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A Comparative Study on Soil Stabilisation using Waste Materials

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ABSTRACT

Expansive soils can cause more damage to structures, particularly light buildings and pavements, than any other natural hazard, including earthquakes and floods. Presently obtaining a construction site that meet the design requirements without ground modification is not possible. The current practice is to modify the engineering properties of the native soils with cementitious materials like cement, lime, fly ash, bitumen or combination of these to meet the design specifications. This paper focuses on the stabilisation of soil through calcium rich cost effective materials such as Sea Shells, Egg shells and puzzolonic materials such as Rice husk ash and Saw Dust Ash at various proportions.The soil used for our study is a black cotton soil collected from Sathankulam, Thoothukudi District, at a depth of 0.5m from the natural ground level. Several tests were conducted to compare the performance of these additives on various properties of the native Black cotton Soil.

Keywords: ***Soil Stabilisation, Black cotton Soil, Sea Shells, Egg shells, Rice husk ash, Saw Dust Ash***

Introduction:

Expansive soils like black cotton soils should be stabilized in order to prevent them from failures. Several methods have been employed to improve and modify the properties of Black Cotton soil since long. Current practices involve the addition of cemetitious materials like cement, lime, fly ash, bitumen or a combination of these materials to meet the requirements. Several research [1] was also made in this area using available industrial wastes. This research focuses on the usage of calcium rich cemetitious materials available naturally. Making use of these materials for soil stabilisation also solves the disposal problems of these waste materials. Maheshwari, et al. (2015) tried to stabilize the black cotton soil with sea shell and bitumen emulsion as sea shells are naturally available materials on the sea shores.

They are the hard exoskeleton of molluscs and contain about 90% of calcium carbonate which is a major component in Lime. Bitumen emulsions which are easily available in our country will act as a binder between the soils particles and prevent the entry of water within the soil. Jasbeer Saini, et al. (2013) presented the effect of stabilization on Black Cotton soil using fly ash and rice husk ash. Addition of rice husk ash in increasing proportion decreases maximum dry density of stabilized soil. Use of fly ash [2] is advantageous than conventional earth material as its specific gravity is low which makes it fit for light weight embankments over soft compressible soil. RHA is a fibrous residue of the rice that remains after incineration of rice husk gives the ash.

The chemical analysis on rice ash was found to contain mainly silica, potassium, iron, calcium, magnesium, aluminium. Similar study with RHA was carried out by Vishal Ghutke, et al. (2018) in proportion of 4%, 8%, 12%, 16% to evaluate then geotechnical properties of the soil.GEETHU SAJI, et al.(2016) used Egg Shell Powder (ESP) and Quarry Dust (QD) [7] to study the effect on the properties of clayey soil. Eggshell primarily contains calcium, magnesium carbonate and protein and the quantity of lime in eggshell is almost the same as in limestone on ton basis. When quarry dust is added with expansive soil it is expected tol make soil more porous, less durable and reduce cohesion . KARAN GUPTA, et al.(2016) used saw dust, generated in huge quantity

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worldwide due to the rapid urbanization as disposal of saw dust in open areas or landfills is not an eco friendly solution. While BIRUNTHA.P, et al. (2017) studied the combined effects of eggshell and quarry dust. HUSSEIN KARIM, et al.(2018) investigated the clay soils using saw dust ash.. The mixture of sawdust ashes with soft clay soils improves physical and mechanical properties of the soil, as expressed by a general reduction in specific gravity and maximum dry density (MDD). KRITHESH, et al. (2016) presented the project that aims at determining the properties of eggshell powder and marble dust stabilized clay with a view to determine its suitability as a substitute for conventional lime stabilized clay [3-5].

Materials and Methodology:

The black cotton soil used in this study is taken from Peikulam, Tuticorin district. The properties of this soil are found and tabulated as below in Table 1.

Properties of Soil	Results
Liquid Limit	60%
Plastic Limit	20.96%
Shrinkage Limit	6.7%
Specific Gravity	2.76
Max. Dry Density	1.582g/cc
OMC	15 %
UCC Strength	77kN\m^2

Table 1. Properties of Clay Soil.

Egg Shell Powder

Chicken eggshell is a waste material from domestic sources such as poultries, hatcheries, homes and fast food restaurants. Eggshells were spread on the ground and air dried to facilitate easy milling. After air drying the eggshells were manually broken and milled into powdery forms which were collected. The eggshell powder was finally sieved through 425µ sieve.

Sea Shell Powder

It is derived from natural sea shell. It is a rich source of calcium and has high absorption rate. The sea shells were finely grained and the sea shell powder passes through 425 Micron Sieve was used for this experiment [6].

Rice Husk Ash

Rice milling generates a by-product known as husk. This surrounds the paddy grain. During milling of paddy about78% of weight is received as rice, broken rice and bran. Rest 22% of the weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process. The rice husk ash passed 425 Micron sieve was used for this experiment [8].

Sawdust Ash

The Saw dust was collected from local Saw mill. The saw dust collected was obtained from sawing of Neem Wood. Saw dust is actually by-products of sawmills generated by sawing timber. It is the loose particles or wood chippings obtained by sawing wood into useable sizes. After collection,clean saw dust not having much bark and so not much organic content was air dried and burnt at the room temperature. The SDA was then sieved through 425 micron sieves to remove the lumps, gravels, unburnt particles and other materials which are deleterious to soil. The specific gravity of SDA is 2.03.

Preparation of Sample:

The soil sample was seived through 425 micron seive to remove any lumps present. The additive materials used in the soil were also seived. These materials are then added on weight basis as per the percentage of addition in dry state. These samples are then used for finding the maximum dry density, optimum moisture content and the UCC strength test. The various compositions used in this study are as tabulated in table 2.

Sample	Composition
Sample 1 -4	BCS + Egg shell powder 4%, 8%, 12% ,16%
Sample 5- 9	BCS + Saw dust ash 4%, 8%, 12%, 16%
Sample 10 - 14	BCS + Sea shell powder 5%, 10%, 15%, 20%,25%
Sample 15- 19	BCS + Rice Husk ash 5% ,10%, 15%, 20% , 25%
Sample 20	BCS +8%Egg shell powder+4% Saw dust ash

Table 2. Composition of various Samples.

Compaction Test:

The compaction characteristics are obtained by performing the standard proctor compaction test. The

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test was started with 10% water content. The mould was weighed and oiled before each trial. The sample soil was divided into three portions and compacted into the mould in three layers. Each layer was compacted by giving three blows with the hammaer as per Indian Standards. . Before filling in the second layer, the surface was scarred using a straight edge, for proper binding of the layers. The collar was placed before filling in the third layer and sufficient soil was filled in such that the compacted height of the soil was above the height of the mould. After the third layer was compacted the collar was removed and the excess soil was struck off using a straight edge. The weight of the mould plus soil was taken after trimming the excess soil. The soil sample was then extruded and a representative sample from the three layers was placed in the oven for water content determination. The trials were continued till the weight of the compacted soil reached a peak value and then decreased. The readings were noted after each trial and the maximum dry density and optimum water content were determined by plotting a graph between dry density and water content [10].

Unconfined Compression Strength Test:

The strength of the soil sample and soil with additives at various percentages was studied by performing unconfined compression tests. The unconfined compression test was performed as follows. The soil sample with pre determined water contents was then prepared by filling the mould. After preparation of the sample it was extruded from the mould. The dimensions of the soil sample were checked and its weight was measured. The sample was placed on the compression testing machine in such a way that the axis of the sample was as close as possible to the loading plate. The dials were adjusted to zero and the proving ring details were noted. The strain rate was set and the motor was started. The load readings and the strain readings were measured at frequent intervals to define the stress-strain relationship. The test was continued till the cracks were well formed. The specimen was then removed and was oven dried to determine the water content [4].

Results and Discussion:

Dry Density and OMC:

The Dry density of black cotton soil without additives was found to be 1.532 g/cc at an optimum moisture content of 15%. Where as the maximum Dry density of 2.187 g/ cc is achieved at an optimum moisture content of 14% for Black cotton soil with the addition of 10% Sea Shell Powder. The second highest dry density 1.718 g / ccis achieved for a combination of Black cotton soil with 8 % Egg Shell Powder and 4% saw dust ash at an optimum moisture content of 16%.

Among the addition of different egg shell percentages such as 4%, 8%, 12% and 16% to the black cotton soil, 8% addition of Egg shell yields a high dry density of 1.73 g\ cc at an optimum moisture content of 22%. Similarly for the addition of Rice Husk Ash in various percentages such as 5%, 10%, 15% and 20% the maximum dry density of 1.52 g / cc is obtained at an optimum moisture content of 22%. Compared to all additives the lowest of maximum dry density is achieved by the addition of 4% Saw dust ash at an optimum moisture content of 20%.

The graphs showing the optimum moisture content and max dry density values are shown in fig1 and fig 2.

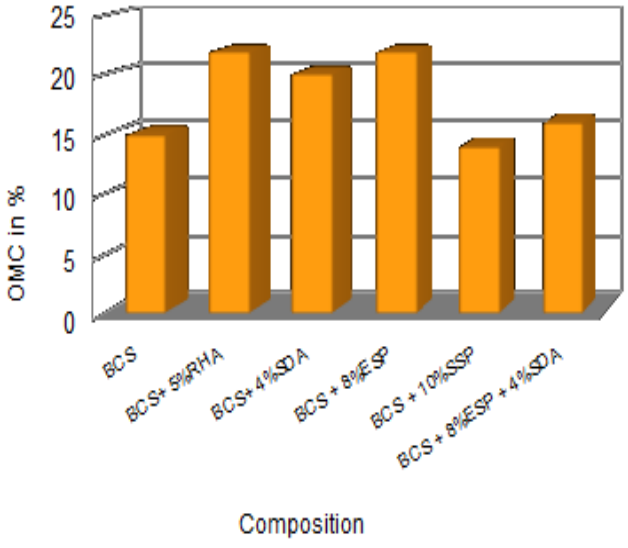

Fig 1 OMC for various Compositions

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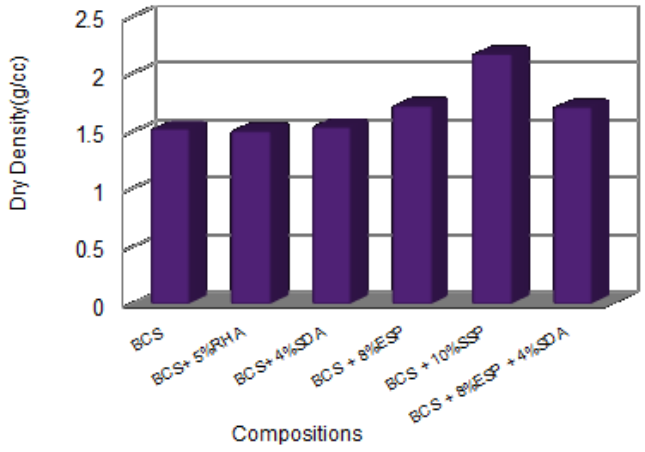

Fig 2 Dry DensityC for various Compositions

The unconfined compressive strength test was done for all samples as represented earlier with different proportions of BCS, Egg Shell powder, Saw Dust Ash, Sea Shell powder and Rice husk ash to obtain the unconfined compressive strength (qu) as follows in Fig 3

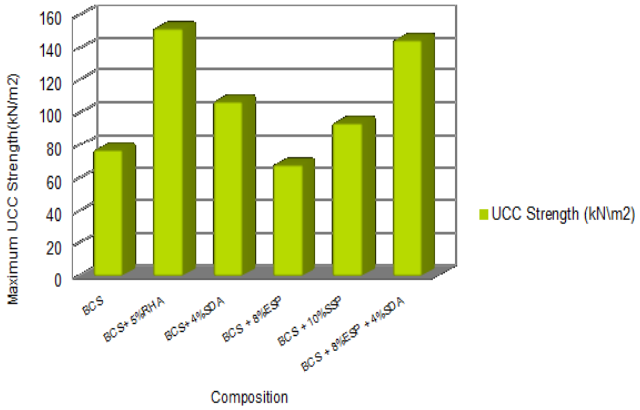

Fig 3 UCC for various Compositions

The results show that a maximum of 152kN / m2 was achieved for the addition of 5% RHA to BCS. Increase in the addition of Sea Shell Powder to Black Cotton Soil increases the UCC and a maximum of 117kN / m2 was achieved for the addition of 10% SSP to black cotton soil. Similarly Egg Shell Powder shows a highest of 110 kN / m2 at 12% addition to Black Cotton Soil. Addition of Saw Dust at 4%gives a maximum strength of 104 kN / m2. The details are shown in figure 4

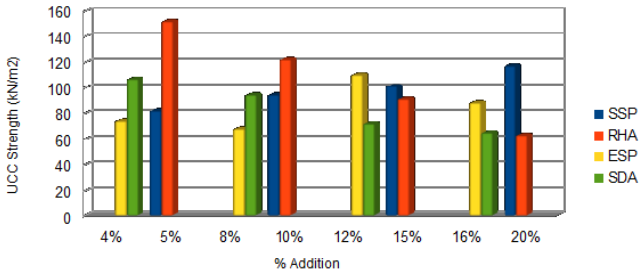

Fig 4 UCC for various Compositions

Conclusion:

It is observed that among the various natural materials added to clay, RHA gave promising improvements in the strength properties of clay. But employing RHA also increases the addition of water require for binding owing to its water absorbing nature.Addition of Saw dust ash exhibits good performance at lower percentages. . The addition of ESP has modified and improved the soil positively by improving the characteristics and hence its use in soil stabilization can be recommended with further related studies on its other characteristics such as water absorption, permeability etc. SSP gives better strength results same as that of ESP and SDA combinations. Hence Sea shells can be tried in combination with other materials as used here. Addition of SSP to clay in combination with RHA may result in better finding and can be researched further.

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