Use of Jute Fiber in Improving Geotechnical Properties of Soil

Parvesh Kumar and Fayaz Ahmad Mir

Abstract Soil improvement is used in the field of geotechnical engineering in order to increase the engineering properties of soil. Various soil improvement techniques have been developed which are very effective in the geotechnical engineering. Soil improvement by adding natural fiber is a common practice used nowadays. In this soil improvement technique, natural fibers are mix randomly in soil. Natural fibers like Jute, coir, bamboo, etc. are easily available and are very cheap as compared to synthetic fibers. These natural fibers are eco-friendly and have no harmful effects on environment. They can easily mix with soil and act as a reinforcing material. In this paper, discussion is made on the enhancement of the properties of soil when Jute fiber is added to soil. Natural Jute fiber after cutting into a certain aspect ratio is mixed with soil. For the present study, the soil sample is taken from NIT Srinagar college campus. From the results, it can be concluded that addition of Jute fiber in soil has significant effects on soil properties.

Keywords Soil · Reinforcing material · Natural fiber · Aspect ratio

1 Introduction

Due to rapid growth of urbanization and industrialization, soil improvement is major concern in the construction activities. The process in which the index properties and other engineering characteristics of soil are improved by using different techniques is called soil improvement. Soil is used as a construction material

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in several fields such as buildings, roads, irrigation, and structure. Soil improvement is required when the mechanical properties and strength of the soil are weak. Soil needs to be improved according to the requirement which varies from site to site. Synthetics nets were used for the first time in civil engineering application work in 1962. Then in 1969, nonwoven fabrics were used as a filter in the upstream face of an earthen dam. Singh and Bagra (2013a, b), performed experimental tests on the soil reinforced with Jute fiber. From the results, it was concluded that with an increase in the quantity of Jute fiber, there is an increase in the CBR value of soil. Md. Akhtar Hossain, Md. Shakhawat Hossain, Md. Kamrul Hasan conducted a study on soil reinforced with Jute fiber. From the results, it was concluded that if the amount of Jute fiber increases in the soil, the optimum moisture content increases and maximum dry density decreases. From the results, it can also be concluded that with an increase in the length of Jute fiber there is an increase in the CBR value. Praveen Aggarwal and Bajinder Sharma, in 2011, conducted a study to analyze the effect of Jute on subgrade characteristics of soil. The soil sample is taken from a depth of 60 cm. Jute fibers of different diameters (2–8 mm) and lengths are mixed in the subgrade in different percentages (.2–1%) to find out the optimal quantity. It was observed that inclusion of Jute fiber reduces the maximum dry density from 1.88 to 1.80 gm/cc and the OMC increases from 13.5 to 15.5%. Dharmendra Kumar, Sudhir Nigam, Abhinav Nangia, and Shailendra Tiwari, in 2015, conducted a study on reinforcing the soil properties by using Jute fiber. For that, five soil samples were taken to study the effect of Jute fiber on CBR value of soil. The result shows that the CBR value increases with fiber content both in soaked and unsoaked conditions. Pankaj Dhemla et al., in 2015, conducted a study to determine the increment in the CBR value with the addition of Jute fibers in Rajasthan. The Jute is used in different proportions of 0.25%, 0.5% of weight of different lengths 20 mm, 40 mm. The CBR value before addition of Jute fiber at 2.5 mm penetration is 5% and when we add 0.50% Jute fiber of its weight then the CBR value increased by almost 50%. During the study, the effect of length of fiber used in the CBR was observed and it is concluded that there is an increase in the strength of soil.

2 Materials and Methodology

2.1 Soil

This study is conducted on soil sample collected from National Institute of Technology Srinagar campus. The soil sample is collected from a depth of 1.5 m. The soil sample is then pulverized and kept for drying. After 24 h oven-drying process, the various properties of soil such as index properties, compaction properties, unconfined compressive strength, and CBR value of soils in soaking and unsoaking conditions were find out in the laboratory.

2.2 Reinforcement Material

Natural Jute fiber is selected as the material for reinforcement purpose in this study. Jute fiber is purchased from the market. Then, it is cut down in a certain aspect ratio and that aspect ratio is kept constant throughout the study. The length of the Jute fiber is kept 25 mm, and the diameter is kept 1 mm. Then, these natural fibers are mixed properly in soil in order to enhance the properties of the soil. The properties of Jute fiber are shown in Table 1 (Fig. 1 and Table 2).

Table 1 Properties of Jute fiber

Specific gravity	1.4
Water absorption	13%
Tensile strength	400–600 MPa
Young modulus	50–60 MPa
Specific modulus	35–40 MPa

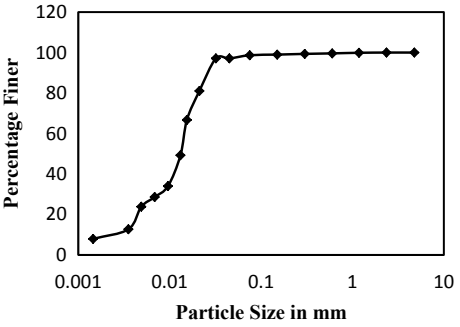

Fig. 1 Particle-size distribution curve of college soil sample from hydrometer test

Table 2 Geotechnical properties of NIT Srinagar campus soil

Property	Value
Specific gravity	2.613
Liquid limit	33.8%
Plastic limit	25.305%
Coefficient of uniformity (C_U)	7.5
Coefficient of curvature (C_C)	2.13
Optimum moisture content	20.5%
Maximum dry density	1.76 gm/cc
Cohesion	.55 kg/cm^2
Angle of internal friction	19°
Unconfined compressive strength	1.0107 kg/cm^2
CBR value under unsoaked conditions	4.01%
CBR value under soaked conditions	2.84%

2.3 Methodology

Soil used in this study is taken from National Institute of Srinagar, Jammu, and Kashmir college campus. Soil is taken from college campus at a depth of 1.5 m from the ground surface. After the process of drying, various tests were carried out on the oven-dried soil sample and its basic properties such as compaction characteristics, unconfined compressive strength, California bearing ratio under both soaked and unsoaked conditions were determined. Then, Jute is used as a reinforcing material in the soil. Jute is added to soil in different percentages which vary from .25 to 1%. Again same tests were conducted on soil and the change in the properties of soil on the inclusion of Jute fiber is determined.

3 Results and Discussion

3.1 Effect on Compaction Characteristics of Soil with Addition of Jute Fiber

To determine the effect of addition of Jute fiber on compaction characteristics, various light compaction tests were conducted on campus soil in unreinforced and reinforced conditions. Based on the average values of maximum dry density and optimum moisture content, following graphs were obtained.

From these graphs, we can conclude that the value of optimum moisture content will increase with increase in Jute fiber content and the maximum dry density of soil will decrease on the inclusion of Jute fiber. It is also noticed that if length and the thickness of the Jute fiber increases there is an relative increase in the optimum moisture content and reduction in maximum dry density. From the graphs, it may be concluded that the inclusion of Jute fibers decreases the maximum dry density and there is an increase in the optimum moisture content (Figs. 2 and 3).

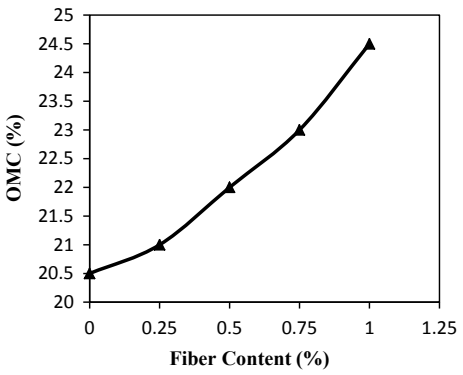

Fig. 2 Variation in optimum moisture content with fiber content

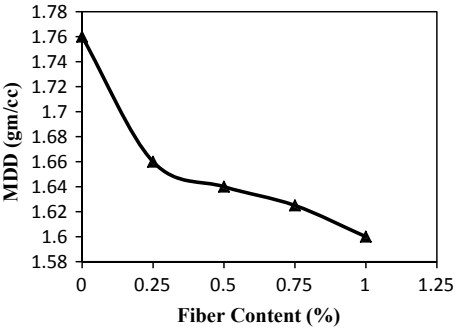

Fig. 3 Variation in maximum dry density with increase in fiber content

3.2 Effect on Unconfined Compressive Strength of Soil with Increase in Fiber Content

To determine the unconfined compressive strength, around 15 tests were conducted on college campus soil. For compressive strength of unreinforced soil, soil specimen is prepared in a standard cylindrical split mold of 38 mm diameter and 76 mm long. After determining the compressive strength of unreinforced soil sample, the Jute fiber is added to soil in different percentages (.25–1%) and the average value of unconfined compressive strength is determined for different percentages of Jute fiber which is shown in Fig. 4.

Based on the above graph, it can be concluded that there is an increase in unconfined compressive strength value of soil with the inclusion of Jute fiber.

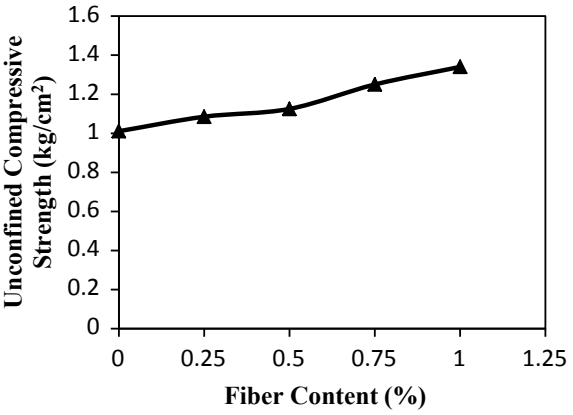

Fig. 4 Variation in unconfined compressive strength with addition of Jute

3.3 Effect on CBR Value Under Unsoaked Conditions

California bearing ratio tests were conducted on soil sample. The CBR tests were initially conducted on unreinforced soil sample, and CBR value in terms of percentage is determined for unreinforced soil sample. After determining the CBR value of plain soil, the Jute fiber is added to soil as a reinforcing material. Initially, the CBR value of soil sample under unsoaked conditions was 4.014%. With the addition of Jute, the CBR value of soil increases up to 8.759%. The maximum increase is experienced at 1% Jute content. The maximum increase in CBR value was found to be more than 118% as compared to the plain soil under unsoaked conditions. After conducting California bearing ratio tests on college soil, following graph can be obtained which clearly show that there is an increase in CBR value in terms of percentage when Jute is added to the unreinforced soil sample in different percentages (Fig. 5).

Based on the above graph, it may be concluded that CBR value increases with increase in fiber content. The CBR value is maximum at 1% Jute content, i.e., 8.759%.

3.4 Effect on CBR Value Under Soaked Conditions

After conducting California bearing ratio tests on college soil under soaked conditions, following graph can be obtained (Fig. 6).

Based on the above graph, it may be concluded that CBR value increases with increase in fiber content. Initially, the CBR value of soil sample under soaked conditions was 2.846%. With the addition of Jute, the CBR value of soil increases up to 6.350%. The CBR value is maximum at 1% Jute content, which is more than 123% over that of plain soil in soaked conditions.

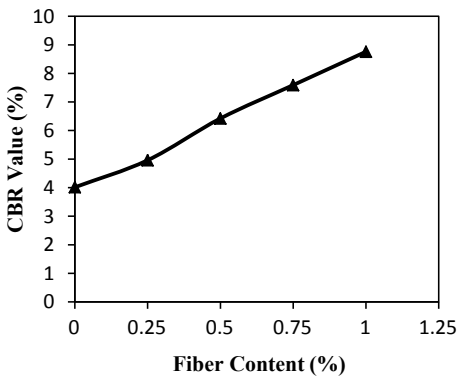

Fig. 5 Variation in CBR value at different Jute fiber contents under unsoaked conditions

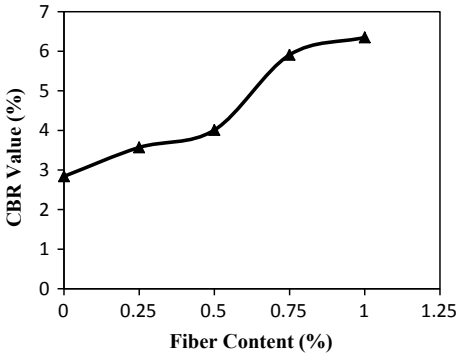

Fig. 6 Variation in CBR value at different Jute fiber contents under soaked conditions

4 Conclusion

After the completion of the study, following results can be summarized.

1. From the results, it is concluded that there is a change in maximum dry density and optimum moisture content with addition of Jute fiber. The value of maximum dry density decreases from 1.76 to 1.60 gm/cc and optimum moisture content increases from 20.5 to 24.5% with the inclusion of .25–1% Jute fiber in soil.
2. The UCS value of plain soil sample increases from 1.0107 to 1.34 kg/cm^2 on inclusion of Jute from .25 to 1%.
3. Under unsoaked conditions, the CBR value of plain soil sample increases from 4.014 to 8.759% on inclusion of Jute. Under soaked conditions, the CBR value increases from 2.846 to 6.350% when the Jute is added from .25 to 1%.

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