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Optimization of coconut shell ash on the improvement of strength of clayey soil.

Optimización de la ceniza de cáscara de coco para mejorar la resistencia del suelo arcilloso.

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ABSTRACT

Due to rapid urbanization and industrialization, there has been gradual increase in the use of land for various constructional activities. This has resulted in the scarcity of the suitable land (soil) for construction. Now a days the structures are frequently build on the problematic soils. In this study, an attempt has been made to explore the possibilities of using Coconut Shell Ash to improve the favourable properties of soil. Alternatively, engineers try to utilize these easily available materials in the civil engineering construction based on its feasibility/suitability on their performance. Extensive experimental investigations, including compaction, unconfined compression test was conducted on different mix proportions of Coconut shell ash that is; 5%, 10%, 15% and 20%. From the results 15% coconut shell was found to be the optimum content. Stabilizing the soil by adding coconut shell ash improves the soil strength and reduces swell and shrink.

Keywords: Coconut Shell Ash, performance, soil strength.

RESUMEN

Debido a la rápida urbanización e industrialización, ha habido un aumento gradual en el uso de la tierra para diversas actividades de construcción. Esto ha resultado en la escasez de terreno (suelo) adecuado para la construcción. Hoy en día, las estructuras se construyen con frecuencia sobre suelos problemáticos. En este estudio, se ha intentado explorar las posibilidades del uso de ceniza de cáscara de coco para mejorar las propiedades favorables del suelo. Alternativamente, los ingenieros intentan utilizar estos materiales fácilmente disponibles en la construcción de ingeniería civil en función de su viabilidad/idoneidad para su rendimiento. Se llevaron a cabo extensas investigaciones experimentales, incluida la compactación y pruebas de compresión libre en diferentes proporciones de mezcla de ceniza de cáscara de coco, es decir; 5%, 10%, 15% y 20%. De los resultados se encontró que el contenido óptimo era un 15% de cáscara de coco. Estabilizar el suelo agregando ceniza de cáscara de coco mejora la resistencia del suelo y reduce la hinchazón y la contracción.

Palabras clave: Ceniza de cáscara de coco, rendimiento, resistencia del suelo.

INTRODUCTION

Soil stabilization is the modification of soil to improve its physical properties. Stabilization enhances the shear strength of the soil or controls the expansion and contraction properties of the soil to improve the load-bearing capacity of the subgrade that supports the pavements or foundation. Clay is a natural material composed primarily of fine-grained minerals. It consists of small particles with plastic and adhesive properties. Clay also has tiny cavities and pores that can hold water. In this state, it becomes easy to expand and contract, which causes settlement. When exposed to water, clay tends to soften and liquefy. Due to its low strength and stiffness, clay often makes construction difficult. This caused serious problems in geotechnical engineering. Weak soils can damage building foundations and cause cracks along the road surface. Due to the rapid development of infrastructure facilities, building on clay cannot be avoided. So, the stabilization of soil can be accomplished by using lime, lime-based products, or other chemicals such as Portland cement. These chemicals rely on pozzolanic reactions to form permanent bonds between soil particles. Usage of such additives was not environment friendly and it poses serious risks. Therefore, this research focuses on determination of the strength that can be produced by using coconut shell ash as part of the additive mixture.

Anil Kumar Sharma et.al (2018) studied the effect of a bottom ash and areca fibre, and its suitability as soil stabilizer. The bottom ash content was varied from 0 to 40%, the fibre content was varied from 0 to 1.5%, and the corresponding performance assessment was done. OMC was found to decrease and MDD increased with the addition of BA up to 30% to the soil, whereas this trend reversed with addition of 40% BA. Ramli R et.al (2018) studied the effect of Coconut Shell (CS) and Rice Husk Ash (RHA) on engineering properties as the expansive soil for roads' subgrade layer. The proportion of constant 20% of RHA content mix with 4%, 6%, and 8% of coconut shell correspondingly was examined with respect to compaction test and California Bearing Ratio (CBR) tests. The CBR value was found to increase appreciably with addition of CS and 20 % of RHA. Hence, the use of 20% of RHA and varying percentage of CS can be an advantage to improve soil engineering properties. Manikandan A.T et al (2017) studied to stabilize clay soil by using coconut shell powder and bottom ash (B.A). The unconfined compression test was carried out using minimum percentage of mix proportion for the admixture bottom ash (10%, 15%, and 20%) and coconut shell powder (5%, 10%, 15%, 20%). Among these samples tested the proportion in the mix of bottom ash 15% + coconut shell powder 15%, gives better stability to soil than the other samples.

From the literature review, it can be observed that coconut shell ash can be used as a stabilizer.

MATERIALS AND METHODS

Soil: The soil used in this study was obtained from a site near in Cheranelloor, Kerala. The grain-size distribution of the soil was found as per IS 2720 (BIS 1980). The particle-size distribution of the soil sample indicates that it is of clayey nature. Physical properties of the soil are given in Table 1.

Coconut shell ash (CSA): Coconut shell given in fig 1 is available in abundant quantity in local agricultural fields and considered as waste product. On the other hand, cement production emits a lot of toxic gases in the

atmosphere which causes environmental pollution and greenhouse gases. Thus, CSA might be utilized as a cementitious material in soil for sustainable development. The material is rich in amorphous silica so it can be used as a replacement of cement.The physical properties and oxide composition of the coconut shell ash is shown in table 2 and table 3.

RESULT AND DISCUSSION

Unconfined Compression Test (UCS): The variation of UCS at various CSA percentages is depicted in Figure 2. The UCS value of virgin soil was found to be 2.04 $\mathrm{kN/m^2}$. According to the results of the UCS tests, the soil's strength increases marginally as the percentage of CSA rises to 15%, whereas the UCS drops dramatically to 20% of CSA. The compaction test results indicate a decrease in MDD, which may be the cause of the decrease in UCS after 15%. The packing of the particles decreases as the density decreases; Consequently, a 20% CSA content results in a decrease in the undrained shear strength.The increasing trend in the UCS value to its peak value could be explicated in terms of the pozzolanic potential of the coconut shell ash. Decrease in the UCS values shortly after the attainment of the peak UCS values, may have resulted from the exhaustion of the silica and alumina present in the CSA that are responsible for the pozzolanic action experienced in the mixture.

Compaction Test: Figs. 3 and 4 present the variation of MDD and OMC, independently, against the varying percentage of the coconut shell ash from 0 to 20. The OMC and MDD value of virgin soil was found to be 35.3 % and 1.24 $\mathrm{g/cm^3}$ Fig. 1, it's clear that as the coconut shell ash content increases, the MDD of the soil also increases; beyond 15% CSA, a drop in MDD was observed. It's possible that the soil-CSA admixture becomes well-graded with the addition of CSA up to 15% andenhances the MDD, whereas a bulk amount of CSA disturbs the intergranular quilting leading to the reduction in MDD. The reduction in MDD might be also due to the lower specific gravity of CSA compared to soil. OMC was set up to reduce with an increase in CSA up to 15% and increased beyond 15% of CSA(Fig. 4). The drop in optimum water content gives an idea that the soil can be stabilized indeed at lower water content. On the other hand, the increase in MDD demonstrates the utilization of soil- CSA admixture for use as subgrade material.

Table 1- Physical properties of soil

Properties	Values
Specific gravity	2.62
Free swell index	40
Water content	41
Liquid limit %	72
Plastic limit %	29
Plasticity index %	43
OMC %	35.3
MDD $\mathrm{g/cm^3}$	1.25
UCS $\mathrm{kN//m^2}$	2.04

Fig 1: Coconut Shell Ash

Table 2- Physical properties of Coconut shell ash

Physical Properties	Values
Specific gravity	1.33
Bulk density g/cm^3	0.8
Shell thickness	2-7mm

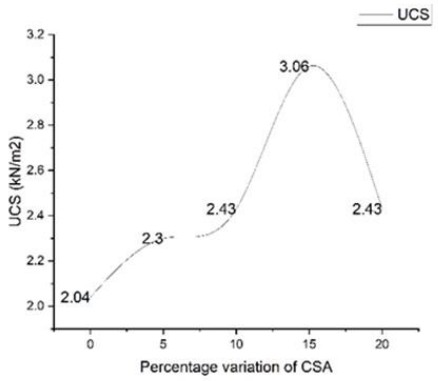

Fig 2- Percentage variation of CSA vs UCS

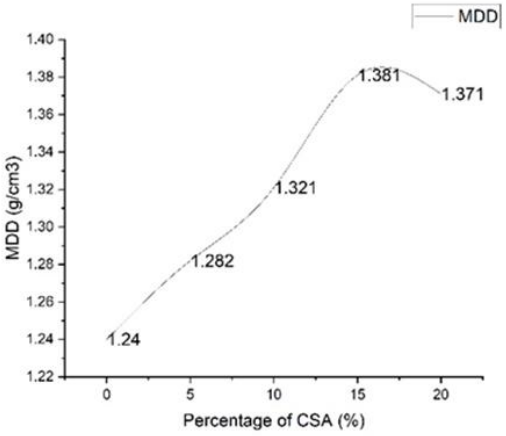

Fig 3- Percentage variation of CSA vs Maximum dry density

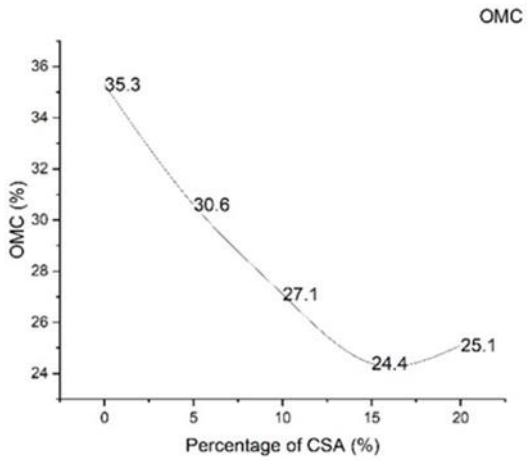

Fig 4- Percentage variation of CSA vs Optimum moisture content

CONCLUSION

The following main conclusions can be drawn from the present study:

- OMC was found to decrease and MDD increased with the addition of CSA up to 15% to the soil, whereas this trend reversed with addition of 20% CSA. This may be attributed to the well graded of the soil-CSA mixture with the addition of CSA up to 15%, whereas with a higher amount of CSA, the disturbance in the intergranular packing can lead to a decrease in MDD. The decrease in optimum water content gives an indication that the soil can be stabilized even at lower water content.
- UCS of the soil-CSA mix was also found to increase up to 15% CSA content, and there was a reduction in UCS with 20% CSA. The increasing trend in the UCS value to its peak value could be explicated in terms of the pozzolanic potential of the coconut shell ash. Decrease in the UCS values shortly after the attainment of the peak UCS values, may have resulted from the exhaustion of the silica and alumina present in the CSA that are responsible for the pozzolanic action experienced in the mixture
- From the results, it was found that 15% coconut shell ash was the optimum content that gives maximum strength to the soil.

In general, the present investigation revealed that using CSA in soil stabilization can lead to eco-friendly construction.

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