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Stabilization of Cochin Clay with ESP and Shredded LPDE

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Abstract: *Soil is one of the important materials in a variety of construction projects including pavements, earth canals and earth dams. Most of the failures of soil have been due to its poor strength. Usage of chemical admixtures such as cement, lime, bitumen etc. in soil stabilization is highly expensive. Therefore it's preferable to replace these by another kind of soil addictive to make them economical and eco-friendly. In our study we will do an experimental study on stabilization of Cochin clay using eggshell powder and plastic waste in varying proportions. Three various proportions of eggshell powder (2%, 5%, 8%) plastic wastes (0.25%, 0.5%, 0.75%, 1%) were added to obtain optimum percentage of each additive. The analysis was done by compaction, unconfined compression. The eggshell powder, shredded plastic waste contents and duration will have significant effect in engineering properties of soil. After the stabilization of the Cochin clay the optimum percentage was obtained and a mathematical model was prepared using Microsoft excel and the concepts behind it is multiple regression and the mathematical model is used for the forecasting purpose of for the prediction of optimum percentage of stabilizing agents needed.*

Key Word*: Eggshell powder; Plastic waste; Optimum percentage; Compaction; Unconfined compression strength; Mathematical modelling.*

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I. Introduction

Structures that are constructed over weak and soft soils possess difficulties like poor strength, differential settlement, and high compressibility. Foundation is important for any land based structure and has to be strong enough to support the entire structure. And for the foundation to be strong its surrounding soil plays a very critical role. In order to work with them we need to have a proper knowledge on soil, its properties and various factors affecting them. To conform to desired characteristics or for the improvement of unstable soil both in case of strength and durability, soil stabilization is a remedy. In our study we are dealing with Cochin clay. Cochin clay is very soft soil deposited around Indian Peninsula. Clay can be located onshore as well. These soft clay are categorized by high compressibility and low shear sstrength. For the past two decades, a large scale construction activities has been witnessed in the port city of Cochin in India due to rapid industrialization of the area. Most of the greater Cochin area consist of extremely soft clay, causing tremendous problems for foundation engineers.

Here we use eggshell powder (ESP) and shredded plastic as the stabilizing agents. Through journals it's proven that ESP has similar chemical composition to lime and hence it could be used as a good replacement to lime. Plastic waste has also become a serious problem in the world. Though plastic has been banned, we have to find some alternatives to dispose the plastic that's been present from its very beginning and usage.Since then an iincrease in the use of plastic waste by the customers has resulted in municipal solid waste, an ever growing plastic waste which were used for a short time and then disposed or discarded. The linear consumption of these plastic waste and its disposal to the environment led to challenges such as marine and urban littering, diminishing landfill etc. Thus it's necessary to find alternate method to use plastic and prevent its harmful effect on environment and society. The main objective of the study is first to investigate the stabilizing effectiveness of Cochin clay using eggshell powder and plastic waste. Secondly to obtain an optimum percentage of stabilizing agent to ameliorate its strength characteristic. And finally to develop a mathematical model for forecasting.

II. Material And Methodology

2.1Soil

The soil has been collected from Cochin refinery, a subsidiary of BPCL Puthuvype. The clay sample was collected from a depth of 10m from the ground surface. The collected sample was dark in colour and rich in moisture ccontent.It was sundried for 4-5 days to proceed with various test.(Figure1)The index, geotechnical and engineering properties are given in table 1.

Table 1: Properties of Cochin clay

PROPERTIES	VALUES
USCS classification of soil	CH
Specific gravity	2.59
Gravel	0.4
Sand	46%
Silt & Clay	53.3%
Clay	48%
Liquid Limit	58%
Plastic Limit	27.655%
Plasticity index	30.345%
Swell index	46%
Optimum moisture Content	15%
Maximum dry density	0.00162 kg/cm^3
UCC	38.424 kN/m^2
Shear strength	19.212 kN/m^2
CBR(IS 2720 Part-16)	5.54

2.2Eggshell Powder

Chicken eggshell is a waste material commonly obtained from domestic sources such as home, poultries, hatcheries etc. Eggshell is under food waste category, if subjected to adequate scrutiny they could be suitable for soil stabilization. For our study eggshells were collected from hotels and restaurants nearby our college, Kalady.Manual process was used to prepare the eggshell. In this process, the egg was firstly cracked and cleaned with distilled water in order to eliminate the outer and the inner membrane. The shells without membrane was washed many times in order to remove all possible traces of impurities. The cleaned shells were dried at room temperature at 27°C and then grinned to obtain the fine powder of eggshell. (Figure 1)The eggshell powder is white in colour and grinded to fine powder so that it passes through 75μm.

Figure 1: Eggshell powder

2.3 Plastic waste

After food and paper wastes, plastic waste is the third major constitute at municipal and industrial waste in the urban. And its ban had been an effective measure to some extend. While using plastic as a soil stabilizer and in other ground improvement techniques as it behaves like reinforcing material, it would really be effective. Thus to develop sustainable path for the use of plastic, let's engineers encourage it to be used in geotechnical engineering. In a way it not only improves soil but also reuse of plastic can be made efficient and effective. Here we are using shredded plastic. It's collected from Kalady Panchayat in Ernakulam district. (Figure 2)The type of plastic used is low density polyethylene whose specific gravity is 0.94 and fusing point 185°C.Its melting point is 140°C.

Figure 2: Shredded Plastic

III. Experimental Methods

In our project we started our study by collecting the sample from the Cochin refinary.The sample was dried in open sunlight and preliminary test on raw sample was conducted. The various test conducted on the sample were specific gravity, sieve analysis, hydrometer, atterberg'slimit, standard proctor, Unconfined compressive strength (UCC) and California bearing ratio (CBR).The clay sample were prepared with a combination of varying proportion of eggshell powder and plastic as 2%, 5%, and 8%(ESP) and 0.25%, 0.5%, 0.75%, and1%(plastic).Standard proctor and UCC were conducted on prepared specimens and obtained the optimum percentage of stabilizing agents required. In our study we mainly focused on compaction and unconfined compression test.

3.1 Compaction test

Compaction is the process of densification of soil by reducing air voids. The degree of compaction of a given soil is measured in terms of its dry density. The dry density is maximum at the optimum water content. A curve is drawn between the water content and the dry density to obtain the maximum dry density and the optimum water content.

$$\text{Dry density} = \frac{M / V}{1 + w}$$

3.2 Unconfined Compression test

The unconfinedcompressivestrength is the load per unit area at which the cylindrical specimen of a cohesive soil fails in compression.

$$q_u = P / A$$

where, P - axial load at failure,

A - Corrected area = $A_o / (1 - \varepsilon)$,

A_o- initial area of the specimen,

ε- Axial strain= change in length/original length

IV. Result and Discussion

After collecting the stabilizing agents and clay sampleits physical properties were analyzed. Thereafter the clay was stabilized with stabilizing agents and various tests were conducted to determine its geotechnical properties. The test conducted on stabilized sample are UCC and standard proctor.The test was done twice to get accurate result and the average of the values were taken. These results are given in the tables below with corresponding graphs.

4.1 Classification of soil

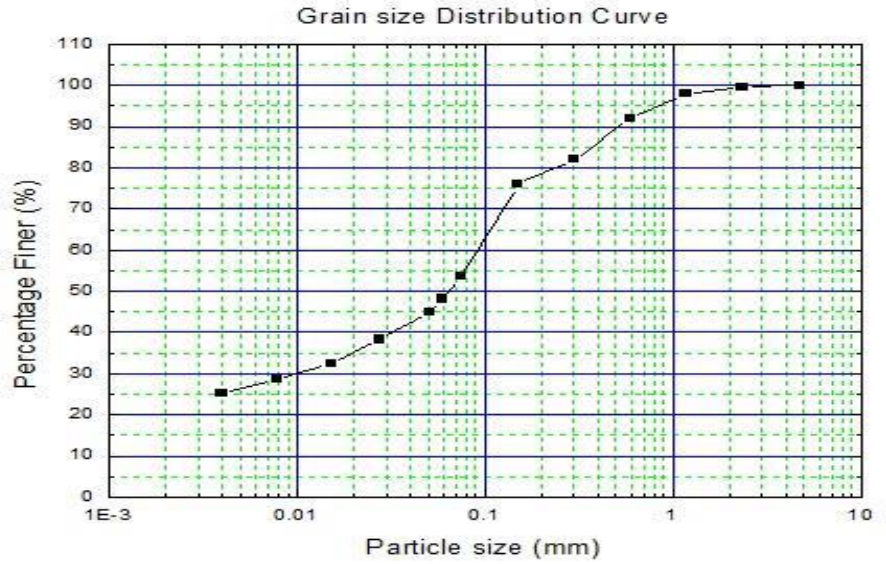

Figure 3: Grain size distribution

From the grain size distribution graph above we obtain the percentage of gravel to be 0.4%,sand to be 46% and that of silt and clay to be 53.5%.Thus we can conclude that the collected sample belongs to silty caly category.

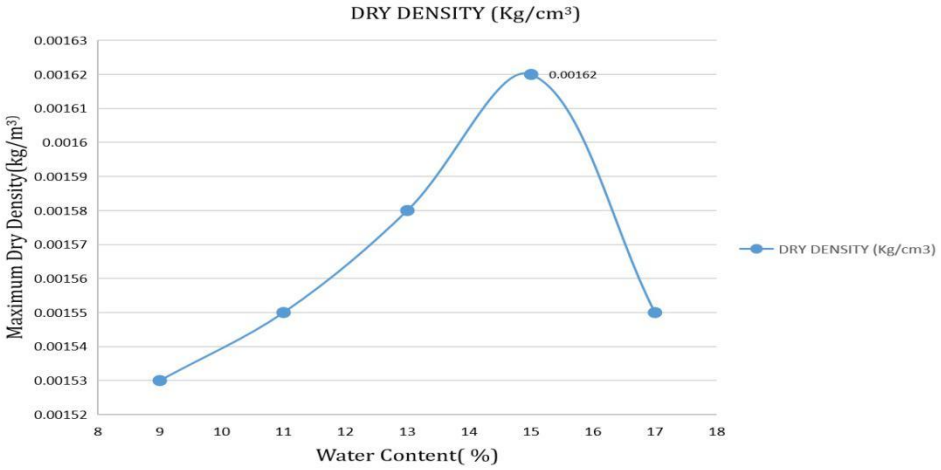

Figure 4: Optimum moisture content

The optimum percentage of moisture obtained is 15%.

4.2 Stabilized sample

On combining the values of UCC with varying proportion of stabilizing agents, the following graph is plotted.

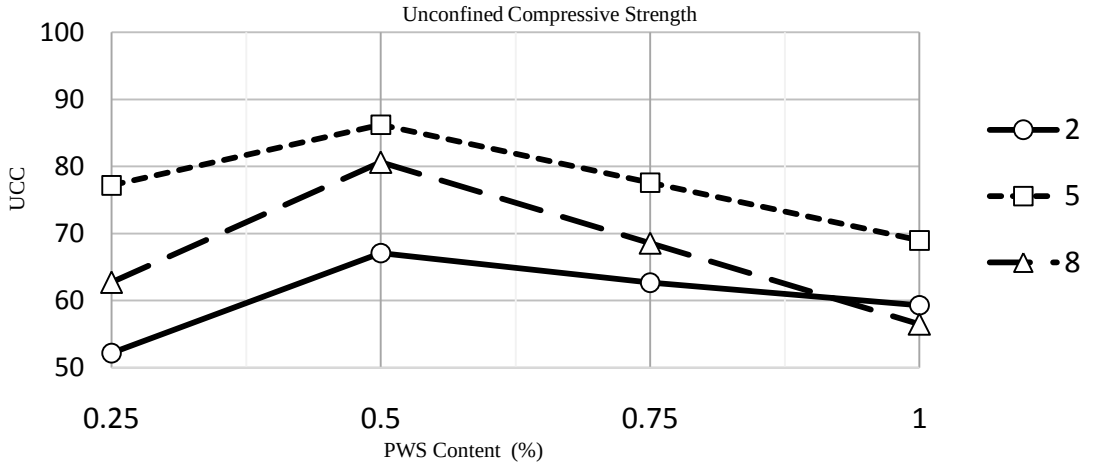

Figure 5: Unconfined compressive strength of stabilized sample

From the above graph it is evident that the optimum percentage of stabilizing agent is 5%ESP and 0.5% of PWS.

On combining the values of OMC with varying proportion of stabilizing agents the following graph is plotted.

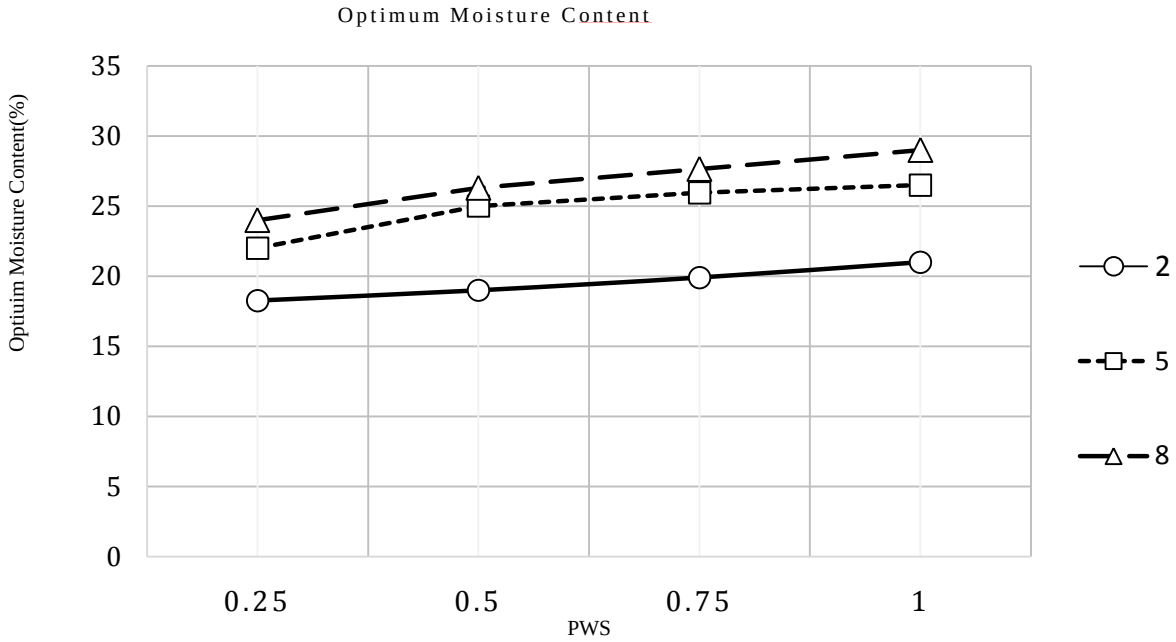

Figure 6: Optimum moisture content of stabilized sample

Similarly on combining the values of shear strength with varying proportion of stabilizing agents the following graph is plotted.

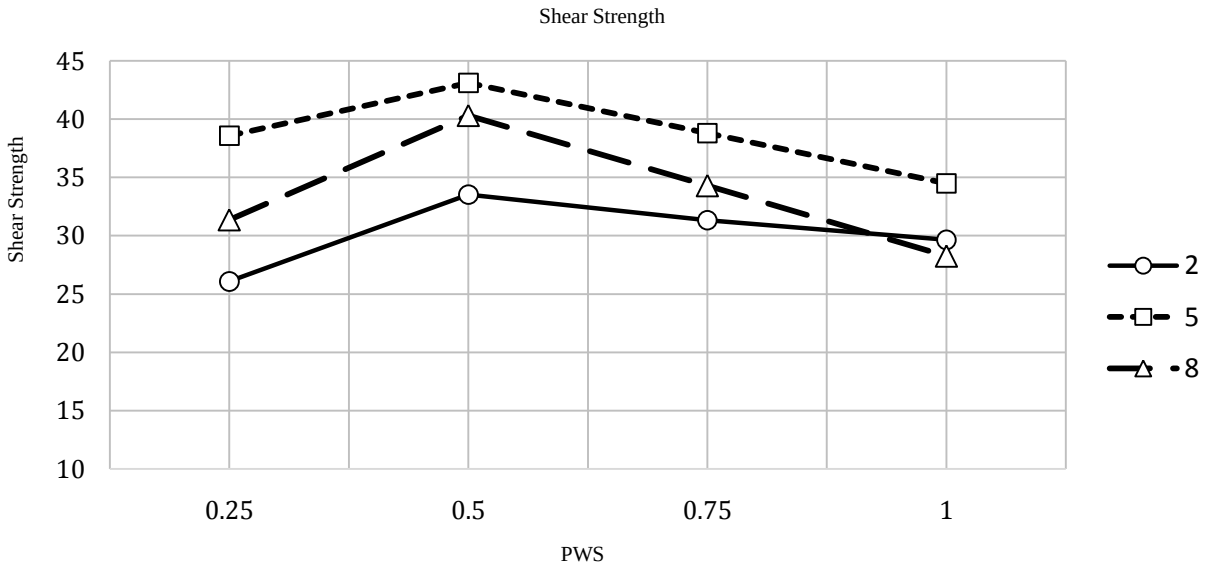

Figure 7: Shear strength of stabilized sample

4.3 Mathematical Modelling

A mathematical model is a description of system using mathematical concepts and language. A process of developing a mathematical model is called mathematical modelling.In our study the mathematical model was delevoped using Microsoft excel.The principle used was multiple regression.
The formulated equation based on the unconfined compressive strength of stabilized sample is:

UCS = 9.958611+16.45722(E) +103.6433(P)-1.5322(E2) - 87.933(P2) ±e

Where,
UCS is the unconfined compressive strength of sample,
E = percentage of Eggshell powder in the range of 0-8
P = percentage of shredded plastic in the range of 0-1
e=standard error 5.14

Model Based on Shear Strength of Sample is:

SS=4.979306+8.2286(E) +51.82167(P)-0.76611(E2) - 43.9667(P2) ±e

Where,
SS=shear strength
E=Eggshell powder in the range of 0-8 in Percentage
P=Plastic waste in the range 0-1 in percentage
e=standard Error 2.57

- The data has a parabolic variation which means the equation having degree of 2 or more will fit the data with the maximum closeness.
- The error can be further decreased by increasing the degree of equation or the corresponding standard error of 5.14 In UCC model and 2.57 in shear model can be added or subtracted as required.

As per the formulated Equation: Optimum Percentage of PWS and ESP is 0.5893 and 5.376.

Table 2: Anticipated values

ESP	Anticipated Maximum value of UCC		PWS
2	67.28	±5.14	0.5893
3	76.08	±5.14	0.5893
4	81.813	±5.14	0.5893

5	84.48	±5.14	0.5893
Similarly for Maximum UCC For different value of PWS			
PWS	Anticipated Maximum value of UCC		ESP
0.25	74.622	±5.14	5.3763
0.5	84.068	±5.14	5.3763
0.75	82.517	±5.14	5.3763
1	69.957	±5.14	5.3763

V. Conclusion

The clay collected from the study area was stabilized using various stabilizing binders which included a combination of eggshell powder and plastic waste. A series of laboratory tests that included basic geotechnical test on the stabilized sample was conducted to evaluate the ameliorating effect of the added stabilizing binder. The following conclusions were obtained:

i. The collected sample comes under silty clay (53.3%) and from the plasticity index, according to Unified soil classification system (USCS) our clay sample is grouped under CH category.

ii. From the graph it's evident that with a combination of 5% ESP and 0.5% plastic we obtain the maximum compressive strength of Cochin marine clay (86.24kN/m2) and thereafter the value goes on decreasing.

iii. Mathematical Model was developed using Microsoft Excel using multiple regression. The optimum percentage of ESP and PWS Obtained from formulated equation is 0.5839 and 5.3763.

iv. From the results it's clearly understood that there is a great improvement in strength. Therefor, 5% ESP with 0.5% shredded plastic can effectively be adopted in stabilization of clay soils as road pavements without much cost.

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