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Improving the Shear Strength of the Soil by using Jute Fabric

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Abstract**: *Bearing capacity of the soil is based on the shear strength of the soil. By improving the shear strength, bearing capacity of soil increases. Various additives such as lime, fly ash, cement, bitumen, tar etc. and easily available on-site materials such as sands, mining waste, natural stone waste etc were using to improve the shear strength of the soil. The main aim of this project is to improve the shear strength of the soil by adding jute fabric in various proportions. Jute fabric is mainly produced from a plant species called Corchorus olitorius. Soil samples were collected from Mangalapuram, Trivandrum and the identification tests such as specific gravity, liquid limit, plastic limit and sieve analysis of soil were done based on IS2720 recommended procedures. As per IS1498 – 1970 the soil is classified as poorly graded sands (SP). Jute fabric is added to the soil on 3%, 6% and 9% of weight of soil sample. Standard proctor test is conducted as per IS 2720 (part VII) to determine the optimum moisture content value (OMC). Optimum moisture content value of the soil sample is 10%. The shear strength of the soil is determined by direct shear strength test, which is conducted on both treated and untreated soil sample. From the result it is concluded that by adding 6% of jute fabric the shear strength of the soil reaches its maximum value, further addition of jute fabric reduces the shear strength of soil. Hence it is recommended to use 6% of jute fabric in sub-grade soils for pavements to improve the shear strength.***

Keywords: Bearing capacity, Jute fabric, Poorly graded sands, Shear strength

I. INTRODUCTION

Shear strength, permeability and compressibility were the three major engineering properties of the soil. By decreasing the permeability and compressibility of the soil and increasing the shear strength, soil can be stabilized. If the soil is stabilized, then the bearing capacity of the soil increases. Various stabilizing materials such as cement, lime, bitumen emulsion, polymers and chemical additives were used to strengthen the soil.

In this project jute fabric is used as the strengthening agent. Jute fabric is a type of textile fiber, which is made from the fibers of jute plant. Fibers of the jute plant consist of large amount of cellulose and lignin. There are little diverse varieties of jute available, in which *Corchorus olitorius* is used for making jute fabric. Most types of jute fabric are loose-fitting with woven networks of bulky yarn. While jute absorbs water readily and also dries quickly, it is greatly resistant to scratch and stains.

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II. LITERATURE REVIEW

[9]Soumya Rani P Thomas *et al.*, (2018) in their paper 'Improvement in shear strength of soil reinforced with pineapple fiber' they studied about the shear strength of the soil by adding pineapple fiber in 0%, 0.25%, 0.5%, 0.75% and 1%. Direct shear test was done to determine the shear strength. It is concluded that by the addition of pineapple fiber at 0.75%, the shear strength of the soil attains its maximum value. Further addition of fiber the strength decreases.

[11]Yagya Sharma *et al.*, (2017), in their paper 'Improvement of soil properties by using Jute fiber as soil stabilizer' they studied about improving the engineering properties of soil by using jute fiber treated with sand. 20mm length jute pieces were added to fine sand at 0.5%, 1%, 1.5%, and 2% by weight of soil. Through experiment it is concluded that addition of 20mm length jute fabric with fine sand increases the strength of soil, thereby applicable in construction of embankment.

[7]Mayank Chandra and Sukhmanjit (2017) in their paper 'A laboratory study on implementation of hydrocarbon emulsion in gravel road' they studied about properties of soil by adding hydrocarbon emulsion as stabilizing agent and cement as filler. Soil samples were collected from local street routes in Suncity Rohtak field and relative density, particle size distribution, liquid limit and plastic limit test were conducted on the sample. Dry density and optimum moisture content of the sample were determined by proctor check. Cosmic radiation check was conducted on hydrocarbon emulsion and cement treated soil sample. Morphological test results shows that there is homogeneity in bitumen emulsion in bitumen matrix. It is concluded that this type of stabilization is suitable for gravel soil road or in shoulder portion of highway.

[8]Parithosha Perika and Prof. G. Venkatarathnam (2015), in their paper 'Laboratory study on use of bitumen emulsion in gravel road' they studied about improving the properties of gravel soil by adding bitumen emulsion. They mainly focused on the properties of soil and its strength based on CBR. In addition to bitumen emulsion, a small amount of cement is also added to improve the strength of the soil. Red colored laterite type gravel soil, which is locally available in the local road routes in Rourkela NIT campus, is used for the experiment. It is identified that by using cationic bitumen emulsion with small amount of cement as filler increases the strength of the soil considerably.

[10]Vidhya A Carmel and Twinkle Vinu (2015) in their paper 'stabilization of soft clay using lime and jute fibers' they studied about engineering properties of soil by adding jute fibers with different diameter and length in varying proportions. 20mm and 40mm length jute fibers of 3mm and 5mm diameter were used with 2%, 4%, 6% and 8% lime in soil. Unconfined compressive strength and consolidation tests were conducted to determine the shear strength and compressibility of the soil. The soil samples were collected from Kuttanad region in Aleppey district. From test results it is concluded that by addition of lime and fiber in 6% the shear strength of the soil increases by 36% and the compressibility of the soil decreases. Further addition decreases the strength of the soil.

III. METHODOLOGY

Soil samples were collected from a local street in Mangalapuram, Trivandrum. Properties of the soil were determined by conducting test on treated and untreated soil sample. Specific gravity, particle size distribution, liquid limit and plastic limit were conducted on untreated soil sample to determine the index properties of the soil. Standard proctor test is conducted to determine the dry density and optimum moisture content of untreated soil sample. Jute fabric is added to the soil in 3%, 6% and 9% by weight of soil. Direct shear test is conducted on both treated and untreated soil sample to determine the variation in shear strength of soil by the addition of jute fabric in various proportions.

IV. MATERIAL TESTING

A. Specific gravity test

Specific gravity is the index property of the soil. For identifying and classifying the soil sample specific gravity value is very much important. Void ratio, porosity and degree of saturation of soil can also calculated using specific gravity value. Soil samples were tested as per Indian standard 2720 (Part III) recommendations. Specific gravity value of soil sample is 2.27.

B. Sieve Analysis

Particle size distribution of coarse grained soil is done by sieve analysis method. The experiment is done based on Indian standard 2720 (part IV) - 1985 recommendation. Values were plotted on semi-log graph with percentage of fines in natural scale and sieve size in logarithmic scale. Soil particles retained on each sieve is shown in fig. 1. Particle size distribution graph is shown in fig.2. The uniformity coefficient of soil sample is 11.75 and coefficient of curvature is 0.085. From IS 1498 – 1970 the soil is classified as poorly graded sands (SP).

Fig. 1 Sieve analysis

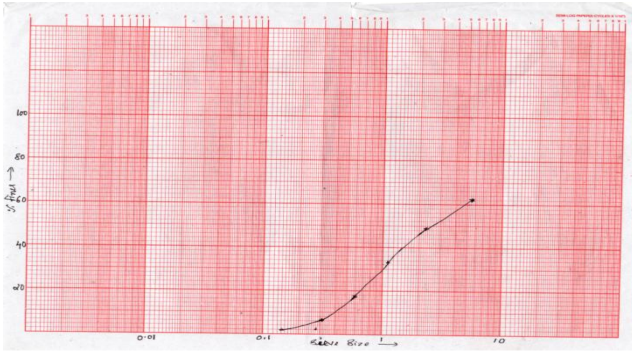

Fig 2. Particle size distribution graph

C. Liquid Limit Test

Liquid limit is defined as the minimum water content at which the soil changes from plastic state to liquid state. Liquid limit test is conducted in Casagrande apparatus. As per Indian standard code (IS 2720 Part V – 1985), liquid limit defined as the water content at which 25 number of blows causes to close over a groove of 12.7mm. From liquid limit test flow index of the soil can be determined. Fig 3 shows the Casagrande apparatus.

Fig 3 Casagrande apparatus

[1]The flow index or the slope of the curve can be determined from

$$I_f = \frac{w_1 - w_2}{\log_{10}\frac{n_2}{n_1}}$$

Where,

W_1 = water content in % at N_1 blows
W_2 = water content in % at N_2 blows

The values are plotted in the semi-log graph with number of blows in logarithmic scale and water content in natural scale. The liquid limit of soil is 57% and flow index of the soil is 39.75.

D. Plastic limit test

The minimum water content at which the soil changes from plastic state to semi solid state is known as plastic limit.

Plasticity index indicate the range of consistency within which the soil exhibit plastic property and it is represented by I_p. As per Indian code (IS 2720 part V 1985), plastic limit is defined as the minimum water content at which the soil starts to crumble when rolled into a thread of approximately 3mm in diameter. The plastic limit of soil sample is 25%.

[2]Plasticity Index $I_p = w_L - w_P$

Where

w_L is the liquid limit

w_P is the plastic limit

The plasticity index of soil sample is 32%.

V. RESULT AND DISCUSSION

A. Standard Proctor Compaction Test

Jute fabric is added 0%, 3%, 6% and 9% in soil sample and determined the optimum moisture content of the soil sample by standard proctor compaction test. The degree of compaction in soil sample is measured in term of its dry density and this is mainly depends upon the moisture content available in the soil. Soil attains its maximum dry density at a particular water content which is known as optimum moisture content. Compaction of soil increases the shear strength and bearing capacity, decreases the void ratio thereby decreases the permeability and compressibility of soil. The experiment is done as per IS 2720 (part VII) and compaction curve is plotted with moisture content as abscissa and dry density as ordinate. The optimum moisture content and maximum dry density of soil with 0% jute fabric were given in table 1.

Table 1. Optimum moisture content and maximum dry density for 0% jute fabric

Sl. No	OMC (%)	Dry density (gm/cm3)
1	8	1.832
2	10	1.925
3	12	2.125
4	14	2.069

Figure 4 shows the optimum moisture content and maximum dry density of untreated soil samples. From the graph the dry density of soil increases up to 12% moisture content and then the dry density value decreases. Hence the optimum moisture content is 12% with maximum dry density 2.125 gm/cc.

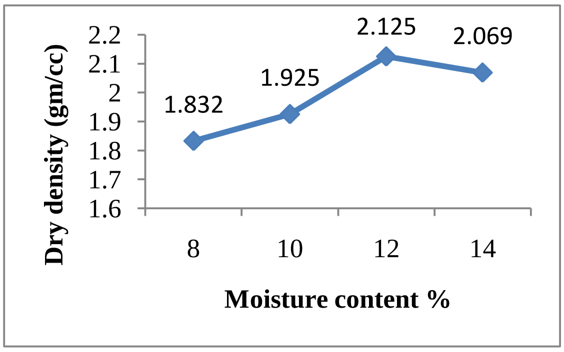

Fig. 4 OMC vs dry density for 0% jute fabric

The optimum moisture content of soil with 3% jute fabric was given in table 2.

Table 2. Optimum moisture content and maximum dry density for 3% jute fabric

Sl. No	OMC (%)	Dry density (gm/cm3)
1	8	2.37
2	10	2.41
3	12	2.383

Figure 5 shows the optimum moisture content and maximum dry density of soil samples with 3% jute fabric. From the graph the dry density of soil increases up to 10% moisture content and then the dry density value decreases. Hence the optimum moisture content is 10% with maximum dry density 2.41 gm/cc.

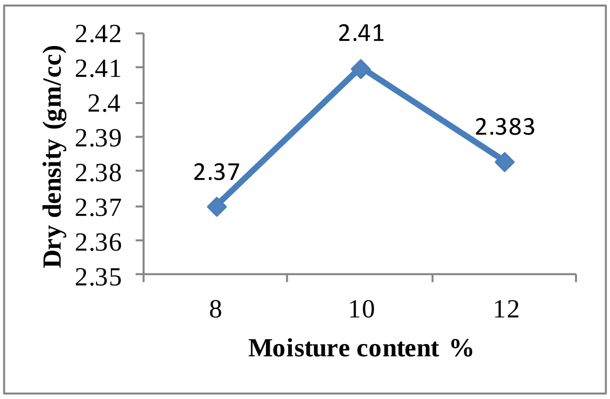

Fig. 5 OMC vs dry density for 3% jute fabric

The standard proctor test results of soil with 6% jute fabric were given in table 3.

Table 3. Optimum moisture content and maximum dry density for 6% jute fabric

Sl. No	OMC (%)	Dry density (gm/cm3)
1	6	2.35
2	8	2.37
3	10	2.28

Figure 6 shows the optimum moisture content and maximum dry density of soil samples with 6% jute fabric.

From the graph the dry density of soil increases up to 8% moisture content and then the dry density value decreases. Hence the optimum moisture content is 8% with maximum dry density 2.37 gm/cc.

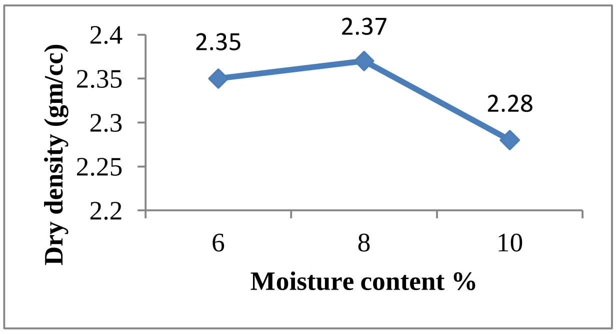

Fig. 6 OMC vs dry density for 6% jute fabric

The standard proctor test results of soil with 9% jute fabric were given in table 4.

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Table 4. Optimum moisture content and maximum dry density for 9% jute fabric

Sl. No	OMC (%)	Dry density (gm/cm3)
1	5	2.32
2	7	2.35
3	9	2.33

Figure 7 shows the optimum moisture content and maximum dry density of soil samples with 9% jute fabric. From the graph the dry density of soil increases up to 7% of moisture content and then the dry density value starts to decrease. Hence the optimum moisture content is 7% with maximum dry density 2.35 gm/cc.

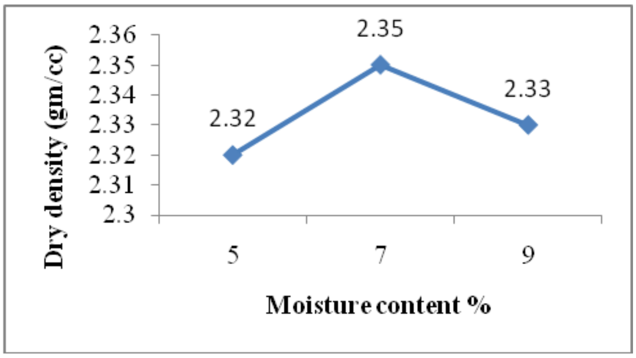

Fig. 6 OMC vs dry density for 9% jute fabric

The optimum moisture content and maximum dry density of soil with 0%, 3%, 6% and 9% jute fabric were compared in table 5. Hence the optimum moisture content of 10% with 3% jute fabric gives maximum dry density.

Table 5. Optimum moisture content and maximum dry density

Sl. No	% of Jute fabric	OMC (%)	Dry density (gm/cm3)
1	0	12	2.125
2	3	10	2.41
3	6	8	2.37
4	9	7	2.35

B. Direct Shear Test

The objective of this test is to determine the shear strength of the soil. The strain occurred due to the applied load is recorded to determine the stress – strain curve. The test result on each specimen is plotted on a graph with peak stress on y-axis and confined stress on x-axis. The slope of the line is the friction angle and y-intercept gives the cohesion value. Thus from graph the shear parameters cohesion (c) and angle of internal friction (Ø) can be measured. Table 2 shows the shear strength of soil with 0%, 3%, 6% and 9% jute fabric. Hence shear strength of the soil is,[1]

$s = c + \sigma \tan Ø$

where

s – shear strength of soil in kg/cm^2

c – cohesion

σ – confined stress

Ø – angle of internal friction

Table 6. Shear strength soil with various % of jute fabric

Sl. No	% of jute fiber	Shear strength of soil (kg/cm^2)
1	0%	0.19
2	3%	0.506
3	6%	1.49
4	9%	1.26

VI. CONCLUSION

Based on the result obtained it can be concluded that the jute fabric used in this project has a significant influence in the shear strength of the soil. Optimum moisture content, maximum dry density and shear strength of the soil were compared on both treated and untreated soil sample. The test results shows that with 3% jute fabric gives optimum moisture content of 10%. Hence maximum dry density is obtained at 10% moisture content. The shear strength of the soil increases upto the addition of 6% of jute fabric. The strength of the soil starts to decline, if jute fabric is added more than 6% by weight of soil. Hence it is recommended to use 6% jute fabric by weight of soil improves the shear strength of the soil.

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