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Strengthening of Black Cotton Soil with Lime

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Abstract - *The expansive soil can imbibe a large amount of water and undergo high volume change, causing seasonal heave and shrinkage according to the availability of the water. This often causes distress and failure of the structure founded on such soil. A method such as preloading moisture control, replacement of the affected soil, and additives have been used to deal with the swelling problem associated with this soil. The literature reveals that studies were conducted to modify the behavior of expansive soil using additives such as lime, cement, fly ash, and other industrial wastes. The main purpose of this study is to find the meaningful application of the lime as an optical modifier of the property wherever required.*
The geotechnical characteristics deal with in this study include plasticity, compaction, consolidation, swelling, and strength. The variation of this property due to lime has been systematically investigated. Some of the properties like plasticity and strength are influenced much by a higher percentage of the lime. In this research paper, we have taken some geotechnical parameters to check the strength of the black cotton soil with lime, that geotechnical parameter is the liquid limit, plastic limit, plasticity index, Compaction test, California Bearing Ratio.

Key Words: Expansive Soil, lime treatment of the soil, soil stabilization, strengthening of soil.

1.INTRODUCTION

In India Black Cotton soil also known as „Regus" is found in extensive regions of the Deccan Trap. They have variable thickness and are underlain by sticky material locally known as "Kali Mitti". In terms of geotechnical Engineering, Black Cotton soil is one which when associated with an engineering structure and in presence of water will show a tendency to swell or shrink causing the structure to experience moments that are largely unrelated to the direct effect of loading by the structure. Black cotton soil is not suitable for the construction work on account of its volumetric changes. It swells and shrinks excessively with the change of water content. Such tendency of soil is due to the presence of fine clay particles which swell, when they come in contact with water, resulting in alternate swelling and shrinking of soil due to which differential settlement of structure takes place, so the stabilization is being done for the Stabilization of black cotton soil has been done in this project work by using lime as an admixture.

The following type of soil stabilization can be used:

a) Cement stabilization
b) Bitumen stabilization
c) Chemical stabilization
d) Lime stabilization
e) Salt stabilization

1.1 The Chemical Ingredient of Black Cotton Soil

The following chemical ingredient found in the black cotton soil, which is given in the table form:

Table-1: Chemical Ingredient of BCS

Sr.No	Chemical Property	Range
1	Montmorrilonite Mineral	30 to 50 %
2	SiO2	50 to 55 %
3	SiO2, Al2O3	3 to 5 %
4	CaCO3	5 to 15 %
5	Organic Content	0.4 to 204 %
6	pH Value	>7(Alkaline)

Black cotton soil is made of varying properties of clay minerals like Montmorillonite, Illite, and Kaolinite, chemicals like iron oxide and calcium carbonate (in the form of kantars), and organic matter like hummus. Montmorillonite is the predominant mineral of Black cotton soils. The swelling and shrinkage behavior of black cotton soil originates mainly from this mineral are hydrous silicates of aluminum and magnesium.

1.2 Stabilization of Black Cotton Soil With lime

Lime stabilization helps in increasing the strength, durability and also minimizes the moisture variations in the soil and lime must be well compacted for obtaining sufficient strength and durability by maintaining Optimum Moisture Content and the same assumption is made in the experimental determination of the required lime proportion. The quality of lime to be added depends upon the specific

surface area of soil particles and it is more for fine-grained soils even up to 15 % by weight of soil. The stabilization of black cotton soil with lime has been done in three different ratios of lime i.e. 0%, 3%, 4%, 5%, and 6%. After the stabilization of soil with lime in the above percentage, the various tests have been performed –

1.3 Liquid Limit Tests

The liquid limit of soil is the moisture content, expressed as a percentage of the weight of the oven-dried soil, at the boundary between the liquid and plastic states of consistency. The moisture content at this boundary is arbitrarily defined as the water content at which two halves of a soil cake will flow together, for a distance of ½ in. (12.7 mm) along the bottom of a groove of standard dimensions separating the two halves, when the cup of a standard liquid limit apparatus is dropped 25 times from a height of 0.3937 in. (10 mm) at the rate of two drops/second. The figure of the liquid limit is given below:

Fig-1: Liquid Limit

1.4 Plastic Limit Tests

The plastic limit of soil is the moisture content, expressed as a percentage of the weight of the oven-dry soil, at the boundary between the plastic and semisolid states of consistency. It is the moisture content at which a soil will just begin to crumble when rolled into a thread ⅛ in. (3 mm) in diameter using a ground glass plate or another acceptable surface.

1.5 Plasticity Index

The plasticity index of a soil is the numerical difference between its liquid limit and its plastic limit and is a dimensionless number. Both the liquid and plastic limits are moisture contents.

Calculation:

Plasticity Index = Liquid Limit– Plastic Limit

1.6 Compaction Test

Compaction is one kind of densification that is realized by rearrangement of soil particles without outflow of water. It is realized by the application of mechanical energy. It does not involve fluid flow, but with moisture changing altering. For the compaction test of the soil, using the Standard Proctor test. The figure of the SPT is given below:

Fig-2: Compaction Test

1.7 California Bearing Ratio (C.B.R.) Test

California bearing ratio is the ratio of force per unit area required to penetrate a soil mass with a circular plunger of 50mm diameter at the rate of 1.25mm/min.

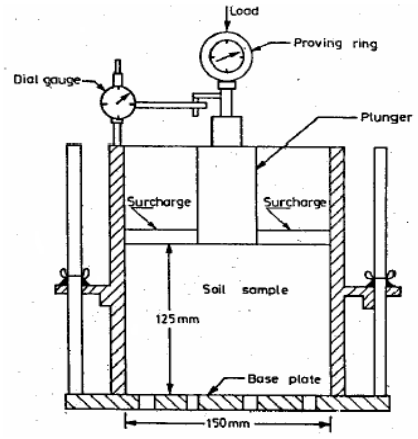

Fig-3: CBR Test

2. ANALYSIS AND RESULT

The calculation of the black cotton soil with different percentage of the lime is done and the result is given below:

2.1 Liquid Limit Test

Calculation of liquid limit of black cotton soil, Weight of sample = 100gms

Table-2: Liquid Limit

S.No	B.C. Soil + 0% Lime		B.C. Soil + 3% Lime		B.C. Soil + 4% Lime		B.C. Soil + 5% Lime		B.C. Soil + 6% Lime	
	Water (%)	*No. of Blows*	Water (%)	*No. of Blows*	Water (%)	*No. of Blows*	Water (%)	*No. of Blows*	Water (%)	*No. of Blows*
1	44	60	21	28	40	30	19.9	38	35	40
2	46	27	28.6	17	42	18	24	32	37	35
3	48	15	31.2	11	44	12	32	16	40	17
4	LL = 46.3		LL = 43.2		LL = 40.7		LL = 36.7		LL = 38.1	

2.2 Plastic Limit Test

Calculation of plastic limit of black cotton soil - Sample was taken = 100gms

Table-3: Plastic Limit Test

S.No	BCS with % lime	Plastic Limit
1	Black Cotton Soil with 0% lime	30.9%
2	Black Cotton Soil with 3% lime	NP
3	Black Cotton Soil with 4% lime	NP
4	Black Cotton Soil with 5% lime	NP
5	Black Cotton Soil with 6% lime	NP

2.3 Plasticity Index

The plasticity index is defined as the difference between the liquid limit and the plastic limit.

i.e,

Plasticity index = Liquid limit – plastic limit.

The result of the plasticity index is given below with different percentages of the lime in the black cotton soil.

Table-4: Plasticity Index

S.No	BCS with different percentage of the lime	Plasticity index = Liquid limit-plastic Limit
1	BCS with 0% lime	46.3- 30.9 = 15.4
2	Black Cotton Soil with 3% lime	NP
3	Black Cotton Soil with 4% lime	NP
4	Black Cotton Soil with 5% lime	NP
5	Black Cotton Soil with 6% lime	NP

2.4 California Bearing Ratio Test of the Black Cotton Soil

A comparative table for California Bearing Ratio is given below –

Table-5: CBR Test

S.No	BCS with different position of Lime	CBR Value
1	Black Cotton Soil with 0% lime	1.95
2	Black Cotton Soil with 3% lime	6.51
3	Black Cotton Soil with 4% lime	11.20
4	Black Cotton Soil with 5% lime	09.520
5	Black Cotton Soil with 6% lime	15.20

2.5 Swelling pressure of Black Cotton Soil

The result of the swelling pressure is given below of the black cotton soil with different position of the lime:

Table-6: Swelling Pressure of BCS

S.No	BCS with different position of Lime	Value of the Swelling Pressure
1	Black Cotton Soil with 0% lime	0.595
2	Black Cotton Soil with 3% lime	0.437
3	Black Cotton Soil with 4% lime	0.387
4	Black Cotton Soil with 5% lime	0.215
5	Black Cotton Soil with 6% lime	0.11

3. CONCLUSION

In this research work, it has been found that the properties of black cotton soil get effectively modified by varying proportions of lime. In this experimental program stabilization of soil has been carried out by mixing lime in varying percentages (0%, 3%, 4%, 5%, and 6%). The following conclusions are drawn from this experimental study:-

1) It has been found that an addition of 03% lime decreases the liquid limit by 6.69 %, the addition of the 04 % lime decreases liquid limit 12.09%, adding 5% lime decrease 21.38% while a 6% addition of lime shows a decrease of only 17.71%.

2) Maximum Dry Density is found to decrease by 2.4% and 5.6% at 4% and 6% lime content respectively.

3) It was found that Optimum Moisture Content . does not change with a decrease of 14.3% in O.M.C. was observed at 6% lime content.

4) 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.

5) The swelling pressure of Black cotton soil mixed with 4% and 6% lime decreased by 34.95 % and 81% respectively.

REFERENCES

[1] Amer Ali Al-Rawasa, A.W. Hagoa, Hilal Al-Sarmib (2005), "Effect of lime, cement, and Sarooj on the swelling potential of an expansive soil from Oman." *Building and Environment* 40, 681–687.

[2] Arulrajah A., M.A. Rahman, J. Piratheepan, M.W. Bo and M.A. Imteaz (2013), "Evaluation of Interface Shear Strength Properties of Geo-grid-Reinforced Construction and Demolition Materials using a Modified Large Scale Direct Shear Testing Apparatus"
Proc., *Journals of Materials in Civil Engineering,* ASCE.

[3] H. N. Ramesh, A. J. Krishnaiah and S. ShilpaShet (2013), "Effect of Lime on the Index Properties of Black Cotton Soil and Mine tailings mixtures" *IOSR Journal of Engineering,*(IOSRJEN), vol-3.

[4] IS 2720 (Part 2)-1973, "Determination of Water Content".

[5] IS 2720 (Part 3/Sec 1)-1980, "Determination of Specific gravity".

[6] IS 2720 (Part 5)-1985, "Determination of Liquid Limit and Plastic Limit".

[7] IS 2720 (Part 7)-1980, "Determination of Water Content-Dry Density Relation using Light Compaction".

[8] Kunal Anand, Awanish Kumar Shukla, Sidharth Sharma (2013), "A Comparative Study B/W Black Cotton Soil and Alluvial Soil for Economical Pavement Design by Lime & Fly-Ash Stabilization." *Int. Journal of Engineering Research and Applications.* Vol. 3, Issue 5, pp. 1609-1620.

[9] Nadgouda, K.A., and Hegde, R.A. (2010), "The Effect of Lime Stabilization on Properties of Black Cotton Soil" *Indian Geotechnical Conference* 2010, IGS Mumbai Chapter & IIT Bombay, 511-514.

[10] Katare R., Pande M.M., and Jain S.K. (2009) "Lime Stabilization Method of Black Cotton Soil" of Gwalior Region. ACSGE, BITS PILANI, INDIA

[11] Arora, Dr. K.R., "Soil Mechanics and Foundation Engineering", Standard publisher Distribution, Delhi-110006.

[12] Garg, S.K., "Soil Mechanics and Foundation Engineering", Khanna Publishers, Delhi- 110006.

[13] Punmia, B.C., "Soil Mechanics and Foundation Engineering" Laxmi Publication (P) Ltd., New Delhi.

[14] Determination of liquid limit and plastic limit. Indian standard methods for testing of soils-IS2720 (a) Indian standard Institution, New Delhi, India, part 5, pp. 109- 144, 1985.