stress value for untreated BC soil is 260 KN/m^2 and it reaches its high value of 308 KN/m^2 when 12% GGBS and Metakaoline is added.
- By adding the GGBS and Metakaoline the bearing capacity of the soil is increased.
- Thus on this Research BC soil is attains its required strength and it is very much useful for pavement laying in road construction.

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