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Stabilization of Locally Available Clay Using Blood Clamshell Powder as Stabilizing Agent

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Abstract: *Land is one of the key elements in building modern infrastructure. Nowadays, most failures happen because of poor performance. To address this problem, a variety of additives such as Lime, sodium carbonate, sodium sulphate, etc. can be used but these are very expensive when you look at the economic perspective. Therefore, it is best to replace this with another type of soil supplement to make it more economical and eco-friendly. Most of the area, with rapid industrial development, consists of soft clay that costs expensive deep foundations. This paper reports on a local clayey soil-based stabilization study using Blood Clamshell powder (BCP) in various doses. Five different BCP values (0%, 2.5%, 5%, 7.5%, 10%) were added to obtain the best percentage. The analysis was performed with a standard proctor compaction test and a test on unconfined compressive strength. Experimental results have shown that BCP has a significant effect on the engineering properties of the soil and the results were analyzed to reach the maximum percentage of ingredients needed for clay to form a solid foundation.*

Keywords: *Locally Available Clay, Blood Clamshell Powder, Optimum percentage, compaction, unconfined compression strength test.*

I. Introduction

Soil stabilization refers to the process of improving various aspects of the soil by adding certain additives, special soil or cement properties to it. It is the biological, chemical or mechanical modification of earth engineering structures. In civil engineering, soil stabilization is a method used to refine and improve land engineering strength. These include mechanical strength, physical strength, durability, compressibility, permeability and plasticity. In any construction project, whether it's a building, a road, or an airport, the ground floor serves as a foundation. But today, most failures occur due to low load capacity. Unstable soils can cause many important structural problems related to overcrowding, slope instability, capacity to carry heavy loads, etc. To address this problem, various additives such as Lime, sodium carbonate, sodium sulphate, etc. can be used, but these are very expensive when you look at the economic perspective. Therefore, it is best to replace this with another type of soil supplement to make it more economical and eco-friendly. Most of the area, with rapid industrial development, consists of soft clay that costs expensive deep foundations. The use of local property to support infrastructure needs, had to be assessed to show that local property has the potential to be used as a building material and building.

Blood Clamshell Powder contain significant amount of lime / calcium oxide (CaO) content, indicating that it is the main ingredient in the reaction of cement when exposed to water. Since Clamshell powder is a waste product, stabilizing using this proves to be an eco-friendly method. In addition, Clamshell powder can be incorporated into a subsoil layer to improve not only strength but also soil stability. Using clamshell as stabilizing materials will reduce the ecological and environmental impact of soil conservation work.

This paper describes the results and results based on the local soil-based stabilization study using Blood Clamshell powder (BCP) in different dosages.

II. Area Of Study

The sample is collected from a site in Aruvikkara panchayat in the Trivandrum region. The site is having a vast area of deposits of clayey soil and lateritic soil in different stratas. The test was performed in the Geotechnical Laboratory of St. Thomas Institute for Science and Technology, located in Kattaikonam, near Kazhakkoottam, Trivandrum.

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III. MATERIALS USED

3.1 Soil

A sample of the clayey soil (Figure 1) is collected from a site in Aruvikkara Panchayat at a depth of about 4 meters from the ground. The collected sample was light in color and rich in moisture content. It is allowed to sundry for a period of 4-5 days to determine its various index, geotechnical and engineering properties as per standard specifications. According to ASTM standards, the collected soil sample is a type of CH, that is, a high plastic clay.

Figure 1: Soil used in the study: Locally available clay

The various properties of the soil sample are given in table1.

Soil Properties	Values
Natural water content	49.624%
Specific Gravity	2.61
Unconfined compressive strength	6.34 kg/cm^2
Shear strength	3.17 kg/cm^2
Cohesion, c	3.17kg/cm^2
Angle of internal friction	45 degrees
Liquid limit	147.5%
Flow index	42.59%
Plastic limit	105.68%
Activity	1.97%
Toughness index	2.48
Liquidity index	0.073
Relative consistency	0.926
pH	6.73
Free swell index	1.96%
% clay	53.5%
% silt	29.5%
% fine sand	17%
Uniformity coefficient	3.42
Coefficient of curvature	0.59
Maximum dry density	1.6g/cc
Optimum moisture content	25%

Table 1: Soil properties of collected sample

3.2 Blood Clamshell Powder

The finely grained blood clamshell powder were purchased from store in Trivandrum and the clamshell powder passing through 75µm sieve were used in this study (Figure 2).

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Figure 2: Blood Clamshell Powder

The chemical constituents contained in BCP can be seen in table 2 as follows.

Component	Content (%)
Silica/ Silicon dioxide (SiO_2)	4.9
Sulfur (SiO_3)	0.37
Calcium Oxide (CaO)	87.47
Titanium/ Titania (TiO_2)	0.1
Chromium (Cr_2O_3)	0.13
Manganese Oxide (MgO)	0.63
Iron (Fe_2O_3)	5.13
Copper (CuO)	0.036
Strontium (SrO)	0.57
Europium (Eu_2O_3)	0.2
Ytterbium(Yb_2O_3)	0.44

Table 2: Chemical composition of BCP (Source: Pebri Putra Hidayat, 2021)

IV. Experimental Methods

In this project, the sample is collected from a site in Aruvikkarapanchayat. The sample was dried in open sunlight for 4-5 days and all the basic laboratory tests were conducted to determine all its engineering properties. The various tests conducted were Natural water content determination, Specific gravity test, Sieve analysis, Hydrometer, Atterberg limit, Standard proctor, pH test, free swell index test, Unconfined Compressive Strength test (UCC). Clay samples were prepared with a combination of different BCP measurements such as 0%, 2.5%, 5%, 7.5% & 10% of dry soil weight. The Standard Proctor Compaction and UCC tests were performed on a modified model to determine the maximum percentage of stabilization agent required.

4.1 Unconfined Compression test (IS:2720 (PART 10)-1973)

Unconfined compressive strength (qu) is defined as the load acting per unit area of an unconfined specimen of cylindrical shape of soil to fail under compression. The unconfined compression test is the most popular method of determining the shear strength because it is one of the fastest and cheapest method. The method is used primarily for saturated, cohesive soils recovered from thin-walled sampling tubes.

Unconfined compressive strength, $q_u = P / A$

where P - axial load at failure, A - Corrected area = $A_o / (1- \varepsilon)$, A_o- initial area of the specimen, ε- Axial strain= change in length/original length.

4.2 Compaction test (IS-2720-PART-7-1980)

Compaction test of soil is carried out using Proctor's test to understand compaction characteristics of the soil with change in moisture content. Compaction of soil is the optimal moisture content at which a soil becomes most dense and achieve its maximum dry density by removal of air voids. A graph is drawn between water content and dry density to obtain maximum dry density and optimum water content and the resulting curve is called compaction curve. Dry density=

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$$= \frac{M\ /V}{1 + w}$$

where, M = total mass of the soil, V= volume of soil, w= water content.

V. Results and Discussion

5.1 Unconfined Compressive Strength Test

Initially, the length and width of the sample are measured and marked. After that, the specimen is kept over the base plate of the UCS machine. It should be noted very carefully that both ends of the specimen are fully in contact with the apparatus. The dial gauge and the proving ring readings were adjusted to zero. The motor is then turned on. The reading was appropriately marked. The specimen is allowed to press until the failure occurs in the form of a crack occurring in the specimen.

Figure 3: Unconfined Compressive Strength Test Apparatus

The load- deflection curve obtained from the unconfined compressive strength test is given in the figure 3.

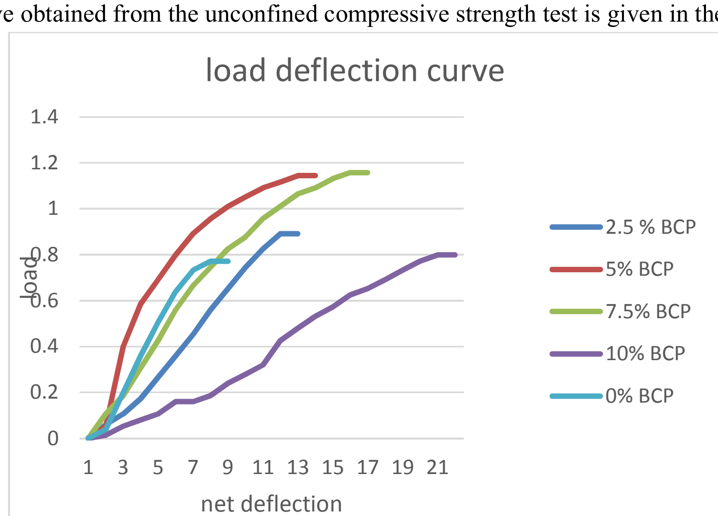

Figure 4: Load deflection curve

After the detailed analysis on the unconfined compressive strength of collected locally available clay has been done, the following results have been achieved. UCS test as per IS 2720 part 10 -1991 were performed using different proportions of clamshell powder and results are shown in table.3 and figure 5.

Blood Clamshell powder (%)	UCC Strength (kg/cm^2)
0	6.34
2.5	7.54
5	9.41
7.5	9.25
10	6.56

Table 3: UCS values

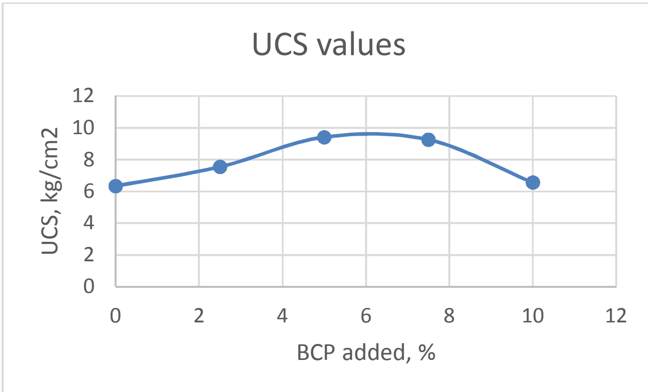

Figure 5: Graph representing variation of UCS with clamshell powder

From the above graph we can clearly state that unconfined compression strength values are increasing up to 5% BCP content and thereafter showing a declining trend. At this stage the clamshell powder absorbs more moisture and acquires a better bond between the powdered clamshells and the particles of the clayey soil.

5.2 Standard Proctor Compaction Test

In this test to determine the density of dry density (MDD) and Optimum moisture content (OMC) with different percentages of BCP, different results were obtained as given in the table 4.

Percentage of BCP in soil sample (%)	Maximum dry density (g/cc)	OMC (%)
0	1.60	25.00
2.5	1.62	24.80
5	1.82	23.70
7.5	1.80	23.36
10	1.77	26.03

Table 4: Summary of MDD and OMC values for different percentages of BCP

From the above data, it can be seen that in every increase the percentage of clamshell powder results in an increase in the amount of maximum dry density. The highest incidence of MDD was found in 5%. In the case of OMC, it can be found that the water content continues to decrease as the percentage of seashell grows. Also, it should be noted beyond a decreasing trend of values, the optimum moisture content increases. This means that the reaction takes place between water and the compounds present in the mixed sample.

While using a cement-dust-shell (DS) shell for the stabilization of soft soils, the addition of additives slightly increases the maximum dry density and reduces optimum moisture content[12,13]. An increase in dry density occurs because particles that are agglomerated and flocculated in the soil takes up large gaps and the reason for the reduction of OMC is that, cement requires more water to react pozzolanic. Similar effects can be seen when crushed marine shell is added to sandy soils for stabilization [14]. The composite soil mixture acts as a bond between the particles such as the soil matrix and the crushed shell as a dispersed phase with little surface contact (shape and size particles) creating more spaces thus reducing soil density [1].

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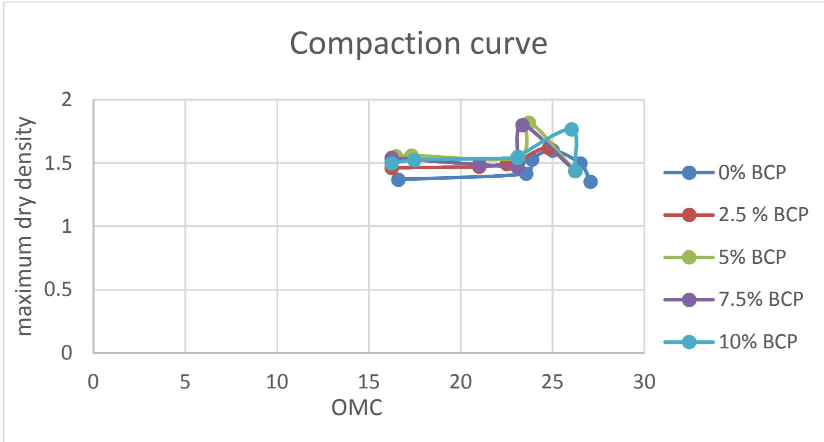

Figure 6: Compaction curve

The graph above shows the relationship between MDD and OMC in the different percentages of clamshell powder and is represented using different colour graph lines.

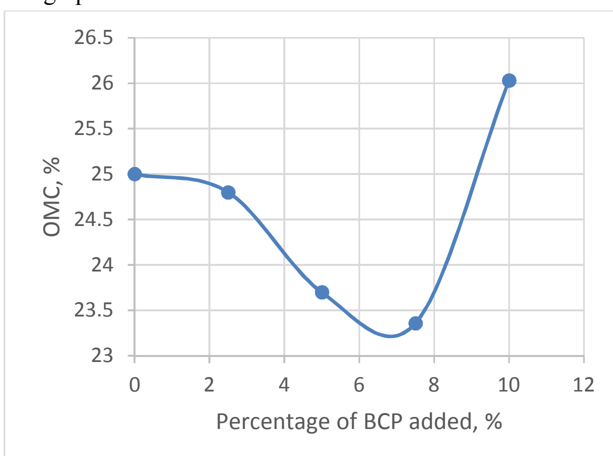

Figure 7: Relationship between OMC with mixed variations

Figure 7 signifies that with an increase in percentages of BCP the OMC is showing a decreasing trend upto 7.5% and beyond that OMC is showing an increase in value.

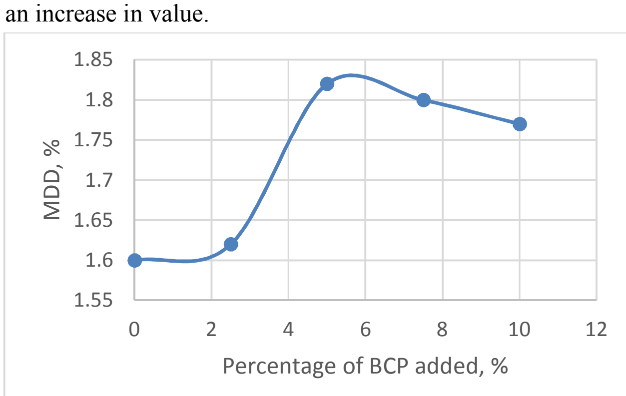

Figure 8: Relationship between MDD with mixed variations.

The figure 8 shows the relationship between MDD and the different percentages of BCP in locally available clayey soil sample. The graph above shows that MDD sample rises to 1.82 g/cc for a BCP content of 5% of dry soil weight and thereafter shows a decreasing trend.

VI. Conclusion

In the present study, various geotechnical properties of locally available clay under the influence of Blood Clamshell powder as a natural economic stabilizer for stabilization were investigated. Clayey soils were reinforced with BCP content from 0, 2.5, 5, 7.5, and 10%. The Index testing, compaction testing and Unconfined Compressive Strength testing were performed to determine stable clay soils with BCP. Based on the results, the following conclusions may be reached:

1. From the results of the compaction test, there is an increase in the maximum dry volume weight for each percentage increase of Clamshell powder. An increase of 0.22 g/cm^3 from a 0% to 5% mixed sample with a maximum value of 1.82 g/cm^3 for a 5% mixed sample. Although the optimum moisture content dropped to 23.36% for 7.5% from 25% for 0%.
2. From the results of the UCC test, there is an increase in the unconfined compressive strength of the clayey sample collected with increase in shell powder. The value increased from 6.34 kg/cm^{2}for 0% BCP to 9.41 kg/cm^{2}for 5% BCP and subsequently decreased to 6.56 kg/cm^2 for10% BCP.
3. The need for clamshell powder to stabilize the clay to meet the minimum stabilization requirements based on the above test and then the need for clamshell powder is 5% of the dry soil weight.

The development is due to the interaction of soil with clamshell powder content containing Calcium carbonate and Calcium oxide show similar to the chemical composition of cement additives.

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