Black Cotton Soil Stabilization Using Eggshell Powder and Lime

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Abstract- *Soil stabilization is the process of improving the engineering properties of soil and thus making it more stable. It is required when the soil available soil for construction is not suitable for the intended purpose.. 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 work 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 Unconfined compression test, Compaction, and California Bearing Ratio (CBR) 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. Results of the, California Bearing Ratio(CBR), and triaxial compression test indicated that lime stabilization 10% is better than the combination of 5% ESP + 5% lime.*

I. INTRODUCTION

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 study the influence of egg shell powder and cement on strength behavior in terms of CBR for BC soil.

- To determine strength parameters of soil with different percentages of eggshell powder and cement by conducting Unconfined Compression test (UCC).

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

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 lime-ESP mixture to general classification and laboratory strength test which includes:

- Compaction test
- California bearing ratio test (CBR)
- Unconfined compression test
- Undrained triaxial test

IV. RESULT AND DISCUSSION

The Result of unstabilized Black Cotton soil as follows: 1.Compaction test: (a) Maximum dry density= 1.57gm/cc, (b) Optimum moisture content= 23%, 2) Unconfined Compression Test= 80.94kn/m^2. 3) Triaxial Compressive Strength: a) Cohesive Soil = 2.90kg/cm^2. (b) Angle of Internal Friction (degrees) = 11.3. 4) California Bearing Ratio: (a)Unsoaked = 5.22 %, (b)Soaked = 2.31%.

4.1 Compaction test

The figure 4.1.1 indicates that variation of Dry Density with varying percentages of water in natural Black Cotton soil using without stabilizer. This figure shows the Optimum Moisture Content is 23% and Maximum Dry Density is 1.57 gm/cc. OMC of Black Cotton soil is usually high.

Table-4.1: Result of Maximum Dry Density and Optimum Moisture Content

% Additive by Weight	MDD (gm/cc)	OMC(%)
0% Lime	1.57	23.0
6% Lime	1.54	22.5
8% Lime	1.53	22.0
10% Lime	1.49	21.0
1% Lime + 9% ESP	1.54	22.0
2% Lime + 8% ESP	1.53	22.0
3% Lime + 7% ESP	1.52	21.5
4% Lime + 6% ESP	1.52	21.0
5% Lime + 5% ESP	1.49	20.0

(Natural Black Cotton soil)

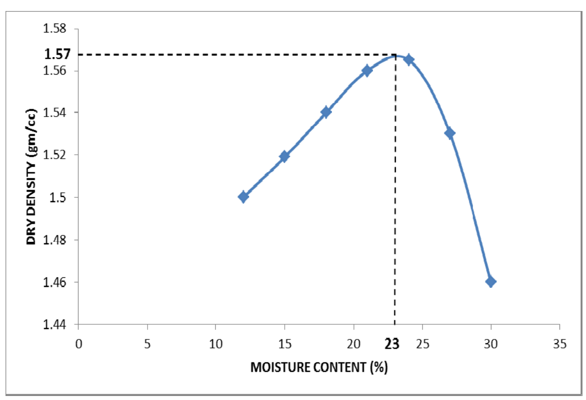
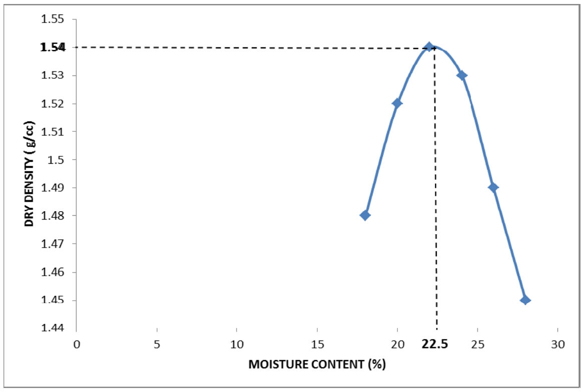


Fig 4.1.1: Variation of Dry Density with varying percentages of water



(Soil + 6% Lime)

Fig 4.1.2: Variation of Dry Density with varying percentages of water

The figure 4.1.2 indicates that variation of Dry Density with varying percentages of water in Black Cotton soil + 6%. This figure shows the Optimum Moisture Content is 22.5% and Maximum Dry Density is 1.54 gm/cc. In this figure, OMC and MDD are reduced compared to the Natural Black Cotton soil.

The figure 4.1.3 indicates that variation of Dry Density with varying percentages of water in Black Cotton soil + 8%. This figure shows the Optimum Moisture Content is 22% and Maximum Dry Density is 1.53 gm/cc. In this figure OMC and MDD are reduced compared to the Natural Black Cotton soil and Soil + 6% Lime. As percentages of lime adding more the OMC and MDD are reduced.

(Soil + 8% Lime)

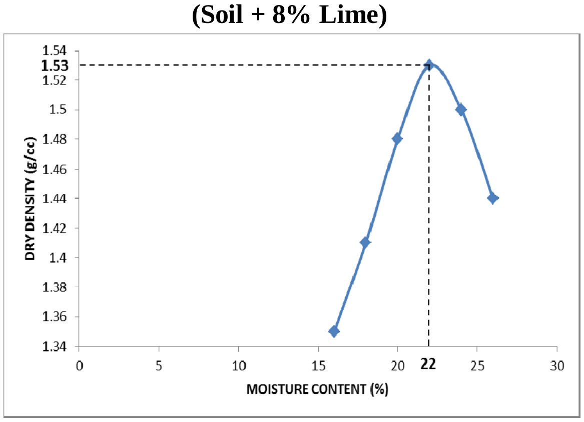


Fig 4.1.3: Variation of Dry Density with varying percentages of water

(Soil + 10% Lime)

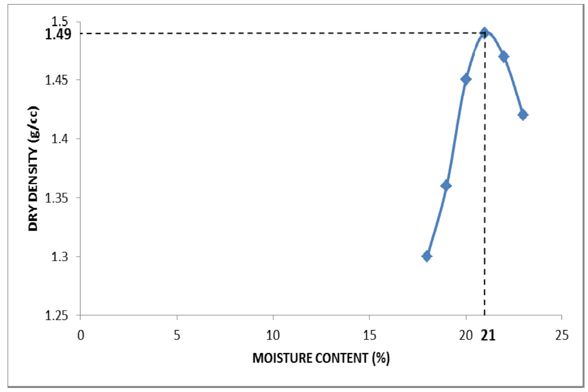


Fig 4.1.4: Variation of Dry Density with varying percentages of water

The figure 4.1.4 indicates that variation of Dry Density with varying percentages of water in Black Cotton soil + 10%. This figure shows the Optimum Moisture Content is 21% and Maximum Dry Density is 1.49 gm/cc. In this figure OMC and MDD are reduced compared to the Soil + 6% Lime and Soil + 8% Lime. As percentages of lime adding more the OMC and MDD are reduced.

(Soil + 1% Lime + 9% ESP)

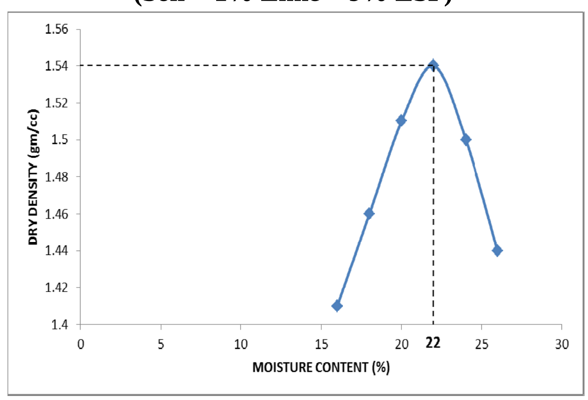


Fig 4.1.5: Variation of Dry Density with varying percentages of water

The figure 4.1.5 indicates that variation of Dry Density with varying percentages of water in Black Cotton soil + 1% Lime + 9% Egg Shell Powder (ESP). This figure shows the Optimum Moisture Content is 22% and Maximum Dry Density is 1.54 gm/cc. In this figure OMC and MDD are reduced compared to the Natural Black Cotton soil and approximately equal to the Soil + 6% Lime.

(Soil + 2% Lime + 8% ESP)

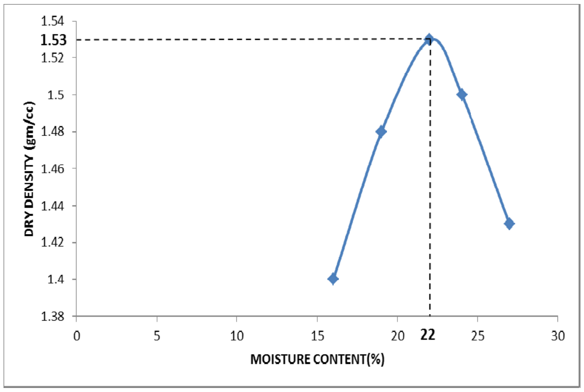


Fig 4.1.6: Variation of Dry Density with varying percentages of water

The figure 4.1.6 indicates that variation of Dry Density with varying percentages of water in Black Cotton soil + 2% Lime + 8% Egg Shell Powder (ESP). This figure shows the Optimum Moisture Content is 22% and Maximum Dry Density is 1.53 gm/cc. In this figure OMC and MDD are reduced compared to the Natural Black Cotton soil and approximately equal to the Soil + 8% Lime.

(Soil + 3% Lime + 7% ESP)

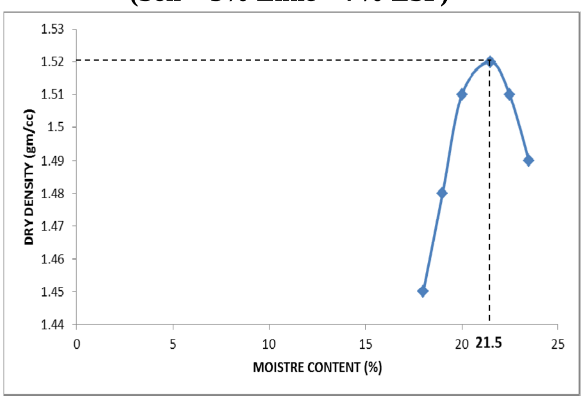


Fig 4.1.7: Variation of Dry Density with varying percentages of water

The figure 4.1.7 indicates that variation of Dry Density with varying percentages of water in Black Cotton soil + 3% Lime + 7% Egg Shell Powder (ESP). This figure shows the Optimum Moisture Content is 21.5% and Maximum Dry Density is 1.52 gm/cc. In This figure OMC and MDD are reduced compared to the Natural Black Cotton soil and Soil + 1% Lime + 9% ESP and also approximately equal to the Soil + 8% Lime.

(Soil + 4% Lime + 6% ESP)

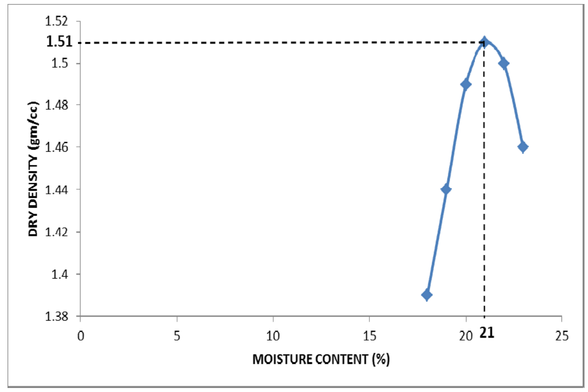


Fig 4.1.8: Variation of Dry Density with varying percentages of water

The figure 4.1.8 indicates that variation of Dry Density with varying percentages of water in Black Cotton soil + 4% Lime + 6% Egg Shell Powder (ESP). This figure shows the Optimum Moisture Content is 21.% and Maximum Dry Density is 1.51 gm/cc. In this figure OMC and MDD are reduced compared to the Soil + 8% Lime and Soil + 3% Lime + 7% ESP and also the OMC is approximately equal to the Soil + 10% Lime

(Soil + 5% Lime + 5% ESP)

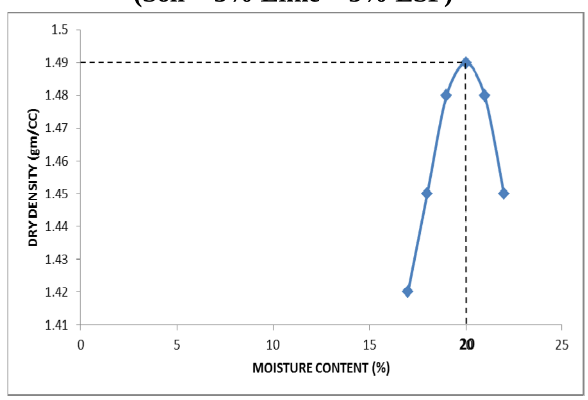


Fig 4.1.9: Variation of Dry Density with varying percentages of water

The figure 4.1.9indicates that variation of Dry Density with varying percentages of water in Black Cotton soil + 5% Lime + 5% Egg Shell Powder (ESP). This figure shows the Optimum Moisture Content is 20.% and Maximum Dry Density is 1.49 gm/cc. In this figure OMC and MDD are reduced compared to the Soil + 8% Lime and Soil + 4% Lime + 6% ESP and also the OMC and MDD is equal to the Soil + 10% Lime.

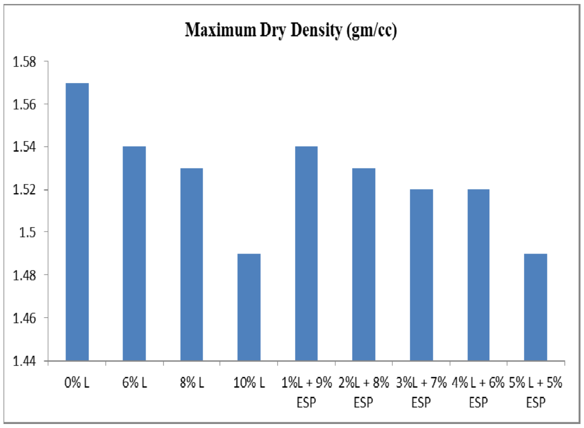


Fig 4.1.10: Variation of Maximum Dry Density with varying percentages of Lime and Lime + ESP stabilization

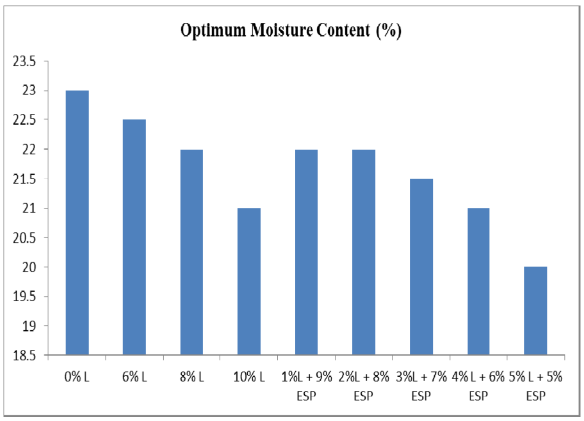


Fig 4.1.11: Variation of Optimum Moisture Content with varying percentages of Lime and Lime + ESP stabilization.

The Fig 4.1.10 indicated that variation of maximum dry density and Fig 4.1.11 indicated that variation of optimum moisture content with varying percentages of Lime and Lime + Egg Shell Powder (ESP) combination. In fig 4.1.10 the natural soil sample had a maximum dry density of 1.57 gm/cc and fig 4.1.11 the optimum moisture content of 23.0%, the addition of 10% lime reduced the maximum dry density to 1.49 gm/cc and decrease the moisture content to 21.0%, while the addition of 5% of lime + 5% of ESP lowered the maximum dry density further to 1.49 gm/cc and decrease the OMC to 20.0%.

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 5% lime + 5% ESP shows the little tendency for swelling as compare with the other two samples. Also, the lower the OMC, the MDD also reduced. This implies that the sample stabilized with 5% lime + 5% ESP is better than the stabilization with only 10.0% lime.

4.2 California Bearing Ratio (CBR) test

Table-4.2.1: CBR Values for Soaked and Unsoaked Conditions

% Additive by Weight of soil	Soaked (CBR %)	Unsoaked (CBR %)
0% Lime	2.31	5.22
6% Lime	5.35	7.07
8% Lime	10.32	14.7
10% Lime	15.4	19.82
1% Lime + 9% ESP	7.50	11.38
2% Lime + 8% ESP	11.09	15.80
3% Lime + 7% ESP	14.59	18.78
4% Lime + 6% ESP	16.25	20.29
5% Lime + 5% ESP	18.25	23.07

(Natural Black Cotton soil for unsoaked CBR condition)

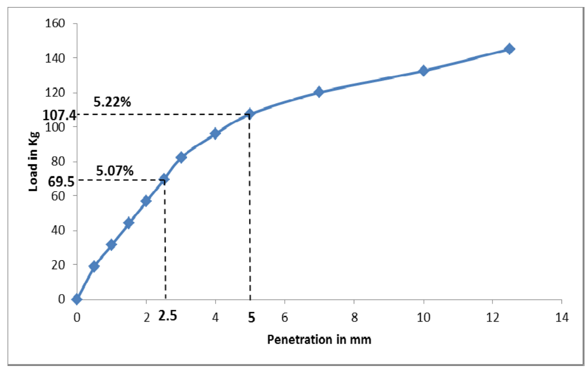


Fig 4.2.1: Variation of Load with different penetration

The figure 4.2.1 indicates that variation of Load with different penetration in natural Black Cotton soil using without stabilizer. This figure shows the at 2.5mm penetration the load value is 69.5 the corresponding CBR value is 5.11% and 5mm penetration the value is load value 107.4 the corresponding CBR value is 5.23%.

(Natural Black Cotton soil for soaked CBR condition)

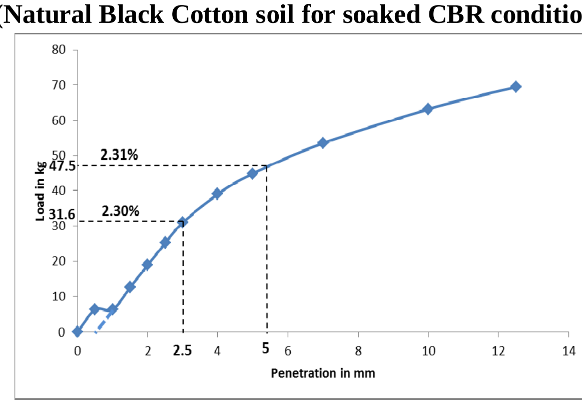


Fig 4.2.2.: Variation of Load with different penetration

The figure 4.2.2 indicates that variation of Load with different penetration in natural Black Cotton soil using without stabilizer. This figure shows the correction applied at 2.5mm penetration the load value is 31.6 the corresponding CBR value is 2.14% and 5mm penetration the value is load value 47.5 the corresponding CBR value is 2.31%.

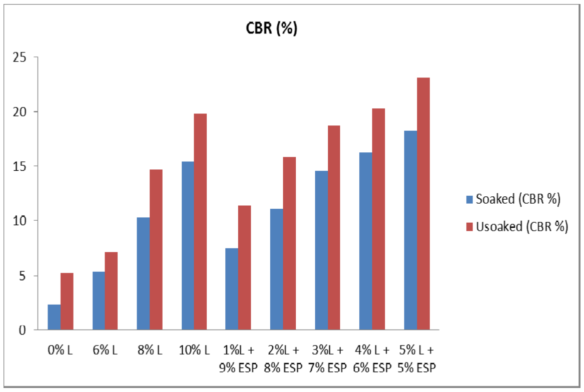


Fig 4.2.3: Variation of CBR value with different percentages of Lime and Lime + ESP stabilization

The fig 4.2.3 indicates that variation of CBR value with different percentages of lime and lime + ESP combination. The CBR of soil is an indefinable index of the strength, which for a given soil, is dependent upon the condition of the material at the time of testing. This means that the soil needs to be tested in condition that is critical to its design

At any given moisture content, the CBR of soil will increase if its dry density is increased, i.e. if the air content of soil is decreased. Thus, a design dry density should be selected which corresponds to the minimum state of compaction expected in the field at the time of construction. In fig 4.2.1the unsoaked CBR value for Black Cotton soil was found to be 5.22%, which is a poor rated sub grade. Addition of 10% lime increased the unsoaked CBR value of 19.82%; while 1% of lime + 9% of ESP reduced CBR value to be 11.37% which is rated a relatively poor sub grade. The soaked CBR value for Black Cotton soil was found to be 2.31% which is poor rated subgrade. Addition of 10% lime increased CBR value to be 15.4% while 5% lime + 5% ESP increased CBR value to be 18.25% this indicates 5% lime + 5% ESP is a good stabilization.

4.3 Unconfined Compression test

Table-4.3.1: Result of Unconfined Compressive Strength Test

% Additive by Weight of soil	Compressive Strength (kN/m^2)
0% Lime	80.94
6% Lime	104.13
8% Lime	129.92
10% Lime	207.72
1% Lime + 9% ESP	92.06
2% Lime + 8% ESP	109.87
3% Lime + 7% ESP	138.4
4% Lime + 6% ESP	201.1
5% Lime + 5% ESP	206.9

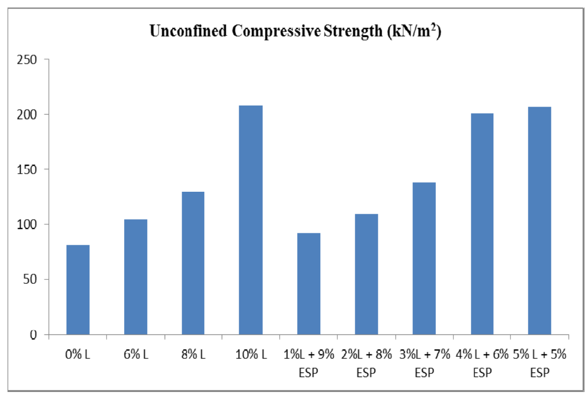


Fig 4.3.1: Variation of Unconfined Compressive Strength result with different percentages of Lime and Lime + ESP stabilization

The fig 4.3.1 indicates that variation of Unconfined Compressive Strength value with different percentages of lime and lime + ESP stabilization of Black Cotton soil. For the fig 6.26 uncured samples, the un drained shear strength of the clay soil was 80.94 kN/m^2; the addition of 10% lime raised this value to 207.2 kN/m^2. The addition of 1% lime + 9% ESP reduced this strength to 92.06 kN/m^2.

The addition of 5% lime +5% ESP increased the shear strength to 206.9 kN/m^2. It could be seen that the addition of 5% lime + 5% ESP still give 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 control purposes.

4.4 Triaxial compressive test

Table-4.4.1: Result of Triaxial Strength Test

% Additive by Weight of soil	Cohession (kg/cm^2)	Angle of Internal Friction (degrees)
0% Lime	2.90	11.30
6% Lime	2.60	14.04
8% Lime	1.90	18.43
10% Lime	1.50	28.30
1% Lime + 9% ESP	2.30	13.50
2% Lime + 8% ESP	2.15	14.68
3% Lime + 7% ESP	1.95	17.50
4% Lime + 6% ESP	1.70	21.80
5% Lime + 5% ESP	1.40	28.70

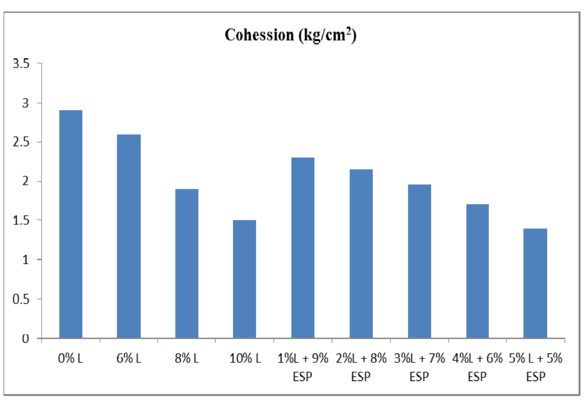


Fig 4.4.1: Variation of Cohesion value with different percentages of Lime and Lime + ESP stabilization

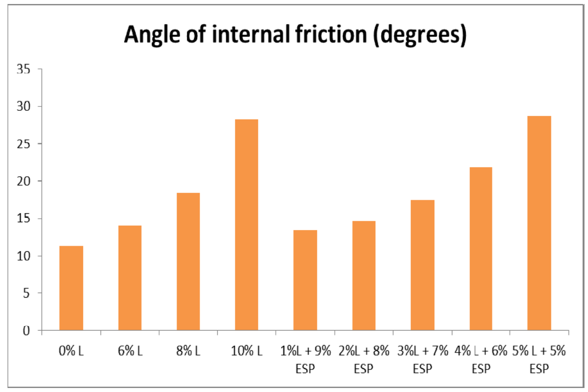


Fig 4.4.2: Variation of Angle of internal friction value with different percentages of Lime and Lime + ESP stabilization

It could be seen that fig 4.4.1 and 6.28 addition of 10% lime reduce the value of cohesion C, from 2.90 kg/cm^2 to 1.50 kg/cm^2 while the angle of internal friction was raised from 11.3 to 28.30 Degree, the addition of 5% lime +5% ESP however reduced the cohesion from 1.5 kg/cm^2 to 1.4 kg/cm^2. These values of cohesion and angle of internal friction wear read from the plots of the Mohr's circles for the additive.

From the result obtained and from cogent cross examination of the behavior of ESP-lime sample with that of 10% lime which is the control for this research, it could be concluded that lime has exhibited its superior potency over (ESP) an a stabilizing agent in all ramifications of engineering properties of except for the MDD and OMC where proved better. It could be seen that ESP cannot successfully replace lime as a material for effective stabilization unless further researches are conducted. However ESP could be used for stabilization of soil where very high sub grade performance is not necessary. Consequently, the low effect of the 5% ESP + 5% lime could be attributed to the presence of egg shell membrane that contains collagen an organic compound which reduced the binding effect of calcium and potassium that could have decreased the cohesion and internal angle of friction of soil considerably.

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. From compaction test result, it can be seen that both eggshell powder + Lime significantly decreases the optimum moisture content and maximum dry density of the soil. 5% lime +5% eggshell powder stabilized with Black cotton soil possesses close optimum moisture content and maximum dry density properties as 10% Lime stabilized Black cotton soil.
4. The unsoaked and soaked CBR values of all soil samples increased considerably with the addition of lime. California Bearing Ratio reveals that 5% lime+ 5% eggshell-stabilized Black cotton soil compares favorably with 10% Lime stabilized Black cotton soil.
5. 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.
6. The Triaxial compression test of this reduces the Cohesion 2.9 kg/cm2 and increases the Angle of internal friction 11.3 Degree, which is approximately equal to the 5% Lime + 5% ESP stabilizer the Cohesion is 1.4 kg/cm2 and Angle of internal friction is 28.7 Degree..

REFERENCES

[1] A.V. Narashima Rao And M.Chittaranjan, "Application of agricultural and Domestic wastes in Geotechnical applications". Journal of Environmental Research and Development, vol.5 No.3. 2011.

[2] E.Nyankson, B.Agyei-Tuffor, E.Annan, D.Dodoo Arhin, "Characteristics of Stabilized Shrink-swell deposits using Eggshell powder" Global Journal of Engineering design and Technology Vol.2 (3): ISSN 2319-7293, 2013.

[3] Arash Barazesh, Hamidreza Saba "Laboratory Investigation of the effect of Egg shell Powder on plasticity Index in clay soils". European Journal of Experimental Biology, , 2(6): 2378-2384, 2012.

[4] A.J, Rewaju and M.O Balogun "Suitability of Egg Shell stabilized Lateritic Soil as a Sub grade material for road construction" Electronic Journal of Geotechnical Engineering (EJGE), Vol.16 pp.889-908, 2011.

[5] Monica Malhotra, Sanjeev Naval, "Stabilization of expansive soils using Low cost Materials" International Journal of Engineering and Innovative Technology (IJEIT), Vol 2,Issue 11, May 2013.

[6] "Consideration of Lime- Stabilization layers in Pavement design", National lime association.

[7] K. R. Arora."Soil mechanics and Foundation engineering", text book.

[8] Osinubi, K.J. "Lime modification of black cotton soil". Spectrum Journal, vol.2 No. 1&2, PP 112-122." 1995.

[9] Phanikumar B R and Sharma R S, "Effect of flyash on engg properties of expansive soil", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 130, No.7, pp. 464-767, 2004.

[10] Amu, O. O. and Salami, B.A, "Effect of Common Salt on Some Engineering Properties of Eggshell Stabilized Lateritic Soil", APRN Journal of Engineering and Applied Science, Asian Research Publishing Network, Vol. 5, No. 9, ISSN 1819-6608, 2010.

[11] Oriola, Folagbade and Moses G., Groundnut shell ash stabilization of black cotton soil, Electron. J. Geotech. Eng., 15, 415-428, 2010.

[12] Pankaj R. Modak, Prakash B. Nangare, Sanjay D. Nagrale, Ravindra D. Nalawade, Vivek S. Chavhan― Stabilization of black cotton soil using admixtures‖ International Journal of Engineering and Innovative Technology (IJEIT) Volume 1, Issue 5, 2012.

[13] AASHTO "Standard Specificaitons for Transportation Materials and Methods of Sampling and Testing". 14th Ed., Am. Assoc. of State Highway and Transport Officials (AASHTO), Washington, D.C, 1986.images and field survey data." Journal of Environmental management, 90, 2130-2137.