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Plasticity Index Improvement of Clay and Soils Using Eggshell Powder

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Abstract: This study is conducted for examining the effect of adding the treated eggshell powder(0,2,5,7,10,15,20,23,25 %wf) with particle size about (63µm) on the plasticity properties of expansive soil with plasticindices (26,35,45).

The eggshell powder was treated with 7% NaOH and characterized for their FTIR, XRD, and particle size has been determined. In the present study, treated eggshell powder was mixed with soil and the plasticity properties of these compounds were investigated. After that, the plasticity properties related to the soil include liquid as well as plasticity limits, plasticity index, already measured, have been put to comparison with those related to experimental specimens which are mixed with the treated eggshell powder in various proportions.

Keywords: soil, treated eggshell powder, liquid limit, plasticity limit, plastic index, characterization.

Introduction

Soil can be defined as a considerable material utilized in various projects of construction involving dams and canals. As soil is providing all the resistance properties required for projects is showing the significance of many approaches utilized for enhancing the quality of soil. The majority of soil failures were due to bad strength. Soil stabilization via adding bitumen, cement, lime, and so on.were costly and thus need economic replacement. With regard to the egg consumption, Tamilnadu is the 2nd in India. Therefore, a lot of eggshell wastes were created annually. Without efficient waste disposal, using eggshells for the improvement of soil is of high importance [1].

Stabilization can be defined as changing the foundation soils for the purpose of confirming the required properties or improving the less stable soil in durability and strength. A lot of soils are subjected to shrinkage and differential expansion in the case when undergoing alterations in the content of moisture. Various soils are move as well as rut in the case when experiencing moving wheel loads. Thus, there is high importance in stabilizing them for reducing volume changes as well as strengthen them for reaching a point in which they might be carrying the imposed load, even in the case when they were saturated. In addition, the stabilization is a change in the foundation soils for confirming the required properties or improving less stable soil in durability and strength [2].Recently, the environmental problems encouraged humans in using industrial wastes as alternates for a few construction materials. Engineers and earthwork researches were focusing on utilizing waste in the soil stabilization and enhancing mechanical and physical characteristics of the soil, this might allow removing environmental issues and contributing to economy[3].

From literature, it has been indicated that eggshell powder is added with combination related to other stabilizing materials (fly ash, lime and cement). Recently, the environmental problems encouraged humans to use the industrial waste as alternate to a few construction materials. Engineers and earthwork researchers are focusing on using wastes in the soil stabilization as well as enhancing mechanical and physical characteristics of the soil, this might allow removing environmental issues and contributing to economy. From literature, it has been indicated that the eggshell powder was added in range of (1-8 %) with the combination related to other stabilizing materials (fly ash, lime and cement). In the case when separately add eggshell powder in the extremely expansivesoils, just the properties of plasticity are examined. In the presented study,eggshell powder is separately added for examining the engineering and index characteristics of soil. Enhancement in strength and index characteristics of soil via adding ESP is going to allow finding application with regard towaste materials for enhancing the characteristics of soil and might be utilized as better stabilizing agent[4].

Eggshell can be defined as one of the biomaterials involving 95% by weight of the CaCO3in calcite form as well as 5% by weight regarding the organic materials, like (MnO, Cl, SiO2, Al2O3, S, and Cr2O3). The eggshell's generalized structure, that is widely varying between specie,was protein matrix which is lined with the mineral crystals, typically of calcium compound like CaCO3 [5].

ArshB.etal. conducted laboratory investigation related to the impact of eggshell powder on plasticity indexin the clay as well asexpansive soils [6]. The researches on the impact of eggshell powder in the index in addition to theengineering characteristics of the soil, viaTamilarasan and Muthu indicated that there is an increment in delayed compaction related to unconfined compressive strength in comparison to that with no delayed compaction. Thus, using eggshell powder as additive is going to enhance the soil strength; yet, utilizing eggshell powder quantities instead of 3% might not result in adequate results.[7].A study conducted by Geethu S. and Nimisha M., indicated that in the case when quarry dust was mixed with the expansive soil, then it will make it more porous, decrease cohesion, less durable, and so on. and enhancement in the soil properties via adding ESP as well as quarry dust is going to allow finding application for the waste materials for the purpose of enhancing the characteristics of clayey soil and might be utilized as better stabilizing agent.[8].

A study related to the enhancement of Subgrade Clayey Soil utilizing Eggshell was carried out via Diana J. and coworkers. Adding eggshell powder to kuttanad clay was of reduced binding characteristics and might be utilized for considerably enhancing the soil strength as sub grade in which extremely elevated performance isn't essential. Also, it might be acting as excellent replacement to be used as stabilizers for the sub grade, yet not for base and sub base. In addition, the capacity as stabilizer doesn't relate with minimum requirements to be used as base and sub base materials for road constructions. [9]. Researches on the impact of eggshell powder on strength characteristics related to Cement-Stabilization on Olokoro Lateritic Soil have been examined via Obikara F. and Maduabuchi M. [10]

Soni D. and Amit K.[1]examined the impact of calcium as well as chloride based stabilizer on the plastic characteristics of fine grained soil [11].

The major aim of this study is examining the effect of treated eggshell powder with various percentages of additives (0-25% wf) on Atterbergcharacteristics of specimens' soil.

Materials

In the presented work, the soil has been collected from piling site at Baghdad, Iraq. Also, the soilhas been driedin oven, weighed as well as stored at 25 Celsius, while the soil's general property is examined in laboratory. Furthermore, the soil is tested for permeability, optimum moisture content, liquid limit, plastic limit,and maximum dry density.

Table 1.General Properties of soil

Properties	Results
LL	78%
PL	32%
Optimum moisture Content	24%
Max. dry density	1.24%
Specific grainty	2.56%
Water content	27.5%

Eggshell powder has been acquired from local market. The collected eggshells were washed and dried in a furnace at 80°C for two hours. Later the shells were crushed using a domestic mixer. A sieve of 63μm was used to get the required average grain size and treated with 7% NaOH. The powder was then analyzed using X-ray fluorescence spectrometer, FTIR and particle size distribution.

Table (1) Inorganic compounds in eggshell powder analyzed by X-ray fluorescence spectrometer

Elements	Concentration %
Al_2O_3	0.001
SiO_2	0.002
S	0.001
Cl	0.008
CaO	99.82
Cr_2O3	0.0030.001
MnO	0.001
CuO	0.001
LOI	0.163

Note: LOI- loss of Ignition

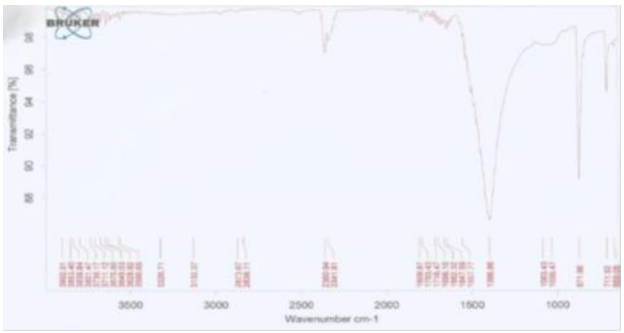

Figure 1. FTIR for eggshell powder treated with NaOH

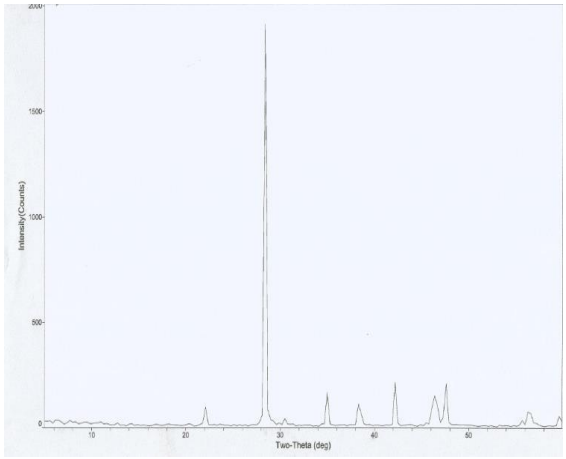

Figure 2. XRD for eggshell powder treated with NaOH

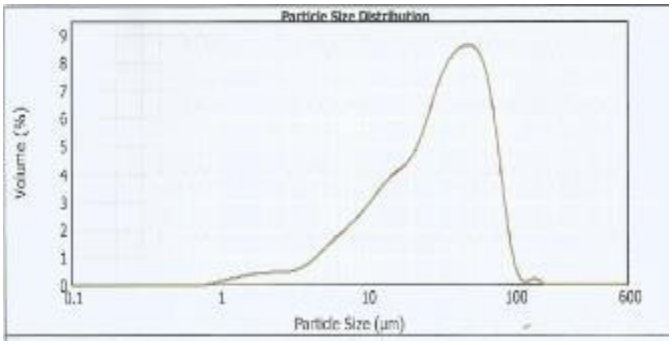

Figure 3. Particle size distribution for eggshell powder treated with NaOH.

Experimental

Take a sample weighing 8 g of the fully mixed wet sample prepared according to the method T89 during mixing the liquid limit sample, so that this sample can be shaped into a ball without sticking to the fingers when pressed, and if the sample is taken before the liquid limit test is completed, set it aside and leave it to dry in the air until the liquid limit test is completed. And if during the test it was taken so dry that a 3 mm drop thread could not be formed by rolling, add water to it and re-mix it Calculate the plasticity limit as a ratio between the moisture content and the dry weight from the following equation:

Plasticity limit = (water weight / dry soil weight) x 100
Liquid limit (LL):
Atterbergproposed specifying the liquidity limit as soil's water content at which it coalesced, also at distance of half an inch sideways a slit in sample from the impact of 25 strokes in liquidity determination device, thus each stroke will fall in 1 cm.

Casagrande and ASTM device

An experiment of Atterberg limits is done on soil passing through sieve No. (40). To determine the value of the liquidity limit in an accurate manner, a relationship is drawn between the number of strokes utilizing logarithmic scale as well as water content utilizing natural scale. Usually, the relation is straight line, thus it will be simply to find water content in such approach. Thus, what is needed is finding (3-6) points specifying the relation between the water content and the number of strikes (the range of strikes should involve 25 strokes), such points are after that drawn on semilogarithmic paper and connected via straight line, while the amount of water content correspond to 25 strokes was read from graph. It must be indicated that the closer the points drawn to 25 strokes, the better the results.

Calculate the plasticity index (PI) as the difference between liquidness limit as well as plasticity limit of the soil from the following equation
Plasticity Index= Liquid limit - Plasticity limit

Results and Discussion

Performing Atterberg limits tests, the selected soil specimens – with primary plasticity indices(26, 35,45) were mixed with different weight fractions of treated eggshell powder (5,10,15,20,25 %wf). In each step of experiments, Atterberg limits tests were performed on soil- treatedeggshell powder mixtures and the results were shown in Figures (4-6).

Soil specimen with primary plasticity index 26

- When the proportion of treated eggshell powder increased in the mixture, variations in the liquid limit of primary soil specimen decreased; however, the addition of different percentages of the treated eggshell powderdidn't significantly affect this decrease.
- The plasticity limit of specimen didn't significantly change as the percentage of treated eggshell powder increased. Overall, the treated eggshell powder had a decreasing effect on the specimen though this decrease was less dramatic inthe final proportions of the mixture.
- Adding different proportions of eggshell powder to this soil specimen reduced the plasticity index. The decreasewas more distinguished in the proportions more than(15% wf)caused a sharper decrease in the plasticity index.

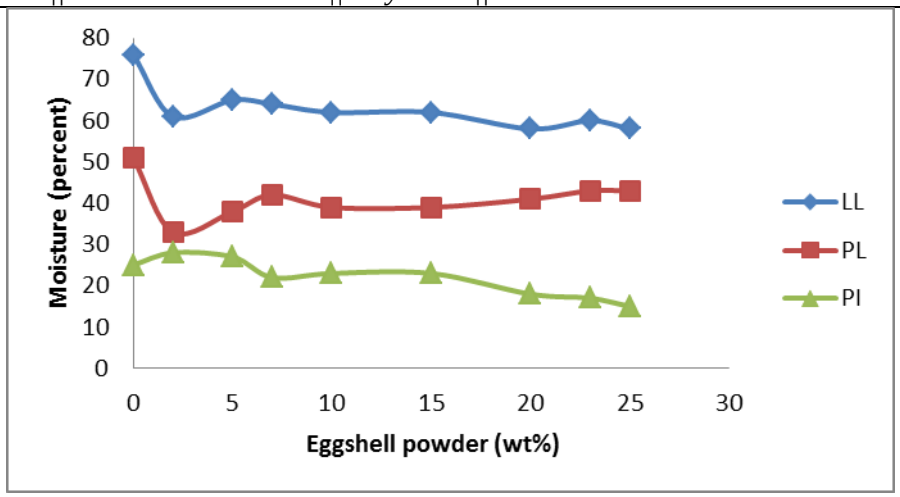

Figure 4.The effect of treated eggshell powder on plasticity properties in soil specimens with primary plasticity index 26

Soil specimen with primary plasticity index 35

- As shown in figure 5, any proportion of soil- treated eggshell powder mixture resulted in reduced liquid limit in thespecimensthough the overall pattern of liquid limit was reductive, the decrease showed a fluctuating pattern in percentages of the intermediate mixture.
- Different proportions of soil- treated eggshell powder mixture showed a decrease in the plasticity limit of specimens comparing with primary plasiticy limit of unmixed soil. The decreased followed a linear slope in final mixtureproportions and the variation alleviated.
- Different proportions of soil-treated eggshell powder mixtures caused a reduced in plasticity index of specimens comparing with the primary unmixed soil specimens.

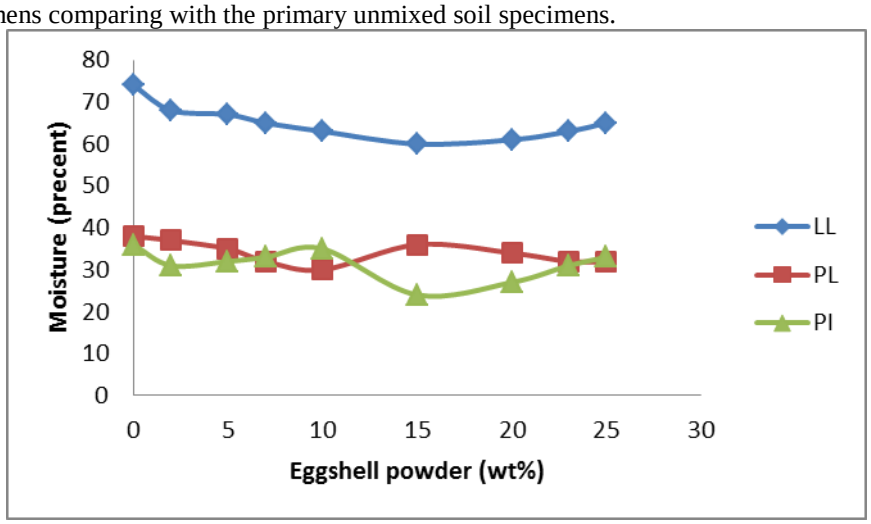

Figure 5.The effect of treated eggshell powder on plasticity properties in soil specimens with primary plasticity index 35

Soil specimen with primary plasticity index 45

- Considering the variations of liquid limits, initial proportions of soil-eggshell powder mixture slightly increased liquid limit, but the increased proportion of eggshell powder caused a decreased in liquid limit comparing with theprimary unmixed soil specimens. Thus, eggshell powder caused a reduction in liquid limit in the soil specimens.
- Soil- treated eggshell powder mixture revealed increased in plasticity limit. The increase was more significant in the initialproportions of eggshell addition but temperate in the final proportions, following a linear slope,comparing with theunmixed soil specimens.
- Different proportions of soil-eggshell powder mixture reduced the plasticity index in the specimens so that the largest decrease was noticed in the specimen with 15 percent eggshell powder.In addition a

high rate of decrease was shown by the experimentsso that the variations in plasticity index were conspicuous.

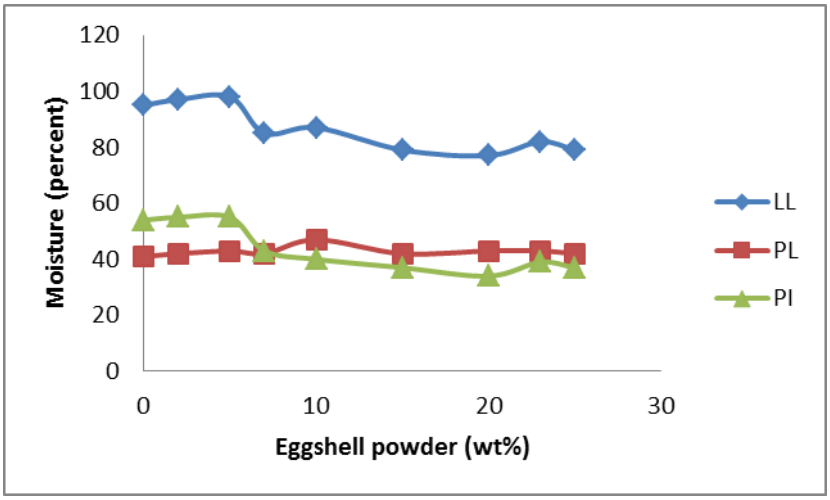

Figure 6.The effect of treated eggshell powder on plasticity properties in soil specimens with primary plasticity index 45.

Conclusions

a) Adding eggshell powder to expansive soil specimens led to reduction in plasticity index in the mixtures. This decrease entailed a relatively sharp slope in all specimens. So, the significant impact of eggshell powder on soil plasticity index is indicated. Elevated proportion of the eggshell powder in specimens resulted in sharper reduction in respective index.

b) Different proportions related to eggshell powder added to the soil specimens resulted in decreasing the liquid limit in specimens, thus with the increase in proportion of eggshell powder, the sharper reduction in respective index.

c) In soil specimens with primary plasticity index 45, there was an increase in plasticity index of soil-eggshell powder mixture. But the same index decreased in other specimens. In addition,greater variations in plasticity index because of lower proportions of soileggshell powder mixture, so that high percentages related to mixture did not indicated considerable changes in indices.

d) The treatment of eggshell powder with 7% NaOHdidn't show significant effect on the plasticity index of the specimens comparing with literature data.

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