

A Study on Stabilization of Black Cotton Soil Using Ferric Chloride

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Abstract: Expansive soils such as black cotton soil are very susceptible to detrimental volume changes, with changes in moisture. This behavior of soil is attributed to the presence of mineral Montmorillonite which has expanding lattice; Expansive soils because of their specific physical & chemical make are subjected to volume changes. In many countries including India, these soils are so extensive that alteration of highway route to avoid the material is virtually impossible. Various remedial measures like soil replacement, prewetting, moisture control, lime stabilization etc have been practiced with varied degree of success. Extensive research is going on to find the solutions to black cotton soils. Recent investigations on chemical stabilization revealed that strong electrolytes like potassium chloride, Ferric chloride can be used in place of conventionally used lime due to their ready dissolvability in water and supply of adequate cations for ready cation exchange. In the present work experimentation is carried out to investigate efficacy of ferric chloride and fly ash in improving the properties of black cotton soil.

Keywords: Fly Ash (F.A.), Ferric Chloride ($FeCl_3$), M.D.D., O.M.C., C.B.R.

I. Introduction

Black cotton soils is one of the problematic soils that has high potential for Shrinking or swelling due to change of moisture content. These soils have the tendency to increase in volume when water is available and decrease in volume when water is removed. These soils covers about 20% of the total area of India. The problem that causes black cotton soils is that deformations are significantly greater. There deformation cannot be predicted movement of soil is usually in an uneven manner & is of such magnitude which causes extensive damage to structures resting on them. Many stabilization techniques are in practice for improving the characteristics of black cotton soil. Additives such as lime, cement, calcium chloride, rice husk, fly ash are also used to alter characteristics of black cotton soil. The effect of additives and the optimum amount of additives to be used depend mainly on the mineralogical composition of soil. The comprehensive review of literature shows that a considerable amount of work related to determination of deformation characteristics of black cotton soils has been done from various investigations on characteristics of black cotton soil. Conducted by Erdal Cokca (2001), B. R. Phanikuma (2004), Dr. K. V. Manoj Krishna (2012), Koteswara Rao D. (2012) P. Venkara Multhyalu, K. Ramu (2012). Prasada D.S.V. (2010), P. Eskioglu (2006), Nawraj Bhatia (2010), Katti R. K. (1966) Sivapulliation P.P. (1994) are note worthy.

To study the influence of Ferric chloride ($FeCl_3$) and Fly ash on properties of black cotton soil.

II. Materials Used

- **Black cotton soil :-** The black cotton soil for the study has collected from Satara, a village 4 km for Aurangabad city Dist. Aurangabad Maharashtra, INDIA.

The properties of soil are assessed based on relevant I.S. code provisions & are given in Table 1.

Table 1: Properties of Black Cotton Soil

Sr. No.	Property	Value
1	Liquid Limit	66%
2	Plastic Limit	24%
3	Plasticity Index	42%
4	Maximum Dry Density	1.465 g/cm ³
5	OMC	25.90%
6	California Bearing Ratio	1.75%

- **Ferric Chloride:** - Laboratory grade Ferric Chloride consisting of 96% $FeCl_3$ was used in this work. The amount of Ferric Chloride used was between 0 to 2% by dry weight of soil.
- **Fly Ash:** - Fly ash was collected from Thermal Power Station, Eklahare Nasik, Maharashtra. Fly ash content was varied from 0 to 12% by dry weight of soil.

The properties of fly ash are given in Table 2

Table 2: Properties of Fly Ash

Sr. No.	Property	Value
1	Liquid limit	28%
2	Plastic Limit	N. P.
3	M.D.D.	1.34 g/cm ³
4	OMC	29%
5	CBR	5.2%

III. Laboratory Test

- **Liquid Limit:** - The liquid limit test was conducted on treated & untreated B.C. soil using casagrande's liquid limit apparatus as per the procedures laid down in IS : 2720 Part 4 (1970)
- **Plastic limit :-** The plastic limit test was conducted on treated & untreated B.C. Soil as per the specification laid down in IS : 2720 Part 4 (1970)
- **Maximum Dry Density & O.M.C. :-** This test was conducted on treated & untreated B.C. Soil as per specification laid down by IS : 2720 Part 6 (1974)
- **California Bearing Ratio :-** This test was conducted on treated & untreated B.C. Soil as per specification laid down by IS:2720 part 16 (1979)

IV. Results And Discussion

The effect of adding FeCl₃ and Fly Ash on properties of B.C. Soil is presented in Table No. 3.

Table 3: The effect of adding FeCl₃ and Fly Ash on properties of B.C. Soil

Soil	FeCl ₃	Fly Ash	MDD g/cm ³	OMC%	CBR%	L. L.	P. L
100.00	0.00	0.00	1.465	25.90	1.75	66.00	24.19
100.00	0.50	0.00	1.469	25.23	2.07	64.00	23.96
100.00	0.50	3.00	1.475	24.75	2.39	63.00	24.18
100.00	0.50	6.00	1.481	24.25	2.55	62.00	24.81
100.00	0.50	9.00	1.486	24.12	2.78	62.00	24.90
100.00	0.50	12.00	1.492	24.01	2.86	61.00	25.10
100.00	1.00	0.00	1.474	25.13	2.47	60.00	25.33
100.00	1.00	3.00	1.481	24.25	2.63	59.00	25.91
100.00	1.00	6.00	1.489	24.21	2.86	58.00	26.14
100.00	1.00	9.00	1.497	23.88	3.34	57.00	26.29
100.00	1.00	12.00	1.503	23.73	3.66	56.00	26.54
100.00	1.50	0.00	1.481	24.25	2.63	58.00	26.08
100.00	1.50	3.00	1.488	23.62	3.02	57.00	26.24
100.00	1.50	6.00	1.497	23.27	3.42	56.00	26.39
100.00	1.50	9.00	1.504	23.04	3.66	55.00	26.75
100.00	1.50	12.00	1.512	22.99	3.98	53.00	26.90
100.00	2.00	0.00	1.489	23.57	3.02	57.00	26.44
100.00	2.00	3.00	1.496	23.31	3.50	57.00	26.64
100.00	2.00	6.00	1.505	22.95	3.82	56.00	26.63
100.00	2.00	9.00	1.512	22.68	4.14	54.00	26.55
100.00	2.00	12.00	1.526	21.88	4.46	53.00	26.70

Effect of FeCl₃ & Fly ash on Atterbergs limit: The variation of liquid limit values with different percentage of FeCl₃ alone is shown in Fig. 1.

It can be observed that there is considerable decrease in liquid limit as the percentage of FeCl₃ increases.

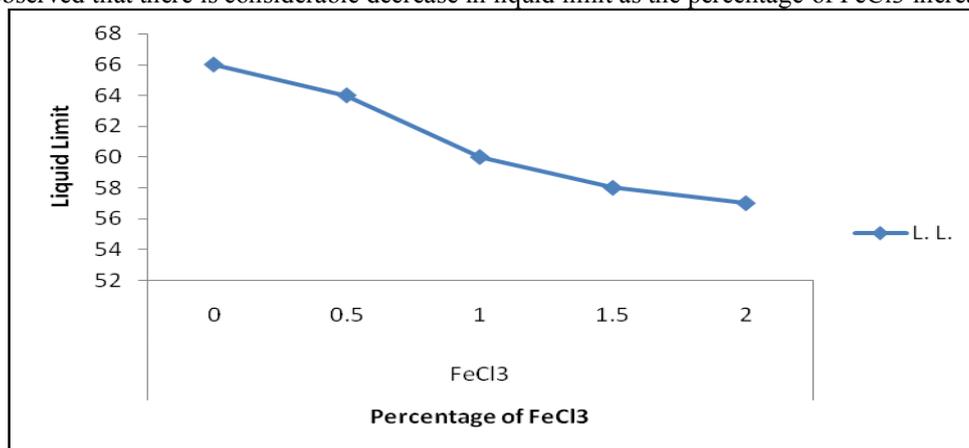


Fig. 1: The variation of liquid limit values with different percentage of FeCl₃

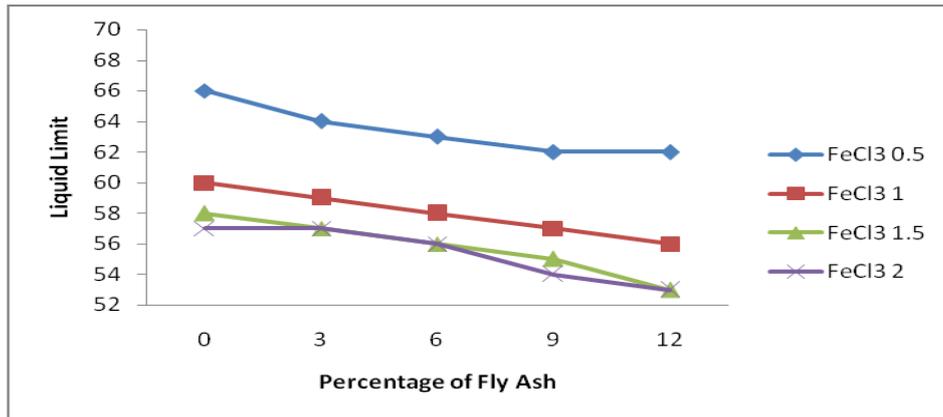


Fig 2: Variation of Liquid Limit

The variation of Liquid Limit for FeCl₃ & fly ash combination is resented in **Fig. 2**. The max decrease in liquid limit is observed for 2% FeCl₃ & 12% fly ash combination. Nominal increase in plastic limit of stabilized B.C. soil is observed with increase in percentage of FeCl₃ and fly ash. Fig 3 shows variation of plastic limit. The improvement in expansive soil properties with FeCl₃ treatment could be attributed to the depressed double layer thickness due to cation exchange and increased electrolyte concentration as chemical is completely soluble in water. The increase in plastic limit and decrease in liquid limit causes a net reduction in plasticity index. It is observed that the reduction in plasticity index is 37.57% for 1.5% FeCl₃ & 12% Fly Ash combination.

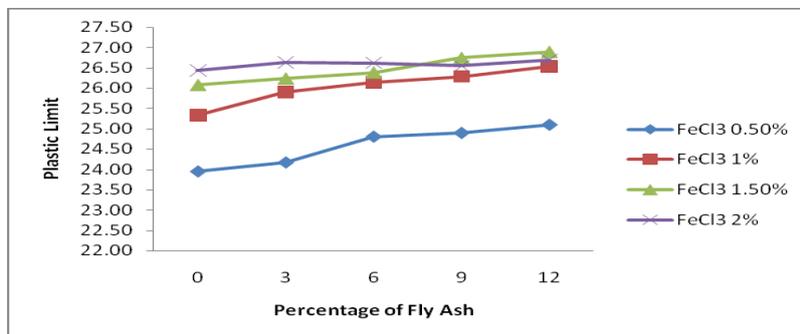


Fig 3: Variation of Plastic Limit

Effect of FeCl₃ & Fly ash combination as on maximum dry density & OMC: - From Fig. 4 it can be seen that MDD increases as the percentage of chemical and fly ash increases. MDD increases from 1.465 g/cm³ for raw soil to 1.526 g/cm³ for 2% FeCl₃ & 12% Fly ash combination. The increase in MDD indicates the increase in strength of soil. This may be due to formation of Slicacious material & cation exchange reactions. Also it is observed that optimum moisture control decreases with increase in percentage of FeCl₃ and Fly ash.

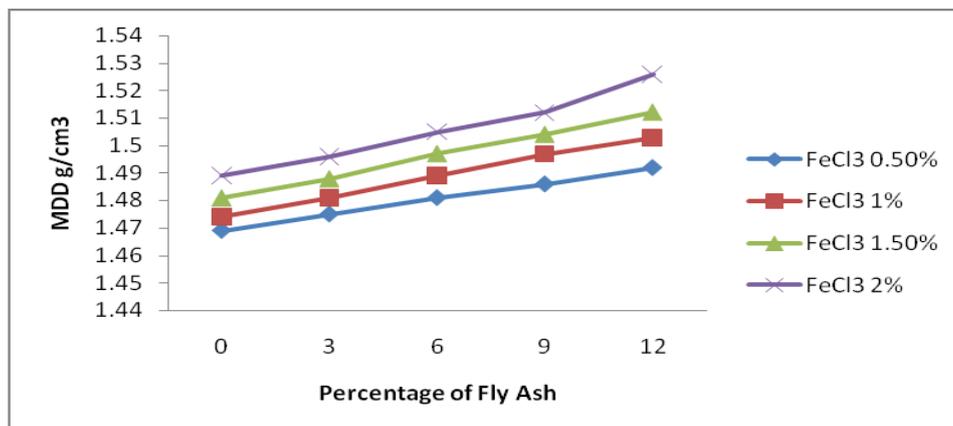


Fig 4: Variation of MDD g/cm³

Effect of FeCl₃ & Fly ash on C.B.R. The Fig. 5 shows the variation of CBR with of stabilized B.C. soil with addition of different percentage of FeCl₃ alone. It is observed that the CBR increase with increased percentage of FeCl₃. The increase in value of CBR with 2% of FeCl₃ is 72.57%. The value of CBR also increase as the percentage of Fly Ash increases which can be observed from Fig. 6. The max increase in CBR value is 154.85%. It is observed for combination of 2% FeCl₃ & 12% fly ahs. The increase in CBR can be attributed cation exchange of FeCl₃ and fly ash and soil minerals. Increase in CBR values show the increase in stability of soil and resistance to penetration which helps to decrease the pavement thickness.

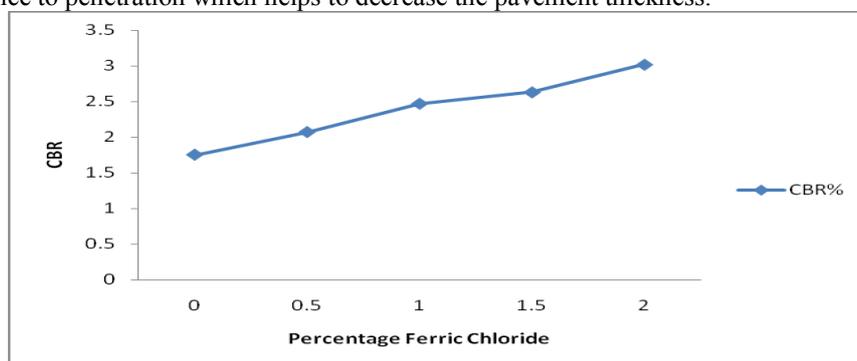


Fig 5: Variation of CBR

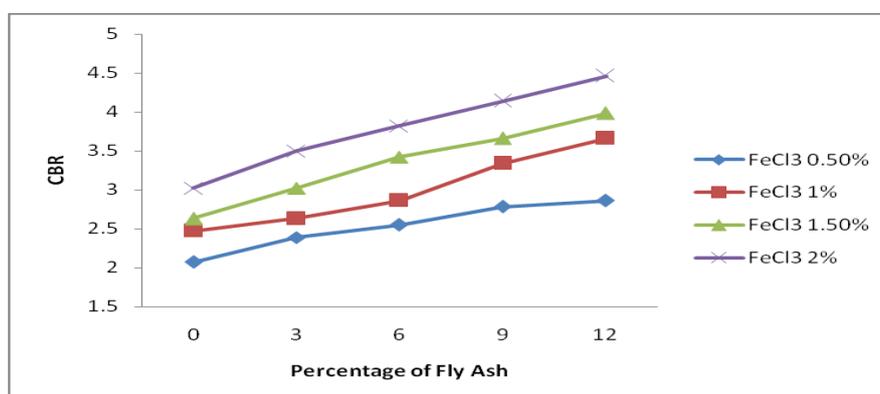


Fig 6: Variation of CBR%

V. Conclusion

The following conclusions are drawn on the basis of test results obtained on black cotton soil stabilized with fly ash and FeCl₃.

1. It was observed that liquid limit of B.C. Soil has been decreased by 19.69% with addition of 2% FeCl₃ of 12% Fly ash.
2. It was observed that plastic limit of black cotton soil has been increased by 10.37% for 2% FeCl₃ + 12% Fly ash.
3. It was observed that M.D.D. of B.C. Soil increased from 1.465 g/cm³ to 1.526 g/cm³ for 2% FeCl₃ + 12% Fly ash.
4. It was observed that CBR value of B.C. Soil increased to by 155% for 2% FeCl₃ + 12% fly ash. Combination of fly ash and ferric chloride can stabilize black cotton soil. The utilization of fly ash is an alternative to reduce construction cost of roads particularly in the area of black cotton soils.

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