

Potential of Egg shell powder as replacement of Lime in soil stabilization

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Abstract— This paper presents a study on the properties of soil stabilized by using lime and egg shell powder. Tests were conducted to assess the potential of egg shell powder in replacing lime, which can make the overall stabilization process economical and eco-friendly. Results obtained show that all the treated mixes gave much better strength than untreated soil. Egg shell powder was introduced in quantities of 0.5%, 1%, 1.5% and 2% of the weight of soil. Tests were conducted replacing up to 50% of the lime used for stabilization. It was observed that 25% replacement of lime by egg shell powder gave better strength properties and can be adopted for practical purposes.

Keywords— Lime, Soil stabilization, Egg shell, improvement, Geotechnical, replacement

I. INTRODUCTION

Improvement of soil properties is necessary in the modern scenario as soils with the required properties are not readily available for construction activities. There have been a lot of issues reported when structures were constructed on weak and soft soils like problems of shear failure, excessive settlement, differential settlement etc. The alternatives left with us are making the soil at site suitable for the expected load by improving its properties or adopting a deep foundation. Adoption of deep foundation is not at all an economically viable solution. Hence improvement of soil properties and in-situ treatment of soil are gaining importance these days. Soil stabilization is an economically feasible solution to one of the major construction problems. Researchers all over the world have studied various materials which can be used in conjunction with soil to improve soil properties. (Basha, 2005) studied the stabilization of soil with Rice husk ash and cement. (Brooks, 2009) conducted stabilization studies on stabilization using fly ash and rice husk ash. (Kamon, 1991) conducted researches on stabilization of soil using lime and industrial wastes. (Paul, 2014) conducted studies on soil stabilization using egg shell powder and quarry dust. (Anoop S P, 2017) conducted studies on improving soil using lime and elephant dung

strips. Of all the various studies conducted around the world, the most commonly used and effective stabilizer was found to be lime. Lime is a not an industrial waste or a by-product, the manufacture of lime requires heating in the order of 750° C, which contribute to the fact that stabilization of large areas of soil with lime alone will increase the cost required for stabilization. In this study an attempt is made to replace lime with egg shell powder and to find out the extent up to which lime can be replaced by egg shell powder without compromising on the strength.

Egg shell powder is an ideal material to replace lime in the stabilization process due to its similar chemical composition. The chief ingredient in egg shell powder is calcium carbonate as in the case of lime. Egg shells are disposed from hotels, restaurants etc in huge quantities and they are currently facing disposal problems. Use of egg shell powder in soil stabilization reduces the disposal problems associated with egg shell generations. Moreover, powdering of egg shell can be done easily. Egg shell powder generation does not involve generation of CO₂ as in the case of lime where heating is done up to 750°C. Hence use of egg shell powder in soil stabilization will make the overall stabilization process economical, sustainable and eco-friendly.

II. MATERIALS AND MIXES

The materials used for this study consist of Soil, Lime and Egg shell powder. Soft clayey soil from Chathanoor area of Kollam district in Kerala was used for the study. Lime was purchased from the local markets and Egg shells were collected from hotels and restaurants in Parippally. The egg shells, thus collected were crushed and made into powder form. This was then sieved through 75 micron IS sieve so as to bring it to the size range of fine grained soil. The egg shell powder used for the study is shown in Fig 1



Fig.1: Egg shell powder

The materials mentioned above were mixed in various proportions for studying its effect on the soil stabilization process. First of all, the untreated soil was tested and its strength was obtained to understand whether there is need for stabilization. To this untreated soil mix, optimum lime content calculated as per ASTM D 6276 standards was added. The optimum lime content was found to be 4% of the weight of soil. Then egg shell powder was introduced as a replacement to lime in the stabilization process. The proportions of lime and egg shell powder were varied keeping the total replacement amount a constant. The various mixes used in this study are mentioned in table 1.

Table.1: Mixes used in this study

Mix designation	Details
C	Untreated soil
C + 4L	Clay + 4% weight of soil replaced by lime
C+3.5L+0.5ESP	Clay + 3.5% lime replacement and 0.5% weight replaced by egg shell powder
C+3L+1 ESP	Clay + 3% lime replacement and 1% weight replaced by egg shell powder
C+2.5L+1.5ESP	Clay + 2.5% lime replacement and 1.5% weight replaced by egg shell powder
C+2L+2 ESP	Clay + 2% lime replacement and 2% weight replaced by egg shell powder

III. TESTS CONDUCTED

Experimental tests were conducted on untreated soil as well on lime and egg shell powder modified mixes in order to study the effect of addition of egg shell powder. The various tests conducted were atterberg limits, compaction and unconfined compression test. All these tests were carried out as per IS 2720 standards.

IV. RESULTS AND DISCUSSIONS

The soil mixes mentioned above were tested and the results obtained are summarized in table 2. Unconfined compressive strength of in situ soil was found to be only 0.45 kg/cm² which indicate the necessity for soil stabilization. When the soil was mixed with optimum lime content, there was a drastic change in the strength of soil sample. The strength almost doubled upon introduction of lime.

Table.2: Results of experimental tests on untreated and modified soil mixes

Sample	Liquid limit (%)	Plastic limit (%)	OM C (%)	γ_d (g/cc)	Mean UCC (kg/cm ²)
Untreated soil	24	11	18	1.76	0.45
C+ 4L	30	12.41	20	1.8	0.88
C+3.5L+0.5ESP	33	12.71	20	1.83	0.85
C+3L+1ESP	34	13.08	22	1.87	0.92
C+2.5L+1.5ESP	35	13.1	22	1.77	0.81
C+2L+2ESP	35	13.01	22	1.77	0.68

There were not much variations in the atterberg limits of the soil sample on addition of egg shell powder. Egg shell powder was not found to alter the flow and consistency behavior of the soil sample. The variation of atterberg limits with the addition of egg shell powder is shown graphically in Fig 2.

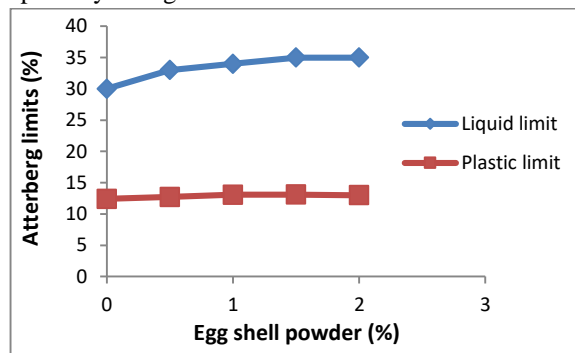


Fig.2: Variation of atterberg limits with Egg shell powder

Compaction tests showed an increase in the dry density upto 25% replacement of lime by egg shell powder. Above 25% replacement of lime by egg shell powder, dry density started to decrease. Egg shell powder is not that compatible a material as lime and hence when added in large quantities to replace lime, soil properties could not be improved. The variations in dry density on the addition of egg shell powder to lime modified mix is shown in Fig 3.

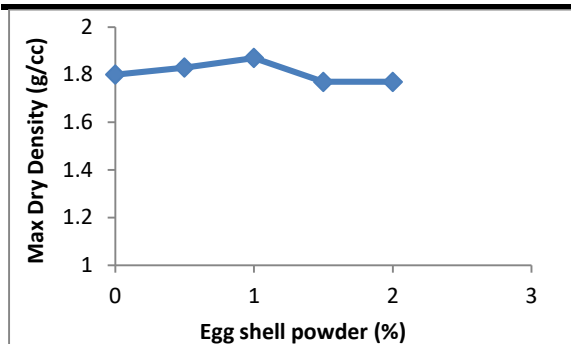


Fig.3: Variation of dry density of soil on adding egg shell powder

All the soil mixes were tested for their unconfined compressive strength. The results show that there is an increase in unconfined compressive strength upto 25% replacement of lime by egg shell powder. Above this level of replacement, the strength was found to decline. Addition of small dosages of egg shell powder improved the strength of lime modified mix. As the replacement percentage increased, the strength started to fall as shown in figure 4. This may be due to the fact that egg shell powder is not an efficient material as lime and increasing egg shell powder will reduce the total lime content. Addition of small dosages of egg shell powder increased the rate of pozzolanic reaction occurring and hence gave a higher strength. All the modified mixes gave much better strength than untreated soil as shown in Fig 4.

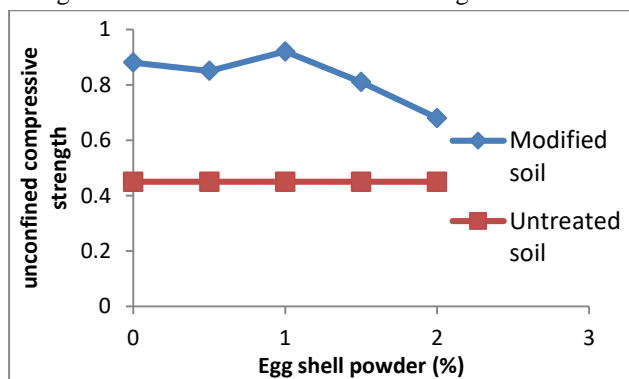


Fig.4: Variation of UCC with Egg shell powder

V. CONCLUSIONS

Egg shell powder was found to be a very good alternative in replacing the costly lime used for soil stabilization. The use of egg shell powder in soil stabilization will reduce the disposal problems of egg shell as well as make the stabilization process economically and sustainable. From the study, it was seen that egg shell powder can replace upto 25% of the lime used for stabilization process. This replacement also increased the strength of treated soil. Thus it can be concluded that egg shell powder is an ideal material to replace lime in the soil stabilization process owing to its similar chemical compositions and properties

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