Compressibility, Permeability, And Shear Strength Characteristics of Robosand and Hemp Fiber Treated Soft-Clay

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Abstract— ***Expensive soils to increase or decrease in volume (compressibility) due to that, shear strength varies under passing moisture content is allowed to change but also measure the ability of a soil media to support the formation of a magnetic field within itself (Permeability). This paper is an experimental study that evaluated the effects of robosand on compressibility, permeability, and shear strength characteristics expansive soil. The initial phase of the experimental program includes the study of the effect of robosand on MDD (Maximum Dry Density) and optimum moisture content (OMC) with different percentages of robosand with Specific gravities. The second phase of the experimental program focuses on the compressibility, permeability, and shear strength characteristics of the soil. In addition to UCS, tests performed to study the effects of robosand on unconfined compressive strength of tested soil. Test results indicated that the addition of robosand increased the permeability and shear strength of the soft soil with increasing robosand with respective percentages. This project ventures to find the feasibility of using robosand as a stabilizer. Different percentages of robosand added to the soil samples collected. The compaction and unconfined compression (UCS) tests are to be conducted, followed by consolidation and permeability tests to determine the soil characteristics of controlling permeability and increasing shear strength.***

Index Terms- Robosand, Improvement of permeability, settlements, UC strength, stabilization, quarry dust, and blasting technique.

I. INTRODUCTION

The properties of soil improvement required in so many constructions and other stabilizing fields, which also mainly improved the expansive with locally available materials, which have less shear strength and more compressibility characteristics [1, 2]. Lime/Cement: three phases can explain lime stabilization; with the first phase being hydration of quicklime, the second phase is flocculation, which results in an immediate reduction of plasticity and the final phase of lime stabilization is the long-term cementation phase [3-4].

Mechanical reinforcement materials are mostly made of polymers and plastics but can also make from wood fibers, glass fibers, etc. [5]. Due to their had highly frictional nature, mechanical reinforcement used as a stand-alone stabilizer, which is limited to coarse-grained materials. Clay soils can be treated with mechanical reinforcement in combination with lime or cement stabilization [6]. The stabilizing agents such as lime/cement, silica flume improved the characteristics of the soil, but these are not available in local, more environmental problems and not economical also [7]. Robosand is a waste cloth acquired from crusher plants. It can be used as a partial replacement of natural river sand in the soil and concrete [8, 9]. The use of Robosand in soil no longer handiest improves the fine of soil; however, it additionally preserves the green river sand for destiny generations. In the existing research, an experimental program turned into achieved to study the workability and compressive strength of soil made using Robosand as partial replacement of satisfactory mixture in the variety of 10%-100% [10-12]. Typical historical uses for sandstone covered: So excellent sandstone, like Credit Valley, has many blessings over both granite and limestone. Sandstone, or any herbal stone, is also a much better preference than any of the "cultured stone" products that might be present to be had. These cement-based building materials aren't similar in appearance or sturdiness and can't expect to close almost as large a real herbal stone [13, 14]. The main objectives of this paper are to improve the index and engineering properties of the weak soil with the different percentages of the robosand and hemp fiber (HF). The robosand is available local material, less environmental problems, and most economical also.

II. MATERIALS USED

2.1 Collected soil

The soil collected at 2m height below the ground surface from the river (Kanigiri) region in Andhra Pradesh. The collected sample kept air-dried, pulverized and sieved for further testing experiments. Table 1 indicated the index and engineering properties of collected soil and with sedimentation analysis also.

Figures 1 a, b, c and d indicated experimental results of soil such as flow curve from consistency limits, soil classified as CH, compaction characteristics, and UC Strength results, respectively.

Table 1 Index and engineering properties of collected soil

Sl. No.	Property	Values
1	Specific Gravity	2.34
2	Consistency limits Plasticity Index (%)	37-21= 16
3	Shrinkage limit (%)	13
4	IS Soil classification	CI
5	Compaction (a) MDD (kN/m^3) (b) OMC (%)	18.5 12
6	UCS (kN/m^2)	39
7	Permeability(cm/s)	1.78× 10^{-5}
8	Settlement (mm) Cv (cm^2/Sec)	4.12 0.0021
9	Soil gradation	
	Clay (%)	52
	Silt (%)	43
	Organic (%)	5

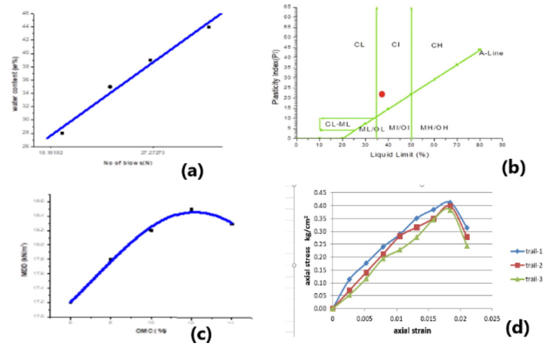

Fig. 1 a) Flow curve for the clay soil, b) A-line chart for the clay soil, c) Compaction response for the soil d) UC strength for the soil

2.2 Robosand and hemp fiber

The stabilizing agents are robosand and hemp fiber; robosand locally available material, waste-dust from quarries of mining. The stabilizing agent Robosand collected from the mining area (Granite, blasting techniques), which is waste, and unwanted residue after blasting in the mining area. The size of the dust contains like soil; for the filling of pores of the soil, the collected dust must sieve through 75microns for best bonding, reached essential characteristics. The mining areas contain more depths and more dust particles and rocks with specified sizes, the process of rock with required sized with blasting techniques. In the process, the residue produced in the form of so many particle sizes called quarry dust. The quarry dust sieved with the required size (75 microns) that materials called robosand. Further improvement process used the robosand. The robosand collected at the Mining area at Kanigiri in Andhra Pradesh. Hemp fiber bought from ERB Textiles at Delhi, its cottonized hemp fiber. Its color is white with size of length 38mm and origin from Himalayan ranges. Figure 2 indicated a) robosand and b) hemp fiber.

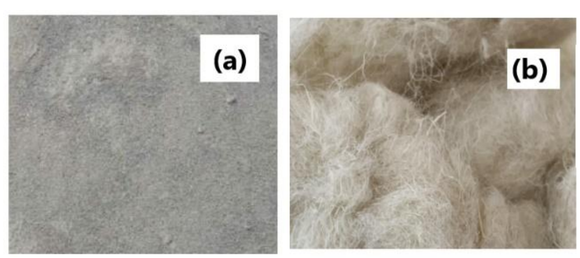

Fig. 2 indicated a) robosand and b) hemp fiber

2.3 Optimal Dosage of Robosand and hemp fiber

The percentages of the stabilizing agents; robosand added in the range from 5% to 25% of the dry mass of the sample, and hemp fiber in the range from 0.5% to 2.5% of the dry mass of the sample. Among all percentages, find the optimal percentage of the robosand and hemp fiber based on the characteristics of compaction. After obtained optimal percentages of the robosand and hemp fiber, find the response of compressibility, permeability, and shear strength characteristics.

2.4 Soil preparation

For experimental studies, the robosand added in the percentages of 5%, 10%, 15%, 20%, and 25% into clay soil, and the hemp fiber added in the percentages of 0.25%, 0.5%, 0.75%, 1%, and 1.25% into clay soil. In the preparation, dry mix performed because of the soil and robosand both solid powdered form, hemp fiber also dried.

III. EXPERIMENTAL INVESTIGATION

The study aims to evaluate the impact of the Robosand and hemp fiber stabilizers agent on Geotechnical properties of soft clay by possessing low compressibility to minimize settlements or differential settlements. It also planned to find the optimum percentage of additives, where the UC strength is maximum. The strength values of treated soils are measured and compared with the strength of untreated clay soil.

3.1 Find the optimal dosage of robosand

The robosand added in the percentages of the robosand added in the percentages of 5%, 10%, 15%, 20%, and 25% into clay soil, and the hemp fiber added in the percentages of 0.25%, 0.5%, 0.75%, 1%, and 1.25% into clay soil. Among all percentages, find the optimal percentage of the robosand based on the characteristics of compaction and specific gravity. Which percentage obtained maximum dry density with optimum moisture content and the maximum specific gravity of the soil.

3.1.1 Compaction Test

To find the optimum content of robosand with maximum dry density values of each robosand and hemp fiber treated clay soil mixture, various Compaction tests performed on samples prepared at different percentages the robosand added in the percentages of 5%, 10%, 15%, 20%, and 25% into clay soil, and the hemp fiber added in the percentages of 0.25%, 0.5%, 0.75%, 1%, and 1.25% into clay soil its dry weight of soil, until getting maximum dry density (kN/m^3). Figure 3 illustrated effect of Robosand and hemp fiber percentages on Compaction characteristics

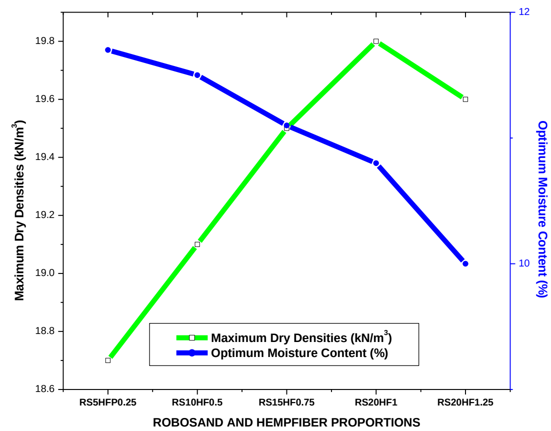

Fig. 3 Effect of Robosand and hemp fiber percentages on Compaction characteristics

Table 2 Compaction characteristics of Robosand treated clay soils at different percentages

Robosand Proportions (%)	Hemp fiber Proportions (%)	Mix name	Maximum Dry Densities kN/m^3	Optimum Moisture Content (%)
5	0.25	RS5HF 0.25	18.7	11.7
10	0.5	RS10HF0.5	19.1	11.5
15	0.75	RS15HF0.75	19.5	11.1
20	1	RS20HF1	19.8	10.8
25	1.25	RS20HF1.25	19.6	10

The effects of the robosand added in the percentages of 5%, 10%, 15%, 20%, and 25% into clay soil, and the hemp fiber added in the percentages of 0.25%, 0.5%, 0.75%, 1%, and 1.25% into clay soil its dry weight of soil listed in the table 2. Among all percentages, the highest maximum dry density obtained with 20% of robosand and 1% of hemp fiber proportions effect on MDD is increasing from 18.5 to 19.8kN/m^3. It indicates the optimum dosage of 20% of robosand and 1% of hemp fiber which one leads to maximum dry density, and respecting optimum moisture content is 10.8%, and mix names as RS20HF1. Further testing follow on mixing with MDD is 19.8kN/m^3, OMC is 10.8%, and the optimal percentage 20% of robosand and 1% of hemp fiber of its dry weight of soil.

IV. THE RESPONSE OF PERMEABILITY OF THE SOIL WITH OPTIMAL PERCENTAGE OF ROBOSAND

4.1 Permeability

Soil sample prepared for the response of permeability of the soil with the optimal percentage of 20% of robosand and 1% of hemp fiber. The prepared soil sample at MDD is 19.8kN/m^3, OMC is 10.8% of the water. The prepared used for testing permeability characteristics.

Table 3 The response of permeability of the soil with optimal percentage of robosand and hemp fiber

Mix name	coefficient of Permeability (cm/sec)		
	untreated clay	Treated clay Trail-1	Treated clay Trail-2
RS20HF1	1.78×10^{-5}	Nil	Nil

From the test concluded that the soil completely impermeable after added optimal percentage of the additives, Table 3 indicated the response of permeability of the soil with the optimal percentage of robosand and hemp fiber.

4.2 The response of Unconfined Compression Strength of the soil with optimal percentage of robosand

Soil sample prepared for the response of Unconfined Compression Strength of the soil with the optimal percentage of robosand 20% of robosand and 1% of hemp fiber. The prepared soil sample at MDD is 19.8kN/m^3, OMC is 10.8% of the water. The prepared used for testing of shear strength characteristics.

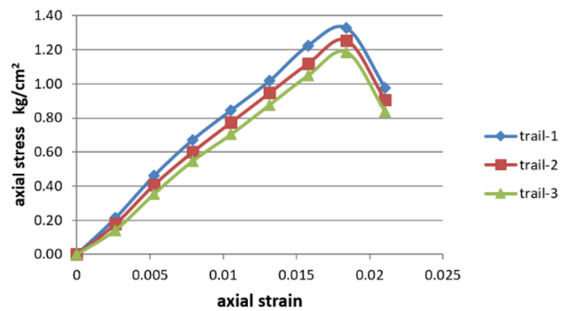

Fig. 4 Effect of robosand with hemp fiber percentages on UC Strength

The unconfined compressive strength of soil increased from 39kPa (untreated soil) to 124kPa at the optimal percentage of the robosand with hemp fiber and improved 3.2% higher than the strength of clay soil. Figure 4 illustrated the response of the Unconfined Compression Strength of the soil with the optimal percentage of robosand with hemp fiber.

4.3 The response of Consolidation of the soil with the optimal percentage of robosand

Soil sample prepared for the response of Consolidation of the soil with the optimal percentage of robosand 20% of robosand and 1% of hemp fiber. The prepared soil sample at MDD is 19.8kN/m^3, OMC is 10.8% of the water. The prepared used for testing of Consolidation characteristics.

Table 4 Consolidation test results treated with robosand

Description	Settlement (mm)	Co-efficient of consolidation (cm^2/Sec)
Un-treated soil	4.12	0.0021
Treated soil with robosand with hemp fiber	1.49	0.091

The settlements reduced from 4.12mm (untreated soil) to 1.49mm. The settlement of soil mixed with the optimal percentage of Robosand with hemp fiber improved by about 2.77% higher than the strength of clay soil.

CONCLUSION

The total experimental results concluded that

- The collected soil, specific gravity, is 2.34. The soil classified as intermediate compressible clay (CI) as the plasticity index is 16%, MDD: 18.5kN/m^3, OMC: 12%, and UCS: 39kPa. The coefficient of permeability is about 1.78× 10^{-5} cm/sec.
- Robosand is introduced into the soil from 5 to 25% with hemp fiber is introduced into the soil from 0.25 to 1.25%.
- The MDD of soil improved from 18.5kN/m^3 (normal soil) to 19.8kN/m^3 (for optimum robosand 20% of robosand and 1% of hemp fiber its dry weight of soil. So, it is clear that additives make the soil stiff.
- The soil completely impermeable after added optimal percentage of the robosand with hemp fiber.
- The unconfined compressive strength of soil increased from 39kPa (untreated soil) to 124kPa at the optimal percentage of the robosand with hemp fiber and improved 3.2% higher than the strength of clay soil.
- The settlements reduced from 4.12mm (untreated soil) to 1.49mm. The settlement of soil mixed with the optimal percentage of Robosand improved with hemp fiber by about 2.77% higher than the strength of clay soil.

In conclusion, the soil- 20% Robosand and 1% hemp fiber is the best soil combination, which is exhibiting the high maximum dry density, higher UC strength, and less permeable value. It is useful for all constructions such as foundations, embankments, and other required stabilization fields.

ACKNOWLEDGMENT

The authors are thankful to the ABR College of Engineering and Technology for their financial support for this work and lab facility during our research work.

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