Experimental Study on Banana Fibre-Reinforcement of a Soil Stabilization with Phosphogypsum

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Abstract — The soils with poor bearing capacity and shear strength need to be stabilized to make them suitable for construction. In this study, banana fiber (obtained from pseudostem) was used as a natural fiber to stabilize the soil. Stabilization with natural fibers is a cost-effective and environmentally friendly way to improve the soil. Chemical or synthetic fibers harm our environment; using natural fibers is a way to achieve balance. This study presents the effect of banana fiber on the soil and compares the engineering performance before and after stabilization. In this study, the effect of banana fiber on soil strength was evaluated by conducting direct and uncompressed compression tests on two different soil samples. The impact samples were collected from two different construction sites. In the laboratory. Proctor compression tests were conducted on various percentages of coconut fiber. Also, direct tests and compression tests were conducted on different parts of banana fibers at moisture content (OMC). The results of experiments with and without banana fiber reinforcement were compared to obtain the best amount of fiber reinforcement (% of soil sample) required to stabilize weak soil and estimate the effect of bearing capacity.

Keywords: Fiber, OMC, UCS, Bearing Capacity, Land Engineering, Equipment, Land Development, Waste Management

I. INTRODUCTION

Soil stabilization is an important process in civil and geotechnical engineering that aims to improve the electrical properties of soil to meet a specific project. Whether it is road construction, foundations or other infrastructure, the strength and stability of the underlying soil is important.

In its natural state, soil will exhibit poor properties such as lack of bearing capacity, lack of compaction, lack of resistance to erosion or lack of shear strength. Soil stabilization technologies solve these problems by changing the physical and chemical properties of the soil to increase strength, durability and overall performance. There are many ways to stabilize soil, from traditional methods such as adding cement, lime or asphalt to more modern methods such as using geosynthetics or additives. Each method is chosen according to the specific soil, the needs of the project and environmental considerations.

The benefits of soil stabilization are many. It not only provides the best solutions, but also extends the life of your property, reduces maintenance and reduces your environmental impact. Stable soil can also withstand good properties such as moisture changes, freezethaw cycles and transportation. Essentially, soil stabilization plays a key role in ensuring the longterm success and sustainability of construction by transforming natural soil into a solid and reliable foundation. This introduction only scratches the surface of these many fields, which continue to evolve with advances in information science, engineering technology, and environmental awareness.

II. LITERATURE REVIEW

This study investigated the feasibility of using a combination of sodium silicate and banana fibre for soil stabilization. Banana fibre is a type of fibre obtained from waste produced by banana plants. Water glass is a liquefied material obtained by heating sand with excess alkali. It can be obtained by mixing sodium carbonate and silica, releasing carbon dioxide. The former reaction produces a white sodium silicate powder, which is then mixed with water to form an alkaline solution.

Phosphogypsum (PG) is a commercial product that can be used to reduce the effects of clay as it is a compound and has been shown to be useful as a stabilizer.

Phosphate fertilizer industrial production product PG. Depending on the temperature used to make phosphoric acid, calcium sulfate can be dihydrate ($CaSO4\ 2H2O$) or hemihydrate ($CaSO4.0.5H2O$).

The chemical composition of PG is similar to gypsum, but PG has some impurities. . Approximately 280 million tons of this waste are produced each year.

III. METHODOLOGY

A. *Soil Sample Collection*

Soil sample collection is a crucial step in various fields. To collect representative samples:

1) Use a suitable auger or core sampler.
2) Employ clean containers, gloves, and safety gear.
3) Label containers with location and depth details.
4) Record information in a field notebook.
5) Consider site selection, depth, and sampling technique.
6) Transport and store samples securely.

This process ensures accurate soil analysis, benefiting agriculture, environmental studies, and construction projects.

B. *Banana fibre collection*

The percentages of fiber reinforcement taken in this study are 0, 0.1, 0.3, and 0.5 of soil sample. Firstly, the sample without fibers is air-dried and mixed with an amount of water depending on the OMC of the soil. Secondly, the sample which has to be reinforced is air dried and then mixed with the adopted content of fibers in small increments by hand, and then the required water was added.

C. *Tests*

Soil testing is a fundamental aspect of understanding soil properties and ensuring successful outcomes in construction, agriculture, and environmental projects. Various tests provide valuable insights into characteristics such as composition, strength, and permeability. Here are some common soil tests:

1) *Particle Size Analysis:*
- Determines the distribution of soil particles (sand, silt, clay) to classify soil type.
- Methods include sieve analysis and hydrometer analysis.

2) *Moisture Content Test:*
- Measures the amount of water present in soil.
- Crucial for assessing soil compaction and determining optimal moisture for construction.

3) *Compaction Test:*
- Evaluates the soil's ability to withstand external loads.
- Helps in designing foundations and assessing soil stability.

4) *Shear Strength Test:*
- Assesses soil resistance to deformation and sliding along internal planes.
- Important for slope stability analysis and foundation design.

5) *Permeability Test:*
- Measures the rate at which water passes through soil.
- Crucial for drainage assessments and understanding groundwater flow.

6) *California Bearing Ratio (CBR) Test:*
- Evaluates the strength of a soil sample under controlled conditions.
- Commonly used in pavement design and construction.

7) *pH Test:*
- Determines the acidity or alkalinity of the soil.
- Important for agriculture and environmental studies.

8) *Organic Matter Content Test:*
- Measures the percentage of organic material in the soil.
- Essential for assessing soil fertility and health.

9) *Atterberg Limits Tests:*
- Consists of the liquid limit, plastic limit, and shrinkage limit tests.
- Defines the range of moisture content at different states of soil consistency.

10) *Consolidation Test:*
- Measures the settlement of soil under a vertical load over time.
- Crucial for predicting settlement in foundation design.

Several tests are conducted to assess and optimize soil stabilization techniques. These tests help determine the effectiveness of stabilizers and ensure the desired engineering properties of the stabilized soil. Here are some common tests for soil stabilization:

1) *Proctor Compaction Test:*
- Determines the maximum dry density and optimum moisture content of the soil-stabilizer mixture.
- Helps in assessing the compact ability and workability of the stabilized soil.

2) *California Bearing Ratio (CBR) Test:*
- Measures the load-bearing capacity of the stabilized soil.
- Indicates the strength improvement achieved through stabilization.

3) *Unconfined Compressive Strength (UCS) Test:*
- Evaluates the compressive strength of the stabilized soil.
- Provides insights into the soil's load-bearing capacity under confined conditions.

4) *Triaxial Compression Test:*
- Assesses the shear strength and stress-strain behavior of stabilized soils.
- Useful for understanding the soil's response under different loading conditions

5) *Atterberg Limits Test:*
- Determines the plasticity of the soil-stabilizer mixture.
- Useful for assessing the soil's ability to undergo volume changes.

6) *Chemical Analysis:*
- Determines the chemical composition of the soil and the stabilizer.
- Helps in understanding the interaction between the stabilizer and soil particles.

7) *Moisture Content Test:*
- Measures the moisture content of the stabilized soil.
- Essential for ensuring proper curing and hydration of stabilizers.

These tests collectively provide a comprehensive understanding of the stabilized soil's mechanical, hydraulic, and durability properties. Engineers and geotechnical professionals use the results to optimize the type and dosage of stabilizers and to ensure that the stabilized soil meets the project requirements.

IV. RESULTS

A. *Optimum Moisture Content% (OMC)*

The OMC increased with increasing banana fibre content with a value of 11.0%at0%banana fibre content and 12.2 % at 0.5 % banana fibre content, respectively.

Soil Sample	Mass of Soil	Fiber Content (%) of soil mass	Optimum Moisture Content (%)
Sample 1	Without Fiber	00	11.0
	With Fiber	0.1	11.20
		0.3	11.23
		0.5	12.3
Sample 2	Without Fiber	00	10.9
	With Fiber	0.1	11.0
		0.3	11.3
		0.5	11.7

Table I: Optimum Moisture Content

B. *Proctor Compaction Test*

The experiment was conducted to obtain the relationship between the dry density of the soil and the moisture content of the soil. The test equipment includes a cylindrical metal mold, a removable base plate, a collar and a hammer (2.5Kg). The compaction process helps to make the volume more compact by removing air from the voids. The concept used in the experiment is that the dry density for each compaction function depends on the moisture content of the soil. The maximum dry density (MDD) is reached when the soil is compacted at high moisture content and almost all the air is removed. This moisture content is called the optimum moisture content (OMC). Based on the data obtained from the experiment, a curve was drawn in which the abscissa of the water content and the dry density are arranged. From this curve, OMC and MDD can be obtained.

Soil Sample	Mass of Soil	Fiber Content (%) of soil mass	Optimum Moisture Content (%)
Sample 1	Without Fiber	00	10.0
	With Fiber	0.1	11.0
		0.3	11.0
		0.5	11.6
Sample 2	Without Fiber	00	10.3
	With Fiber	0.1	9.3
		0.3	13.0
		0.5	13.5

Table II: Optimum Moisture Content

C. Unconfined Compression Test

This test is usually performed on clay to obtain its accurate results. Undisturbed cylindrical specimens of 38 mm diameter and 76 mm length were used in the tests. In this study, the UCS of both models 1 and 2 were negligible and could not be determined despite repeated efforts. The results paint a picture of anxiety versus depression.

Soil Sample	Mass of Soil	Fiber Content (%) of soil mass	Optimum Moisture Content (%)
Sample 1	Without Fiber	00	0.36
	With Fiber	0.1	0.62
		0.3	1.12
		0.5	1.70
Sample 2	Without Fiber	00	0.37
	With Fiber	0.1	0.67
		0.3	1.18
		0.5	1.79

Table III: Optimum Moisture Content

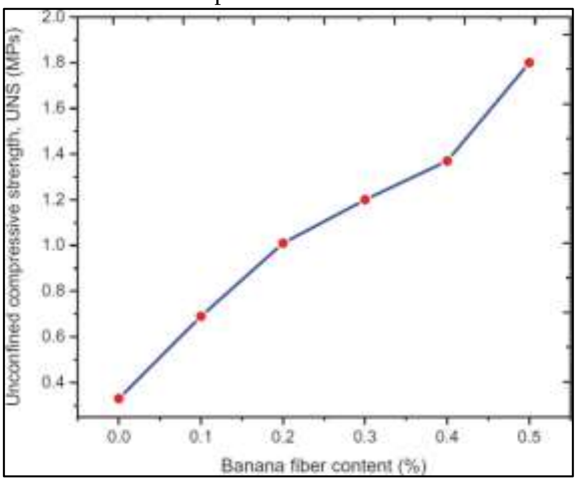

Fig. 1. Unconfined compressive strength vs Banana Fiber content

V. CONCLUSIONS

This study provides experimental understanding of the effect of banana fiber added water glass stabilized soil on the geotechnical properties of stabilized soil. The results showed that with the increase of banana fiber, both OMC and UCS increased, the increase in UCS of soil reinforcement means that the strength properties of soil reinforcement increased. After the application of 0.5% banana investigated in this study to increase its strength and performance, UCS increased by 445%, and it is recommended to be used as a coating layer.

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REFERENCES

[1] C. H. Baretto, M. M. Costa, A. S. B. Sombra, D. S. Rosa, R. F. Nascimento, S. E. Mazzetto, and P. B. A. Fechine, (2010), "Chemically Modified Banana Fiber: Structure, Diectrical Properties and Biodegradability", Journal of Polymers and the Environment, Vol. 18(4), pp. 523-531.

[2] A.A. Al-Rawas, R. Taha, J.D. Nelson, T.B. Al-Shab, H. Al-Siyabi, "A comparative evaluation of various additives used in the stabilization of expansive soils".Geotech. Test. J. 25 (2002) 199–209. doi:10.1520/GTJ11363J.

[3] https://textilelearner.net/banana-fiber-properties-manufacturing/.

[4] Sayyed Mahdi Hejazi a, Mohammad Sheikhzadeh, Sayyed Mahdi Abtahi, Ali Zadhoush "A Simple Review of Soil Reinforcement By Using Natural And Synthetic Fibers" Construction and Building Materials 30 (2012) 100–116.

[5] Gobinath R, Ganapathy GP, Akinwumi II,Kovendiran S, Hema S, Thangaraj M (2016) Plasticity, strength, permeability and compressibility characteristics of black cotton soil stabilized with precipitated silica

[6] Shivanand Mali, Baleshwar Singh "Strength Behaviour of Sand Reinforced with Glass Fibres" SAITM – RSEA 2013:28-31 6] Himadri Baruah (2015): "Effect of Glass Fibres on Red Soil" International journal of advanced technology in enginerring and science, Volume 3, issue 1, 217- 213.

[7] Ashwin KRN, Arun M, Sasikumar S, Krishnaraj T, Mithuna R, Gobinath R, Akinwumi II (2017) Freeze-thaw resistance of an alluvial soil stabilized with ecosand and asbestos-free fiber powder. Int J Geomatics Geosci 7:352–357

