Sustainability, Agri, Food and Environmental Research, (ISSN: 0719-3726), vol 13, 2025
http://dx.doi.org/

A review on stabilization of clayey soil using egg shell powder (esp) along with chicken feather fiber(cff)

Una revisión sobre la estabilización de suelos arcillosos utilizando cáscara de huevo en polvo (esp) junto con fibra de pluma de pollo (cff)

Sreerema Prasad .S [1] and Sruthi B Dharan [2]

[1]M.Tech Scholar, Department of Civil engineering, Sarabhai Institute of Science and Technology, Vellanad, Thiruvananthapuram, Kerala. sreeremaprasad@gmail.com

[2]Assistant Professor, Department of Civil engineering, Sarabhai Institute of Science and Technology, Vellanad, Thiruvananthapuram, Kerala. sruthibdharan@gmail.com

ABSTRACT

Today the construction industry faces drastic problems because of availability of good quality of land for construction. This occurs due to increase in population and industrialization. Overcome such situations civil engineers focus to construct structures on weak soil by improving its properties. The technique utilized for the enhancement of soil properties is known as ground improvement techniques. Here, a review on clayey soil treated with locally available waste materials, such as Egg Shell Powder (ESP) and Chicken Feather Fiber (CFF). Soil stabilization is the process of enhancing the physical properties of soil in order to improve its strength, durability etc.by adding different stabilizing agents. Egg Shell Powder is a waste product from homes, restaurants, etc. Chicken feather is also a poultry waste. Soil was first treated with varying percentage of ESP to find the optimum value for gain strength. Then the soil again treated with varying percentage of CFF along with optimum percentage of ESP to find optimum value to gain maximum strength. The study concluded that the addition of waste additives enhance the engineering properties of clayey soil. Both ESP and CFF are waste products which may cause severe environmental problems. The utilization of these products as soil stabilizers makes economical and become a best solution for sustainable environmental protection.

Keywords: Soil stabilization, Egg Shell Powder (ESP), Chicken Feather Fiber (CFF), Engineering properties, Soil Stabilizers.

RESUMEN

Hoy en día, la industria de la construcción se enfrenta a problemas drásticos debido a la disponibilidad de terrenos de buena calidad para la construcción. Esto se debe al aumento de la población y a la industrialización. Para superar estas situaciones, los ingenieros civiles se centran en construir estructuras sobre suelos débiles mejorando sus propiedades. La técnica utilizada para la mejora de las propiedades del suelo se conoce como técnicas de mejora del suelo. A continuación, se presenta una revisión de los suelos arcillosos tratados con materiales de desecho disponibles localmente, como la cáscara de huevo en polvo (ESP, por su sigla en inglés) y la fibra de pluma de pollo (CFF, por su sigla en inglés). La estabilización del suelo es el proceso de mejora de las propiedades físicas del suelo con el fin de mejorar su resistencia, durabilidad, etc. mediante la adición de diferentes agentes estabilizadores. La cáscara de huevo en polvo es un residuo doméstico, de restaurantes, etc. La pluma de pollo también es un residuo avícola. El suelo se trató primero con diferentes porcentajes de ESP para encontrar el valor óptimo para ganar resistencia. Luego, el suelo se trató de nuevo con un porcentaje variable de CFF junto con el porcentaje óptimo de ESP para encontrar el valor óptimo para obtener la máxima resistencia. El estudio concluyó que la adición de aditivos residuales mejora las propiedades de ingeniería del suelo arcilloso. Tanto el ESP como el CFF son residuos que pueden causar graves problemas medioambientales. La utilización de estos productos como estabilizantes de suelos resulta económica y se convierte en la mejor solución para la protección sostenible del medio ambiente.

Palabras clave: estabilización de suelos, cáscara de huevo en polvo (ESP), fibra de pluma de pollo (CFF), propiedades de ingeniería, estabilizadores de suelos.

INTRODUCTION

Soils are used in most construction activities; the most important challenge is how to deal with problematic soils such as clayey soils. In general, clays expand due to an increase in moisture and shrink due to decreased moisture [1]. Soil stabilization can be achieved by soil crushing and by mixing it with a particular chemical additive, then compacting it. [2].

Soil stabilization process widely used to enhance the strength of soil, reduce its compressibility and increase its bearing capacity and durability through bonding the soil particles together. Stabilization is the alteration of foundation soils to improving of less stable soil in both strength and durability. Soil stabilization involves the effective use of different stabilizing agents for the improvement of weak soils. There are various types of soil present in the earth depending upon the material property, size, texture, various properties. Depending upon the material composition clay also possess various properties. It is slow to drain, quickly to harden, and difficult to use for anything because of its finer particle size. Some situations construction on the clay soil is not avoidable one therefore soil

stabilization is one of the most commonly used methods to increase the engineering properties of the soil, as a result of soil stabilization, the bearing capacity of the foundation of the structure is increased.

The basic methods of stabilization are cementation, bituminization, solidification, methods using electrochemical or thermal action, and artificial freezing. These methods can cause some effects on the environment as well as down the economic benefits. In the context of sustainable development in terms of durability and strength and compaction characteristics of soil/soft soil, the use of soil additives and reinforcement using natural fibers in geotechnical applications is desirable.

In this study focuses on clayey soil stabilization using egg shell powder along with the reinforcement of chicken feather fiber. It is preferable to replace these by another kind of soil addictive to make them economical and eco-friendly manner. Here two additives were used as stabilizing materials which are waste products and easily available. The additives used in this study are, Egg Shell Powder (ESP) and Chicken Feather Fiber (CFF).

LITERATURE SURVEY

Various authors are already studied about using Egg Shell Powder and Chicken Feather Fiber individually and in conjuction with other stabilizers in stabilizing clayey soil

Alqaisi.R.O (2020) He conducted the study on the effect of ESP as a supplementary additive to lime stabilization in expansive soil. The addition of Egg Shell Powder alone to soil had a marginal effect on the geotechnical properties of stabilized expansive soils. The unconfined compressive strength (UCS) of treated soils increased.

Alzaidy.M.N.J (2019) In this paper, the effect of the combination of Egg Shell Powder and Plastic Waste Strips in some engineering properties of clayey soil represented by compaction characteristics, unconfined compressive strength, swelling potential, California bearing ratio test and finally shear strength parameters have been studied. The aim of this paper is to investigate the influence of plastic wastes, eggshell powder contents and the curing duration in the strength behavior of clayey soil. An increase in ESP content causes to an increase in unconfined compressive strength. A significant net positive change has been noticed in the engineering characteristics of the clayey soil after adding both of ESP and PWS. These beneficial changes depend on ESP, PWS contents and the curing duration.

Aneesh P.C,et.al (2020) It is an experimental study focused on stabilization of cochin clay with Egg Shell Powder(ESP) and Shredded LPDE. 3 various proportions of ESP (2%, 5%, 8%) plastic wastes (0.25%, 0.5%, 0.75%, 1%) were added to obtain optimum percentage of each additive. The collected sample comes under silt clay (53.3%) and from the plasticity index, according to Unified soil classification system (USCS) our clay sample is grouped under CH

category. The combination of 5% ESP and 0.5% plastic we obtain the maximum compressive strength of 86.24kN/m^2 and thereafter the value goes on decreasing.

Birundha.P,et.al (2017) In this journal paper, Egg Shell Powder and Quarry Dust were used to study the effect on the properties of clayey soil. An improvement in the engineering properties of soil by addition of ESP and QD will help to find an application for waste materials to improve the properties of clayey soil. Addition of various percentages of ESP and QD into the soil decreases optimum moisture and increases maximum dry density.

Dr.Mathada.V.S (2019) It is an experimental study on black cotton soil is stabilized by using admixture which is easily available and waste material. The admixture used is Chicken Fur (CF) is a waste from poultry farming. Here, tests are carried out such as, Compaction Test and Unconfined Compressive Strength Test for the Soil and also for the soil replaced with CF in Percentage variation of 1%, 2% and 3%. The Compressive strength value increased by 857.07% when compared with the original Soil sample and the Soil replaced with 2% CF by the weight of soil mass.

Elias.T (2016) This research paper is conducted to stabilize clayey soil using human hair fiber and lime.The optimum percentage of lime and human hair that should be added in Kuttanad Clay is 9%, 1.5% respectively. The compressive strength increase of 90.4% is observed. Human Hair Fibres can be added to soil as a stabilizing agent. Hair as a cheap reinforcing agent is abundantly available as a waste product from saloons and is facing a major disposal issue. In the present study lime is added to clay in its natural water content. Lime content was varied from 3%, 6%, 9%and 12% by weight of soil. In case of hair stabilization, human hair was added by hand to achieve a homogeneous soil-hair mix. The hair used in the present study were of length 4-40mm and it was added to the mix in varying percentages of 0.5%,1.0%,1.5%,2.0% and 2.5% by weight. The optimum percentage of lime and human hair that should be added in Kuttanad Clay so as to make it properly stabilized is 9%, 1.5% respectively.

Krishnakumari.B,et.al (2019) In this study discussed about the stabilization of clayey soil using various additives. Egg shell primarily consists of magnesium carbonate, protein, calcium and the quantity of lime. The increase is because of the addition of ESP, that decreases the quantity of free silt, clay fraction and coarser materials with larger surface areas.

Manoj.N,et.al (2017) This study focused on stabilization of soft soil using chicken feathers as biopolymer. We know that, biopolymer means a polymeric material created by living life forms, e.g. protein, starch, cellulose. The compressive strength of soft soil increases with the increase in biopolymer up to 5% and after that eventually the compressive strength of the soil decreases. Generally, these chicken feathers are the dumped wastes of poultry farms. Chicken feathers are used as an animal feeder, melted and made into plastic. The usage of chicken feathers in any field is very less and they become debris to over this problem, they are for stabilization of soft soils which are very weak in nature and contain many voids.

Sharmila.S.M.R,et.al(2019)This literature deals about the experimental study on the stabilization of soil using organic waste and coir fibres of varying lengths. Basic properties of virgin soil like Atterberg's limits, unconfined compressive strength, compaction characteristics, California bearing ratio, were determined. The soil was then treated with an optimum percentage of eggshell powder and varying percentages of coir fibres of different lengths (L=1cm, 1.5cm). Addition of 10% ESP gives an increment of about 39.5 %. in UCC values. It can be observed that as the length increases, the fibre-fibre interaction dominates over the fibre-soil interaction and reduces the effect of interlocking. The CBR and UCC value for the virgin soil sample was found to be 5.71% and 124 kN/m2 respectively. Addition of 10% ESP gives an increment of about 54.6 % and 39.5 %. in CBR and UCC values. The CBR and UCC values showed an increment of 107% and 182 % when the soil was treated with 10% ESP and 1.25% of coir fibre, when the length of the fibre was limited to 1 cm.

Soundara.B and Vilasini.P.P (2015) In this paper, the suitability of Egg Shell Powder (ESP) as a possible stabilizing agent to improve the strength of soils is studied by various laboratory test.The maximum dry density slightly increases and after then decreases for increasing percentage of ESP. The OMC values are constantly decreasing upon increasing percentage of ESP. There is an increasing trend of UCS upon increasing percentage of ESP is observed.

MATERIALS USED

Materials used in this project are clayey soil, Egg Shell Powder (ESP), Chicken feather Fiber (CFF) which are described in details below

CLAYEY SOIL: Clayey soil deposit collected from Plamoottukada. in Thiruvananthapuram district by manual excavation at a depth of 1 m below the ground. It lies at Latitude $8^0$20'15.7452"N and Longitude $77^0$7'2.9856"E.

EGG SHELL POWDER (ESP): Eggshells, preferably the chicken eggshell perceived a waste material. It used as a replacement for soil stabilizer like lime since they have the same chemical composition. The eggshell powder was sieved using IS Sieve No.200 (75μ), and the powder passing through the sieve was used. The eggshell primarily contains lime, calcium and protein. It has been in use as a source of lime in agriculture, which confirms that lime is present in considerable amount in eggshell. Most good quality eggshells from commercial layers contain approximately 2.2 grams of calcium in the form of calcium carbonate. Specific Gravity of Egg Shell powder (ESP) =1.31.

Fig 1 : Egg Shell and ESP
[Source : Veerabrahmam.K and Prasad.D.S.V (2021)]

CHICKEN FEATHER FIBER (CFF) : Chicken feathers are obtained as a waste from the poultry farms. Chicken feathers are washed with water, rinsed with ethanol and are oven dried for 2 to 3 days until the CF dried completely, remove the odour. after that the CF's are cut into small pieces.

Fig 2: Chicken Feather
[Source: Dr.Mathad.V.S,et.al (2019)]

RESULTS AND DISCUSSION

EFFECT OF VARYING PERCENTAGES OF EGG SHELL POWDER ON CLAYEY SOIL

LIGHT COMPACTION TEST

The result of compaction test is presented in the form of a plot of dry density with water content. Here, we get the optimum percentage of range between 10-20 ESP treated with clayey soil gives maximum strength. MDD changes occur due to the size of the particles, specific gravity of the soil specimen and stabilizer

UCS TEST :

It was observed that the unconfined compressive strength of soil stabilized with Egg shell powder increases as the percentage of powder increases. The optimum percentage of ESP for maximum strength was found to be between 10-20%. The gradual formation of cementitious compounds such as calcium silicate hydrate is become a reason for initial increase in the UCC values. The decrease in the shear strength values after getting the optimum value of additive, due to the excess eggshell powder that occupies spaces within the soil and it makes weak bond between the soil and the cementitious compounds.

CONCLUSION

The physical properties and engineering characteristics of virgin soil were studied, which includes moisture content, compaction characteristics and unconfined compressive strength. By using the eggshell powder as a soil stabilizing agent, we can minimize the amount of problem related to disposal eggshell. It can be concluded that fiber reinforced soil can be considered as a good ground improvement technique specially in engineering projects and Egg Shell Powder acts as a cementitious material on weak soils where it can act as a substitute to deep/raft foundations, and makes it economical in all respects. Egg Shell Powder and Chicken Feather Fiber are two sustainable waste materials. By the journals of references proved that by adding these two additives to clayey soil gains maximum strength. The best result gains when clayey soil treated with 10-20% of ESP along with reinforcement of 1-3% CFF gives maximum strength.

Author Note

Sreerema Prasad S

Sruthi B Dharan

We have no conflict of interest to disclose

Correspondence concerning this article should be addressed to Sreerema Prasad S, Sarabhai Institute of Science and Technology, Vellanad, Thiruvananthapuram, 695543: sreeremaprasad@gmail.com

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Received: 06th May 2022; Accepted: 19th January 2023; First distribution: 25th April 2023