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J-SUE

http://publisher.uthm.edu.my/ojs/index.php/j-sue

e-ISSN : 2821-2851

Journal of Sustainable Underground Exploration

The Effect of Groundnut Shell Ash on Soil Stabilization

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DOI: https://doi.org/10.30880/jsue.2022.02.01.005
Received 06 October 2022; Accepted 17 November 2022; Available online 30 November 2022

Abstract: The purpose of this study was to focus on how the groundnut shell ash affect the soil stabilization. Groundnut shell ash was used in this study to replace the excessive reliance on industrially created soil enhancing chemicals (cement, lime, and so on) has kept the cost of stabilizing a road high. It was determined that groundnut shell ash may be used and effective as a soil stabilizing component after studying the stabilization of black cotton soil using groundnut shell ash. Therefore, a laboratory study was led to assess the impacts of groundnut Shell Ash on the unconfined compression strength (UCS) and california Bearing Ratio (CBR) of laterite soil. Results show that the addition of groundnut shell can increased the UCS and CBR of the soil samples. It can be concluded that the groundnut shell ash can utilise as gorund improvement option.

Keywords: Groundnut Shell Ash, soil's stabilization, ground improvement, soil's improvement, soil's moisture, soil's strength, soil's durability

1. Introduction

The search for a new binder or pozzolanic material has become a national development issue. Laterite soil has a lot of potential as a long-lasting and dependable construction material, and it has long been one of the most common building materials. Laterite is one of the most common soil types in the tropics and subtropics, and it is particularly beneficial in the construction of buildings and roads. Laterite soils are heavily worn soils that include significant concentrations of iron and aluminium oxides and also quartz and other minerals, in varying proportions.

Laterite soil has been used successfully in a range of civil engineering construction projects. Laterite is utilized in the construction of, among other things, airports, runways, highways, earth fill dams, and low-cost structures. Laterite soil is the most common pavement material in the tropics and subtropics (1997). Some laterite soils, such as laterite clays, needed to have their engineering qualities improved before they could be utilized in any way. Because these soils have large swelling potentials, which pose construction issues, they are unsuitable for use as building materials in their natural condition.

Assessing the impact of stabilizers on soil strength involves looking at changes in consistency limits, compaction characteristics, undrained cohesion, and modulus of elasticity. The investigation of the durability properties of stabilized soil employed the augmentation of undrained shear strength over many days of curing by increasing the percentage of cement [1-6]. The stabilized soil's strength and uniformity increased to a suitable level[1]. The stabilized soil's strength and uniformity increased to a suitable level.

Some of the oxides found in pozzolanas and Portland cement are also present in groundnut shell ash and it would be appropriate to use up to 30% Groundnut Shell Ash instead of standard Portland cement in concrete [2]. With the addition of 10% GSA by weight of soil, the Liquid Limit and Plasticity Index values substantially decreased from 36.50 percent to 31.20 percent and from 19.30 percent to 16.48 percent, respectively. GSA was used to treat the lateritic soil, often lowering the Maximum Dry Density (MDD) and increasing the Optimum Moisture Content (OMC)[3].

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An agricultural byproduct is groundnut shell that results from the processing of groundnuts. Groundnut shell accounts for around a quarter of the full-scale mass produced from the few million tons of groundnuts that are consistently processed on the globe and is primarily utilized in steer and poultry feed. The commercial potential of groundnut shell is unimaginable. Among other things, it's used as a fuel, a filler in animal feed, a substitute for plugs in hard particleboard, and activated carbon. In the semi-arid region, especially during the dry season, the large peanut shell is utilized to feed farmed animals[4]. This study aimed to investigated the effectiveness of groundnuts shell as stabilizer agent.

2. Methodology

2.1 Preparation of Soil Samples

Using the standard proctor compaction test, each soil sample is compacted to determine the maximum dry density (MDD) and optimum moisture content (OMC). The groundnut shell ash is added in three percentages: 3%, 6%, and 9%. The following equation determines the amount of fiber in the soil:

$$\rho_f = \frac{w_f}{w} \qquad Eq.1$$

here, ρ_f = Ratio of fiber content
W_f = Weight of the fiber
W = Weight of the air-dried soil

If fibre was not utilised in the sample preparation, the air-dried soil was mixed with a quantity of water based on the soil's OMC. When using groundnut shell ash, the required quantity was manually mixed into the air-dried soil to create a homogeneous mixture before being combined with a water amount determined by the soil's OMC. If fibre reinforcement was employed, the fibre content was first manually mixed into the air-dried soil in tiny amounts, making sure that all of the fibres were thoroughly mixed, resulting in a relatively homogeneous mixture. Then, a water quantity depending on the soil's OMC was blended in.

2.2 Properties of Unreinforcement Soil Sample

This table below shows the properties of the unreinforcement soil sample.

Table 2.1 - Properties of unreinforement soil sample

No.	Description	Value
1	Specific Gravity	2.53
2	Free Swell Index	13%
3	Liquid Limit	38%
4	Plastic Limit	22%
5	Plasticity Index	16%
6	Maximum Dry Density	1.85 gm/cm^3
7	Optimum Moisture Content	16.2%
8	Cohesion	0.225 Kg/cm^2
9	Angle of Internal friction	22.1°
10	Unconfined compressive strength	0.12 Mpa

2.3 Effect on Groundnut Shell Ash on Shear Strength Properties of Soil

A very homogeneous combination of groundnut shell ash and air-dried soil was first mixed by hand; the mixture was then combined with a quantity of water determined by the OMC of the soil. After that, the soil sample is compressed to its maximum dry density. Both the unconfined compressive strength test and the direct shear test were carried out on those soil samples.

2.4 Effect of Polypropylene on Shear Strength Properties of Soil

To create a somewhat uniform mixture, polypropylene fibre reinforcement was first manually mixed into the air-dried soil in tiny amounts, making sure that all the fibres were thoroughly mixed. Then, a certain amount of water was added, depending on the OMC of the soil. After that, the soil sample is compressed to its maximum dry density. Both the unconfined compressive strength test and the direct shear test were carried out on those soil samples.

3. Results and Discussion

3.1 Chemical Composition of Groundnut Shell Ash (GSA):

Table 3.1 - Chemical composition of groundnut ash shell

Elemental Oxide	Weight Composition (%)
SiO_2	51.54
Al_2O_3	22.45
Fe_2O_3	2.40
CaO	15.63
MgO	1.20
TiO_2	0.13
MnO	0.05
P_2O_5	0.60
S	0.38
SO_3	0.94
LOI	3.98
$others$	0.70

The elemental oxides found in the GSA are listed in Table 3.1 along with their corresponding weight compositions in percentages[5]. The highest number is 51.54 percent for Silica-SiO_2, followed by 22.45 percent for $Al_2 0_3$. CaO, with a value of 15.63 percent, is the compound with the third highest value. According to [3], The presence of CaO in GSA suggests that it has some self-cementing properties (15.63 percent). It is established that the combined proportion of these three elemental oxides— Fe_2O_3, Al_2O_3, and SiO_2 —is higher than the necessary minimum of 70% for pozzolanas. A siliceous substance known as pozzolana combines with calcium hydroxide, or Ca(OH), in the presence of water to create cementitious compounds, despite not having cementitious capabilities on its own[3].

3.2 Preliminary Test on the Unstabilized Soil Sample

Table 3.2 displays the properties of the lateritic soil sample that was not treated. Its natural moisture content was 13.4% at this point, and its specific gravity was 2.40. This soil's specific gravity is comparable to clay minerals like halloysites[6], which have a specific gravity of 2.0 to 2.55. It had a liquid limit of 36.50 percent, a plastic limit of 19.30 percent, and a plasticity index of 17.20 percent. A-2-6 was also assigned to the soil. Maximum materials passing through No. 200 sieve for the A-2 group is 36 percent; maximum liquid limit for the A-2-6 group is 40 percent; and plasticity index is anticipated to be at least 11 percent[7]. The unstabilized lateritic soil underwent a compaction test, and the results showed that it had a maximum dry density (MDD) of 1960 kN/m^3, an optimum moisture content (OMC) of 12.70%, a California bearing ratio (CBR) of 24.42%, and unconfined compressive strengths (UCS) of 510. kN/m^3, respectively.

Table 3.2 - Properties of the natural lateritic soil

Property	Value
Natural moisture content	13.40%
Specific gravity	2.40
Liquid limit	36.50%
Plastic limit	19.30%
Plasticity index	17.20%
AASHTO classification	A-2-6
Soil type (USCS)	GP
Maximum dry density (MDD)	1960 kg/m^3
Optimum moisture content (OMC)	12.70%
California bearing ratio (CBR)	24.42%
Percentage passing BS Sieve No 200	29.4%
unconfined compressive strength (UCS)	510.25 kg/m^2

3.3 Compaction Tests on Lateritic Soil Containing the Additives

GSA has a 1.85 specific gravity. The ASTMC-218 range for pulverized fuel ash is 1.9–2.4, and this specific gravity result falls within the range. Figure 3.1 shows that a the MDD was decrease with increment of GSA content, while The OMC numbers increased with increment of GSA content. The substitution of GSA for soil in the combination, which has a lower specific density (1.85) than soil, can be attributed to the decrease in MDD values (2.40). It could also be brought on by the soil's GSA covering, which leads in larger particles with greater voids between them and lesser density. Additionally, by considering GSA as a filler (with a lower specific gravity) in soil voids, the decrease in MDD may be explained[8]. The rise in OMC is due to the addition of GSA, which decreases as the amount of free silt and clay fraction increases, resulting in coarser materials with greater surface areas (Figure 3.2). Water is required for these processes to occur. Since the Optimum Moisture Content increased from 12.70% at 0% to 14.95% at 10% GSA by weight of soil, it indicates that more water is required to compress the soil-GSA combinations.

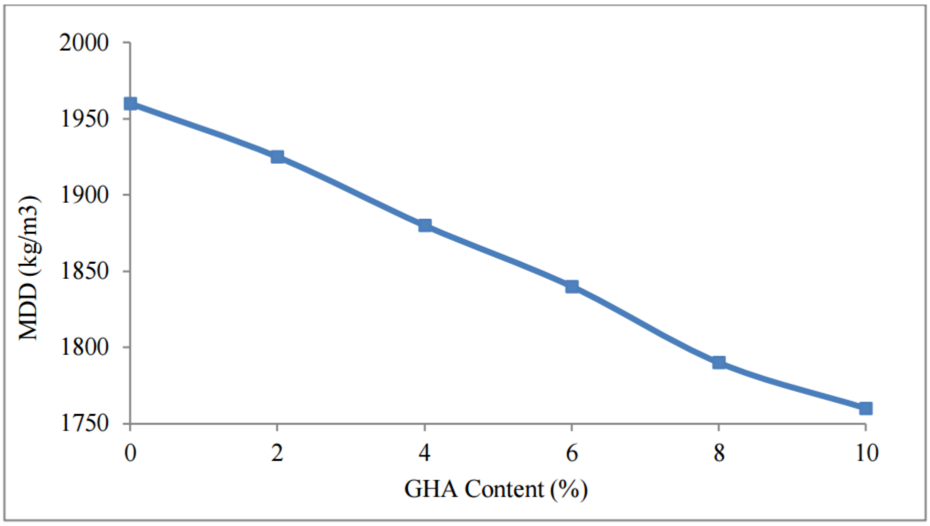

Fig. 3.1 - MDD values measured as a function of GSA values added

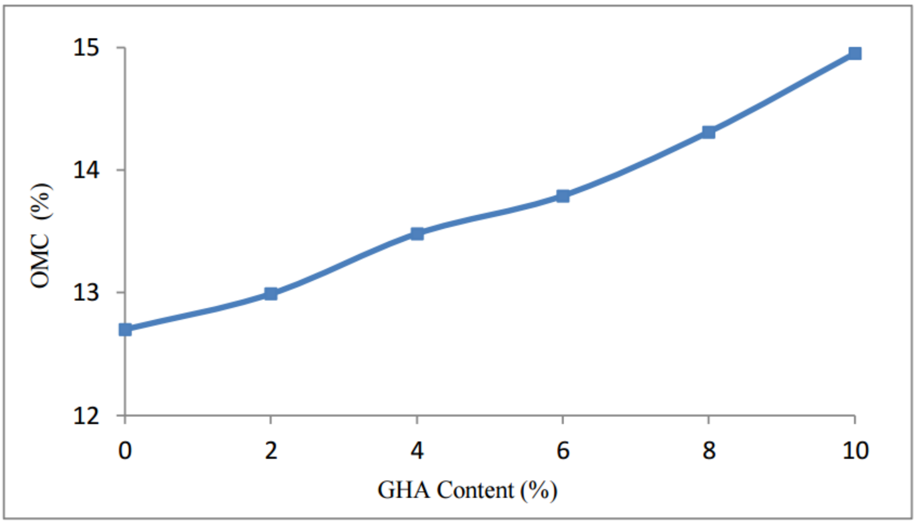

Fig. 3.2 - OMC values measured as a function of GSA values added

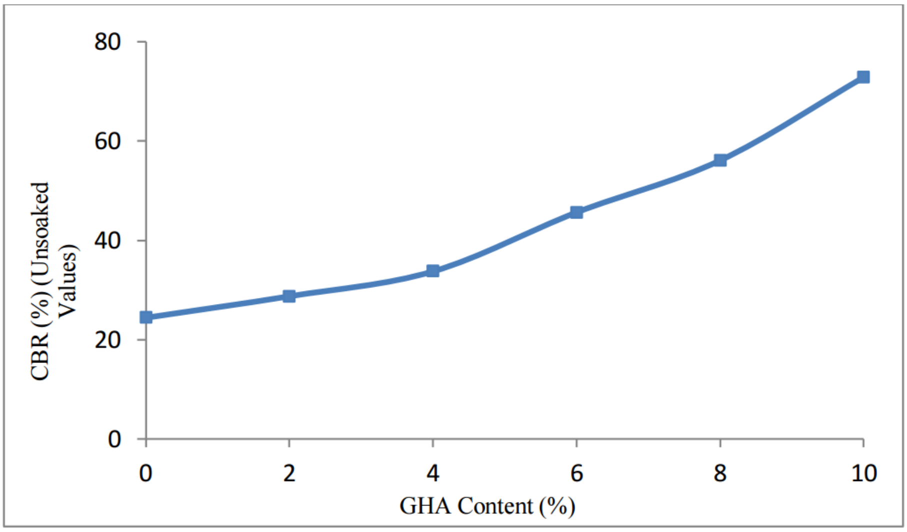

Fig. 3.3 - CBR values measured as a function of GSA values added

Thus, according to figure 3.3, the CBR value rises from 24.42 percent at 0% GSA to 72.88 percent at 10% GSA as soil weight increases. The progressive appearance of cementitious compounds in the soil due to the interaction between GSA and a particular calcium hydroxide in the soil may be the cause of this rise[9]. The findings demonstrated that GSA stabilization significantly boosted the samples' strength in terms of their samples.

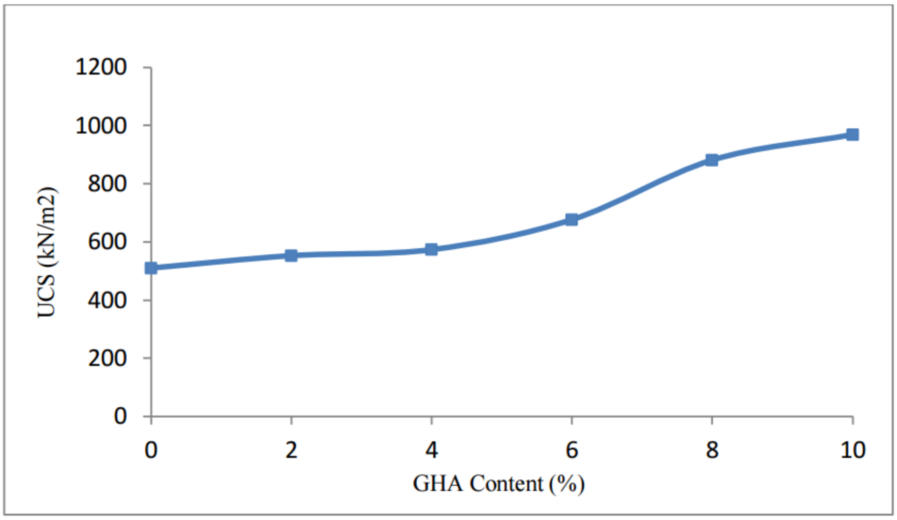

Fig. 3.4 - UCS values measured as a function of GSA values added

Figure 3.4 demonstrates that the UCS value for untreated soil is 510.25kN/m^2 increase to 1186.46kN/m^2 at 10% GSA content. The highest value was reached on the 28th day, i.e. once the pozzolans in the GSA and the calcium hydroxide in the soil produce cementitious compounds[8].

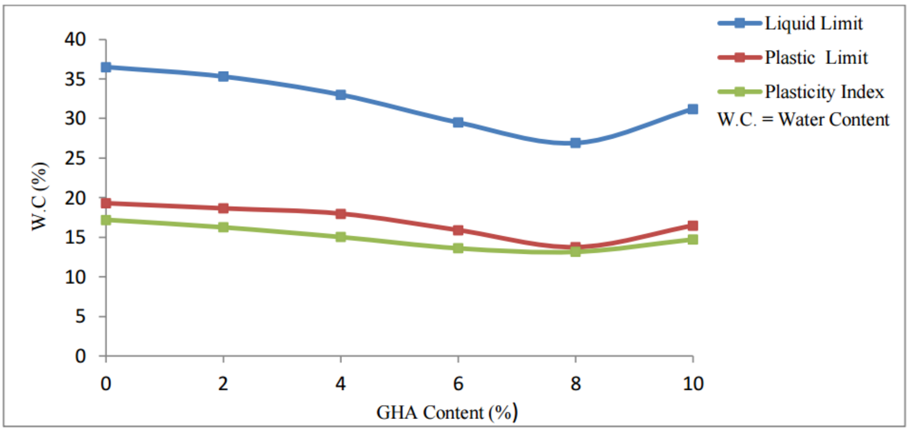

Fig. 3.5 - UCS values measured as a function of GSA values added

Figure 3.5 demonstrates how the plastic limit (PL) drops from 19.30 percent at 0% to 16.48 percent at 10% GSA, while the liquid limit (LL) drops from 36.50 percent at 0% to 31.20 percent at 10% GSA. The Plasticity Index (PI) score therefore falls from 17.20 percent at 0% to 16.48 percent at 10%. When the LL and PI values are decreased together with the GSA value, compressibility and swelling characteristics are decreased. The observed trend suggests that the performance of the lateritic soil is enhanced by the addition of GSA. The substitution of soil particles with GSA, which has a lower affinity for water, may account for the decrease in LL and PL values[9].

4. Conclusion

The study is findings support the following assertion: Lateritic soil is a member of the A-2-6 group. The LL and PI values dramatically dropped from 36.50% to 31.20% and from 19.30% to 16.48%, respectively, with the addition of 10 percent GSA by weight of soil. Additionally, the lateritic soil's maximum dry density (MDD) decreased overall because of the addition of GSA, but its optimum moisture content (OMC) was increased. The unsoaked CBR values increased to an ideal level of 72.88% at 10% GSA by weight of soil when GSA was added to the lateritic soil sample. The UCS values climbed to an ideal value of 1186kN/m^2 at 10% GSA by weight of soil when GSA was added to the lateritic soil sample. In light of this, we can say that groundnut shell ash performs well as a cheap agent for stabilizing lateritic soil, especially for subgrade and subbase applications in road building.

Acknowledgement

The authors would like to express their gratitude to the Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia for its support.

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