STUDY ON THE EFFECT OF ADDITION OF EGG SHELL POWDER (ESP) ON PROPERTIES OF BLACK COTTON SOIL

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Abstract - *Soil is one of the most important materials used in a variety of construction projects. Clay soil is widely used in most of the construction projects. Clay soils, particularly soft clay soils, have good plastic properties so that increased moisture results in their decreased shear strength, compressive strength and volume changes. These damages typically take an irreparable toll on structures, which further clarifies the importance of soil improvement. In the present study, eggshell powder (ESP) was used as a waste to combine with soil so that the plasticity properties of clay soil were investigated in different mixture proportions. Then the plasticity properties of soils including liquid and plasticity limits as well as plasticity index, already measured, were compared with those of the experimental specimens mixed with ESP in different proportions and also to study the effect of ESP on the stabilizing potential of lime on an expansive clay soil. Tests were carried out to determine the optimal quantity of lime and the optimal percentage of lime-ESP combination; the optimal quantity of lime was gradually replaced with suitable amount of eggshell powder. The optimal percentage of lime-ESP combination was attained at a 4% ESP + 3% lime, which served as a control. Results of the Maximum Dry Density (MDD), unconfined compression test and Undrained triaxial shear strength test all indicated that lime stabilization at 7% is better than the combination of 4% ESP + 3% lime.*

***Key Words*: Black cotton soil, Egg shell powder, Lime powder, MDD (Maximum dry density), Unconfined compression test, Triaxial shear strength.**

1. INTRODUCTION

Any superstructure to stand, the foundation is very significant and has to be strong to hold up the entire structure. In order for the foundation to be strong, the soil around it plays a vital role. So, to work with soils, we need to have proper understanding about their properties and factors which affect their behavior. The method of soil stabilization helps to reach the required properties in a soil needed for the construction work. A Black cotton soil is composed of clay minerals and which has plasticity and cohesion. Though the black cotton soils are fine grained but, not all fine grained soil possess plasticity and cohesion.

The presence of water, its content plays a significant role in the engineering behaviour of a black cotton soil. On the other hand, grain size distribution and grain shape influence the engineering properties of granular soils and hardly affect the behavior of black cotton soil. Black cotton soils though possess good strength, when they are thoroughly dry, when comes in contact with moisture content have a greater tendency for upheavement, which in turn shrinks after the moisture content is drained out or lost. This swell-shrink behaviour of black cotton soil and also termed as Expansive soil. Soil stabilization is one of the most common methods resorted to for enhancing the engineering properties of a soil by altering the original properties of the soil. Egg shell Powder (ESP) has not being in use as a stabilizing material and it could be a good substitute for stabilizing material and it could be a good substitute for industrial lime, as its chemical composition is as that of lime.

1. Materials

1.1 Black cotton soil :

Soil was collected from Vidurashwatha, Gauribidanur Taluk.

The properties of the soil were given in Table-1.

1.2 Egg shell powder:

Chicken eggshell is a waste product from domestic sources such as poultries, hatcheries, homes and fast food restaurants. Eggshells were spread on the ground and air dried for 2 days to make easy milling. After air drying the eggshells were manually broken and crushed into powdery forms which were collected in polythene bags. The eggshell powder in the end sieved through 425µ sieve. Eggshell powder contains 99.83% of CaO and remaining consists of Al2O3, SiO2, Cl, Cr2O3, MnO and CuO.

Table -1: Properties of Soil

Sl. No	Description	Result
1	Colour	Black
2	**Atterberg limits**	
	Liquid Limit	61.2%.
	Plastic Limit	36.35%
	Plasticity Index	24.85

4	Specific Gravity	2.66
5	**Compaction characteristics**	
	Optimum Moisture Content	25%.
	Maximum Dry Density	1.648 g/cm^3
6	Unconfined Compressive Strength	59.45 kN/m^2
7	**Grain Size Distribution**	
	Gravel	3.2%
	Sand	25.9%
	Clay and Silt	70.9%
8	IS Soil Classification System	Clay of intermediate plasticity

2. EXPERIMENTAL METHODOLOGY

Conduction of standard tests on soil samples to determine the basic properties of soil used:-

1. Specific gravity.

2. Particle size distribution/grain size distribution.

3. Atterberg's limits- liquid limit and plastic limit

The effects of ESP on lime-stabilized soil were assessed further by subjecting the natural soil, the natural soil plus lime and the natural soil plus optimal lime-ESP mixture to general classification and laboratory strength tests which includes:

1 .Compaction Test (standard proctor)

2. Unconfined Compression Test

3. RESULTS AND DISCUSSIONS

3.1 Liquid limit

The liquid limit value was decreased gradually when the lime of 7% was added, Decrease in the value of liquid limit was due to the porous property of lime .According to the result the liquid limit of the black cotton soil+7% Lime is 55.14% and liquid limit of only black cotton soil is **61.2**%.

3.2 Plastic limit and plasticity index

The *plastic limit* value was decreased gradually when the lime of 7% was added, decrease in the value of *plastic limit* was due to the porous property of lime .According to the result the plastic limit of the black cotton soil+7% Lime is 27.90% and plastic limit of only black cotton soil is 36.354%.

Plasticity index for Black cotton soil is

=24.85

Plasticity index for BC soil +7% lime

= 27.24

3.3 Compaction test:

- The natural soil sample had a maximum dry density of 1.648 g/cm^3 and optimum moisture content of 25%.
- As per the references made with respect to many literatures, 7% of Lime was found to be the Optimum dosage, and hence, 7% of lime was added to the BC soil and compaction was carried out.
- The addition of 7% lime reduced the maximum dry density to 1.484 g/cm^3 and increased the optimum moisture content to 22.75%.
- Different trials were conducted with varying percentages of Lime + ESP combinations, i.e. 6% lime+1% ESP, 5% lime+2%ESP, 4% lime+3% ESP and 3% lime+4% ESP. Out of which The 3% lime+4% ESP was found to yield a better result as when compared to other combinations, as the addition of 3% lime + 4% ESP lowered the maximum dry density further to 1.473 g/cm^3 and increases the optimum moisture content to 23.8%.
- Generally, the higher the MDD, the better the soil for construction works, but for expansive soil, a higher MDD usually indicates a high swelling potential. This shows that the sample mix of 3% lime + 4% ESP shows little tendency for swelling as compared with the other two samples. Also, the lower the OMC, the better the soil. This implies that the sample stabilized with 3% lime + 4% ESP is better than stabilization with only 7% lime.

OMC and MDD curve for Standard Compaction Test

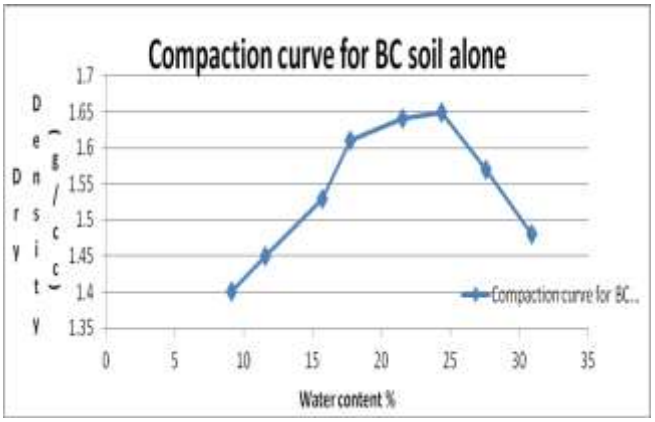

Chart -1:

For BC soil alone

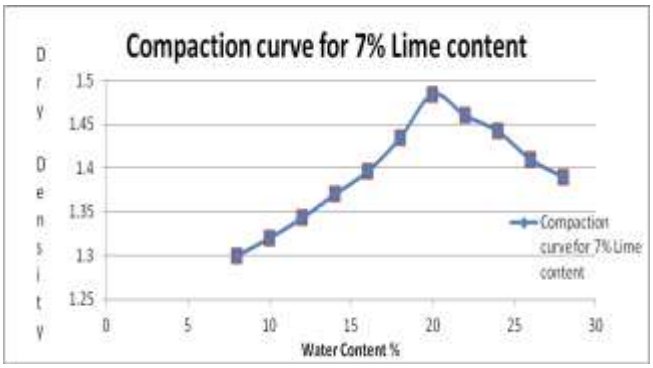

Chart -2:

Soil+7%Lime

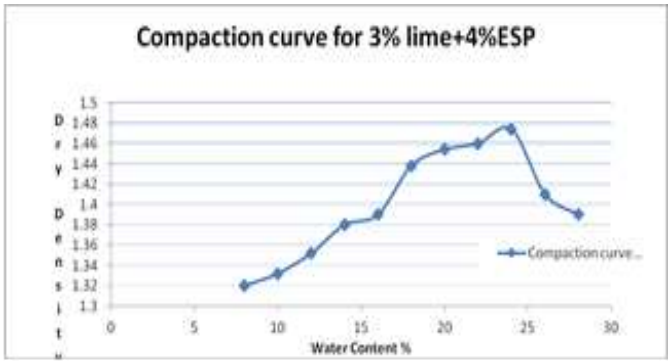

Chart -3:

Soil+3%Lime+4%ESP

3.4 Unconfined compression test*:*

For the uncured samples, the UCC strength of the clay soil was 59.45 kN/cm^2; The addition of 7% lime raised this value to 189.52kN/cm^2. The addition of 3% lime + 4% ESP reduced this strength to 93.50 kN/cm^2. For the cured samples, the undrained shear strength of the soil was found to be 14.66kN/cm^2, while the addition of 7% lime increased shear strength to 50.96 kN/cm^2. It could be seen that the addition of 7% lime still gave the best overall result. The extra strength displayed by the lime mixture is due to the binding action that lime has with fine soil particles. The measured strength is not used for design purposes; rather, the unconfined compressive strength data are principally significant for field control purposes.

Table.2: Unconfined compression values for cured and uncured conditions

Additive by Weight (%)	Uncured (kN/cm^2)	Cured (kN/cm^2)
0 %	14.66	59.45
3% lime+4%ESP	35.98	93.50
7% lime	50.96	189.52

CONCLUSIONS

- The Liquid limit of the BC Soil which was around 61.20% got reduced to 55.14% which indirectly indicates less water absorption property of BC soil treated with lime, and hence less tendency for volume change.
- The plastic limit of the BC soil which was initially around 36.354% got further reduced to 27.90% after addition of Lime.
- The plasticity Index of the BC soil changed from 24.85 to 27.24 on addition of Lime.
- Based on the results that were obtained from the Standard Compaction Test it can be concluded that addition of Lime reduced the MDD value of the BC soil which indicates a lesser potential for Swelling, and also the OMC value was enhanced, which indicated a betterment of the soil
- However, when the 7% Lime content was replaced by 3%Lime+4%ESP, there was a further decrease in the Dry Density value of the soil, which again in turn reduced the Swelling potential of the soil at a later stages, but this was achieved at a much lesser water content.
- The UCC test results shows that, the soil added with lime or mix of Lime+ESP exhibits higher strength as when compared to untreated soil sample.

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