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Improvement of CBR and Compaction Characteristics of Black Cotton Soil Using Lime and Blast Furnace Slag

Ashutosh Rawat[1], Rajesh Jain[2], Shyam Singh Parte[3]
[1]M.E. (Geotechnical Engineering), [2]Associate professor, [3]Asst. professor
Civil Engineering Department, Jabalpur Engineering college (JEC), Jabalpur, (M.P.) India

Abstract: ***Stabilization is an unavoidable for the purpose of highway and runway construction, stabilization denotes improvement in both strength and durability which are related to performance good qualities of sub grade soils are preferable for durable road but not always available for highway construction. So the most appropriate method will usually be determined by economic considerations, for example it may be cheaper to stabilize a soil using relatively expensive additives rather than excavate and dispose of unsuitable materials and place suitable fill, as well as the properties of the sub grade. In this experimental study has been conducted in two stages as- stage i: variation of bfs are added i.e. 10, 20, 30, 40 and 50% by dry weight of soil into the soil. The result obtained in stage i is not satisfactory as at increases a cost of stabilization due to higher amount of bfs consumed during stabilization thus we move on next stage. Stage ii: two proportion of bfs are added i.e. 10%, 20% with fixed amount of lime (=2%) are added to soil and is used to study the stabilization of soil. The performances of stabilized soil are evaluated using strength performance tests like standard proctor test and california bearing ratio (cbr) test at optimum moisture content. Addition of bfs to soil in an optimum quantity i.e. 20% with 2% of lime proved beneficial and got best result for maximum dry density and cbr.***

keywords: blast furnace slag, back cotton soil, cbr, mdd.

I. INTRODUCTION

Now-a-days the utilization of waste products with soil has gained attention due to the shortage of suitable soil and increasing problems of industrial waste management. In any highway engineering work the construction of the embankment or the sub grade is a very important activity. Many researchers have worked on improving properties of black cotton soil with the help of BFS, results of some are as;

K.V. Manjunath, It is observed that with increase of slag, more stability of soil is achieved as compared to using lime alone. UCC strength of Ordinary Black Cotton Soil which was found out to be 188.5kN/m2, increased to 3429.37 kPa. Finally, this study concluded that For the proportion of (BC soil + 30% slag) + 4% lime at OMC on 28th day with proper curing, UCC strength has increased up to 18 times that of ordinary Black Cotton Soil i.e. (3429.37 kN/m2).

GyanenTakhelmayum, It is investigated that the increase in dry density with increase in fine and coarse GGBS mixture is due to enhanced C-S-H formation compared to using Soil alone. this enhanced C-S-H occupies pore spaces, normally occupied by calcium hydroxide in the hydration of pozzolanic reaction taking place in mixtures which uses the excess SiO_2 from the slag source, Ca $(OH)_2$ produced by the hydration of the silicates, and water to produces more of the desirable C-S-H making slag a beneficial mineral admixture to attain and increase in dry density. It is found that the maximum density was about 1.72 g/cc for 70% soil and 30% GGBS mixture.

Abhlilash Devanoor, Studied that the soil stabilization using blast furnace slag and found that the optimum MDD value 1.80g/cc at 50% BFS and optimum CBR value 9.8 at 50% BFS. It is observed this effect is mainly attributed to the hydration reaction of Blast furnace slag were the
pores are filled by crystalline growth.

II. MATERIALS

A. Black cotton soil

The soil is selected for this study is black cotton soil collected from sagda railway station, sagda Jabalpur (M.P.). Coordinates of this

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site work are: $23^0$8'30"N and $79^0$51'53"E.

Table-1: Physical Properties of Black Cotton Soil without any stabilizer

S.NO.	PROPERTIES	VALUES
1.	SOIL CLASSIFICATION	CH
2.	SPECIFIC GRAVITY	2.45
3.	LIQUID LIMIT	61.34%
4.	PLASTIC LIMIT	25.51%
5.	PLASTICITY INDEX	35.83%
6.	DFS	70%
7.	OPTIMUM MOISTURE CONTENT	16.1%
8.	MAXIMUM DRY DENSITY(g/cc)	1.82
9.	CBR	2.37

B. Blast furnace slag

Blast furnace slag is produced as a by-product during the manufacture of iron in a blast furnace. Molten blast furnace slag has a temperature of 1300-1600°C and is chilled very rapidly to prevent crystallization. The granulated material thus produced is known as granulated blast furnace slag. Blast furnace slag has a glassy, disordered, crystalline structure which can be seen by microscopic examination which is responsible for producing a cementing effect. The blast-furnace slag (BFS) samples were collected from the *Monnet Ispat & energy limited Distt. Raigarh (chhatisgarh).* Black cotton soil used in this study was replaced with Blast furnace slag in different proportions i.e. 10, 20, 30, 40, and 50% by weight of the soil to obtain the optimum amount for stabilization.

Table-2: Chemical composition of Blast furnace slag

S.NO.	Name of the chemical	Symbol	% by weight
1.	Silica	SiO_2	27 -38
2.	Alumina	Al_2O_3	7 – 15
3.	Ferric Oxide	Fe_2O_3	0.2 – 1.6
4.	Manganese Oxide	MnO	0.15 – 0.76
5.	Calcium Oxide	CaO	34 – 43
6.	Sulphur Trioxide	SO_3	up to 0.07
7.	Potassium Oxide	K_2O	0.08 to 1.83
8.	Loss on ignition		0.20 to 0.85

IV. METHODOLOGY

The following tests were conducted on black cotton soil and BFS mixes as per relevant IS codes of practice:
MODIFIED PROCTOR TEST
CBR TEST

V. MIX PREPARATION

STAGE I: Following mix has been prepared with different percentage of BFS.
Soil Sample + 0% BFS (CB0)
Soil Sample + 10% BFS (CB10)
Soil Sample + 20% BFS (CB20)
Soil Sample + 30% BFS (CB30)
Soil Sample + 40% BFS (CB40))
Soil Sample + 50% BFS (CB50)
STAGE II: Following mix has been prepared with different percentage of BFS and fixed quantity oh lime i.e. 2% by dry weight of dry soil.

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Soil sample+2% Lime+10% BFS(CL2B10)
Soil sample+2% Lime+20% BFS(CL2B20)

VI. RESULTS AND DISCUSSION

Stage I: In these stage variation of BFS are added i.e. 10, 20, 30, 40 and 50% by dry weight of soil into the soil.
The results obtained during experimental investigation in stage I are as-

Table-3: Test results of Black Cotton Soil with BFS (%)

S.NO	SAMPLE TYPE	OMC (%)	MDD (g/cc)	CBR (%)
1.	CB0	16.10	1.82	2.37
2.	CB10	15.70	1.84	3.26
3.	CB20	14.65	1.89	4.37
4.	CB30	13.8	1.93	5.26
5.	CB40	11.40	1.98	7.41
6.	CB50	10.20	2.05	8.74

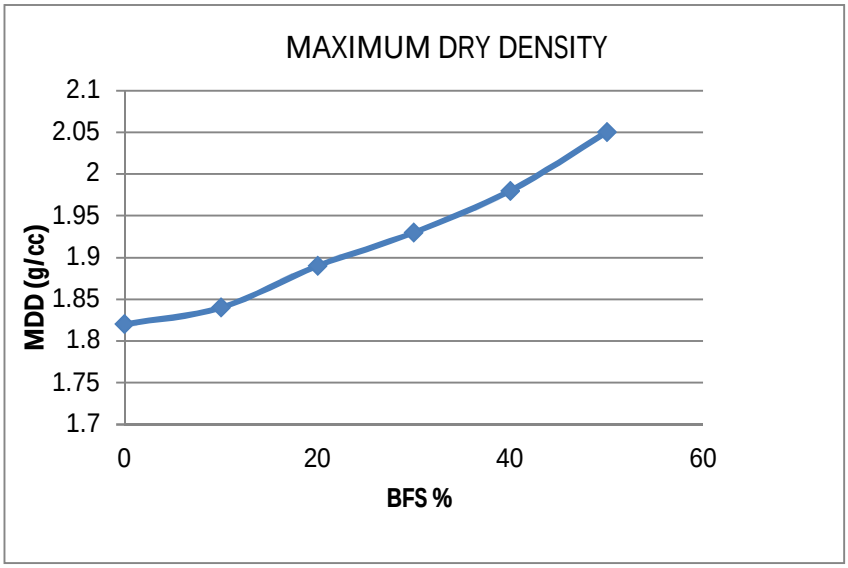

Fig-1: Variation of MDD due to increase in BFS content

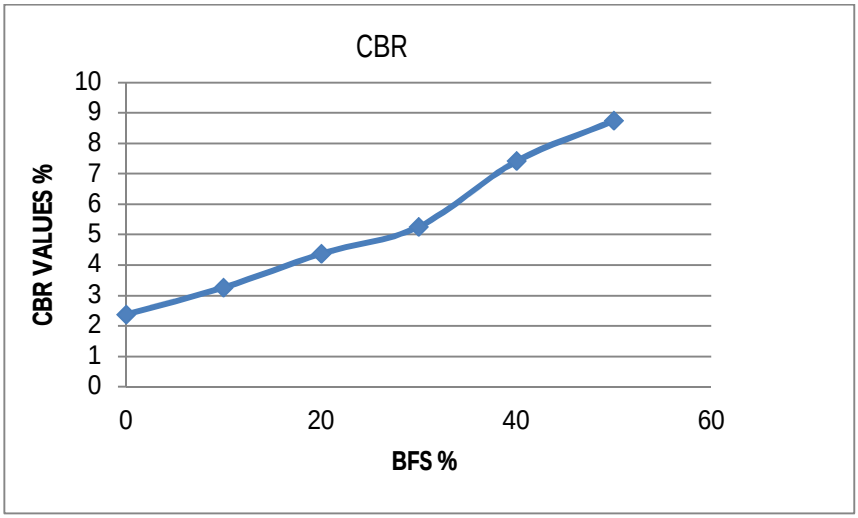

Fig-2: Variations in CBR values due to increase in BFS content

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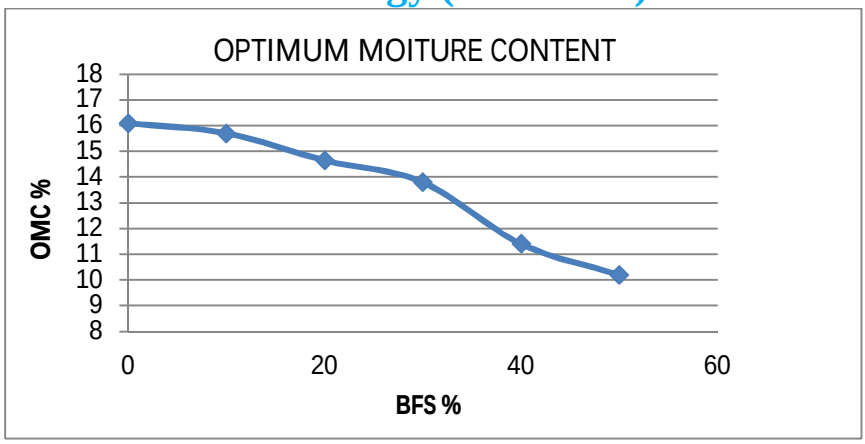

Fig-3: Variation of OMC due to increase in BFS content

A. Lime treated clay soil

The lime treated clay soil was prepared after mixing the 2% lime by weight of dry soil into black cotton soil. Further, Laboratory tests like modified proctor test and CBR test were conducted on lime treated black cotton soil with 10% and 20% of BFS.

Table-4: Test result of black cotton soil treated with lime(2%)

S.NO	PROPERTY	VALUE
1.	Liquid limit(%)	55.31
2.	Plastic limit(%)	35.33
3.	Plasticity index(%)	19.88
4.	OMC(%)	14.9
5.	MDD(g/cc)	1.84
6.	CBR(soaked) value(%)	7.85

The results obtained during experimental investigation in stage II are as-

Table-5: Test results of lime(2%) treated black Cotton Soil with BFS (%)

S.NO	SAMPLE TYPE	OMC (%)	MDD (g/cc)	CBR (%)
1.	B.C SOIL+2%LIME+10%BFS	14.82	1.86	8.07
2.	B.C. SOIL+2%LIME+20%BFS	14.12	1.94	11.41

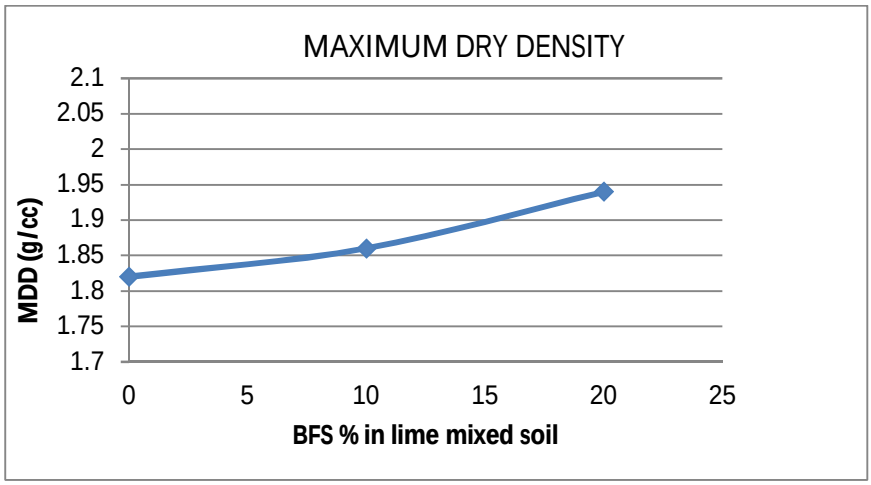

Fig-4: Variation of MDD due to increase in BFS content in lime(2%) mixed soil

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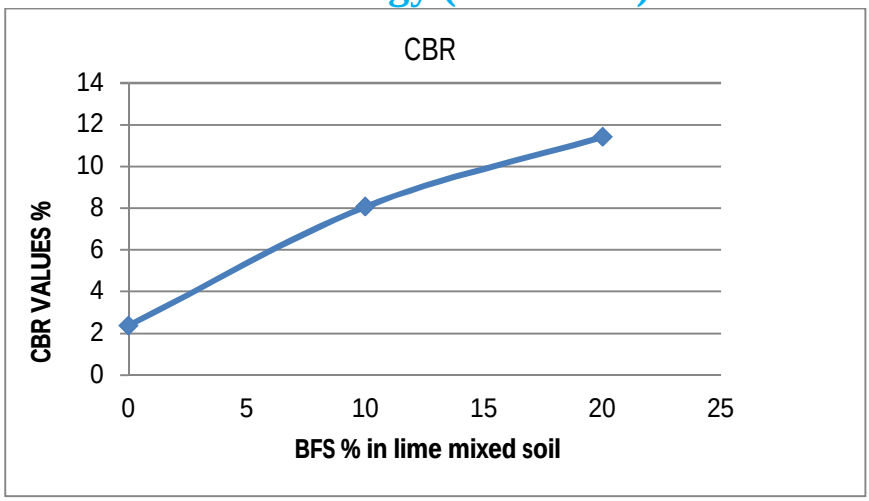

Fig-5: Variations in CBR values due to increase in BFS content in lime(2%) mixed soil

The result obtained in stage I is not satisfactory as at increases a cost of stabilization due to higher amount of BFS consumed during stabilization thus we move on next stage. Then Blast furnace slag was found to be very effective with lime (2%), especially in California bearing ratio and maximum dry density tests. This effect is mainly attributed to the hydration reaction of Blast furnace slag were the pores are filled by crystalline growth.

The variation in density and CBR value is primarily due to chemical composition, glass phase content, particle size distribution and surface morphology. The increase in the maximum dry unit weight with the increase of the percentage of BFS mixture is mainly due to high specific gravity and immediate formation of cemented products by hydration which increases the density of soil. The increase in dry density and CBR value, with increase in BFS mixture is due to enhanced C-S-H formation compared to using Soil alone. this enhanced C-S-H occupies pore spaces, normally occupied by calcium hydroxide in the hydration of pozzolanic reaction taking place in mixtures which uses the excess SiO_2 from the slag source, $Ca(OH)_2$ produced by the hydration of the silicates, and water to produces more of the desirable C-S-H making slag a beneficial mineral admixture to attain and increase in dry density and CBR value.

So in second stage it was found that the behavior of soil mixed with BFS and 2%lime is far better than the soil mixed with BFS alone(without lime).

VII. CONCLUSIONS

From the results of investigation following conclusions can be drawn.

The lowest dry density was observed to be about 1.84g/cc for 90% soil and 10% GBFS mixture and maximum density was about 2.05 g/cc for 50% soil and 50% GBFS mixture.

The lowest CBR value was observed to be about 3.26% for 90% soil and 10% GBFS mixture and maximum CBR value was about 8.74% for 50% soil and 50% GBFS mixture.

The CBR value was observed to be about 11.41% for soil mixed with 2% lime and 20% BFS mixture. While the value of CBR for soil mixed with 50% BFS alone(without lime) is 8.74. Thus it proves that the addition of BFS in soil is more beneficial when mixed with lime in comparison to BFS mixed alone to soil.

Initially the CBR value of soil is 2.37% which get improved upto 11.41% at optimum percentage i.e the 2% lime with 20%BFS.

Above results shows that the soil get improved and best results are found when soil is mixed with 2% lime and 20%BFS weight of dry soil.

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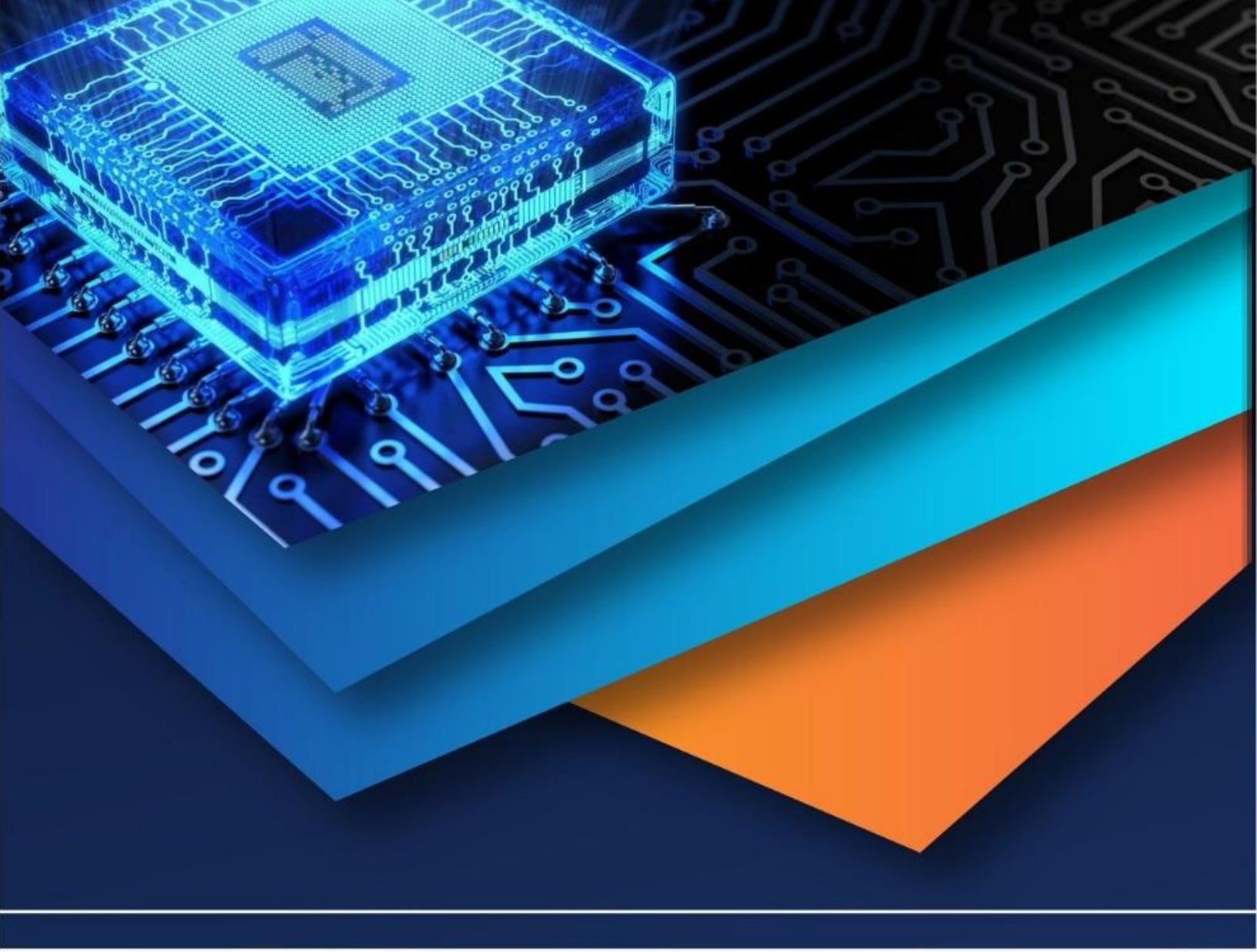

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