The Effect of Using Kaolin Powder and Jute Fiber as Admixture for Loose Sand

Mohamed Hendawy, Tarek Elbasha, and Ahmed Hamouda
Military Technical college, Egypt, m.hendawy@gmail.com, Tlshref@gmail.com, a.hamouda@gmail.com

Supervisor: Prof. Dr. Nabil Nagy
Military Technical College, Egypt, Nnagy@mtc.edu.eg

Abstract*– In this paper we focus on the improvement of engineering properties of loose sand by using jute fiber and kaolin fine powder as admixture. The loose sand is treated with Jute fiber and kaolin powder to enhance its engineering properties. In this study the effect of using the jute fiber as soil reinforcement and the kaolin powder as soil stabilizer is investigated experimentally. Present work has been performed by adding 20 mm jute pieces as admixture. Variable percentages of 0.1%, .2%, .3% by weight of jute pieces were mixed with loose sand at different moisture contents. Also variable percentages of 1%, 2%, 3% of kaolin powder are added to the loose sand with different moisture contents. The maximum dry densities and optimum water contents are determined for all sampels by using Standard Proctor Test. On the basis of the experiments performed, it is determined that the stabilization of loose sand using 20mm pieces of jute and kaolin powder as admixtures improve the maximum dry unit weight of the loose sand so that it become usable as soil improvement method.

Keywords-- jute fiber, loose sand, kaolin powder, compaction and Standard Proctor Test.

I. Introduction

Soil is considered by the civil engineer as a complex material. Apart from the testing and classification of various types of soil, in order to determine the stability and physical properties, the knowledge of problems related to foundation design and construction, pavement design, design of embankments and excavation, design of earth dams are necessary. Numerous methods have been used to improve the performance of loose soil and enhance its properties, including soil stabilization methods. Soil mixing with additives can enhance the soil parameters, and this technique has been used earlier for soil stabilization [1]. In order to enhance the engineering properties, soil can be reinforced using jute fiber. Jute fiber is preferable because of its better durability and high tensile strength. Moreover, jute is locally available, cheap, eco-friendly and biodegradable. There is a need to investigate the effect of adding different materials on soil properties. Kaolin and jute fiber are new additives that can modify the physical properties of soils. The aim of the research was to investigate the effect of mixing loose sand with different materials as kaolin, and jute fiber on compaction parameter such as maximum dry density (MDD) and optimum moisture content (OMC). To achieve this purpose, laboratory tests were performed. Standard Proctor tests was performed on the sand, jute-sand and kaolin-sand subjected to different moisture content. The effects of changing the percentage of the additive was studied.

II. MATERIALS USED FOR PRESENT STUDY

A. Sand

The used sand in this research is collected from a site in New Capital of Egypt, the used sand is classified as Fine clean sand according to Unified Soil Classification System (USCS). The grain size distribution curve is shown in Figure 1. The physical properties of the used sand are shown in .

B. Kaolin

The kaolin fine powder used was procured from a local factory. The chemical properties of the kaolin published by the manufacturer is presented in Error: Reference source not found. The kaolin was mixed in percentage of 1%, 2% and 3% by dry weight of loose sand.

Table 1
Chemical composition of the kaolin powder was used in tests

Chemical properties	Percentage composition (%)
Silicon dioxide (SiO_2)	47.4
Aluminum oxide (AL_2O_3)	35.4
Iron oxide (Fe_2O_3)	1.1
Magnesium oxide (MgO)	0.06
Calcium oxide (CaO)	0.11
Potassium oxide (K_2O)	0.05
Sodium oxide (Na_2O)	0.04
Titanium dioxide (TiO_2)	2.14
Manganese oxide (MnO_2)	0.01
phosphorous pentoxide (P_2O_5)	0.16

C. Jute Fiber

The jute fiber used was procured from the local market. The diameter of the jute fiber used was 0.5mm. Jute fiber are generally available in the threaded form [2]. The Fibers were cut into pieces of approximately 20 mm lengths and are mixed in percentage of 0.1%, 0.2% and 0.3% by dry weight of loose sand.

D. Mixing water

Tap water was used to mix of kaolin and jute fiber both separately with different percentage 6%, 8%, 10%, 12% and 14% from weight of dry loose for mixing with loose sand specimens.

III. Experimental Program

6th IUGRC International Undergraduate Research Conference,
Military Technical College, Cairo, Egypt, Sep. 5th – Sep. 8th, 2022.

The laboratory investigation on loose sand stabilization with jute fiber pieces and fine kaolin powder as admixtures were performed. This work is performed for beneficial utilization of jute fiber and fine kaolin powder. The objective of the present study is to evaluate the use of loose sand as a construction material after stabilizing it with jute fiber or kaolin powder as admixture. The present study has been undertaken with the following objectives:

1. To study the effect of moisture content on dry density of loose sand.
2. To study the effect of use deferent percentage of the jute fiber as admixtures for loose sand on its maximum dry unit wight and study the effect of change the water content.
3. To study the effect of use deferent percentage of the fine kaolin powder as admixtures for loose sand on its maximum dry unit wight and study the effect of change the water content.

The experimental program included the preliminary tests for loose sand and mix compositions of loose sand with jute fiber and fine powder kaolin.

Following tests were carried out:

1. Determination of particle size distribution of sand.
2. Standard Proctor Test (Proctor Compaction Test) for determining different dry densities for loose sand and sand with admixture under the condition of changing the water content.

Table 2 showed the details of the experimental program including the percentage of admixtures, the type of admixtures and the water content (%) by dry weight of soil.

It is should be noticed that the sieve analysis test was carried on the loose sand only.

TABLE 2
EXPERIMENTAL PROGRAM

<table>
<tr><th>Series</th><th>Mixing percent</th><th>Water content</th></tr>
<tr><td>1</td><td>Sand only*</td><td rowspan="7">WW_C = 6%, 8%, 10%, 12%, 14%</td></tr>
<tr><td rowspan="3">2</td><td>Sand + 1% kaolin</td></tr>
<tr><td>Sand + 2% kaolin</td></tr>
<tr><td>Sand + 3% kaolin</td></tr>
<tr><td rowspan="3">3</td><td>Sand + 0.1% jute fiber</td></tr>
<tr><td>Sand + 0.2% jute fiber</td></tr>
<tr><td>Sand + 0.3% jute fiber</td></tr>
</table>

*Sieve analysis test for the sand only

A. *Particle Size Distribution Test of sand*

The particle size distribution test was carried out with standard sieve size 6.25 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 µ, 425 µ, 300 µ, 150µ, 75µ, pan and balance in the laboratory. A typical sieve analysis involves a nested column of sieve with wire mesh [3-4]. A representative sample of 1000 gm is poured into the top sieve which has the largest screen opening of 4.75 mm. Each lower sieve in the column has smaller opening than the one above. The sample was shaken for 10 minutes on sieve shaker. After the shaking, the weight of material retained on each sieve was weighed. Percentage passing through each sieve was calculated and plotted against particle size. Since percentage passing 75 µ is within 1% only, hydrometer analysis was not done.

$$percentage\ (\%)\ Retained = \frac{W_{sieve}}{W_{total}} \times 100\%$$

Where W_{sieve} is the weight of aggregate in the sieve in (gm) and W_{total} is the total weight of the aggregate in (gm). The cumulative percentage passing of the aggregate is found by subtracting the percent retained from 100%.

Percentage (%) Cumulative Passing = 100% - Percentage (%) Cumulative Retained.

The results of particle size distribution have been shown in Table 3, and Figure 1.

TABLE 3
RESULTS OF PARTICLE SIZE DISTRIBUTION

Sieve Size (mm)	Weight Retained (gm)	% Weight Retained	Cumulative % Weight Retained	Cumulative % Weight Passing	% Finer
6.250	86.98	10.23	10.23	89.77	89.77
4.750	126.41	14.87	25.10	74.90	74.90
2.360	64.15	7.55	32.65	67.35	67.35
1.180	447.58	52.66	85.31	14.69	14.69
0.600	18.94	2.23	87.54	12.46	12.46
0.425	29.91	3.52	91.06	8.94	8.94
0.300	9.76	1.15	92.20	7.80	7.80
0.150	5.96	0.70	92.90	7.10	7.10
0.075	60.21	7.08	99.99	0.01	0.01

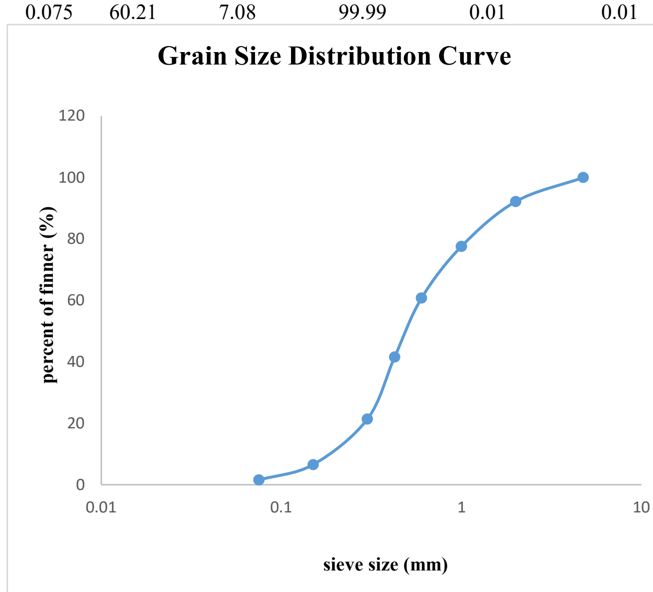

Figure 1. Grain Size Distribution Curve

TABLE 4
THE PHYSICAL PROPERTIES OF THE USED SAND

S. No.	Property	Loose sand
1.	Coefficient of Uniformity (Cu)	1.28
2.	Coefficient of Curvature (Cc)	1.06
3.	Mean Diameter (D_{50}) mm	0.20
4.	Effective Size (D_{10}) mm	0.18
5.	Fine Soil Fraction (75 µ)	0.10%

B. *Standard Proctor Test*

1) *Sample Preparation*

In order to investigate the effect of kaolin and jute fiber on the engineering properties of sand, many samples were prepared in this research:

1. Untreated sand with only tap water, (Untreated sand is a soil with no additives but only with water, while treated soil is a soil with additives.).

2. Sand mixed with (1%, 2% and 3%) of kaolin.
3. Sand mixed with (0.1%, 0.2% and 0.3%) of jute fiber.

2) Mixing Methods

Mechanical mixing method was used for mixing the soil with different materials with solutions of different percentages. Researchers found that the mechanical mixture is the best method to obtain more homogenous soil sample.

3) Test Procedure

Standard proctor test is performed to determine the relationship between the optimum water content and maximum dry unit weight of soil. In this test, a standard mould of 100 mm internal diameter and an effective height of 127.3 mm, with a capacity of 1000 ml is used. The mould has a detachable base plate and a removable collar of 50 mm height at its top. The soil was compacted in the mould in 3 equal layers; each layer was given 25 blows of 2.6 kg rammer falling through a height of 310 mm.

V. RESULTS AND DISCUSSION

The result tabulated in The result tabulated in The result tabulated in The result tabulated in The result tabulated in and) shows that with the increase of water content, an increase of the dry unit weight occurred, which was followed by gradual decrease. In the curve, dry unit weight first increase due to bulking of sand. After reaching maximum dry unit weight on optimum moisture content, dry unit weight decreases. and Figure 2Figure 3Figure 4) shows that with the increase of water content, an increase of the dry unit weight occurred, which was followed by gradual decrease. In the curve, dry unit weight first increase due to bulking of sand. After reaching maximum dry unit weight on optimum moisture content, dry unit weight decreases. and Figure 2Figure 3Figure 4) shows that with the increase of water content, an increase of the dry unit weight occurred, which was followed by gradual decrease. In the curve, dry unit weight first increase due to bulking of sand. After reaching maximum dry unit weight on optimum moisture content, dry unit weight decreases. and Figure 2Figure 3Figure 4) shows that with the increase of water content, an increase of the dry unit weight occurred, which was followed by gradual decrease. In the curve, dry unit weight first increase due to bulking of sand. After reaching maximum dry unit weight on optimum moisture content, dry unit weight decreases. and Figure 2Figure 3Figure 4) shows that with the increase of water content, an increase of the dry unit weight occurred, which was followed by gradual decrease. In the curve, dry unit weight first increase due to bulking of sand. After reaching maximum dry unit weight on optimum moisture content, dry unit weight decreases.

TABLE 5
The result of all tests

water content		6%	8%	10%	12%	14%
Sand only	γ_d	1.71	1.767	1.847	1.808	1.761
	W_c	5.88	7.339	9.459	11.357	13.846
Sand + 1% kaolin	γ_d	1.688	1.758	1.859	1.819	1.764
	W_c	5.61	7.744	10	11.475	13.636
Sand + 2% kaolin	γ_d	1.677	1.757	1.867	1.804	1.772
	W_c	5.769	7.758	9.929	11.982	13.564
Sand + 3% kaolin	γ_d	1.684	1.799	1.88	1.826	1.766
	W_c	5.37	7.894	10	11.89	13.86
Sand + 0.1% jute fiber	γ_d	1.709	1.77	1.859	1.799	1.758
	W_c	5.6	7.843	10	11.79	13.79
Sand + 0.2% jute fiber	γ_d	1.738	1.804	1.877	1.826	1.785
	W_c	5.828	7.358	9.756	11.579	13.127
Sand + 0.3% jute fiber	γ_d	1.759	1.808	1.885	1.84	1.806
	W_c	5.88	7.34	9.459	11.357	13.85

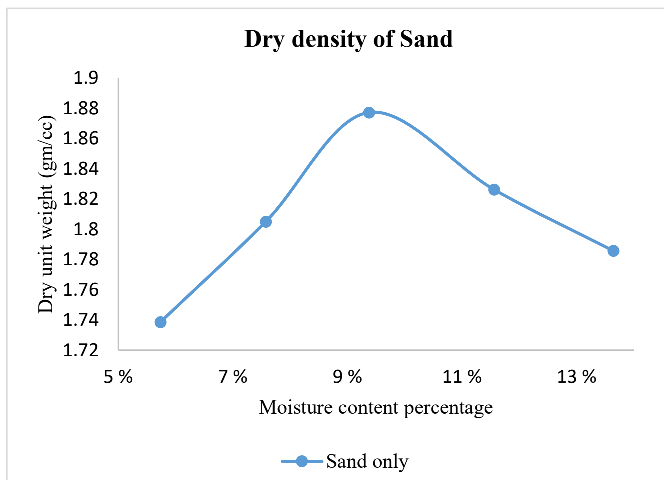

Figure 2. Dry density and moisture content curve

A comparative study of variation of dry density (γ_d) and moisture content (W_c) with different percentage of jute fiber has been performed from the test results. The variation of moisture content on X-axis corresponding dry unit weight on Y-axis with variable percentage of jute fiber 0.1 %, 0.2% and 0.3% as admixture have been shown Figure 3). It is noticed that the maximum dry unit weight increased by increasing the percentage of the jute fiber [5-6].

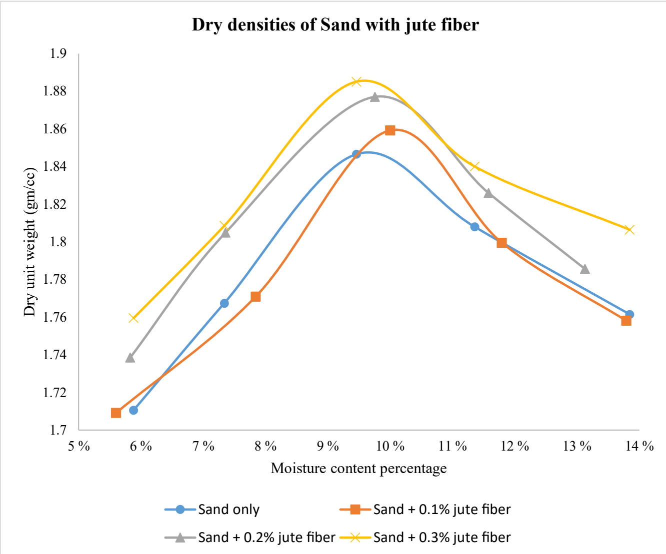

Figure 3. Dry densities of jute-sand and moisture content curves

A comparative study of variation of dry unit weight (γ_d) and moisture content (W_c) with different percentage of kaolin has been performed from the test results. The variation of moisture content on X-axis corresponding dry unit weight on Y-axis with variable percentage of kaolin 1 %, 2% and 3% as admixture have been shown Figure 4). It is noticed that the maximum dry unit weight increased by increasing the percentage of kaolin [5-6].

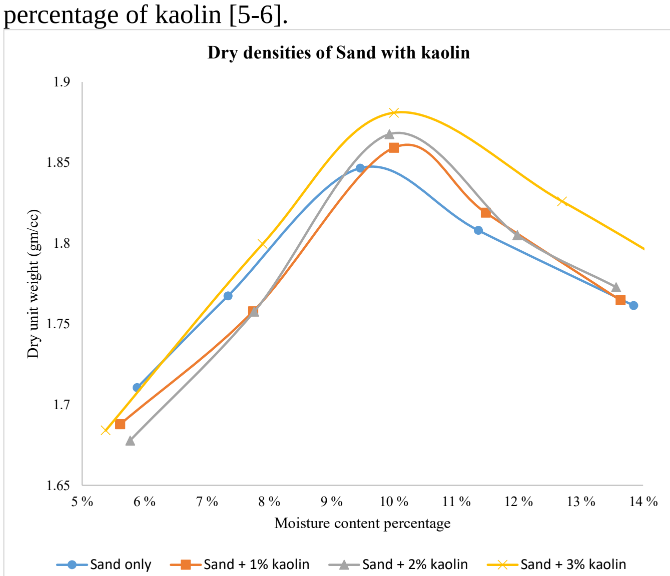

Figure 4. Dry densities of kaolin-sand and moisture content curves

IV. CONCLUSIONS

In this investigation jute fiber pieces and kaolin were used in different percentage to study its effect on dry unit weight of treated loose sand. The results of the testing program illustrated that the dry unit weight of the sand improved considerably due to stabilizing with jute fiber and kaolin powder. In the present investigation, increasing the quantity of admixture of jute fiber pieces or increasing the percentage of kaolin powder contributed to increasing the dry unit weight of the soil. The jute-sand as well as kaolin-sand stabilization is found to be an effective method to stabilize the soil.

ACKNOWLEDGMENT

REFERENCES

[1] Punmia B. C. (2007). Soil Mechanics & Foundations. Laxmi Publications, Available at: https://www.amazon.in/Soil-Mechanics Foundations-B-C-Punmia/dp/817008791M. Young, *The Technical Writer's Handbook*, Mill Valley, CA: University Science, 1989.

[2] N. Islam, N. Ahmed, S. Akter, and A. Hossain "Sandy Soil Stabilization using Jute Fiber as Admixture," *Journal of Geotechnical Studies*, vol. 6, no. 2, pp. 30-34, May-August 2021.

[3] T Sanyal (2017). Jute Geotextiles and their application in civil engineering. Developments in Geotechnical Engineering, Available at: https://link.springer.com/ book/10.1007/978-981-10-1932-6.M. King and B. Zhu, "Gaming strategies," in Path Planning to the West, vol. II, S. Tang and M. King, Eds. Xian: Jiaoda Press, 1998, pp. 158-176.

[4] Yagya Sharma, Dr. D. G. M. Purohit & Dr. Sunil Sharma (2017). Improvement of Soil Properties by Using Jute Fibre as Soil Stabilizer. American Journal of Engineering Research, 6(10), Available at: http://www.ajer.org/papers/v6(10)/P061J.-G. Lu, "Title of paper with only the first word capitalized," *J. Name Stand. Abbrev.*, in press.

[5] Grain Size Distribution. Available at: http://home.iitk.ac.in/~madhav/expt4.ht ml.

[6] C. Venkatramaiah. Types of soil. Available at: http://www.civileblog.com/types-of-soil/