Feasibility of Eggshell Powder and Lime Stabilized Black Cotton Soil as Sub Grade Material for Road Construction

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Abstract- *Soil stabilization is the process in which improving the different type of engineering properties of Black Cotton soil and it is making for stable soil. It can be done by the use of controlled compaction, proportioning and the addition of suitable different types of admixtures and stabilizers. Soil stabilization is very necessary for various construction works like road pavement and foundation because it improves the engineering properties of BC Soil. The objective of this work is to estimate the effect of lime and Eggshell powder on some geotechnical properties of black cotton soil, in order to determine the suitability of lime and Eggshell powder for use as a modifier or stabilizer in the treatment of black cotton soil for roadwork. This paper represents a study of the lime and Eggshell powder as the admixtures or stabilizers in improving some engineering Properties of Black Cotton (BC) soils. This experimental program evaluates the effect of the lime and Eggshell powder on the some basic engineering properties of BC soil such as Liquid limit, Plastic limit, Shrinkage limit test of BC Soil. The study on effect of Eggshell powder (ESP) on the stabilizing potential of lime on expansive clay soil. Tests were carried out to determine the optimal percentage of lime-ESP combination; the optimal quantity of lime was gradually replaced with suitable amount of Eggshell powder. The lime stabilized and lime-ESP stabilized mixtures were subjected to engineering tests. The optimal percentage of lime-ESP combination was attained at a 5% ESP+ 5% lime, which served as a control. All indicated that lime stabilization 10% is better than the combination of 5% ESP + 5% lime.*

Keywords- Black cotton Soil(BC), Egg shell powder(ESP).Liquid Limit(LL),Plastic Limit (PL),Plastic Limit (PL),Shrinkage Limit(SL),Flow Index (FI)

I. INTRODUCTION

Every civil engineering structure whether it a building, bridge, highway pavement or railway track will in general have super structure and foundation. The civil engineers are the forerunners of all developmental activities, that the environment is consciously given due to consideration while embarking on development activities, which are essential to meet the aspiration of people, especially in developing countries, like India. In developing countries, limited finances are available for planning and development of construction network. The conventional hard quality stones construction material in regards to strength and durability .but the sources of these material are depleting fast which has increased the leads in transporting material from source to site. Moreover, in India, many state governments have imposed ban in earth cutting and quarrying to preserve the eco-system. So, the proper utilization of low grade material should be made useful, which not only bring about significant savings in construction work.

In general way it has been found that soils can be classified into groups, according to their engineering properties. Consequently proper classification of such surface material is an important step in connection with any foundation job because that may be anticipated during and after construction.

Black cotton soil is produced geologically by the disintegration of volcanic rock and is very rich loamy earth of great fertility and unusually power of retaining moisture. Black cotton soil is an expansive soil called Montmorilllonite. One day they are dry and hard, and the next day wet and soft. Swelling soil always create problem for lightly loaded structure, by consolidating under load and by changing volumetrically along with seasonal moisture variation. As a result the superstructures usually counter excessive settlement and differential movements, resulting in damage to foundation systems, structural elements and architectural features. In a significant number of cases the structure becomes unstable or uninhabitable the purpose was to check the scope of improving bearing capacity value and reduce expansiveness by adding additives. There are many methods of stabilizing soil to gain required engineering specifications. These methods range from mechanical to chemical stabilization. Most of these methods are relatively expensive to be implemented by slowly developing nations and the best way is

to use locally available materials with relatively cheap costs affordable by their internal funds.

II. OBJECTIVES

- To study the physical properties of Black Cotton soil.
- To determine optimum moisture content and maximum dry density for Black Cotton soil using eggshell powder and cement with varying percentages.
- Effective utilization of eggshell waste for the stabilization of soil as a sub grade material for the road construction

III. MATERIALS AND METHODOLOGY

3.1 Materials

The different materials used are:

1. Black Cotton soil
2. Lime powder
3. Egg shell powder

3.2 METHODOLOGY

The eggshell was collected from puttur city hotel and fast food centre. The eggshell was air dried, broken manually and then milled into powdery form which was collected in polythene bags and stored under room temperature. The eggshell was finally sieved through BS 425μm.

Test were carried out first on the natural soil without any additive to ascertain the PI, such that the effect of the additive could easily be measured form their PI values when mixed with

Natural soil. Since the project is direct towards the measurement of the effect of ESP on the lime stabilized clay, the optimal percentage of lime was determined before the addition of ESP.

The quantity of lime added was calculated by 200g weight of natural soil specified for the test in BS1377 so that the total weight (lime + soil) still equal 200g. The optimal percentage of lime-ESP combination was obtained from the PI of the sample with various proportions.

The sample was prepared by weighing the quantities of additives required for each batch and first mixing thoroughly before adding water.

The effect of ESP on the soil was assessed by comparing the plasticity index (PI) value of soil earlier stabilized with an optimal percentage of lime and the value when a certain percentage of the optimal lime was replaced by eggshell. The best result of the on with the lowest PI. Tests were carried out on the samples, first to determine the optimal quantity of lime and subsequently the optimal of ESP-lime combination by varying the proportion by weight. The optimal percentage of lime was gradually reduced the complemented with suitable percentages of ESP in the following ratios: 1% lime + 9% ESP, 2% lime + 8% ESP, 3% lime + 7% ESP, 4% lime + 6% ESP, 5% lime + 5% ESP. For each variation, Atterberg"s limit test (liquid and plastic limit) were carried out to determine the optimal lime-ESP combination.

IV. RESULT AND DISCUSSION

4.1 Index properties

Preliminary tests results were conducted for the identification of the natural soil and the determination of its properties that are summarized in Table 4.1 The soil is classified under the (A–7–6) subgroup of the American Association of State Highway and Transportation Officials (AASHTO) classification system, low plasticity clay (CL) according to the Unified Soil Classification system (USCS) (ASTM, 1992) and high swell potential soil according to the Nigerian Building and Road Research Institute (NBRRI, 1983) classification. The tests results revealed that the soil is not suitable for use as sub-grade, sub-base or base course material for pavement construction.

4.2 Natural moisture content test.

The natural moisture content of the soil was 15.43%. This value is minimal and does not have much effect on engineering and main test.

4.3 Specific gravity test

The specific gravity of the soil was found to be 2.37, which is within the range for silts and silty soil according to ASTM results of the particle.

4.4 Grain size distribution test

A particle size distribution curve gives us an idea about the type and the gradation of the soil.

Grain size distribution indicates if a material is well graded, poorly graded, uniformly graded, fine or Coarse. In this figure the Coefficient of curvature (Cc) is 1.38 and Uniform coefficient (Cu) is 14, we conclude that the soil is well graded soil. According to Particle size distribution curve indicated that the soil is well graded soil and a component proportion of Gravel is 2%, sand is 10.9%, silt is 13.6% and clay is 73.5% respectively.

Table-4.1: Index Properties Result of unstabilized Black Cotton soil

Sl No.	Property of the soil	Value
1	Grain size distribution	
	Sand(%)	25
	Silt+Clay (%)	75
2	Specific Gravity	2.37
3	Natural moisture content (%)	15.43
4	Atterberg's limits	
	(a) Liquid limit (%)	56
	(b) Plastic limit (%)	21
	(c) Plastic Index (%)	35
	(d) Shrinkage limit (%)	13.78
	(e) Flow Index (%)	35
5	Compaction characteristics	
	(a)Maximum Dry Density (gm/cc)	1.57
	(b)Optimum Moisture Content (%)	23
6	Unconfined Compression Strength (kN/m^2)	80.94
7	Triaxial Compressive Strength	
	(a) Cohession (kg/cm^2)	2.90
	(b) Angle of Internal Friction (degrees)	11.3
8	California Bearing Ratio (%)	
	(a)Unsoaked	5.22
	(b)Soaked	2.31
9	Soil classification	CH (Inorganic fat clay with high compressibility)
		A-7-6 (Clayey soil with High Plasticity, LL>40% and PI>10%)

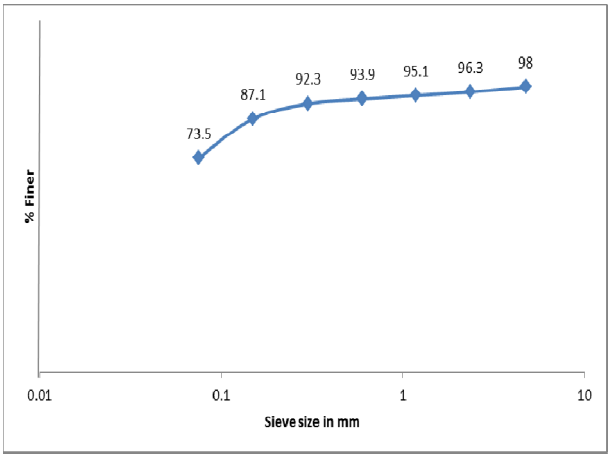

Fig 4.1: Grain size distribution curve

While adding different percentages of Lime and different percentages of Lime + Egg Shell Powder (ESP) to the soil, the results of the engineering property tests Atterberg's limits tests are presented and discussed below.

Table-4.2: Atterberg's Limits for Lime Stabilization

% lime by weight of soil	LL (%)	PL (%)	PI (%)	SL (%)	FI (%)
0	56	21	35	13.78	35
6	50	37	13	11.60	23
8	47	36.7	10.3	10.13	18
10	45.45	36.05	9.4	9.20	21.5

LL-Liquid Limit (WL), PL-Plastic Limit (WP), PI-Plastic Limit (IP), SL-Shrinkage Limit,FI- Flow Index (If) ESP- Egg Shell Powder.

Table-4.3: Atterberg's Limits for ESP-Lime Stabilization

% lime by weight of soil	% ESP by weight of soil	LL (%)	PL (%)	PI (%)	SL (%)	Fl (%)
1	9	57.1	31.67	25.43	12.32	29.00
2	8	58.3	33.33	24.97	11.54	32.50
3	7	52.94	36.95	15.99	10.92	25.00
4	6	47.06	36.4	10.66	10.03	22.80
5	5	46.15	35.35	10.80	9.34	18.50

The following graphs are showing variation of water content with number of blows and also showing the liquid limit at 25 blows.

The figure 4.2 indicates that variation of water content with number of blows in natural black cotton soil using without stabilizer. This figure shows the corresponding values of 25 blows and liquid limit obtained is 56%. The liquid limit of Black Cotton soil is normally range from 35 to 100%. So, the value obtained lies in-between that range and this soil is considered as a expansive soil. According to IS and HRB classification Plasticity chart CH (Inorganic fat clay with high compressibility).A-7-5 (Clayey soil with high LL > 40% and Plasticity index > 10%).

The figure 4.3 indicates that variation of water content with number of blows in Natural Black Cotton soil + 6% Lime. This figure shows the corresponding 25 blows liquid limit is 50%. When 6% Lime is added to the soil the liquid limit will be reduced to some percentages when compared to the natural Black Cotton soil. This result shows that lime is a good stabilizer to the Black Cotton soil.

(Natural Black Cotton soil)

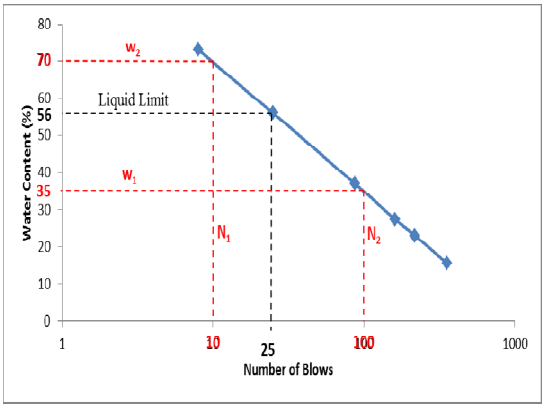

Fig 4.2: Variation of water content with number of blows

(Soil + 6% Lime)

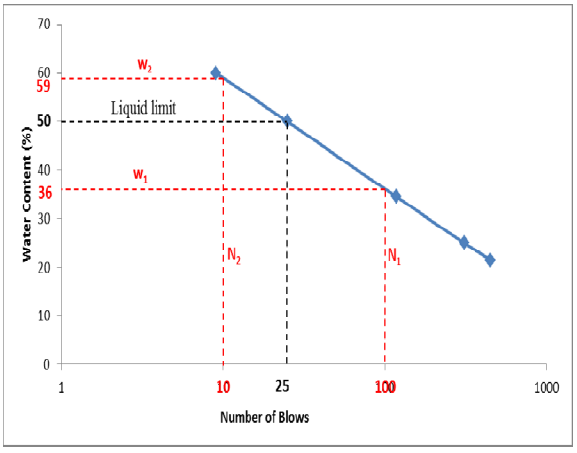

Fig 4.3: Variation of water content with number of blows

The figure 4.4 indicates that variation of water content with number of blows in Natural Black Cotton soil + 8% Lime. This figure shows the corresponding 25 blows liquid limit is 47%. When 8% Lime is added to the soil the liquid limit will be reduced to some percentages compared to the Black Cotton soil and soil + 6% Lime. This result shows that when lime is added to soil in more percentages to the Black cotton soil liquid limit will be reduced at certain limit.

(Soil + 8% Lime)

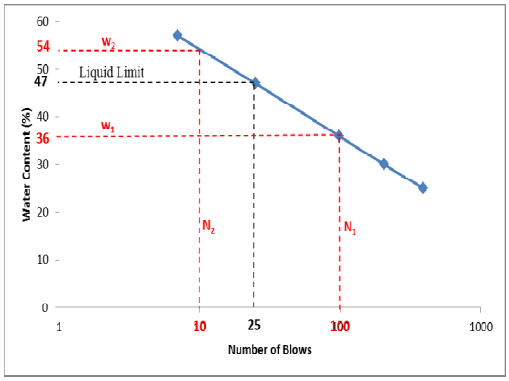

Fig 4.4: Variation of water content with number of blows

(Soil + 10% Lime)

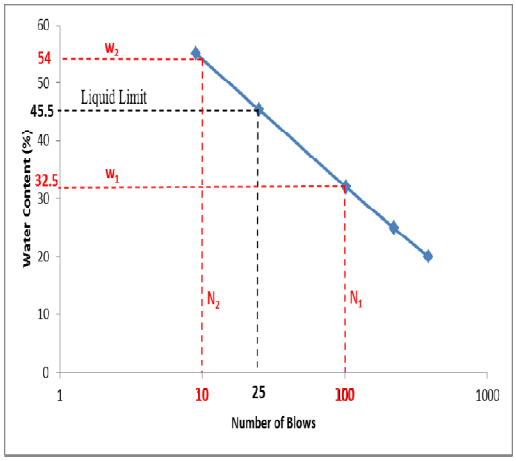

Fig 4.5: Variation of water content with number of blows

The figure 4.5 indicates that variation of water content with number of blows in Natural Black Cotton soil + 10% Lime. This figure shows the corresponding 25 blows liquid limit is 45.5%. When 10% Lime is added to the soil the liquid limit was be reduced to some percentages when compared to the Soil + 6% Lime and Soil + 8% Lime. This result shows that lime is added in more percentages to the Black cotton soil liquid limit will be reduced at certain limit. After the 10% lime stabilization soil changes the type. According to IS and HRB classification Plasticity chart our soil changes CH (gravelly, sandy or silty) group and A5 type (Plasticity < 10% and LL > 40%).

(Soil + 1% Lime + 9% ESP)

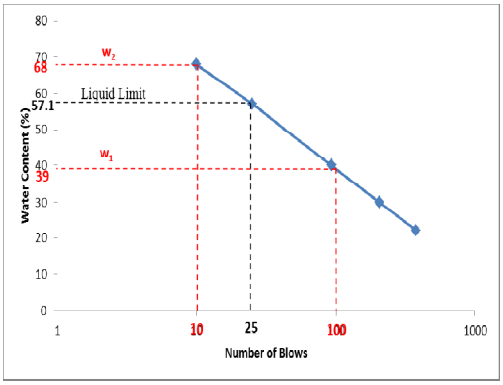

Fig 4.6: Variation of water content with number of blows

The figure 4.6 indicates that variation of water content with number of blows in Natural Black Cotton soil + 1% Lime + 9% Egg Shell Powder (ESP). This figure shows the corresponding 25 blows liquid limit is 57.1%. When 1% Lime + 9% ESP was added to the soil the liquid limit will be increased in some percentages compared to the Natural Black Cotton soil.

(Soil + 2% Lime + 8% ESP)

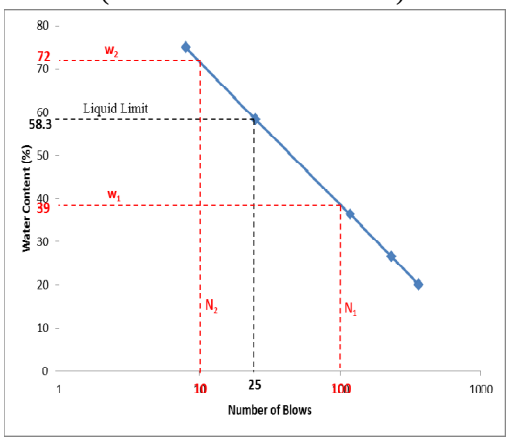

Fig 4.7: Variation of water content with number of blows

The figure 4.7 indicates that variation of water content with number of blows in Natural Black Cotton soil + 2% Lime + 8% Egg Shell Powder (ESP). In this figure shows the corresponding 25 blows liquid limit is 58.3%. When adding 2% Lime + 8% ESP to the soil the liquid limit will be increased little percentages compared to the Natural Black Cotton soil and 1% lime + 9% ESP adding to the Black Cotton soil.

(Soil + 3% Lime + 7% ESP)

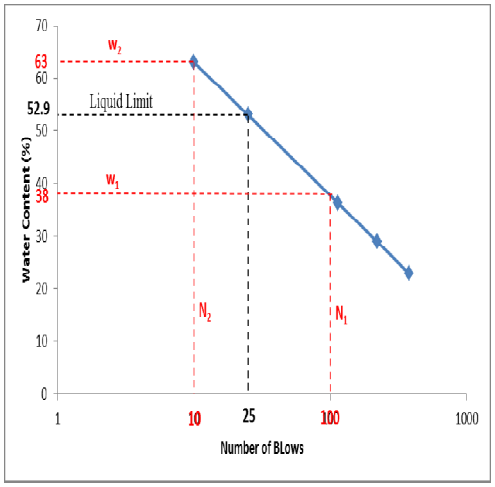

Fig 4.8: Variation of water content with number of blows

The figure 4.8 indicates that variation of water content with number of blows in Natural Black Cotton soil + 3% Lime + 7% Egg Shell Powder (ESP). This figure shows the corresponding 25 blows liquid limit is 52.9%. When 3% Lime + 7% ESP was added to the soil the liquid limit will be reduced in some percentages compared to the Natural Black Cotton soil and 1% lime + 9% ESP adding to the Black Cotton soil.

(Soil + 4% Lime + 6% ESP)

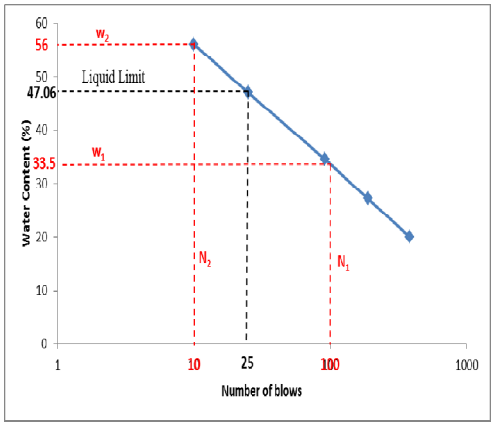

Fig 4.9: Variation of water content with number of blows

The figure 4.9 indicates that variation of water content with number of blows in Natural Black Cotton soil + 4% Lime + 6% Egg Shell Powder (ESP). This figure shows the corresponding 25 blows liquid limit is 47.06%. When 4% Lime + 6% ESP was added to the soil the liquid limit will be reduced in some percentages compared to the Natural Black Cotton soil and 1% lime + 9% ESP adding to the Black Cotton soil. It is almost equal to the Soil + 8% lime.

(Soil + 5% Lime + 5% ESP)

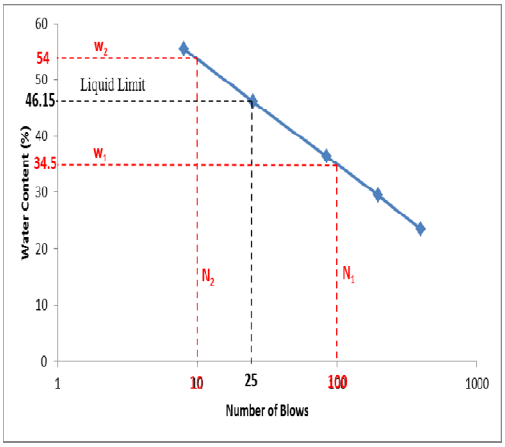

Fig 4.10: Variation of water content with number of blows

The figure 4.10 indicates that variation of water content with number of blows in Natural Black Cotton soil + 5% Lime + 5% Egg Shell Powder (ESP). This figure shows the corresponding 25 blows liquid limit is 46.15%. When 5% Lime + 5% ESP was added to the soil the liquid limit was reduced in some percentages compared to the 4% lime + 6% ESP adding to the Black Cotton soil. It is almost equal to the Soil + 10% lime.

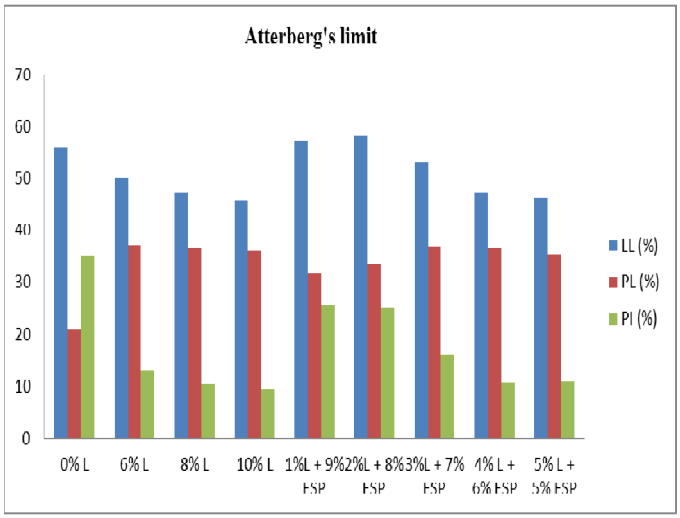

Fig 4.11: Variation of Atterberg's limits with lime and lime + ESP stabilization

The fig 4.11 indicated that variation of Atterberg"s limits with lime and lime + ESP combination, plasticity index of natural soil was 35.0% with a liquid limit of 56.0% and plasticity limit of 21.0%, indicating that the clay is of high plasticity. It is generally believed that high plasticity is an indicator for swelling potential, clay is susceptible to large volume changes if the PI is greater than or equal to 30%.

The effect of the additives on the natural soil as earlier stated was measured by the changes in the plasticity indices of the samples. The addition of lime at 10.0% reduced the PI 35.0% to the smallest value of 9.4%, indicating optimal mixture of lime. The PI of lime however increased further with the addition of 15% lime, this is due to extra water required by the excess lime which makes the soil of swell.

The addition of combination of ESP + lime resulted in the higher PI of 25.43% lime than the 10.66% value obtained for the optimal mixture of lime. The values however reduced with subsequent reduction of ESP in the mixture. An optimal mixture was achieved at 5% lime+5% ESP combination. The PI at the optimal mixture was 10.8%, indicating that the addition of ESP has a positive effect on the PI when compared with the PI of sample with 8% lime and 0% ESP, but was not affective of the optimal mixture of lime.

V. CONCLUSIONS

The following conclusions are drawn from the present investigation,

1. The black cotton soils have high degree of expansion and possess high swelling potential and require stabilization for their better performance.
2. 10% Lime improved the quality of the soil samples by significantly reducing their plastic indices 35% to 9.4% and the combination of 5% lime + 5% Eggshell powder reduces the plasticity indices 35% to 10.8% which is approximately equal to 10% lime stabilized.
3. The unconfined compressive strength of this soils increases from 80.94 kN/m2 to 207.72 kN/m2.with 10% lime stabilizer which is approximately equal to the 5% lime + 5% ESP stabilizer this value is 206.9 kN/m2.

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