

# Comparative Analysis of the effect of using Groundnut Shell and Rice Husk Waste Ashes for Soil Stabilization

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Accepted: 20<sup>th</sup> December, 2023

Review: 27<sup>th</sup> December, 2023

Approved: 2<sup>nd</sup> January, 2024

## Abstract

Traditional methods of soil stabilization have limitations, prompting the search for sustainable alternatives, particularly in waste materials. Groundnut shell ash (GSA) and rice husk ash (RHA) were used to stabilise laterite soil due to their high silica content. Different mix ratios of GSA and RHA were subjected to standard compaction tests, California bearing ratio tests and unconfined compressive strength tests. Generally, the results showed improved soil mechanical properties by adding GSA and RHA. The California Bearing Ratio (CBR) of the laterite soil increases following the addition of RHA and GSA. A mixture composed of 90% soil and 10% GSA demonstrates the least incremental increase at 62.07%, ultimately resulting in a CBR of 5.17%, while a combination of 75% soil, 15% RHA, and 10% GSA exhibited the most substantial rise, boasting an impressive 196.24% increase and achieving a CBR of 9.45%. The unconfined compressive test gave an unconfined compressive strength (UCS) and cohesion of 48.95 Kpa and 24.475 Kpa respectively for untreated laterite soil. These values were increased to 76.96 Kpa and 38.48 Kpa for UCS and cohesion of a treated soil consisting of 90% soil and 10% GSA. The mixture comprising 75% soil, 15% RHA, and 10% GSA demonstrates the most significant rise, boasting an impressive 286.31% increase in UCS values and culminating in a UCS of 189.1 Kpa and cohesion of 94.55 Kpa.

**Keywords:** laterite, groundnut shell, rice husk, ash, soil test.

## I. INTRODUCTION

Soil Stabilization is an important technique in civil engineering that aims to improve the soil's engineering qualities such as its durability, decrease compressibility, and boost strength, increasing its load-bearing capacity when used for building and construction. In civil engineering and construction, soil stabilization is essential because it directly affects the strength and longevity of infrastructures such as foundations, embankments, and roadways. Some soils are naturally too weak, unstable, or inappropriate for construction, so soil stabilization becomes necessary. Traditional soil stabilising techniques frequently use chemical additions such as cement, lime, or other similar substances. However, these techniques can be expensive, harmful to the environment, and not always

long-term sustainable [6]; as such the need for affordable and ecologically friendly ways to stabilize soil arises. The use of waste materials is one such option that not only solves environmental issues by recycling garbage but also offers a cost-effective way to improve soil [1]. This strategy decreases the use of non-renewable resources and lessens trash disposal concerns, which are in line with sustainable development goals [18].

Rice husk ash (RHA) and groundnut shell ash (GSA) are two waste products that have demonstrated potential for stabilizing soil. Ash from groundnut shells is a waste product that is produced as a result of agriculture. Similar to that, rice husk ash is produced by burning rice husks that would otherwise be thrown away. Due to their high silica content, GSA and RHA

may be effective in enhancing the characteristics of soil [5].

The amorphous silica, which has pozzolanic qualities is abundant in GSA and RHA. This can combine with calcium hydroxide to generate cementitious compounds and will in turn lead to an increase in the strength and stability of soils as a result of this pozzolanic reaction [1]. However, based on variables including their origin, makeup, and the particular type of soil, these waste materials' efficacy may differ [6] and as such, the goal of this study is to provide a thorough comparative examination of how GSA and RHA affect soil stabilization. The effects of these waste materials on laterite soil were analysed by determining the soil's unconfined compressive strength, California Bearing Ratio, and maximum dry density. The results of this research will support the responsible use of waste materials in civil engineering and will also lead to sustainable development of construction techniques, supporting international efforts to lessen environmental effects.

## 2. METHODS

### 2.1 MATERIALS

The materials for the experimental work are Laterite, groundnut shell ash, rice husk ash and water

#### i. MIX PROPORTIONS

Laterite Soil, Groundnut Shell ash and rice husk ash were mixed thoroughly to have a uniform and homogenous mixture. The samples were prepared using different combinations of Laterite Soil, Groundnut Shell ash, and rice husk ash as shown in Table I different tests were conducted on each prepared sample and the results were compared with those of the original Laterite Soil.

Table I: Samples and their Mix Proportion

S/N	Soil (%)	RHA (%)	GSA (%)
1	100	0	0
2	90	10	0
3	90	0	10
4	85	10	10
5	75	10	15

7	75	15	10
6	70	15	15

Experiments were carried out on each mixed proportion (Table I). These experiments include:

1. Moisture Content Test
2. Particle Size Distribution (Sieve Analysis) Test
3. Specific Gravity/Density
4. Atterberg Limits Test (liquid limit and plastic limit tests)
4. Standard Proctor Compaction Test
5. California Bearing Ratio (CBR) Test
6. Unconfined Compression Strength (UCS) Test

## 3 RESULTS AND DISCUSSION

### 3.1 CHARACTERIZATION OF SOIL

Characterization of the soil is the first stage of this study endeavour that gives an overview of the basic characteristics of the soil. It is important to evaluate the initial state before administering any stabilizing drugs. This test gives important details regarding the soil's flexibility and clay content, two important components of soil behaviour. The findings (Table II and Fig I) defined the soil's baseline characteristics and acted as a benchmark for assessing how well waste items stabilize the soil.

Table II: Soil test results for natural laterite soil

Soil test	Average moisture content (%)	Average specific gravity	Maximum dry density (g/cc)	Optimum moisture content (%)
Result	23.24	2.58	1.8	22.8

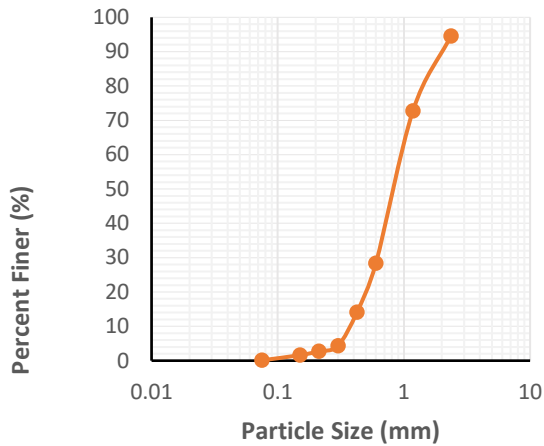


Fig. I: Particle size distribution curve for Laterite Soil

### 3.2 MECHANICAL PROPERTIES OF THE NATURAL AND STABILIZED SOIL

Compaction Test, California Bearing Ratio Test and Unconfined Compressive Strength Test were performed to obtain the mechanical properties of the natural and stabilized soil as shown in Table III.

Table III: Mechanical Properties of Natural and Treated Soil

S/N	Mix Proportion	OMC (%)	MDD (g/cc)	CBR (%)	UCS (KPa)	Cohesion (Kpa)
1	100% SOIL	22.85	1.8	3.19	48.95	24.475
2	90% soil + 10% RHA	19.8	1.981	5.21	85.92	42.96
3	90% Soil + 10% GSA	18.8	1.921	5.17	76.96	38.48
4	75% soil + 10% RHA + 15% GSA	18.85	1.948	6.65	164.9	82.45

5	75% soil + 15% RHA + 10% GSA	21.7	1.8805	9.45	189.1	94.55
6	80% soil + 10% RHA + 10% GSA	18.7	1.911	8.56	136.03	68.015
7	70% soil + 15% RHA + 15% GSA	20.35	1.948	7.59	155.53	77.765

Fig. I to VI shows the comparative mechanical properties of the natural and stabilized soil

### 3.3 OPTIMUM MOISTURE CONTENT

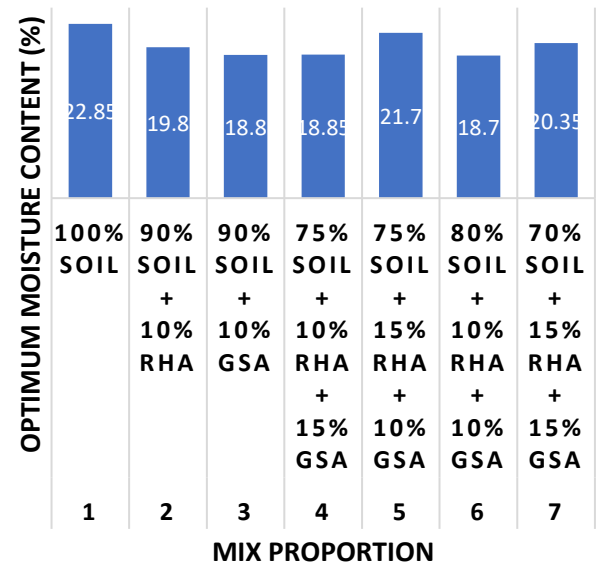


Fig. II: Comparative Optimum Moisture Content of Natural and Stabilized Soil

The initial OMC of the lateritic soil was determined to be 22.85%. Subsequently, incorporating different proportions of RHA and GSA led to a reduction in the OMC (Fig. 2),

signifying an improvement in soil properties. Specifically, the mixture comprising 75% soil, 15% RHA, and 10% GSA produced the least OMC value of 21.7% showing a 5.033% reduction in OMC.

### 3.4 MAXIMUM DRY DENSITY

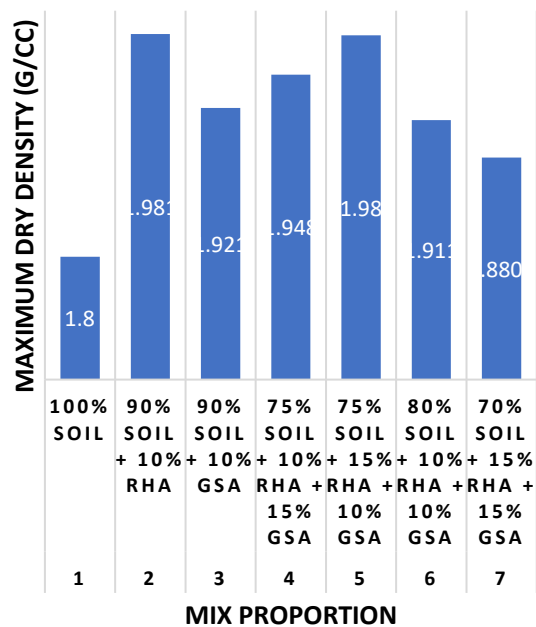


Fig II: Comparative Maximum Dry Density of Natural and Stabilized Soil

The soil was compacted with different proportions of RHA and GSA introduced. Before the introduction of RHA and GSA, the initial MDD of the lateritic soil was determined to be 1.80 g/cc. It was observed that the MDD consistently increased after RHA and GSA were introduced (Fig. 3), signifying an improvement in soil compaction and density. The most substantial increment was 1.981 g/cc, obtained at 90% soil + 10% RHA signifying a 10.06%, increase in values. Similarly, the mixture of 75% soil + 15% RHA + 10% GSA exhibited a significant 10% increment, achieving an MDD of 1.98 g/cc. On the other hand, the sample composed of 70% soil + 15% RHA + 15% GSA showed the smallest increment at 4.47%, yielding an MDD of 1.8805 g/cc. These results emphasize the capacity of waste materials like RHA and GSA to improve the compaction characteristics of soil.

### 3.5 CALIFORNIA BEARING RATIO

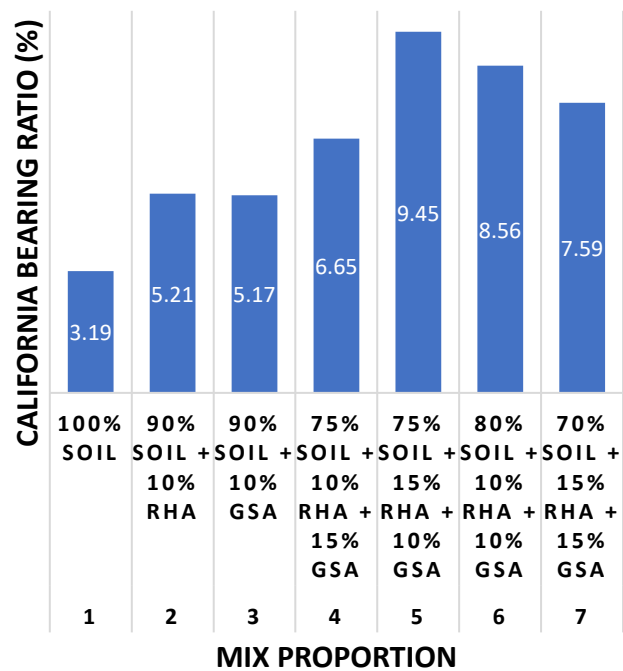


Fig. IV: Comparative California Bearing Ratio of Natural and Stabilized Soil

The initial CBR of the natural laterite soil was established at 3.19%. As different combinations of RHA and GSA were introduced into the soil, it was observed that the CBR consistently increased, signifying an enhancement in the soil's load-bearing capacity. Remarkably, the mixture composed of 90% soil and 10% GSA exhibited the lowest CBR increment, demonstrating an increase of 62.07% (Fig. 4). The CBR value reached 5.17%, emphasizing the effectiveness of this composition in improving the soil's load-bearing capacity. Conversely, the composition consisting of 75% soil, 15% RHA, and 10% GSA demonstrated the most substantial CBR increment, showing a remarkable increase of 196.24%. This led to a CBR value of 9.45%, highlighting the significant enhancement of load-bearing capacity achieved by this particular combination.

### 3.6 UNCONFINED COMPRESSIVE STRENGTH AND COHESION

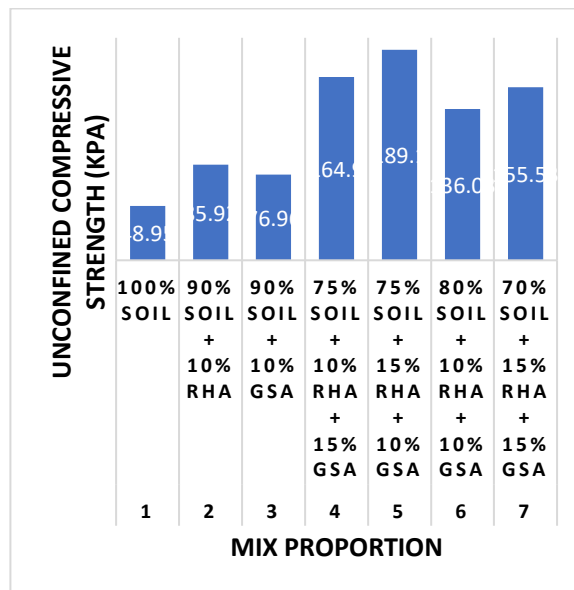


Fig. V: Comparative Unconfined Compressive Strength of Natural and Stabilized Soil

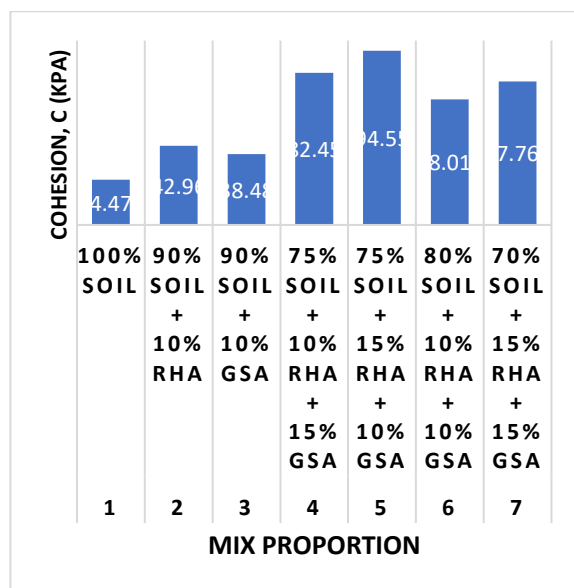


Fig. VI: Comparative Cohesion of Natural and Stabilized Soil

The UCS and cohesion of the untreated laterite soil were 48.95 Kpa, and 24.475 Kpa respectively. As various combinations of RHA and GSA were incorporated into the soil, it was observed that both the UCS and Cohesion consistently increased (Fig. 5 and Fig. 5),

reflecting an improvement in the soil's load-bearing and cohesive characteristics.

Notably, the mixture composed of 90% soil and 10% GSA produced UCS of 76.96 Kpa (Fig 5) and a Cohesion of 38.48 Kpa (Fig. 6), indicating a 57.22% increase. Conversely, the composition consisting of 75% soil, 15% RHA, and 10% GSA exhibited the most substantial increments, with a remarkable increase of 286.31%. This led to a UCS of 189.1 Kpa and a Cohesion of 94.55 Kpa, highlighting the significant enhancement of load-bearing and cohesive properties achieved by this specific combination.

### 4. CONCLUSION

Utilizing rice husk and groundnut shell waste materials in soil stabilization is an ecologically friendly and cost-effective way to stabilize soils. Stabilizing soil with GSA and RHA significantly improves the stability and compaction properties of the soil. The unconfined compressive strength tests showed that soil treated by both GSA and RHA is considerably enhanced. Soils treated with GSA and RHA are appropriate for road construction as shown by the California Bearing Ratio (CBR) test results.

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