International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 02 | Feb 2021 www.irjet.net p-ISSN: 2395-0072

Strengthing of Black Cotton Soil with Lime- A Review

Abhishek Kumar Chaubey[1], Asst.Prof. Shashikant B. Dhobale[2]

[1]M.E Transportation Engineering & JIT Borawan, M.P
[2]Assistant Professor, Civil Engineering Department & JIT Borawan, M.P

Abstract - In this review paper, we have studied some research papers related to this topic and some properties of the black cotton soil. The design of foundation on black cotton soil (expansive soil) has always been a difficult task for the engineers as the structure resting on black cotton soil cracks without any warning. Black cotton soil is mainly found in M.P., Karnataka, Maharashtra, and Andhra Pradesh in our country. Soil proportion changes depending upon their constituents, i.e. water content, density, bulk density, angle of friction, shear strength, etc. The properties of black cotton soil can be modified by stabilizing the soil with help of the chemicals, but here we have studied to improve the strength of the black cotton soil with lime. When the Lime is added to black cotton soil and stabilization takes place under pozzolanic reaction. A reaction takes place between hydrated lime and clay particles and resulting in the formation of a permanent strong cementation matrix.

Key Words: Black cotton soil, Lime, Soil Stabilization, Lime treatment of soil, Expansive soil.

1. INTRODUCTION

The term soil stabilization means the improvement of the stability or bearing power of the soil by the use of controlled compaction, proportioning, or the addition of suitable admixtures or stabilizers. Soil stabilization deals with physical, physicochemical, and chemical methods to make the stabilized soil serve its purpose as pavement materials. Chemical stabilization is one of the oldest methods of stabilization of problematic soil. In general, all lime-treated fine-grained soils exhibit decreased plasticity, improved workability, and reduced volume change characteristics. However, not all soils exhibit improved strength characteristics. It should be emphasized that the properties of soil lime mixtures are dependent on many variables. But Soil type, lime type, lime percentage, and curing conditions (time, temperature, and moisture) are the most. The basic objectives of the study of black cotton soil are as following:
1) Improvement of bearing capacity of Black Cotton Soil on the addition of lime.
2) Variation of Strength of soil at different water content.
3) Effect of lime on CBR value of the soil.
To achieve the above objective, the black cotton soil has been arbitrarily mixed with lime. So the suitability of lime is considered to enhance the properties of black cotton soil. The figure of the black cotton soil is given below:

Fig -1: Black Cotton Soil

1.1 Property of Black Cotton Soil

The following property of the black cotton soil is given below in the form of the table:

Table -1: Property of the Black Cotton Soil

Sr. No	Property of Soil	Black Cotton Soil
1.	Specific Gravity	2.7
2.	Liquid limit (%)	68
3.	Plastic limit (%)	27
4.	Shrinkage limit (%)	11
5.	Maximum Dry Density of BCS (KN/m^3)	15.5
6.	OMC (%)	25.21
7.	Specific Surface Area (m^2/gm)	63
8.	Percentage of the Fine Sand	38

2 LITERATURE REVIEW

In this review paper, we studied some research paper related to strengthening the black cotton soil with different admixture, and the conclusion of that research paper is given below:
[1] Nadgouda(2010): The research paper written by this author "The Effect of Lime Stabilization on Properties of Black Cotton Soil" and conclusion is given below:

An immediate benefit obtained by the addition of lime to swelling soils is to reduce the potential for swelling upon contact with water. The plastic nature of the soil decreases and the stiffness of the soil increases as the lime content increases. For improving the properties described in this paper, the optimum lime content was found to be within the range of 3.5% to 4.5%. These values are found to be in general agreement with work carried out by other researchers (Ranganatham, 1961, Subba Rao, et. al., 1983).

[2] Shailendra Singh(2013): The research paper written by these authors "Stabilization of Black Cotton Soil using Lime" In this experimental program stabilization of soil has been carried out by mixing lime in varying percentages (4% and 6%). The following conclusions are drawn from this experimental study:-
It has been found that an addition of 4% lime decreases the liquid limit by 12.1 %, while a 6% addition of lime shows a decrease of only 17.7%. M.D.D. is found to decrease by 2.4% and 5.6% at 4% and 6% lime content respectively. It was found that O.M.C. does not change with a decrease of 14.3% in O.M.C. was observed at 6% lime content. The C.B.R. value of black cotton soil mixed with 4% and 6% lime at 2.5 mm penetration showed an increase of six folds and eight folds respectively. At 5.0 mm penetration, the increase in C.B.R value was also found six-folds and eight folds respectively. The swelling pressure of Black cotton soil mixed with 4% and 6% lime decreased by 40% and 80% respectively.

[3] Brajesh Mishra(2014): The research paper is written by this author "A Study on Engineering Behavior of Black Cotton Soil and its Stabilization by Use of Lime" In this research varying percentages (3% and 5%) of lime was used to stabilize the black cotton soil. Points that were drawn from this study are listed below-
It was observed that the addition of 3% lime decreases the liquid limit by 2.70% while with 5% addition of lime reflects a decrease of 15.27%. M.D.D. was increased slightly by 6.29% and 5.59% at 3% and 5% lime content respectively. It was observed that there was a decrease in O.M.C. of 3.4% and 10.7% at 3% and 5% lime content. respectively. The C.B.R. value of black cotton soil improves considerably to 3.25 times and 4.76 times with 3% and 5% lime respectively.

[4] Kavish S. Mehta(2014): The research paper written by this author "Analysis of Engineering Properties of Black Cotton Soil & Stabilization Using By Lime" and the conclusion is given below:
Some clayey sand mixes with determined gradations, abundant in northern India, were stabilized with different lime contents and then subjected to Bearing strength, Shrinkage property, and CBR tests. Materials were reconstituted in the laboratory and the fine content of mixes was provided from Kaolinite clay to reach a constant plastic characterization for all specimens. Results of this investigation are as below: At finally we perform the all properties of the soil which we have taken. And after the all laboratory test we found that our soil is a high clay content and sat that black cotton soil. We found the value of liquid limit and plastic limit and which is very high and high content of water so we cannot use directly for the construction or highway pavement purpose. In the test of a proctor of soil, we found that there is a high value of optimum moisture content and as well as low dry density of soil. And more air voids in the soil. So soil loses its strength. In the test of C.B.R., we found the value of the C.B.R. is the less and high value of the swelling pressure and due to low C.B.R. value soil has no high strength and no stabilization.

[5] Dr.A.V.Narasihma Rao(2014): The research paper is written by this author "Compressibility Behavior of Black Cotton Soil Admixed with Lime and Rice-Husk Ash" Based on the results reported in this investigation, the following conclusions are drawn:
Optimum moisture content increases as the percentage of lime or RHA or lime & RHA increases. Maximum dry unit weight decreases as the percentage of lime or RHA or lime& RHA increases. 1:1 mix is more effective than all other admixtures investigated in indicating an extra pre-consolidation effect on the soil. Compression index as well as swelling index decreases as the percentage of admixture increases. 1:1 mix is more effective and economical among all the admixtures in reducing compression index.

[6] Sujit Kawade (2014): The research paper is written by these authors "Stabilization of Black Cotton Soil with Lime and Geo-grid" The results of tests conducted on rectangular BC soil blocks (200mm×100mm×100mm), reinforced and unreinforced with geo-grid is presented in chapter 4. Based on the results, the following conclusions were drawn:
The compressive strength of these soils increases upon the addition of lime. The trend of improvement in the compressive strength is observed to be more pronounced with the curing of the soil and lime mix. A curing period of 28 days is observed to yield the maximum compressive strength of BC soil blocks reinforced with 15% lime content and geo-grid.
A curing period of 14 days is observed to yield the maximum enhancement in the compressive strength of BC soil blocks for the addition of 15% lime content and geo-grid reinforcement concerning the addition of 5% lime content.

[7]Amruta A. Badge(2015): The research paper is written by this author "Quality Assessment for Stabilization of Black Cotton Soil by Using Lime" and the conclusion is given below:
It has been observed that an addition of 6% lime to black cotton soil cuts down its plasticity, shrinkage & swelling characteristics considerably. The compressive strength rises to about 15.22 kg/cm2 under wet conditions. The CBR values rise from 3.3% of virgin soil to about 62.8%. The treated black cotton soil can be safely used as a sub-grade, sub-base, or base material, thereby cutting down considerably the thickness of the upper crust of a road which is of an expansive material like hard stone.

[8] Pramod Kilabanur(2015): The research paper written by these author "Stabilization Of Black Cotton Soil Using Envirobase And Sodium Silicate With Lime" and the conclusion is given below:
The liquid limit decreases in the addition of sodium silicate with lime. The addition of 1%Envirobase liquid limit remains constant then reduces after further increment in Envirobase percentage. Sodium silicate with lime reduces the plasticity index and holds good in case of consistency limits. Envirobase reduces the optimum moisture content by a remarkable amount and reduces maximum dry density also. California bearing ratio values show a huge amount of increment when Envirobase is added to the soil.

[9] Shailendra Singh(2015): The research paper is written by this author "Stabilization of Black Cotton Soil using Lime" and The following conclusions are drawn from this experimental study:-
It has been found that an addition of 4% lime decreases the liquid limit by 12.1 %, while a 6% addition of lime shows a decrease of only 17.7%. It was found that O.M.C. does not change with a decrease of 14.3% in O.M.C. was observed at 6% lime content. The C.B.R. value of black cotton soil mixed with 4% and 6% lime at 2.5 mm penetration showed an increase of six folds and eight folds respectively. At 5.0 mm penetration, the increase in C.B.R value was also found six-folds and eight folds respectively.

[10] Chayan Gupta(2016): The research paper is written by the author "Black Cotton Soil Modification by the Application of Waste Materials" and the conclusion is given below:
The standard compaction parameters i.e. maximum dry density of black cotton soil increase from 1.53 g/cm3 to 1.76 g/cm3 for the final optimum composite whereas the optimum water content of black cotton soil decreases from 22.8% to 19% for the final optimum composite.
The result of the UCS test shows that, after stabilization of soil, unconfined compressive strength values of black cotton soil increase from 138.01 kPa to 286.13 kPa i.e. increased up to 107.32%.

[11] Shreyas. K (2017): The research paper is written by the author " Stabilization of Black Cotton Soil By Admixtures" and the conclusion is given below:
Replacement of some percentage of cement with fly ash will increase the engineering properties of Black Cotton soil which also increases its stability. With the conduction of the CBR test by varying the percentage of admixtures like Cement, M–sand, and Fly ash in the soil mix, there is an increase in the CBR values with the increase in the percentage of stabilizers. It has been found that with the increase in the percentage of M-sand with cement & fly ash there is an increase in Maximum dry density values whereas there is a considerable reduction in optimum moisture content for the given soil.

[12] Harish G R(2017): The research paper is written by this author " Studies on Stabilization of Black Cotton Soil Using Lime" and the conclusion is given below: Addition of Lime imparted reduction in plasticity index and free swell index. At 9% of Lime, the plasticity index was reduced by 17%. The addition of Lime leads to a slight reduction in the maximum dry unit weight when compared with the natural soil and this is due to the resistance offered by the flocculated structure of the soil–lime mix against impact. The unconfined compressive strength of the black cotton soil treated with Lime increased with an increase in the % of Lime and curing period. The strength increased by 8 times with a curing period of 28 days under both unsoaked and soaked conditions when compared with the untreated black cotton soil.
The CBR of the lime-treated black cotton soil increased when compared to untreated black cotton soil and with 9% of lime, the CBR of 10% was obtained with a curing period of 7 days.

[13] Syed Sumair Razvi (2018): The research paper is written by this author " Soil Stabilization by using Lime" and the conclusion is given below:
The CBR of the lime-treated black cotton soil increased when compared to untreated black cotton soil. It has been observed that CBR value increases with lime content 2%-3%, for black cotton soil. Soil stabilization is the process that improving the different types of engineering properties of black cotton soil and it is making for stable soil.

3. CONCLUSIONS

From the above study related to increasing the strength of the black cotton soil with the lime, the following conclusion comes outs:

1. The effect of the lime taken place in the black cotton soil, then the percentage of the clay present in it is maximum as compared to the sand.
2. The unconfined compression strength of the Black Cotton Soil increased as the curing period of the specimen increases.
3. It is also concluded that the soil treated with limestone powder can be utilized as a soil stabilizer which minimizes the settlement problems in the soil after the construction of the building, highway, etc.
4. The swelling pressure of Black cotton soil is decreased with increasing the lime in the black cotton soil.

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