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Effect of Lime and Fly Ash on Geotechnical Properties of Black Cotton Soil

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Abstract: ***In our country large area covered with highly plastic soil and expansive Black cotton soil which is unsuitable for construction purpose. The widespread of the Black cotton soil create problems to the construction activities. Black cotton soil is very susceptible to detrimental volume changes with changes in moisture. The properties of black cotton soil can be modified by stabilizing the soil with the use of additives or by mechanical means. In this study, lime and fly ash are used as a stabilizing material to stabilize the black cotton soil. The experimental work has been carried out to analyze the improvement in geotechnical properties of expansive soil mixed with lime and fly ash at different proportion. The soil was mixed with lime at 2% and 4% and with fly ash at 10% and 20% by weight of dry soil. The test results indicated that liquid limit and plasticity index of soil decreased with increase in lime and fly ash percentage in a soil sample. The maximum value of dry density and CBR obtained at 4% lime and 10% fly ash mixed soil sample.***
Keywords: Black Cotton Soil, Lime, Fly Ash, Index Properties, Engineering Properties.

I. INTRODUCTION

The soil is the basic construction material. It supports the substructure of any structure and it is the subgrade which supports the sub-base and base in the pavement. The main function of pavement is to support and distribute the heavy wheel loads of vehicles over a wide area of the underlying subgrade soil and permitting the deformations within elastic range. The quality and life of the pavement are greatly affected by the type of sub-grade, sub base and base course materials. The most important of these are the type and quality of the sub-grade soil**.** Subgrade performance is a function of the strength of soil and its behaviour under traffic loading. The subgrade should be stable enough to prevent excessive deformation. The existing soil at a particular location may not be suitable for construction due to poor bearing capacity and higher compressibility or even sometimes excessive swelling in case of expansive soils. The properties of soil can be improved by stabilization with admixtures. For many years admixtures such as lime, cement and cement kiln dust are used to improve the qualities of various types of soils. Stabilization of black cotton soil has been done in this project work by using lime and fly ash as an admixture.

II. LITERATURE REVIEW

Singh and Pani (2014) investigated evaluation of lime stabilized fly ash as a highway material. They concluded that dry unit weight of compacted specimen decreased from 1.142 to 1.255 kJ/m^3 with change in compaction energy from 118.6 kJ/m^3 to 2483 kJ/m^3, whereas the OMC is found to decrease from 30.2% to 24.2%. The highest unsoaked and soaked CBR values are found to be 25.39% and 1.546% at compaction energy of 2483 kJ.

Choudhary et al. (2015) investigated the effect of lime on compaction characteristics of soil-fly ash mixtures. The results of their work indicated that OMC of the soil fly ash lime mix increases with increases with increase in the percentage of lime and 20% fly ash and MDD of the soil fly ash lime mix decreases with increase In percentage of lime.

Rajak and Pal (2015) studied CBR values of soil Mixed with fly ash and lime. They concluded that MDD value of soil decreases with increase in lime and fly ash content. The OMC value of soil increases with increase in fly ash and lime content. The CBR of the soil increases as an increase in percentages of fly ash and lime.

Nadgouda and Hegde (2010) studied the Effect of Lime Stabilization on Properties of Black Cotton Soil. The results of their work indicated that liquid limit of soil decreased from 59.8% to 53.2% with increase in lime content up to 4.5% after that it goes on increasing with increase in lime content. Plasticity index of soil decreased from 25.9% to 15.1%. DFS decreases gradually with increase in lime content.

Manjularani et al. (2015) investigated augmenting the properties of Black cotton soil using additives they found that the MDD increases with decreasing in OMC up to 50% fly ash addition, thereafter MDD decreases with increase in OMC. The addition of 1

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to 5% lime to optimum fly ash treated soil, MDD increase up to 3% lime addition, thereafter MDD decreases with increase in OMC.

III. MATERIALS

A. *Black Cotton Soil*

Black cotton soil sample used in this project was collected from JASUJA CITY near Dhanwantri Nagar Jabalpur (M.P.). Geotechnical properties of black cotton soil are given in TABLE-1

TABLE-1
Geotechnical properties of black cotton soil

S.NO.	Properties	Values
1.	Soil Classification	CH(clay of high Plasticity)
2.	Liquid Limit (LL)	67.49%
3.	Plastic Limit (PL)	30.33%
4.	Plasticity Index (PI)	37.16%
5.	Specific Gravity	2.40
6.	Differential Free Swell (DFS)	60%
7.	Optimum Moisture Content (OMC)	18.74%
8.	Maximum Dry Density (MDD)	1.69g/cc
9.	California Bearing Ratio (CBR)	2.82%

B. *Lime*

Lime used in this investigation was purchased from local market.

C. *Fly Ash*

Fly-ash Used in this project was obtained from Beersinghpur Pali thermal power plant, District Shahdol , Madhya Pradesh.

D. *Methodology*

A series of laboratory tests were conducted on black cotton soil mixed with lime and fly ash at different proportion. The following tests were conducted on both natural soil and stabilized soil.

1) Liquid limit
2) Plastic limit
3) Plasticity index
4) Differential free swell (DFS) Test
5) Compaction characteristics
6) California bearing ratio (CBR) Test

E. *Mix Preparation*

Following mix has been prepared with different percentage of lime and fly ash.

1) BCS + 0% Lime + 0% Fly ash (CL_0F_0)

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2) BCS + 2% Lime + 10% Fly ash (CL_2F_{10})
3) BCS + 2% Lime + 20% Fly ash (CL_2F_{20})
4) BCS + 4% Lime + 10% Fly ash (CL_4F_{10})
5) BCS + 4% Lime + 20% Fly ash (CL_4F_{20})

IV. RESULTS AND DISCUSSION

Test results are summarized in Table-2 and Table-3. Variation of LL, PI, DFS, MDD, OMC and CBR of Black Cotton Soil mixed with two different proportion of Fly Ash along and Lime as shown in figure 1 to 6. Liquid Limit decreased from 67.49% to 52.95%, Plasticity Index of soil decreased from 37.16% to 14.54% and DFS decreased from 60% to 30%. Optimum moisture content decreased from 18.74% to 13.5%, dry density increased from 1.69g/cc to 1.74g/cc and CBR value increased from 2.82% to 11.11% at 4% lime and 10% fly ash mixed soil sample. For soil sample mixed with two different proportion of fly ash i.e. 10% and 20% along with fixed percentage of lime i.e. 6% by weight of dry soil, it was observed that brittle failure occurred during the CBR test.

TABLE-2
LL, PI & DFS Test result

S.NO.	SAMPLE TYPE	LL (%)	PI (%)	DFS (%)
1	CL_0F_0	67.49	37.16	60
2	CL_2F_{10}	59.09	19.9	50
3	CL_2F_{20}	56.25	16.03	35
4	CL_4F_{10}	54.93	17.75	42
5	CL_4F_{20}	52.95	14.54	30

TABLE-3
OMC, MDD & CBR Test result

S.NO.	SAMPLE TYPE	OMC (%)	MDD (g/cc)	CBR (%)
1	CL_0F_0	18.74	1.69	2.82
2	CL_2F_{10}	16.12	1.71	4.15
3	CL_2F_{20}	16.47	1.7	3.11
4	CL_4F_{10}	13.5	1.74	11.11
5	CL_4F_{20}	14.28	1.72	8.29

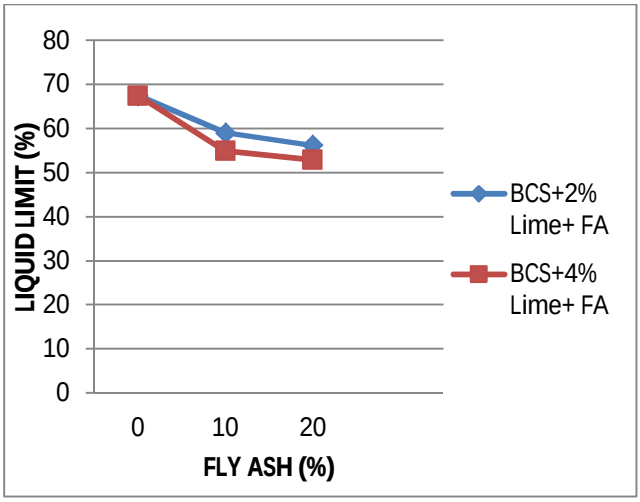

Fig 1: Variation of LL with BCS-Lime-Fly Ash mix

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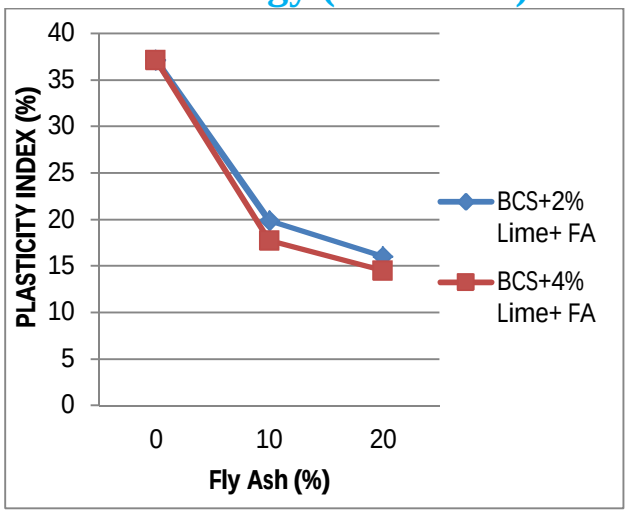

Fig 2: Variation of PI with BCS-Lime-Fly Ash mix

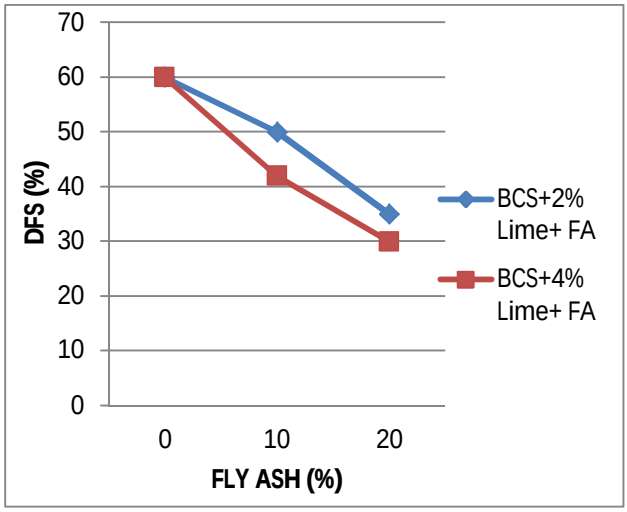

Fig: 3 Variation of DFS with BCS-Lime-Fly Ash mix

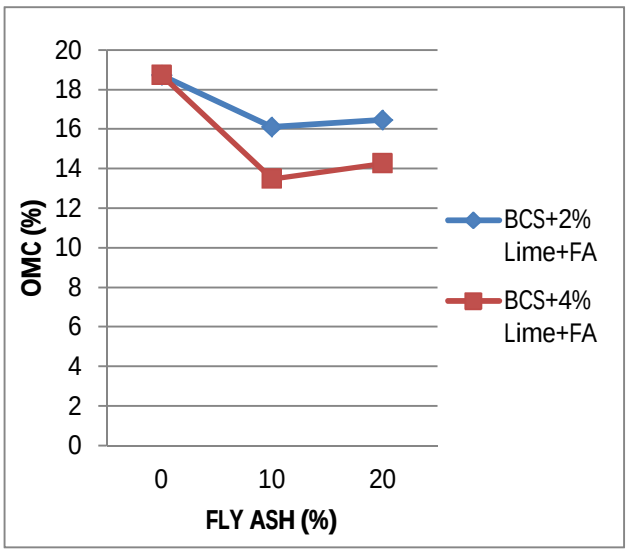

Fig: 4 Variation of OMC with BCS-Lime-Fly Ash mix

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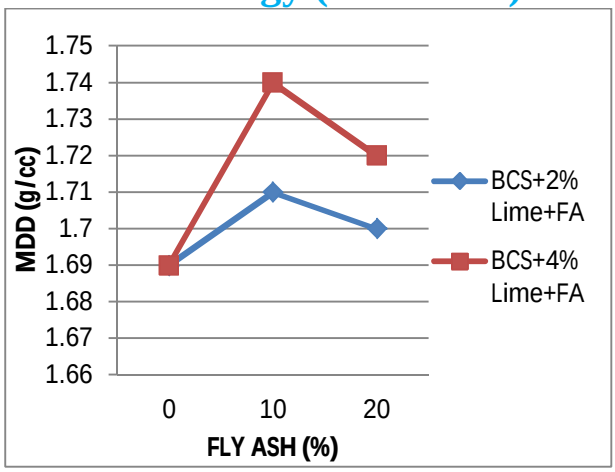

Fig: 5 Variation of MDD with BCS-Lime-Fly Ash mix

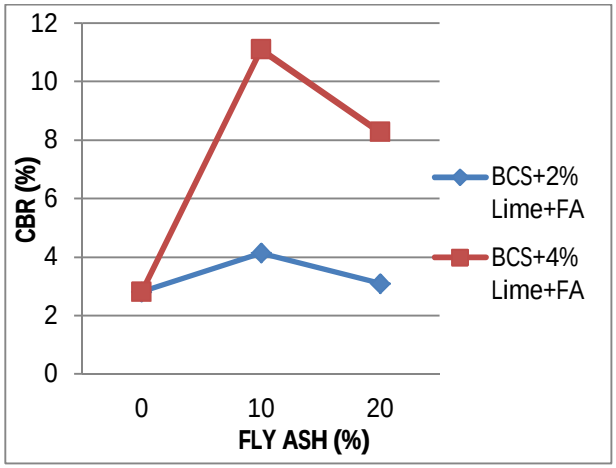

Fig: 6 Variation of CBR with BCS-Lime-Fly Ash mix

V. CONCLUSION

For the stabilization of BC soil, the optimum quantity of lime and fly ash was found as 4% and 10% respectively, by weight of dry soil. If these two materials are mixed in the above proportion into the BC soil the CBR value increased from 2.82% to 11.11% and the proctor density was increased from 1.69 g/cc to 1.74 g/cc.

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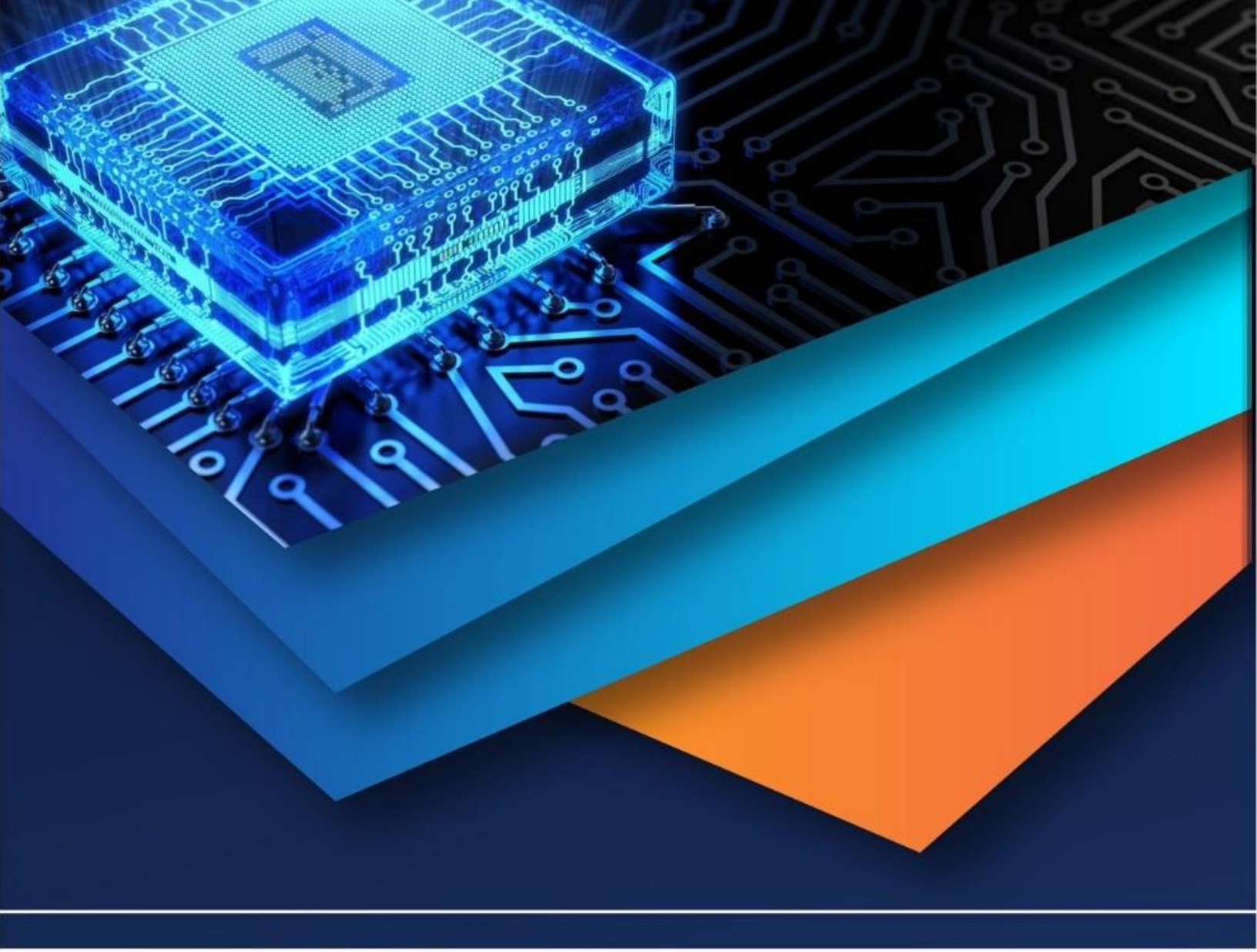

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