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ENHANCEMENT OF ENGINEERING PROPERTIES OF SAND BY USING JUTE FIBRE AS A SOIL STABILIZER

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Abstract —***Soil is a base of structure, which actually supports the structure from beneath and distributes the load effectively. If the stability of the soil is not adequate then failure of structure occurs in form of settlement, cracks etc. Sub grade soil is an essential part within the pavement structure because it provides support for that pavement from beneath. The qualities of sub grade soil are very important in the perception of pavement structure. Elevated earth can be a composite material that's a mix of soil and reinforcement, placed to address the developed tensile stresses plus it enhances the resistance within the soil for the finest stress. Jute fibre is a promising reinforcement for use in composites on account of its low cost, low density, high specific strength and modulus, no health risk, easy availability, renewability and much lower energy requirement for processing. In recent years, there has been an increasing interest in finding new applications for jute fibre reinforced composites that are traditionally used for making ropes, bags, hessians, sacking, mats, and carpet. The object of the present investigations is to study the strength characteristics of sand of western Rajasthan stabilized with cheap and readily available material like Jute fibre. Sand which covers a big part of western Rajasthan is weak in strength and possesses problems in construction of road. Soils are permeable materials because of the existence of interconnected voids that allow the flow of fluids when a differencein energy head exists. This study discusses the possibility of stabilization of sand using jute fibre as admixture. The varying percentage 0.10%, 0.20, 0.50%, and 1% of strips of Jute fibre mixed with sand of different densities 1.54gm/cc, 1.56gm/cc and 1.58gm/cc (M.D.D.). All the C.B.R. Tests were conducted at different mix compositions of jute fibre and 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 sand using jute fibre as admixture improves the strength characteristics of the sand so that it becomes usable as construction of embankment.***

Keywords-C.B.R. Test, Jute fibre, Sand.

I. INTRODUCTION

Soil has been used as a construction material from time immortal. Being poor in mechanical properties, it has been putting challenges to civil engineers to improve its properties depending upon the requirement which varies from site to site. During last 25 years, much work has been done on strength deformation behaviour of fiber reinforced soil and it has been established beyond doubt that addition of fibre in soil improves the overall engineering performance of soil. Among the notable properties that improved are greater extensibility, small loss of post peak strength, isotropy in strength and absence of planes of weakness. Fiber reinforced soil has been used in many countries in the recent past and further research is in progress for many hidden aspects of it. Fiber reinforced soil is effective in all types of soils (i.e. sand, silt and clay). Use of natural material such as Jute, coir, sisal and bamboo, as reinforcing materials in soil is prevalent for a long time and they are abundantly used in many countries like India, Philippines, Bangladesh etc. The main advantages of these materials are they are locally available and are very cheap. They are biodegradable and hence do not create disposal problem in environment. Processing of these materials into a usable form is an employment generation activity in rural areas of these countries.

Soil stabilization is the process of improving the Engineering properties of the soil and thus making it more stable. It is required when the soil available for construction is not suitable for the intended purpose. In its broadest senses, stabilization includes compaction, preconsolidation, drainage and many other such processes. Stabilization is being used for a variety of engineering works, where the main objective is to improve the performance of permeability, increase the strength, durability or to prevent dust generation and erosion of soil and to reduce the construction cost by making best use of locally available materials.

Jute fibres are usually strong with low extensibility. It has a tenacity range of 4.2 to 6.3 g/ denier, depending on the length of the fibre. Elongation-at-break of jute fibres is between 1.0% and 1.8%. Tossa jute is stronger than white jute. Jute fibre breaks within elastic limit and is resilient which is evident from its recovery to the extent of 75% even when strained quite a bit (1.5%). Its flexural and torsional rigidity are high compared to cotton and wool. Presence of hemicellulose in jute fibres makes it hygroscopic, second only to wool. Tossa jute is slightly more hygroscopic than white jute. Jute fibres swell on absorption of water. Jute is not thermoplastic like other natural fibres. Charring and burning of jute fibres without melting is a feature of jute fibres. Due to high specific heat, jute possesses thermal insulation properties. Ignition temperature of jute is of the order of 193° C. Long exposure of jute fibresto hot ambience reduces the fibre strength. The stability and reliability of geotechnical structures can therefore be achieved by reinforcing the soil. Towards this end, randomly reinforcing the soil by using jute fibre may provide an easy and sometimes an economical means to improve the engineering performance of soils.The laboratory tests studies have been done on by direct admix of sand with pieces of jute fibre.

II. LITERATURE REVIEW

Bairagi, (2014) studied the Effect of jute fibers on engineering characteristics of black cotton soil and gave result that CBR and UCS values of soil were increased significantly when mixed with jute fiber from 0% to 5%. Choudhary et al, (2012) studied the improvement in CBR of expansive soil with a single Jute reinforcement layer and gave results that reinforcement in layer controls swelling and enhances CBR value. Singh, (2013) conducted work on strength and stiffness of soil reinforced with jute geotextile sheets and concluded that there is increase in shear strength of soil with inclusion of jute in soil. Pandit et al, (2016) conducted experimental work on Effects of Jute Fiber on Compaction Test and concluded that OMC of soil increases upto 1.25% of jute fibres and then decreases for 1.50%. MDD decreases upto 1.25 % of jute fibre and then increases for 1.50%. Das and Singh, (2014) studied on Deformation and strength Characteristics of jute geotextile in reinforced soil concluded that jute layer reinforcement is very effective in stabilizing and protecting of weak soil. Gill and singh, (2012) studied CBR improvement of clayey soil and concluded that CBR was improved by 9.4% with different positions of layer. Jagan, (2016) conducted a case study on a critical review on applications of natural jute fibers and concluded that the cbr value of soil was increased after mixing the jute fiber in soil.

III. MATERIALS USED

2.1. Sand

Sand is found in abundance in western Rajasthan (India). The sand used in present study was brought from location near from Mathaniya town, at about 30-35 km away from Jodhpur, Rajasthan on Jodhpur–Phalodi Highway. Sand is fine grained, uniform clean sand as per Unified Soil Classification System. Particle size ranges between 75 μ to 4.75 mm which is fine to coarse sand, round to angular in particle shape as per Indian Standard Classification system.

2.2. Jute Fibre

The jute fiber used was procured from the local market. The diameter of the thread was 4 mm and 8 mm and length was 15 mm and 30 mm. These fibers were generally available in the threaded form. These were mechanically woven fibers with very fine threads. The physical appearance of jute thread is shown in Figure 1.

Figure 1:- Jute fibre

Table 1:- Properties of Jute Fibre

S. No.	Property	Value
1.	Color	Yellowish brown
2.	Specific Gravity (G_s)	1.14
3.	Diameter Used (mm)	4 and 8
4.	Length Used (mm)	15 and 30
5.	Hoiocelluiose (%)	85-89
6.	Lignin (%)	10-12
7.	Wax (%)	0.5 to 0.80

8.	Ash (%)	0.5 to 1.08
9.	Nitrogen (%)	0.6

III. TEST PROGRAM AND PROCEDURE

The laboratory investigation on sand stabilization with Jute Fibre as admixture was performed. This work is done for beneficial utilization of Jute Fibre and a mix proportion that can be mixed with sand as a best stabilizer with limited detrimental effects.

The objective of the present study is to evaluate the use of sand as a construction material after stabilizing it with Jute Fibre as admixture. The present study has been undertaken with the following objectives:

1. Determination of particle size distribution of sand.
2. To study the effect of moisture content on dry density of sand.
3. C.B.R. test to determine shear stress of sand and mix compositions with Jute Fibre.

3.1. Sieve Analysis or Particle Size Distribution Test

The grain size distribution is found out by conducting sieve analysis test. The test was carried out with Indian Standard Sieve size 4.75 mm, 2.0 mm, 1.18 mm, 600 µ, 300 µ, 150 µ, 75 µ, pan and weigh balance in the laboratory. In sieve analysis there is a nested column of sieve with wire mesh screen. A representative sample of 1000 gm of sand have been taken for the analysis and poured into the top sieve which has the largest screen opening of 4.75 mm. The sieves are arranged in descending order from top to bottom according to their opening size. The base is a round pan, called the receiver. 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. The cumulative percentage passing of the sample is found by subtracting the percent retained from 100%.The particle size distribution curve plotted on semi-log scale is shown in Fig. 2.

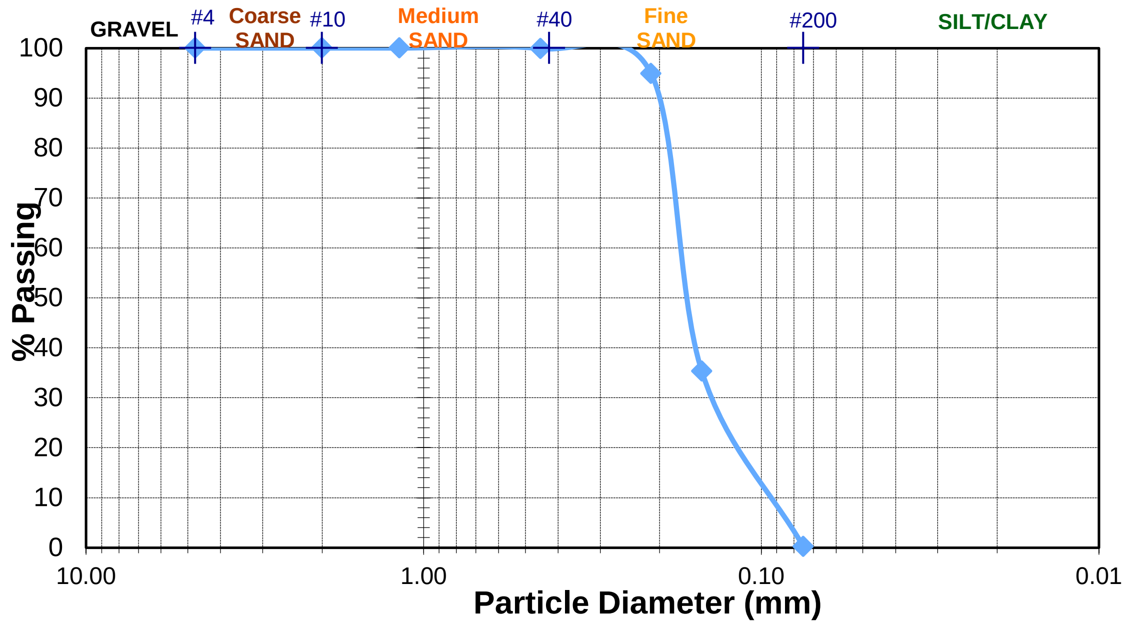

Figure 2:- Particle Size Distribution Curve

Table 2:- Properties of Sand.

S. No.	Property	Test Media (Sand)
1.	Coefficient of Uniformity (C_u)	1.30
2.	Coefficient of Curvature (C_c)	1.09
3.	Mean Diameter (D_{50}) mm	0.28
4.	Effective Size (D_{10}) mm	0.19
5.	Fine Soil Fraction (75 µ)	0.10%

3.2 Standard Proctor Test.

According to IS 2720 (Part VII), in the proctor test the mould recommended is of 100 mm diameter, 127.3 mm height and 1000 ml capacity. About 3 kg of air dried samples were taken for the test. The soil is compacted by 25 blows of the rammer of 2.6 kg mass, with a free fall of 310 mm and a face diameter of 50 mm. the soil is compacted in three layers. The mould is fixed to a detachable base plate.

The result shows that initial decrease of dry density with addition of water is due to capillary tension which is not fully counteracted by the compacted effort and holds the particle in loose state resisting compaction. Dry density further increase with water content and then decrease with further increase in water content. The maximum dry density is obtained as 1.58 gm/cc at O.M.C 12.34%. Two more dry densities as 1.54 gm/cc and 1.56 gm/cc were considered for the present study.

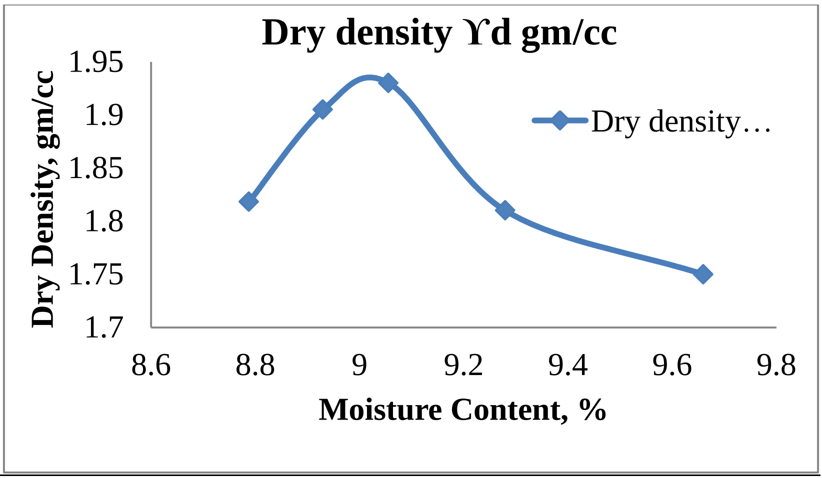

Fig 3:- Dry Density v/s Moisture Content Curve.

3.3. C.B.R. Test.

In CBR test, 5 kg of soil was taken and mixed with water corresponding to required dry density and proportion of jute fibre. The mix was compacted in 2250 ml CBR (150 mm diameter and 127.3 mm height) using light compaction. The mix was compacted in three equal layers; each layer being given 56 uniformly distributed blows of 2.6 kg hammer. Top surface of the specimen was finished properly to make it for even loading test. For the soaked condition, the samples were tested for the determination of CBR values on the next day.

For obtaining the CBR values of unsoaked and soaked samples, penetration tests were done. The mould, containing the specimen was mounted on the testing machine and a surcharge weight equal to 5 kg (two spacer discs) was placed on the top of specimen before starting the penetration test. After setting the plunger on the surface of specimen, setting the load and penetration measuring dial gauge to read zero, the load was applied. Load readings at every 0.5 mm penetration were noted and a graph was drawn between the actual load (ordinate) and penetration (abscissa). In most of the tests the curve was either straight or convex upwards in the initial portion. In such cases the test load corresponding to 2.5 mm and 5.0 mm were read from the curve. In the case of the initial upward concavity, the corrected zero is obtained by drawing a tangent to the curve at the point of the greatest curvature. The corresponding to 2.5 mm and 5.0 mm penetration are measured from the corrected zero.

Test results obtained show that CBR value increases with increase in dry density of sand. The CBR value also increases with increase in percentage of jute fibre for same dry density sand. The test results are shown in tables and graph.

Comparative Study:-

The variation in CBR values have been tabulated and graphically represented in table 3, figure 4, for unsoaked condition and in table 4 and figure 5 for soaked condition. On the graph, at abscissa (X-axis) dry density of sand varying 1.54 gm/cc, 1.56 gm/cc and 1.58 gm/cc has been marked and on ordinate (Y-axis) CBR values in % have been plotted for mix compositions of jute fibre of different percentage 0.10%, 0.20%, 0.50%, and 1%.

It can be seen that on increment of dry density, the CBR value of the mix composition increases. The CBR value of the mix composition also increases as the percentage of admixture increases for both unsoaked and soaked conditions. Hence it can be concluded that to use the mix compositions in base and sub base construction, the CBR values can be increased or decreased as needed.

Table 3: CBR Value Variation in Mix Compositions in Unsoaked Conditions

Dry Density (gm/cc)	CBR (%) Mix Composition			
	0.10% Admixture	0.20% Admixture	0.50% Admixture	1% Admixture
1.54	2.384	2.86	3.099	6.286
1.56	2.384	2.861	3.338	7.868
1.58	3.815	4.292	4.53	8.226

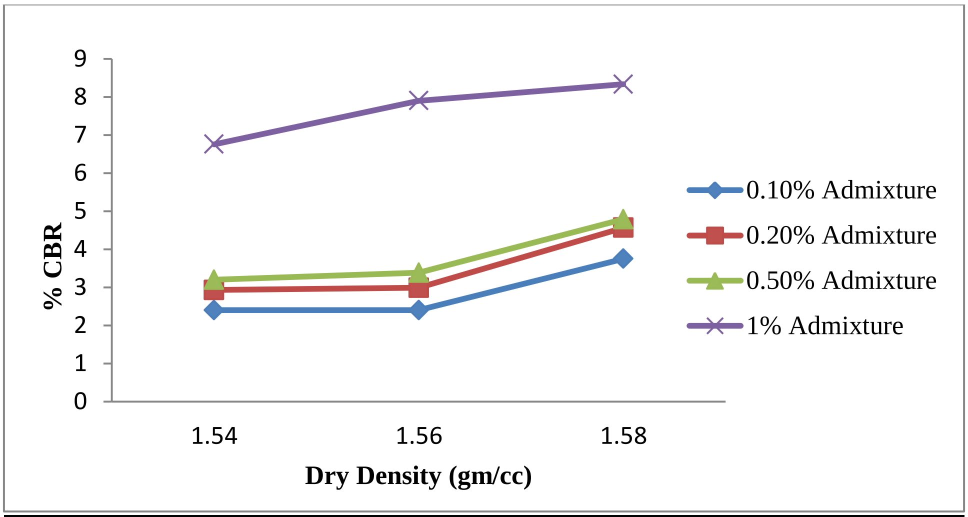

Figure 4: CBR Value Variation in Mix Compositions in Unsoaked Conditions

Table 4: CBR Value Variation in Mix Compositions in Soaked Conditions

S.No.	Mix Composition	CBR (%)
1.	1.58 gm/cc dry density sand mixed with 0.10% Admixture	1.07
2.	1.58 gm/cc dry density sand mixed with 0.20% Admixture	1.43
3.	1.58 gm/cc dry density sand mixed with 0.50% Admixture	1.67
4.	1.58 gm/cc dry density sand mixed with 1% Admixture	2.38

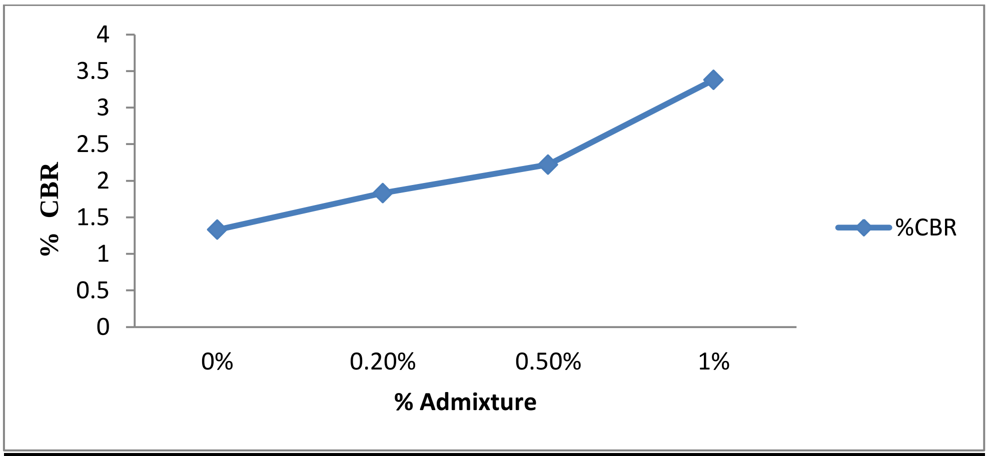

Figure 5: CBR Value Variation in Mix Composition in Soaked Conditions

IV. CONCLUSIONS

In this investigation we have used jute fibre pieces in different proportions to study its effect on various geotechnical properties of sand of Western Rajasthan. The results of the testing program clearly show that the engineering properties of the sand improved considerably due to stabilizing with jute fibre. 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.

CBR tests were performed on mix compositions of fine sand and square pieces of jute fibre as admixture. Jute fibre of varying percentage 0.10%, 0.20%, 0.50%, and 1% were mixed with sand of different densities 1.54 gm/cc, 1.56 gm/cc and 1.58 gm/cc. A linear increment was observed in CBR values in both unsoaked and soaked conditions. For unsoaked condition, CBR values are greater than that of soaked condition for same dry density of sand and same quantity of admixture. As the CBR value is increasing, the required thickness for flexible pavement is reduced.

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