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Improvement of Soil Properties by Using Jute Fibre as Soil Stabilizer

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ABSTRACT: *In this paper we focus on the improvement of engineering properties of soil by using jute fiber treating with the sand. Jute fiber is treated with the sand to enhance the engineering properties in case of pavement and earthen slopes. The aim of the present investigation is to determine the jute geo textile as soil reinforcement or soil stabilizer.This analysis discusses the potential of fine sand stabilization with jute is cut into approximately 20mm lengths as admixture. Present work has been taken up by addition of 20mm jute pieces as admixture. The varying percentage 0.5%, 1%, 1.5%, 2% of jute pieces of jute geotextile were mixed with fine sand of different densities and moisture content. All the Unconfined Compressive Strength Tests were conducted at different mix compositions of square pieces of plastic waste and fine sand of different dry densities as arrived from Standard Proctor Test. On the basis of the experiments performed, it is determined that the stabilization of fine sand using 20mm pieces of jute as admixture improves the strength characteristics of the fine sand so that it becomes usable as construction of embankment.*

Keywords: *20mm pieces of jute fibre, fine sand, Standard Proctor Test, Unconfined Compressive Strength Tests*

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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.

Subgrade is the lowest layer of the pavement. It takes all the loads of the pavement as well as the loads coming on the pavement. So, it should possess sufficient stability under adverse climatic and loading conditions. The defects in black top pavement surface like rutting, corrugation, etc. are generally attributed to poor subgrade. Thus the stability of the pavement depends upon the stability of the subgrade and it is done with soil stabilization. In order to enhance the engineering properties, soil can be reinforced using jute fibre. Jute fibre is preferable because of its better durability, high tensile strength and capacity to withstand rotting and heat, porous texture which gives it good drainage and filtration properties. Moreover, jute is locally available, cheap, eco-friendly and biodegradable. Reinforcing in soil masses increases its strength, bearing capacity and ductility; reduces settlement and inhibits lateral deformation. Jute fibre Stabilized soils show greater extensibility, small loss of post peak strength, isotropy in strength and absence of planes of weakness and good compressive strength.The jute is biodegradable and no environmental hazard. In this paper jute fibre is used with varying amount and their effect was analysed on shear strength and frictional angle. Jute is used in various works due their cheapness and soft in nature.

II. MATERIALS USED FOR PRESENT STUDY

2.1 Fine Sand

Fine sand is found in abundance in Western Rajasthan. The fine sand has similar characteristics which are found in various Towns of Jodhpur. Hence the sand used in present study was brought location near Osian villages, at about 35-40kms away from Jodhpur on Jodhpur-Falodi Road. Fine sand has nil cohesion and poor compressive strength and hence need stabilization. Fine sand is uniform clean sand as per Unified Soil

Classification System. Particles size ranges between 75μ to 1 mm that is fine coarse sand, round to angular in particle shape as per Indian Standard Classification System. Physical and engineering properties of fine sand are shown in table 1.

Table 1: Summary of the Physical and Engineering Properties of the Tested jute fiber Material

Sr. No.	Parameters	Range / Value
1	Light Compaction Test I. MDD (gm/cc) II. OMC (%)	 1.60 - 1.62 8.47
2	Liquid Limit (%)	39.67
3	Plastic Limit (%)	10.69
4	Plasticity Index (%)	28.98
5	Specific Gravity	2.67
6	Indian Soil Classification	CI

2.2 Jute Fibre

Fibres possess good pliancy and render a high degree of flexibility and fineness to fabric construction. High initial modulus, consistency in tenacity (depends on thickness of the filament), high torsional rigidity and low percentage of elongation-at-break make Jute a suitable fibre for geosynthetics. The other remarkable property of Jute is its capacity to absorb water because of its high cellulosic content. Jute fibres/yarns can absorb water up to about 500% of their dry weight. Hygroscopic property of Jute is the highest among all fibres natural & of course man-made. Jute Geotextiles can be manufactured conforming to customize specifications in regard to porometry, tensile strength, permittivity (passage of water across the fabric) & transmissivity (transmission of water along the fabric) which are comparable to man-made geotextiles as shown in table below. Puncture strength and burst strength of Jute Geotextiles are also close to man-made geosynthetics. Besides, JGT has a distinct environmental edge. Jute Fibres have been purchased from the market of Jodhpur city. The Fibres are cut into pieces of approximately 20 mm lengths and are mixed in percentage of 0.5%, 1%, 1.5% and 2% by dry weight of soil. Fig.1 shows the jute pieces of admixture which is used for present research. Physical and engineering properties of jute material are shown in table 2.

Figure 1: 20mm Pieces of jute fibre Admixture

Table 2: Summary of the Physical and Engineering Properties of the Tested jute fibre Material

Sr. No.	Property	Range / Value
1	Fibre length, mm	20
2	Fibre Diameter, mm	0.3 – 0.45
3	Specific Gravity	1.32
4	Bulk Density, Kg/m^3	1290
5	Ultimate tensile strength, N/mm^2	3350
6	Modulus of Elasticity, N/mm^2	74
7	Elongation at Break, (%)	2.5 - 3

III. TEST PROGRAM AND PROCEDURE

The laboratory investigation on fine sand stabilization with jute fibre pieces as admixture was performed. This work is done for beneficial utilization of jute fibre and a mix proportion that can be mixed with fine sand as a best stabilizer with limited detrimental effects. The objective of the present study is to evaluate the use of fine sand as a construction material after stabilizing it with jute fibre as admixture. The present study has been undertaken with the following objectives:

1. To study the effect of moisture content on dry density of fine sand.
2. To study the changes in compressive strength of fine sand of different dry densities mixed with jute fibre in different proportions.

3.1 Test Program

The test program included the preliminary tests for fine sand and mix compositions of fine sand with jute fibre. Following tests were carried out:

1. Determination of particle size distribution of fine sand.
2. Standard Proctor Test (Proctor Compaction Test) for determining different dry densities for fine sand.
3. Unconfined Compressive Strength Test to determine compressive strength of fine sand and mix compositions with jute fibre.

Table 3 shows the variables which are investigated in present study.

Table 3: Variables Investigated

S. No.	Effect of	Variables	Range Investigated
1	Moisture content in sand	Dry density	Various ranges
2	Jute Fibre on different properties of sand	Length	Jute are 20mm size
3	Mix Jute Fibre by dry weight of sand	Proportion percentage	0.5%, 1%, 1.5% and 2%

3.1.1 Particle Size Distribution or Gradation Test of Fine sand

The particle size distribution test or gradation test was carried out with Indian Standard Sieve size 4.75 mm, 2.36 mm, 1.18 mm, 600 µ, 425 µ, 300 µ, 150µ, 75µ, pan and weigh balance in the laboratory.

A typical sieve analysis involves a nested column of sieve with wire mesh cloth (screen). 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 base is a round pan, called the receiver. The sample was shaken vigorously 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.

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

Where W_{sieve} is the weight of aggregate in the sieve in gm

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 4, table 5 and figure 2.

Table 4: Particle Size Distribution of Fine Sand

S.No.	Sieve Size	Weight Retained (gm)	% Weight Retained	Cumulative % Weight Retained	Cumulative % Weight Passing	% Finer
1.	10	86.98	10.23	10.23	89.77	89.77
2.	6.25	126.41	14.87	25.10	74.90	74.90
3.	4.75	64.15	7.55	32.65	67.35	67.35
4.	2	447.58	52.66	85.31	14.69	14.69
5.	1	18.94	2.23	87.54	12.46	12.46
6.	0.425	29.91	3.52	91.06	8.94	8.94
7.	0.15	9.76	1.15	92.20	7.80	7.80
8.	0.075	5.96	0.70	92.90	7.10	7.10
9.	0.04	60.21	7.08	99.99	0.01	0.01

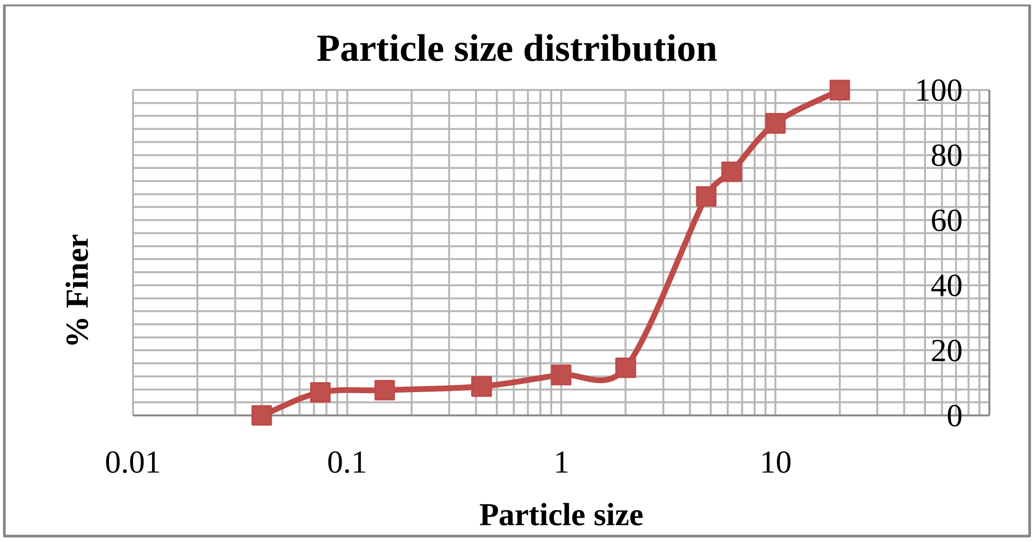

Figure 2: Particle Size Distribution Curve

Table 5: Results of Particle Size Distribution

S. No.	Property	Test Media (Fine Sand)
1.	Coefficient of Uniformity (C_u)	1.28
2.	Coefficient of Curvature (C_c)	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%

3.1.2 STANDARD PROCTOR TEST

Standard proctor covers the determination of the relationship between the moisture content and density of soils. The standard proctor test was performed in accordance with IS 2720 (Part VII) on fine sand. 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 are used. The mould had 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.

The result tabulated in table 6 and figure 3 shows that on increment of moisture content, dry density first decrease and then increase. In the curve dry density first decrease due to bulking of sand. After reaching maximum dry density on optimum moisture content, dry density decreases.

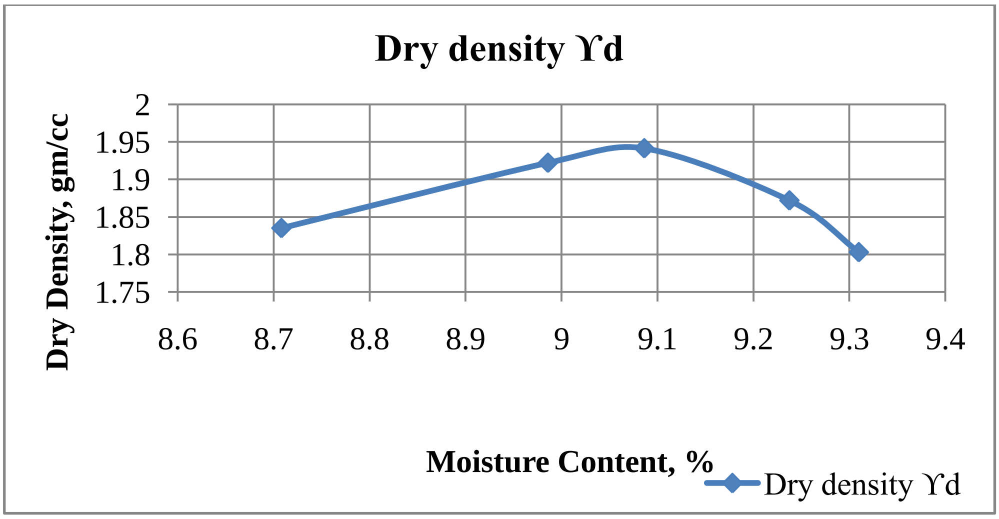

Figure 3: Dry Density v/s Moisture Content Curve

3.1.2.1 Comparative Study

A comparative study of variation of dry density and moisture content with jute fibre percentage has been made from the test results. The variation of moisture content graphs, showing on Y-axis corresponding jute fibre percentage 0.5 %, 1%, 1.5% and 2% admixture have been shown figures 4.

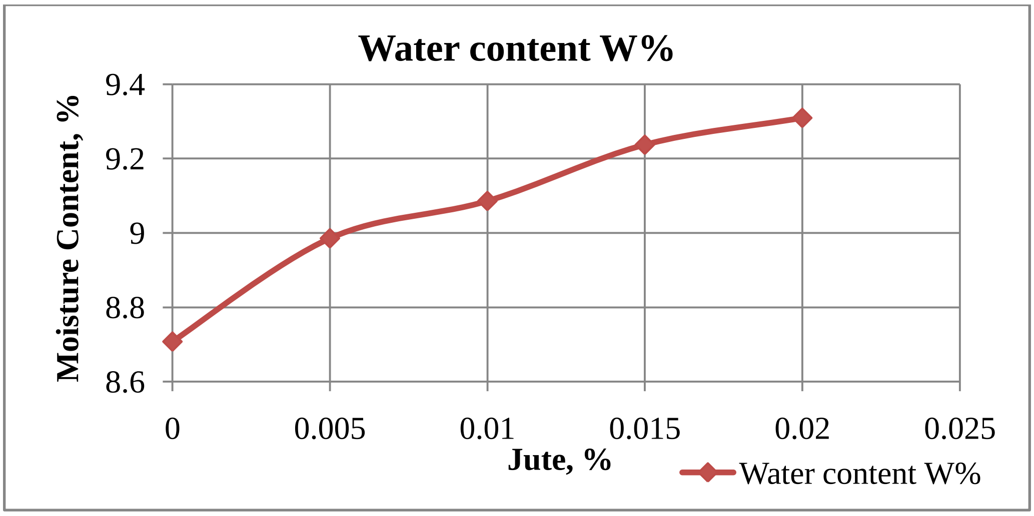

Figure 4: Moisture Content v/s Jute % Curve

Another comparative study of variation of dry density and moisture content with jute fibre percentage has been made from the test results. The variation of dry density graphs, showing on Y-axis corresponding jute fibre percentage 0.5 %, 1%, 1.5% and 2% admixture have been shown figures 5.

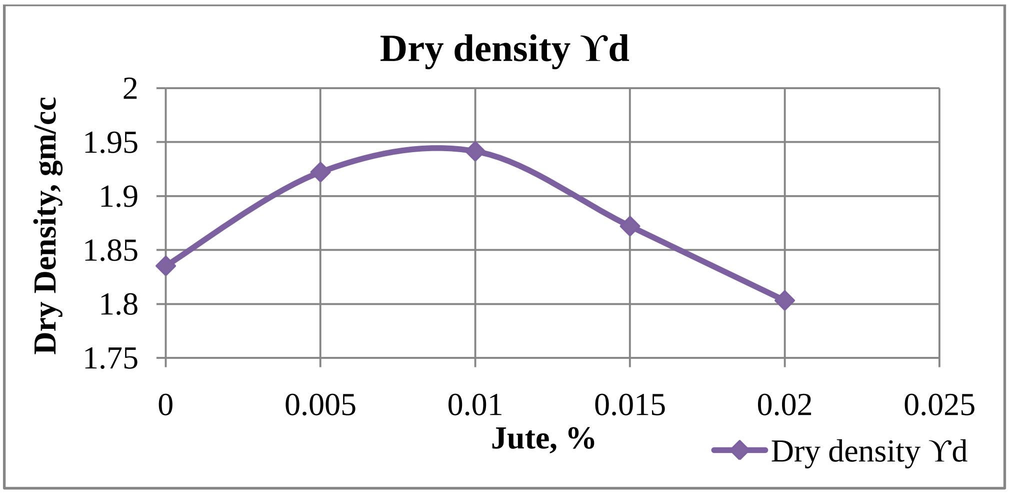

Figure 5: Dry Density v/s Jute % Curve

Table 6: Properties of composite soil

% Jute	0%	0.50%	1%	1.50%	2%
Weight of empty mould(Wm) gms	2072	2072	2072	2072	2072
Internal diameter of mould (d) cm	10	10	10	10	10
Height of mould (h) cm	13	13	13	13	13
Volume of mould (V)=(π/4) d2h cc	1000	1000	1000	1000	1000
Weight of Base plate (Wb) gms	2068	2068	2068	2068	2068
Weight of empty mould + base plate (W') gms	4140	4140	4140	4140	4140
Weight of mould + compacted soil + Base plate (W1) gms	6135	6235	6258	6185	6105
Weight of Compacted Soil (W1-W') gms	1995	2095	2118	2045	1965
Weight of Container (X1) gms	20.27	20.27	20.27	20.27	20.27

Weight of Container + Wet Soil (X2) gms	84.81	85.4	85.7	85.9	85.56
Weight of Container + dry soil (X3) gms	79.64	80.03	80.25	80.35	80
Weight of dry soil (X3-X1) gms	59.37	59.76	59.98	60.08	59.73
Weight of water (X2-X3) gms	5.17	5.37	5.45	5.55	5.56
Water content W%= X2-X3/X3-X1	8.71	8.99	9.09	9.24	9.31
Dry density $\Upsilon d = \Upsilon_t/(1 + (W/100))$ gm/cc	1.84	1.92	1.94	1.87	1.80

3.1.3 Unconfined Compressive Strength Test

After the compaction test the compressive strength of the sample is measured. Cylindrical specimen is compacted by static compaction in 3.8 cm diameter and 7.6 cm high mould. The inner surface of the mould is lubricated with mobile oil so as to extrude the sample from mould with minimum disturbance. The sample is placed inside the specimen mould in seven layers using spoon, leveled and gently compacted. Pressure pad will be inserted into the mould and the whole assembly will be statically compacted in loading frame to the desired density. The sample is to be kept under static load for not less than 10 minutes in order to account for any subsequent increase in height of sample due to swelling. The sample will then be removed from the mould with the help of sample extruder. Initial dimensions are measured.

From UCS test conducted for the same sample, the strength of samples shows increasing tendency for some samples with the increment of jute percentage in the soil strength. The unconfined compressive strength in both the samples increases with the increase in percent of jute up to 1.5 %. The UCS decreases with further addition of jute. Considering results of the samples the maximum UCS observed at the 3.62 as shown in table 7 and figure 6.

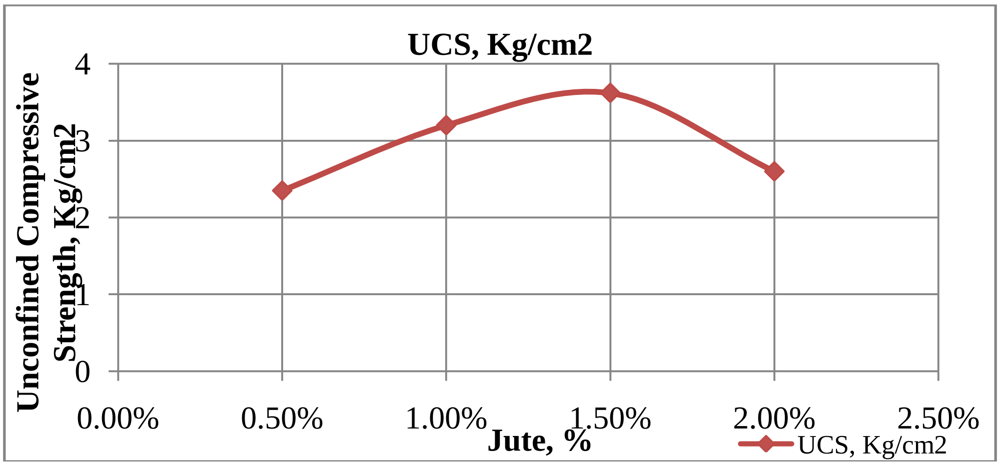

Figure 6: Unconfined Compressive Strength

Table 7: Unconfined Compressive Strength

Sr. No.	Jute	UCS, Kg/cm^2
1	0.50%	2.22
2	1%	3.4
3	1.50%	3.82
4	2%	3

IV. CONCLUSIONS

In this investigation we have used jute fibre pieces in different proportions to study its effect on various geotechnical properties of fine sand of Western Rajasthan. The results of the testing program clearly show that the engineering properties of the fine sand improved considerably due to stabilizing with jute fibre Geotextile. In the present investigation, as we are increasing the quantity of admixture of jute fibre pieces, the compressive strength increases. So we have stopped the further increment of admixture. Further study can be done by addition of more amount of admixture.

The jute-sand stabilization is found to be very much effective for stabilizing the soil, the changes observed in the soil after stabilization is remarkable. Based on the observations and the results obtained, it can be concluded that the dry density increases with the increase of jute textile and maximum dry density was obtained at 1 % addition of Jute textile.

The unconfined compressive strength increases with the increases of jute textiles up to 1.5%, whereas the maximum unconfined compressive strength was reported at 1.5% is 3.82 Kg/cm^2 Jute fibre textile content.

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