EGGSHELL POWDER UTILIZATION AS CBR MODIFYING AGENT TO IMPROVE THE SUBGRADE SOIL

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ABSTRACT

The soils in natural state do not present adequate geotechnical properties to be used as road service layers in all situations. In order to improve their geotechnical parameters to meet the requirements of technical specifications of construction industry, soil stabilization techniques is normally emphasized. This study aims to improve subgrade CBR value by using eggshell powder at varying percentages respectively and to find out the optimum percentage of eggshell powder beyond which CBR value decreases of soil. Soil is treated with eggshell powder using different percentages up to CBR value increases. Soil is treated with eggshell powder using different percentages (1%, 3%, 5%, 7%, 9%, 11% and 13%). The results shows that initially the optimum moisture content of soil is 13.8% and for addition of eggshell powder up to 13% the initial optimum moisture content of soil has become in increase up to 15.25%. Initially the CBR value of soil is 6.47%. For addition of eggshell powder up to 11% the CBR value of soil has become in increase up to 9.52% and after then for addition of 13% eggshell powder it has become in decrease 9.38%.

Keywords: *Eggshell powder, optimum moisture content, CBR value.*

1. INTRODUCTION

A road pavement may be defined as relatively stable layer or crust constructed over the natural soil. The main function of pavement is to support and distribute the heavy wheel loads of vehicles over a wide area of the underlying subgrade soil and permitting the deformations within elastic or allowable range and to provide an adequate surface. Subgrade performance is a function of a soil's strength and its behaviour under traffic loading. The subgrade should be sufficiently stable to prevent excessive rutting and shoving during construction, provide good support for placement and compaction of pavement layers. The existing soil at a particular location may not be suitable for the construction due to poor bearing capacity and higher compressibility or even sometimes excessive swelling in case of expansive soils. To achieve above all these characteristics, it is very important to have a pre-knowledge about subgrade soil properties and to suggest suitable methods to improve the subgrade soil properties. The properties of soil can be improved by stabilization with admixtures such as lime; cement and cement kiln dust are used to improve the qualities of various types of soils such as Lateritic Soil, Clayey soil. However, the cost of introducing these admixtures has also increased in recent years. This has opened the door for researchers to find alternate admixtures such as plastic, fibers, fly ash, sugarcane bagasse ash, Eggshell powder etc. Soil is treated with instead of using only 7% lime by using 4% lime and 3% ESP and same soaked CBR value can be found (Amu et al, 2005). With addition of ESP, there was a considerable decrease in Atterberg's Limits, and after 20% the value seems to be almost constant. The optimum moisture content increases and maximum dry density decreases, permeability increases, coefficient of consolidation increases and compression index decreases with increase in percentage of ESP (Paul et al, 2014). The geotechnical properties of lateritic soil modified with sugarcane straw ash with a view to obtaining a cheaper and effective replacement for the conventional soil stabilizers. The results showed that optimum moisture content increased and CBR increased from and unconfined compression strength also increased (Amu et al, 2011). A 2% cement stabilized lateritic soil possess similar characteristic as 2%, 4%, 6% and 8% eggshell-stabilized lateritic soil as they are all in the class of inorganic clay of medium plasticity. From compaction test result, it is seen that both eggshell powder and cement significantly increased the optimum moisture content and maximum dry density of the soil (Akinlolu et al, 2011). Another paper showed an increase maximum dry density with increasing dosage of Groundnut shell ash up to about 4% of GSA (Oriola Folagbade and Moses George, 2010). The soil used in this investigation is high plasticity silty clay with liquid limit of 52 and plasticity index of 29 (Ansary and Hasan,

2011). Among the above researches, it has been observed that local soil, lateritic soil and black cotton soil have been used in some researches. Lime, quarry dusts have been used as additive with eggshell powder. In some other researches eggshell powder has been used as a partial replacement of industrial lime. But in this research, another type of soil has been used with varying percentages of eggshell powder to improve subgrade CBR value & to find out the optimum percentage of eggshell powder.

2. MATERIALS AND METHODS

Soil used in this study was collected from Tanore Upazila in the district of Rajshahi in Bangladesh. It was collected from 2 feet below from the top surface. The soil sample was taken in the laboratory and dried for 24 hours. Then the soil sample was subjected to various laboratory tests including specific gravity test, liquid limit test, plastic limit test, shrinkage limit test, modified proctor test and California bearing ratio test to find out the engineering properties related to various purposes. The engineering properties of soil were determined according to procedure specified by AASHTO, ASTM standards.

Eggshell powder (ESP) has not being in use as a stabilizing material and it could be a good replacement for industrial lime, since it's chemical composition is similar to that of lime. Chicken eggshell is a waste material from domestic sources such as fast food joints and homes. Literature has shown that eggshell powder primarily contains CaO (99.83%) and the remaining consists of Al_2O_3, SiO_2, Cl, Cr_2O_3, MnO and CuO. The eggshell waste was washed and dried before grinding. The eggshell powder was sieved using IS Sieve No.200 (75μ), and the powder passing the sieve was used. This sieve was chosen in order to achieve a uniform powdery.

2.1 General Properties of Soil Sample

The soil sample was thoroughly oven dried, weighed and stored in sacks at room temperature. The general properties of the soil were thoroughly studied in the laboratory. The soil was tested for liquid limit, plastic limit, optimum moisture content, maximum dry density, California bearing ratio etc. For the soil, the general properties obtained are tabulated as following table.

Table 1: Fundamental engineering properties of soil

Properties	Value
Textural classification	Clay Loam
Sand content (%)	40
Silt content (%)	31
Clay content (%)	29
Specific gravity	2.78
Liquid limit (%)	29.41
Plastic limit (%)	15.18
Shrinkage limit (%)	11.87
Plasticity index (%)	14.23
Optimum moisture content (%)	14.10
Maximum dry density (gm/cm^3)	1.92
California bearing ratio (%)	6.47

2.2 Preparation of Eggshell Powder

At first eggshell was collected and then it was oven dried (Figure 1). After that it was grinded by using a blender (Figure 2). Then it was turned into powder form (Figure 3&4). Then it was sieved through IS Sieve No.200 (75μ). This sieve was chosen in order to achieve a uniform powdery.

Figure 1: Eggshell

Figure 2: Blender

Figure 3: Preparing for grinding

Figure 4: Preparing for grinding

3. RESULTS & DISCUSSUIONS

The following grain size distribution curve is found by using the data obtained from sieve analysis and hydrometer analysis of soil.

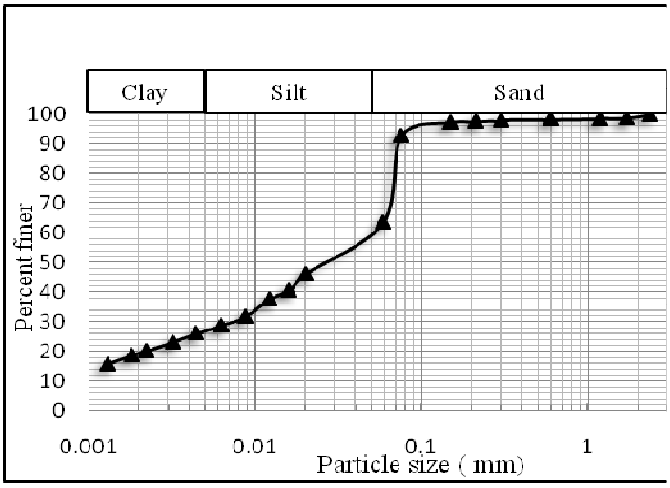

Figure 5: Grain size distribution curve

According to Textural classification (U.S. Bureau of Soil and Public Road Administration (PRA) classification) from grain size distribution curve it is found that the soil sample is clay loam. As the liquid limit of soil is within the range of 0 to 35% and plasticity index is 14.23% from the plasticity chart, it has been found that it is a low plastic soil.

Table 2: Variation of moisture content and dry density of soil with eggshell powder

Properties	Soil	Soil + % Eggshell powder						
		1%	3%	5%	7%	9%	11%	13%
Optimum moisture content (%)	13.80	14.05	14.20	14.40	14.80	15.10	15.20	15.25
Maximum dry density (gm/cm$^{3)}$	1.920	1.917	1.904	1.888	1.872	1.867	1.862	1.857

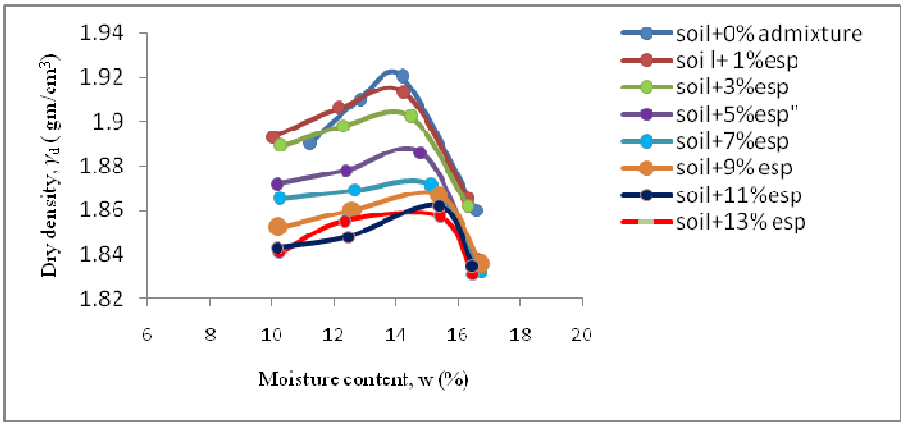

Figure 6: Moisture content and dry density of soil with different percentage of eggshell powder

The addition of eggshell powder by weight (0%, 1%, 3%, 5%, 7%, 9%, 11%, 13%) to the soil samples caused an increase in the optimum moisture content at the rates of 13.80%, 14.05%, 14.20%, 14.40%, 14.80%, 15.10%, 15.20%, 15.25% respectively and caused a decrease in maximum dry density at the rates of (1.920, 1.917, 1.904,1.888, 1.872, 1.867, 1.862, 1.857) gm/cm^3 respectively as shown in table 2, figure 6, figure 7, figure 8.

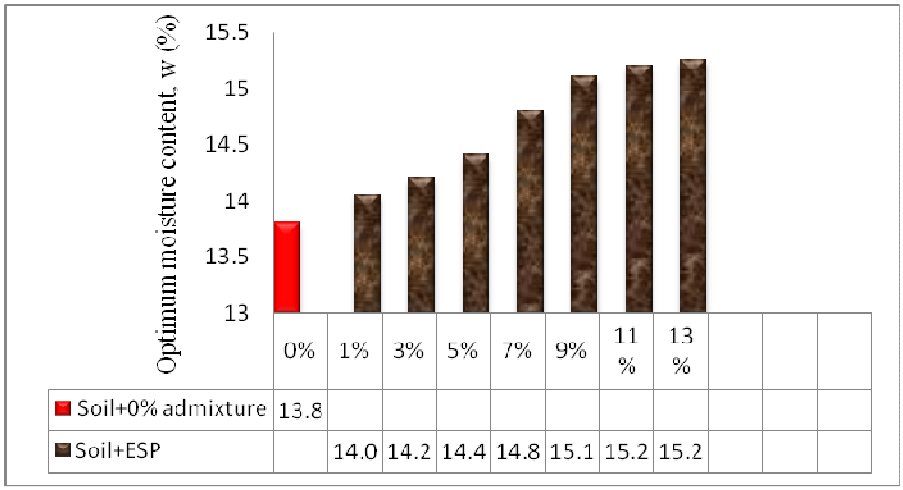

Figure 7: Optimum moisture content of soil with various percentages of eggshell powder

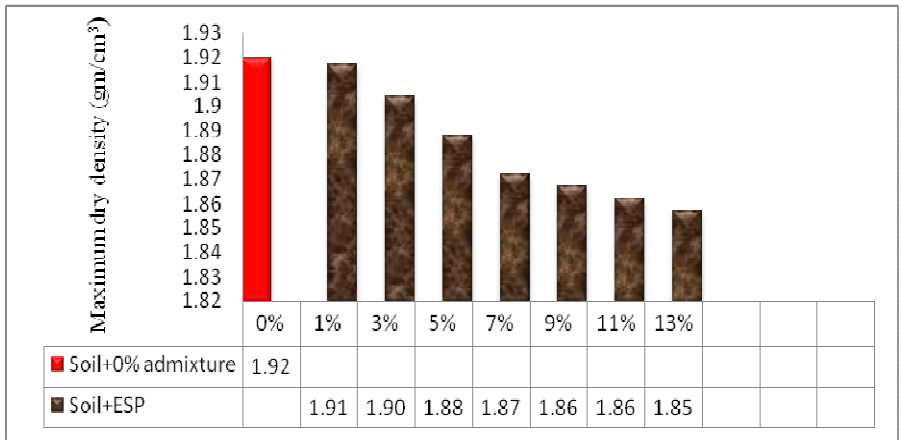

Figure 8: Maximum dry density of soil with various percentages of eggshell powder

The California Bearing Ratio test of soil is conducted with various percentages of eggshell powder.

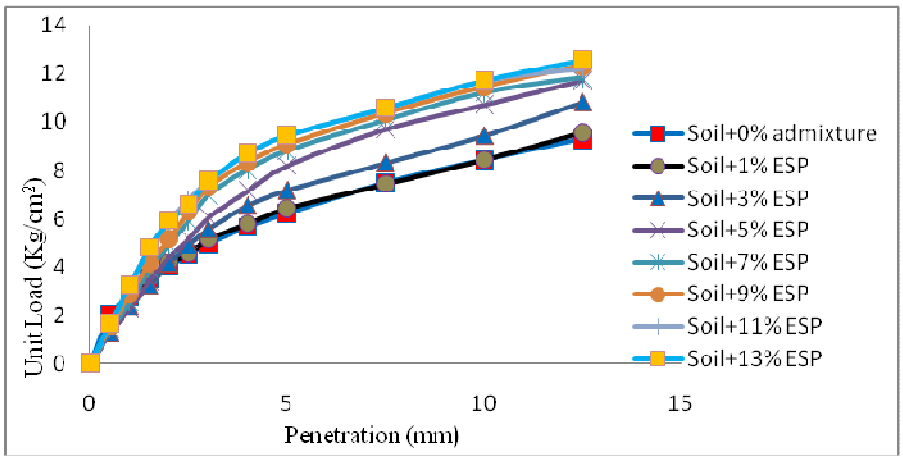

Figure 9: Unit load of soil with various percentages of eggshell powder

From above curves (Figure 9) it is clearly observed that the unit load carrying capacity of soil increases with the addition of eggshell powder. The addition of eggshell powder up to weight of 0%, 1%, 3%, 5%, 7%, 9%, 11% to the soil samples caused an increase in CBR value at the rate of 6.47%, 6.47%, 7.01%, 7.79%, 8.45%, 8.99%, 9.68% respectively and at the addition of 13% eggshell powder CBR value decreased 9.38 %. So 11% is the optimum percentage of eggshell powder for CBR value.

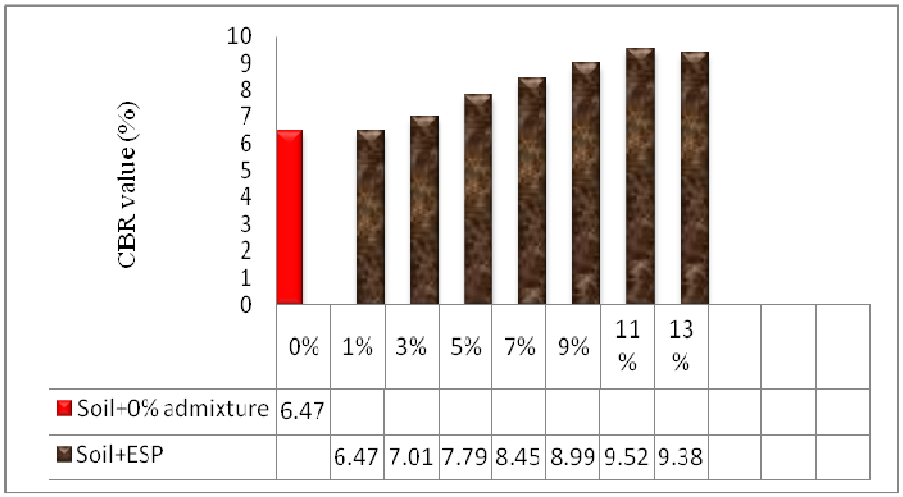

Figure10: CBR value of soil with different percentage of eggshell powder

4. CONCLUSION

From the test results it is found that properties of the soil have been improved by the addition of eggshell powder by comparing the behaviour of soil sample with and without admixture. The maximum dry density decreases and the optimum moisture content increases with the addition of eggshell powder. The results of the tests also draw another conclusion that the more percentage of eggshell powder we add to the soil up to optimum percentage, the CBR value increases gradually and after optimum percentage the CBR value decreases. From the test results it has found that the optimum percentage of eggshell powder is 11%.

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