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The Improvement of Engineering Properties of Expansive Soil using Lime and Ground Granulated Blast Furnace Slag

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Abstract: ***This laboratory work is an attempt to investigate the effect of ground granulated blast furnace slag and lime on the stabilization of expansive soils. Expansive soils are always characterized by their high expansive and shrinkage behavior and low bearing capacity, on drying along with wide polygonal cracks and high swelling on wetting. Expansive soils (problematic soil) are present in different parts of the world and in many states of India. In the resent study samples of expansive soil were collected from Jabalpur city. Currently many techniques are used for improvement of expansive soil; we have used ground granulated blast furnace slag (GGBFS) and lime. GGBFS is a waste product produced by manufacturing process of steel. Different lab tests on expansive soil without the addition of this waste and with the addition of this waste were performed and their effect on MDD and other properties were determined and this may be an economical and environmental solution for the areas where steel plants are located.***
Keywords: Black cotton soil (BCS), Ground granulated blast furnace slag (GGBFS), Lime, Engineering properties, Optimum moisture content (OMC), UCS test.

I. INTRODUCTION

Expansive soils are known worldwide for their volume change behavior due to variation of water content in it. Expansive soil are found worldwide, mainly in the arid and semi arid regions such as Australia, Canada, China, India, united state and south Africa. In India expansive soil are popularly known as black cotton soil due to its black in color and high productivity of cotton in it. In India the black cotton soil covers an area about 0.66 million sq. Km. which is about 20% of the total land area. Expansive soils are considered as problematic due to significant volume changes associated with changes in water content. It expands when water is added and shrinks when they dry out. This change in volume can exert sufficient stress on a building, sidewalls, driveways, basements floors, pipelines and even foundations to cause damage. An expansive soil expands due to the presence of highly reactive clay mineral such as montmorilonite. So this soil at the site is not ideal for construction, the engineer can go for removing or replacing the soil. Thus the need of treating soil arises in order to utilize the locally available soil, Lime is well known additive for the stabilization of expansive soils. This additive is produced from industrial processes and is associated with the emission of greenhouse gases such as carbon dioxide (CO_2), sulfur dioxide (SO_2) and nitrous oxide (N_2O). Industrial by-product materials such as fly ash, GGBFS, cements kiln dust and lime stone dust can also used as a stabilizer. By using this by- products environmental and economical problems can be solved.

The purpose of this study is to investigate the joint effect of lime and ground granulated blast furnace slag (GGBFS) in the stabilization of expansive soils. The industrial waste product GGBFS is an annual production of 12 to 15 million tones. And this by-product has great potential to be used as a stabilizing agent.

II. MATERIALS AND PROPERTIES

1) *Black Cotton Soil:* The black cotton soil (BCs) used in this study was collected from Jabalpur, Madhya Pradesh. While selecting the site it was visually inspected, soil sample were collected from area having wide cracks in soil in dry condition. The properties of the soil collected from the site tabulated such as:

Table 1 Properties of black cotton soil

S. no.	Particulars	observation
1.	Specific gravity	2.21
2.	Liquid limit	62.23
3.	Plastic limit	21.56
4.	Plasticity index	40.67
5.	Passing 75µ sieve	77.54%
6.	Differential Free soil index	52.22%

2) *Ground Granulated Blast Furnace Slag (GGBFS):* Ground-granulated blast-furnace slag (GGBS or GGBFS) is a non- metallic by product obtained in the process of iron and steel manufacturing. Produce by quenching of molten iron slag from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. The GGBFS used in this study is obtained by Ambica steel limited, Sahibabad, Ghaziabad, uttar Pradesh, India. The properties of GGBFS are tabulated in table 2 and 3.

Figure1. Ground granulated blast furnace slag (GGBFS)

Table 2 Physical properties of GGBFS

S. no.	Particulars	Observation
1.	Type	powder
2.	Specific gravity	2.82
3.	Passing 75µ sieve	98%

Table 3 Chemical properties of GGBFS

S. No.	Particulars	Percentage
1.	SiO_2	37.5 %
2.	Al_2O_3	11.43 %
3.	CaO	42.8 %
4.	MgO	6.61 %
5.	Fe_2O_3	3.8 %
6.	K_2O	0.41 %
7.	Na_2O	0.21 %
8.	Cr_2O_3	<0 .01 %
9.	TiO2	0.22 %
10.	MnO	0.03 %

Source: http://www.nationalslag.org/blast-furnace-slag

3) *Lime:* Lime is a calcium-containing inorganic mineral in which oxides and hydroxides predominate. The term, lime is calcium oxide or calcium hydroxide. It is also the name of the natural mineral (native lime) CaO. Lime has number of effects when it added in to the soil like soil drying, soil modification and soil stabilization. Commercial lime used in this laboratory work which is easily available in the market.

4)

III. TESTING METHODOLOGY

The various tests can be conducted in the geotechnical laboratory to characterize the engineering properties of plain black cotton soil and stabilized soil. Following tests were performed in the laboratory as per the relevant IS codes:

A. Proctor test (IS: 2720 PART--VII)-1980.
B. Unconfined compressive strength test (IS: 2720 PART-X)-1991.

IV. SAMPLE PREPARATION

The samples used in the study are prepared by blending black cotton soil with different percent of GGBFS. Lime is used as a stabilizer in this research.

The samples are prepared as such-

A. The black cotton soil, lime and GGBFS are oven dried separately.
B. The oven dried black cotton soil, lime (0%, 4%, and 6%) and GGBFS (0%, 10%, 20%, and 30%) are mixed in proportions by weight to form various mixes.
C. The formed dry mixes are being blended together with water in order to get a homogeneous blend as per the requirement of test.
D. In these blended soil samples geotechnical test performed as per the IS specifications.

V. RESULTS AND DISCUSSION

The laboratory tests are conducted in the geotechnical laboratory, Jabalpur engineering college, Jabalpur. Based on the extensive laboratory investigations on the various samples the following test results have been made.

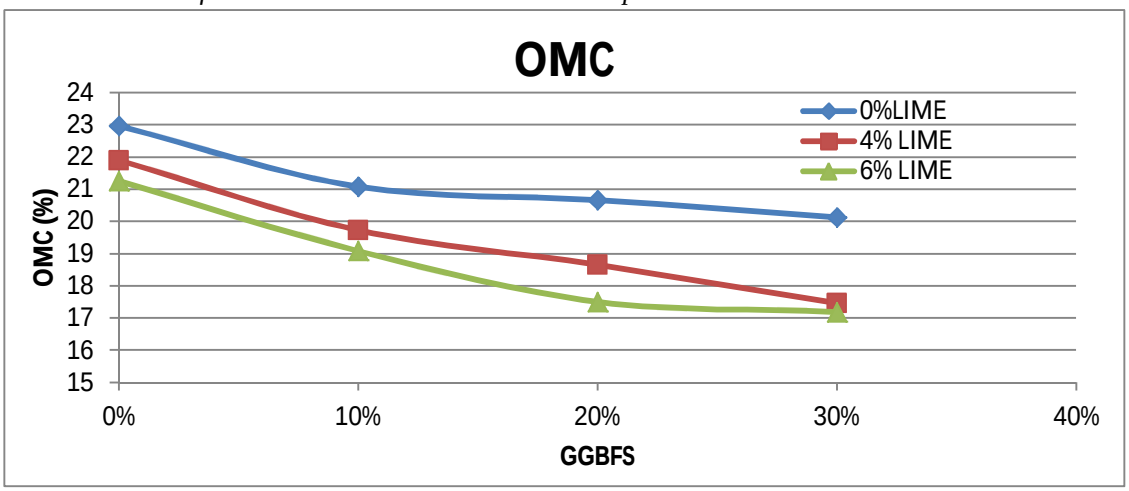
Figure2. Unconfined compressive strength test (UCS)

Table 4 Effect of GGBFS and lime on engineering property of BCs

Content (%)		Engineering properties		
Lime (%)	GGBFS (%)	OMC (%)	MDD (gm/cc)	UCS (KN/m^2)
0	0	22.96	1.597	111.75
0	10	21.08	1.645	144.05
0	20	20.66	1.658	161.20
0	30	20.13	1.671	177.03
4	0	21.90	1.627	130.33
4	10	19.73	1.683	165.65
4	20	18.65	1.702	188.48
4	30	17.46	1.720	204.23
6	0	21.25	1.632	139.28
6	10	19.08	1.734	177.08
6	20	17.50	1.745	210.73
6	30	17.19	1.729	201.03

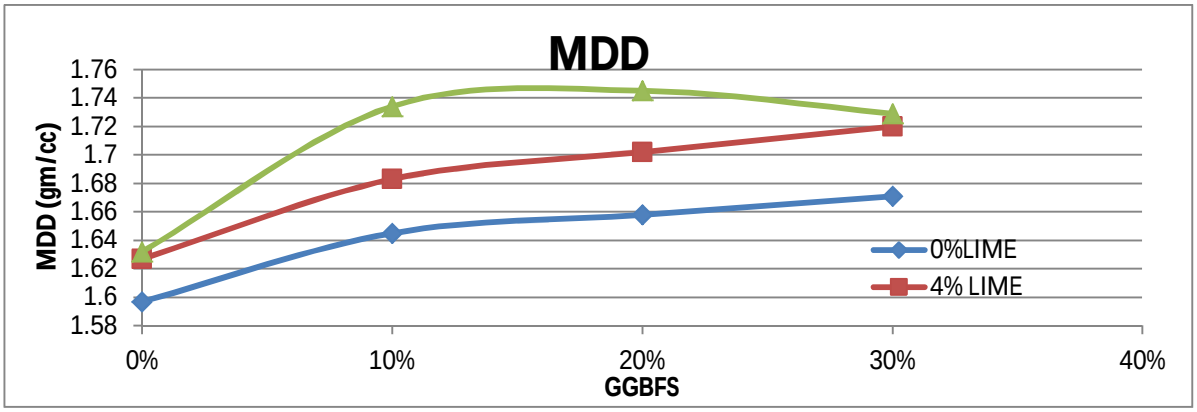
The following graphs were observed

A. Optimum Moisture Content Of Lime Stabilized Soil And Blended Samples



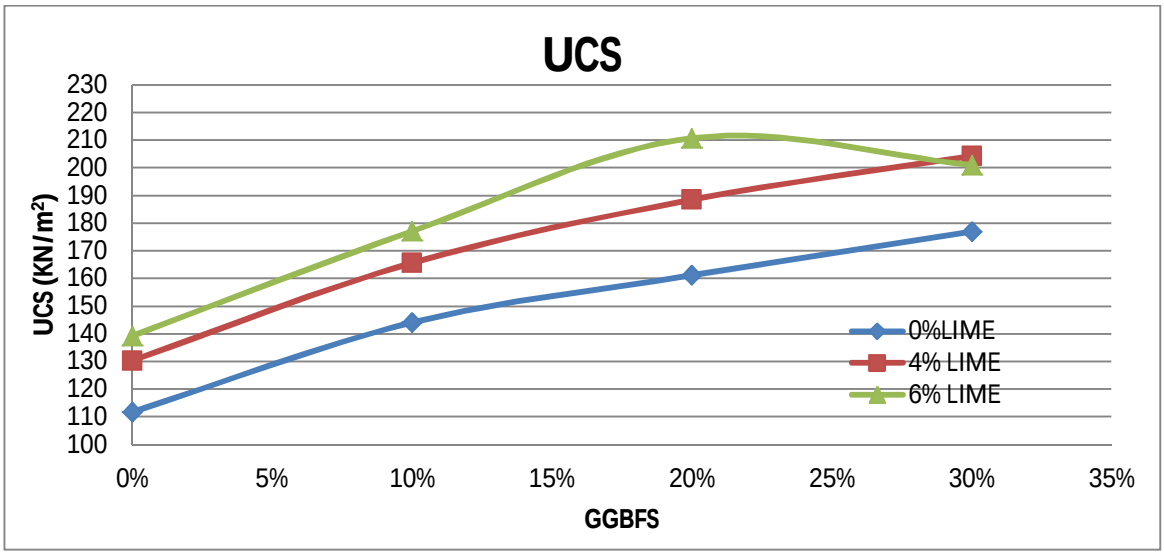
Graph 1 Variation of Optimum moisture content of soil in different percent of GGBFS

B. Maximum Dry Density Of Lime Stabilized Soil And Blended Samples



Graph 2 Variation of maximum dry density of soil in different percent of GGBF

C. Unconfined Compressive Strength Of Lime Stabilized Soil And Blended Samples



Graph 3 Variation of unconfined compressive strength of soil in different percent of GGBFS

VI. CONCLUSION

The maximum dry density of the plain BCs is 1.597 gm/cc, it increases to 1.645 gm/cc on addition of 10% GGBFS with 0% lime in the soil and goes to increase with increasing the GGBFS and lime percent. The maximum value of MDD, 1.745 gm/cc achieved by adding 20% GGBFS and 6% lime on dry weight of the black cotton soil, and OMC at this percentage of stabilizer is 17.5%. Based on the above study it can be concluded that ground granulated blast furnace slag has good potential to utilize it for the stabilization of weak soil and to utilize it in many geotechnical applications like road sub grades, foundation soils and embankments etc.

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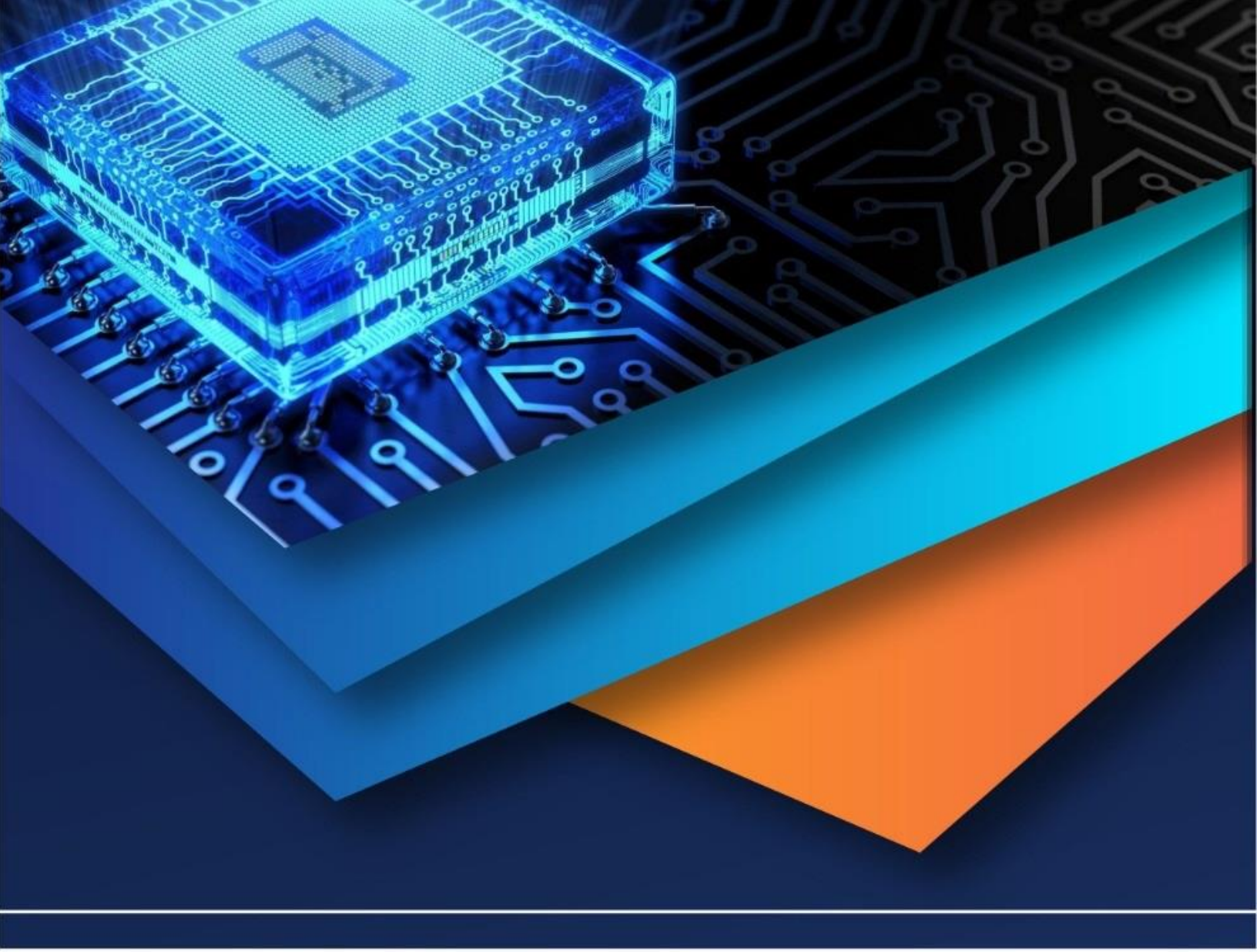

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