

Effect of Eggshell Powder in the Index and Engineering Properties of Soil

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Abstract—

Soil is one of the most important materials used in a variety of construction projects including earth canals and earth dams. The fact that soil may provide all the resistance characteristics necessary for a project illustrates the importance of various methods used to improve soil quality. Most of the failures of soil have been attributed to poor strength. Stabilization of soil by adding lime, cement, bitumen etc. are expensive and therefore require an economic replacement. In egg consumption, Tamilnadu stands second place in India. Hence a huge amount of eggshell wastes are produced every year. In the absence of an effective waste disposal, the utilization of eggshell for soil improvement will be a welcome development. In this paper, we studied the suitability of egg shell powder as a possible additive material to improve the strength of soils. Soil samples were collected and stabilized with eggshell powder in proportions of 0.5% to 5.5% at 0.5% interval by dry weight. The index and engineering properties were carried out to access the behaviour of soil with the addition of eggshell powder. The unconfined compressive strength test was carried out with and without delay in compaction. Addition of eggshell powder to soil sample lead to increase in unconfined compressive strength. The maximum unconfined compressive strength was attained at 3% eggshell powder stabilization. The unconfined compressive strength was increased in the delayed compaction than the without delayed compaction. The use of eggshell powder as an additive will therefore improve the strength of soils; however, using eggshell powder quantities in excess of 3% may not yield ample results.

Keywords— Soil, Eggshell powder, Liquid limit, Unconfined compressive strength

I. INTRODUCTION

For any land-based structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong the soil around it plays a very critical role. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behaviour. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work. From the literature, it was observed that the eggshell powder was added with the combination of any other stabilizing materials (cement, lime, flyash). Over the last years, environmental issues have prompted human to use industrial wastes as alternatives to some construction materials. Both earthwork researchers and engineers have paid considerable attention to use wastes in soil stabilization and

improving physical and mechanical properties of soils. This may help both remove environmental problems and contribute to the economy. From the literature, it was seen that the eggshell powder is added (1% to 8%) with the combination of any other stabilizing materials (cement, lime, flyash). When the eggshell powder was added separately in highly expansive soils, only the plasticity properties were studied. In this paper, we have decided to add the eggshell powder separately to study the index properties and engineering properties of the soil. An improvement in the index and strength properties of soil by addition of ESP will help to find an application for waste materials to improve the properties of soil and can be used as a better stabilizing agent.

II. MATERIALS

2.1 Soil:

Soil was collected from Tiruchendur. It is basically a seashore area and also it is one of the religious and tourist spot in Tamilnadu. So there is a need for improvement of such soil. The degree of expansiveness of the soil was moderate. The properties of the soil were given in Table-1.

2.2 Eggshell powder:

Chicken eggshell is a waste material 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 facilitate easy milling. After air drying the eggshells were manually broken and milled into powdery forms which were collected in polythene bags. The eggshell powder was finally sieved through 425 μ sieve. Eggshell powder contains 99.83% of CaO and remaining consists of Al₂O₃, SiO₂, Cl, Cr₂O₃, MnO and CuO.

Table 01 Properties of Soil

S.No	Description	Result
1	Colour	Brown
2	Atterberg limits	
i	Liquid limit	45%
ii	Plastic limit	26.6%

iii	Shrinkage limit	11.98%
3	Free swell index	20%
4	Specific Gravity	2.76
5	Compaction characteristics	
i	Optimum Moisture Content	20%
ii	Maximum dry density	1.663 g/cc
6	Unconfined compressive strength	100.694 kN/m ²
7	Grain size distribution	
i	Gravel	0%
ii	Sand	12.3%
iii	Clay and silt	87.7%
8	IS soil classification system	Clay of Intermediate plasticity

III. EXPERIMENTAL PROGRAM.

3.1 Methodology

The experimental program consisted of by varying the percentage of eggshell powder to the soil and studied the compaction characteristics and Unconfined compressive strength of soil. The eggshell powder was varied between 0.5% and 5.5% by weight of soil.

3.2 Experiment details

Study on Soil Properties using varying percentages of Egg Shell Powder consisted of

Proctor Compaction Test
Atterberg Limits
Unconfined Compressive strength with and without delayed compaction

IV RESULTS AND DISCUSSIONS

4.1 Liquid limit

Figure 1 explained about the addition of eggshell powder changed the liquid limit of soil. The liquid limit value was decreased gradually when the eggshell powder was added from 0.5% to 5.5% at an interval of 0.5% to the soil. The gradual decrease in the value of liquid limit was due to the porous property of eggshell powder

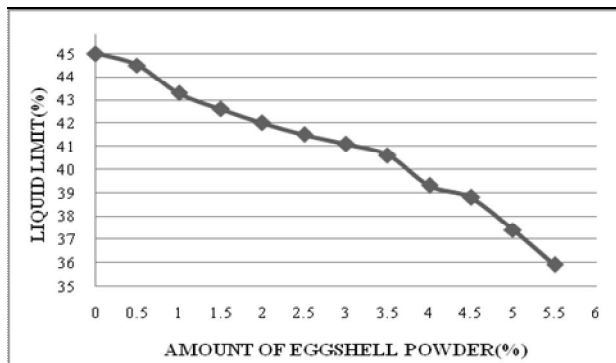


Figure 1 variation of liquid limit with the addition of eggshell powder

4.2 Plastic limit

The figure 2 showed the effect of eggshell powder in the plastic limit of soil.

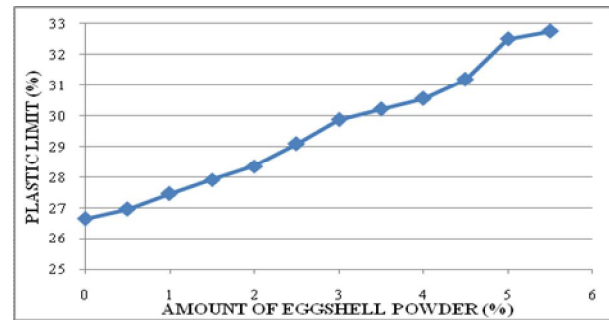


Figure 2 variation of plastic limit with the addition of eggshell powder.

The plastic limit value was increased gradually when the eggshell powder was added from 0.5% to 5.5% at an interval of 0.5% to the soil. Increase in the addition of eggshell powder to the soil sample caused a change in the liquid limits and plastic limits, which consequently affects the plasticity index of the soil. The plasticity index of the soil was reduced from 18.35% to 3.16% with the addition of eggshell powder. The reduction of plasticity index was an indication of improvement of soil property. Due to the addition of eggshell powder to the soil results in the soil of friable nature.

4.3 Compaction characteristics

By addition of eggshell powder to the soil, the maximum dry density and optimum moisture content was found by Proctor compaction test as per IS 2720. The figure 3 explained about variation of OMC with the addition of eggshell powder.

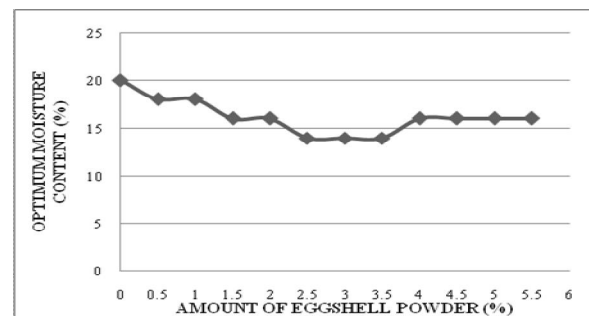


Figure 3 Variation of OMC (Optimum Moisture Content) with the addition of eggshell powder

The initial decrease in OMC was attributable to the absorption capacity of the eggshell powder due to its porous properties. The subsequent increase was a result of the pozzolanic action of eggshell powder and soil, which needs more water. The lower the OMC states that the better workability of good soils. Therefore, the behavior of the soil between 0% and 3% eggshell powder stabilization (based on OMC) indicates the improvement of soil properties with the application of an optimum of 3% of eggshell powder by dry weight.

Figure 4 represented the variations in maximum dry density with the increase in eggshell powder content. The initial increase in the dry density indicates the improvements in the soil properties and further attested to the enhancement of soil

properties with the application of an optimum 3% of eggshell powder.

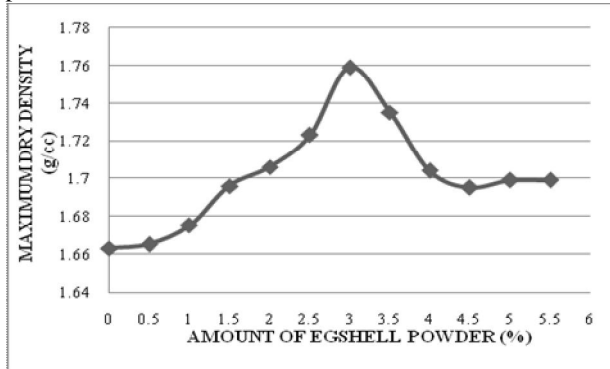


Figure 4 Variation of MDD (Maximum Dry Density) with the addition of eggshell powder

4.4 Unconfined compressive strength

From the value of unconfined compressive strength test result with and without delayed compaction, upto 3% addition of eggshell powder to the soil the UCS value was increased and a sudden decrease was observed at 3.5% addition of eggshell powder to the soil. It was noticed that the strength of the soil was increased approximately by 25% for every addition of 0.5% of eggshell powder to the soil. Figure 5 indicated the relationship between UCS value and the different percentage of eggshell powder at 0 day (without delay in compaction) and 3 day (compaction delayed for 3 days).

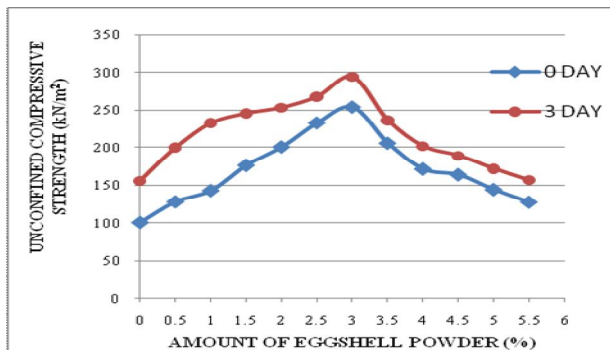


Figure 5 Variation of UCS (Unconfined Compressive strength) with the addition of eggshell powder

The initial increase in the UCS value was expected because of the gradual formation of cementitious compounds (calcium silicate hydrate) due to the reaction between the calcium carbonate present in the eggshell powder, soil and water. The decrease in the UCS values after the addition of 3% eggshell powder was attributable to excess eggshell powder that occupies spaces within the soil to form weak bonds between the soil and the cementitious compounds formed by reaction, thus having a negative effect on the cohesive nature of the soil. The unconfined compressive strength was improved in delayed compaction. The increase in strength at 3 days was due to the pozzolanic reaction between soil and eggshell powder.

Based on UCS value, initially the soil was of medium consistency. Addition of eggshell powder to the soil from 0.5% to 2% changes the consistency of the soil from medium

to stiff state. At 3% addition of eggshell powder changes the soil to very stiff consistency. Further addition of eggshell powder to the soil leads to stiff consistency from very stiff consistency.

V Conclusion

The following conclusions were made from this experimental study

1. We can utilize the eggshell waste as a useful soil stabilizing material. By using the eggshell powder as a soil stabilizer, we can minimize the waste disposal problem of eggshell.
2. The optimum usage of eggshell powder added to the soil was 3%.
3. The delayed compaction effect leads to increase in unconfined compressive strength of soil when compared to the without delay in compaction.

Further study is going on by varying the delayed compaction time in hours and days

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