Experimental Investigation of Shear strength and Permeability of River sand Reinforced with Rice Straw Fiber

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ABSTRACT

Several researchers have developed Sand reinforcement methods in order to enhance engineering properties and their Index properties of Sand over the last few decades. This paper describes an experiment that looked at how adding randomly focused Rice Straw to an alluvial fine to medium sand in a loose state affected its behavior. The effect of fiber inclusion on the shear strength and permeability of reinforced sand is investigated at low, medium, and high strain levels. A soil layer mass that includes randomly distributed discrete components, i.e. fibers, can be described as a principle of reinforced soil with their fiber., i.e. fibers (Rice Straw fiber), that contribute to the improvement of the soil matrix's engineering properties and mechanical behavior Permeability and direct shear test conduction with improved fiber (Rice Straw fiber) percentages of 0.5%, 0.75% and 1.%. Comparison of findings from river sand and fiber addition. The use of fiber inclusions to improve the mechanical properties of weak sands is a geotechnical engineering technique that has recently gained popularity.

Keywords: Index properties, Rice Straw fiber, Shear strength, Permeability, Direct Shear test.

INTRODUCTION

India which has a large geographical area and population, demands vast infrastructure that is network of roads and buildings. Universally land is being used for various formations from ordinary house to high rise, airports to bridges and from rural roads to highways. Sand is a granular material consisting finely divided rocks and mineral particles of sand has various configuration but is described by its grain size gravel are bigger than sand grains and silt is coarser. Sand has a number of drawbacks, including a lack of cohesion and a loose particle structure, as well as a high porosity. These sand limitations can trigger a number of engineering hazards if they are not strengthened. (Rao, G.V., Balan, K. 2000). The stability of a sandy slope, for example, was severely harmed by liquefaction caused by ground vibrations and erosion caused by seepage after heavy rains. Riverbank sandy slopes erode and eventually collapse due to landslides and other natural disasters, resulting in channel blockage. (Helming et al., 2006; Wan and Fell, 2004; Xiao and Shwiyhat, 2012) Civil engineers are concerned about the existence of soft soils near infrastructure building projects because of their low shear strength and excessive deformations. Soft soil disposal is both time taking and is not cost effective. Additionally, the construction of Infrastructure built on soft soils can necessitate ongoing post-construction maintenance minimize the danger. Soft clays and marine deposits can be found up to large depths in coastal soil layers, posing a risk to houses, highways, and rail tracks built on them. Infrastructure projects must be built on soft compressible soil deposits due to project alignment, which also necessitates the substitution of lower-quality bearing materials or the use of ground improvement techniques. (Gray D.H., Ohashi H., 1983) Soft soil stabilization is a popular option for many infrastructure projects. The soil Mechanical, chemical, and biological approaches to stabilization are available. Reduce the post-settlement of structures by increasing the density of the soil by compaction based on soft soils with effective drainage systems or chemical or biological amendments additives to strengthen the mechanical properties of certain difficult soils. Many engineering applications necessitate that polymers' strength and stiffness be increased in order to withstand stress. (Vidal H 1978) Adding reinforcing fillers in the form of fibers to composites is one way to accomplish this with increased stiffness and strength Glass, Rice Straw , rice straw, and other synthetic fibers are commonly used as insulation for polymers.

Natural fibers, such as jute, coir, and grass, on the other hand, are biodegradable, environmentally friendly, and abundant in India. They can be used as an additive if they are suitable sand and dirt in the sub base and sub grade as a product of a rise in strength and a decrease in strength the power to deform the cost of such an application would be reduced road building, by allowing for a thinner layer of asphalt paving stones the addition of fibers to constructions is required. To create a more compact interlocking mechanism between the

AIMS AND OBJECTIVES

This study contains various objectives and they are as follows:

- To determine the effect of percentage of fibers on the strength on Rice Straw Fiber reinforced sand.
- To determine the effect of percentage of fibers on the Permeability on Rice Straw fiber reinforced sand.
- To determine the effect of percentage of fibers on the strength and Permeability on Rice Straw fiber reinforced sand.
- To determine the effect of percentage of fibers on the Relative Density on Rice Straw fiber reinforced sand.
  IS classification of particle size

Materials and Methodology:
River sand:

River sand is a fine-grained building sand that can be found between rivers and lakes. This sand is white-grey in nature and is one of the fine-graded sands used in building construction. They're used mostly in masonry and concrete work. They're also good for RCC, plastering, and a number of other brick and block works. This sand has a finer texture and more good grain shape. The river or natural sand, but in the other hand, needs very little water. The moisture trapped between these particles is useful in a variety of construction material. The silt content of a medium quality river sand varies from 5 to 20%. River sand becomes less costly since it is obtained naturally. This kind of sand is used in construction and involves silica.

Sand properties	Values
Specific gravity , Gs (mm)	2.67
Mean particle size , d10 (mm)	0.20
Mean particle size, d60(mm)	0.71
Uniform coefficient, Cu	3.55
Curvature coefficient , Cc	1.2
Maximum void ratio,Emax	1.19
Minimum void ratio, Emin	0.81

Table 1: properties of sand

Rice straw:

Paddy Grass is an agricultural by product which is fibrous in nature so we are using it to stabilize river sand. Natural fibers are now widely used for a variety of engineering areas of applications, such as the automobile, food, and agricultural industries, advantages such as low cost, durability, cost benefits, low density, desirable strength, stiffness, and other qualities. Rice straw fibre had a specific gravity of 1.25 to 1.5

Liquid Latex

Liquid latex is usually made of 33% latex and 66% water and less than 1% ammonia (to increase its shelf life and to control the pH of the solution). It is used as preservative to prevent decay of rice straw as it dries, it solidifies to a rubbery consistency and in the process ends up shrinking.

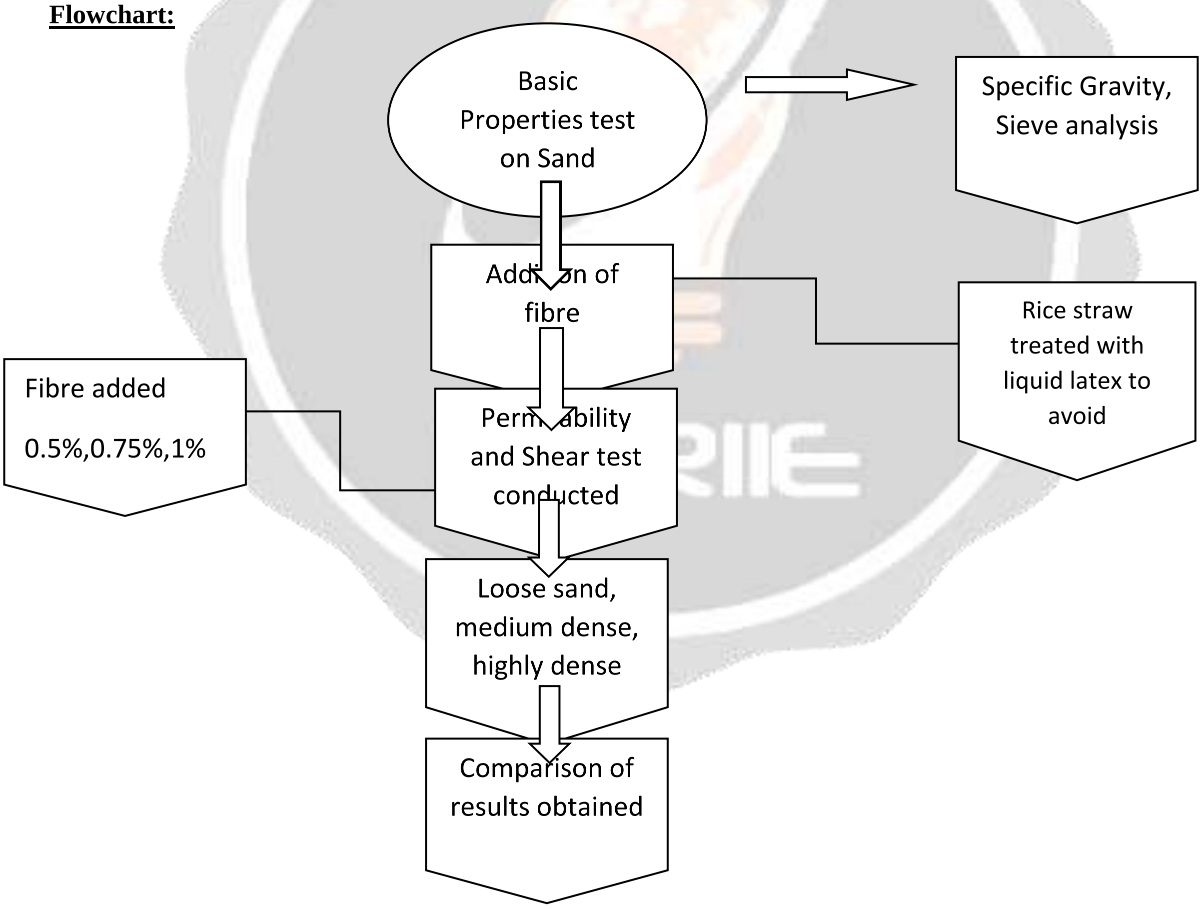
METHODOLOGY:

Basic tests performed on the River sand:
1) Specific gravity as per IS 2720: part 3:1985
2) Particle size distribution IS 2386: part 1:1963
Further tests conducted on the sample are:
1) Permeability test as per IS 2720-17:1986
2) Direct shear test as per IS 2720: part 15:1986

Preparation of Sample:

By studying the literature, stabilization of sand using Rice Straw looks to be economical and Effective. In this test we are going to stabilize the river sand by keeping the length of Rice Straw Fibers constant and varying the percentage of fibers. The length of rice straw is taken as 6mm And percentage of fiber to be added is 0.5%, 1%, 1.5%. In a similar way the length of Rice Straw is changed to 12mm and varying percentage of fiber is added 0,5%,1%,1.5%. As the Rice Straw Fiber taken is an organic material it will decomposes in sand after few days so to overcome this Hurdle the Rice Straw is treated with liquid latex to prevent it from decaying after mixing with Sand. At the end we are going to compare the results obtained by various tests with the basic Properties of river sand

Flowchart:



Here basic properties tests are done on the river sand such as specific gravity test, sieve analysis and specific gravity of sand is 2.67 after the initial tests on the sand further Emax and Emin are found out for the sand by considering relative density as 30%, 50%, 70% for loose sand, medium dense, highly dense state and fiber content in the sand is varied from 0% to 0.5%, 0.75%, 1% before the tests the rice straw fiber is treated with liquid latex to avoid the decomposition of the fiber (rice straw) as it is a natural polymer and further shear strength and permeability tests are conducted on the sand with varying percentage of fibers. In shear strength tes relative density is taken as 30%, 50%, 70% and the normal stresses are considered as 50kpa, 100kpa, 150kpa according to IS code the tests are conducted similarly in permeability fiber is added after the initial tests in varying content 0.5%, 0.75%, 1% and the results obtained are compared and the conclusions are drawn

Tests Performed on the river Sand

Specific gravity:

The test has been performed as per the IS 2720: part 3:1985 specific gravity. The specific gravity of sand is used in calculating the permeability of sand and shear strength. The specific gravity of sand is used to calculate the density of the sand.

Particle Size Distribution:

The test has been performed as per IS 2386: part 1:1963. It is a list of values or a mathematical function that defines the relative amount, typically by mass, of particles present according to size

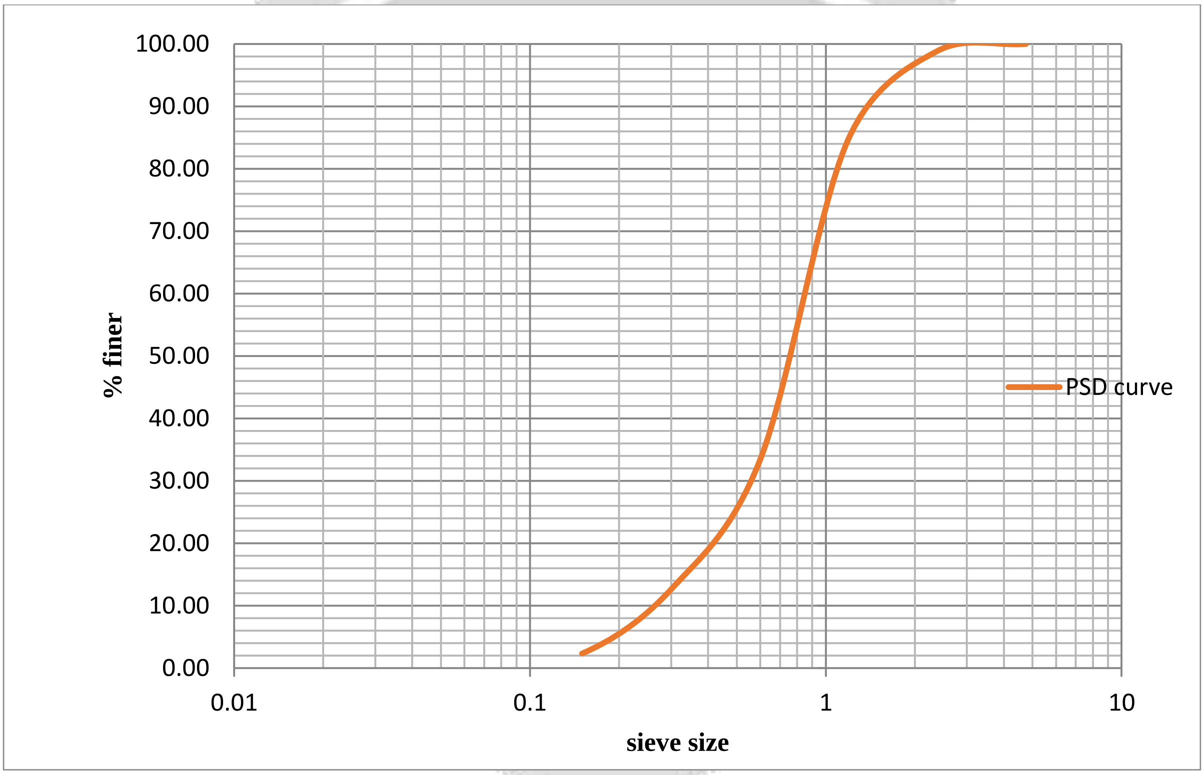


***Figure 1**: Particle size distribution curve for river sand*

Permeability test:

The test is performed as per IS 2720-17:1986. It is to determine the coefficient of permeability(K) of a sample, which is defined as the rate of flow of water under laminar flow conditions through a porous medium area of unit cross section under unit hydraulic gradient

Direct Shear test:

The test is performed as per IS 2720: part 15:1986. The purpose of direct shear test is to determine the shear strength of sand this is done by forcing the sand to shear along an induced horizontal plane of weakness at constant rate peak shear stress and residual shear stress is noted down

Results and Discussions:

After the initial analysis of the sand according to the above mentioned methodology following our objective we found the following results

Shear strength of sand with fiber content

The shear strength parameter was calculated by varying the percentage of fiber content in the sand. The relative density of the sand was kept constant i.e 30%, 50%, 70% and the length of the fiber is kept 5mm and fiber content was varied for each and every relative density fiber content is taken as 0.5%, 0,75%, 1% after conducting the shear strength test we got the following stress-strain graphs

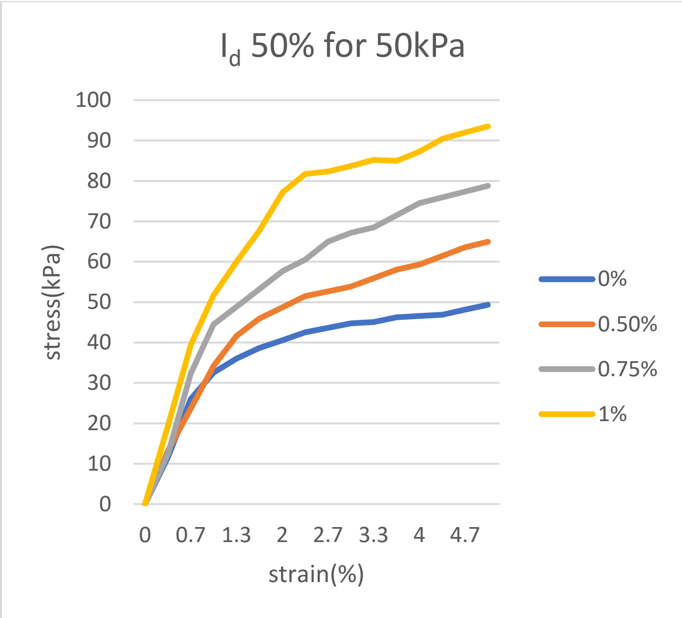


Figure 2: stress-strain graph for 50% I_d and 50kPa normal stress

In the figure 2 relative density is constant 50% and fiber percentage is varied and normal shear stress is 50kpa. Shear strength for 0%fiber content is 49.35 kPa and for 0.5%fiber content shear strength is 64.94kPa for 0.75%strength is 78.80 kPa for 1% fiber content 93.52 kPa is the shear strength Here the enhanced strength was mainly attributed to mobilization of friction between fibers and sand from graph it is found that when normal stress increase there is enhancement in shear stress

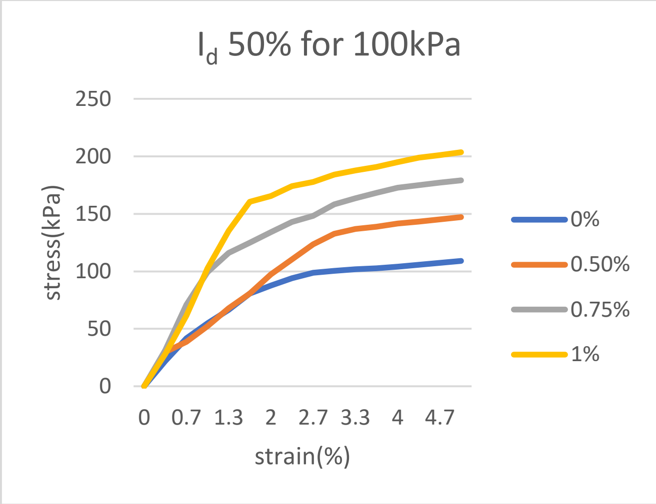


Figure 3: *stress-strain graph for 50% I_d and 100kPa normal stress*

In the figure 3 relative density is constant 50% and fiber percentage is varied and normal shear stress is 100kpa. Shear strength for 0% fiber content is 109.16kPa for 0.5% fiber content shear strength is 147.21kPa for fiber content of 0.75% strength is 178.9 kPa and for 1% fiber content 203.49 kPa is the shear strength Here the enhanced strength was mainly attributed to mobilization of friction between fibers and sand from graph it is found that when normal stress increase there is enhancement in shear stress

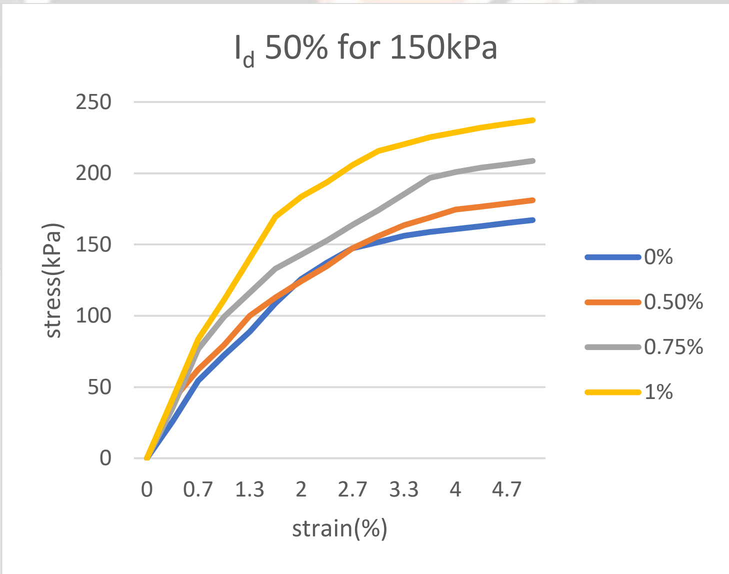


Figure 4: *stress-strain graph for 50% I_d and 150kPa normal stress*

In the figure 4 relative density is constant 50% and fiber percentage is varied and normal shear stress is 150kpa. Shear strength for 0% fiber content 167.12kPa for 0.5% fiber content 180.98kPa is the shear strength and 0.75% fiber content shear strength is 208.69 for 1% shear strength is 237.26 kPa Here the enhanced strength was mainly attributed to mobilization of friction between fibers and sand from graph it is found that when normal stress increase there is enhancement in shear stress

Fiber content	Normal stress 50kpa		Normal stress 100kpa		Normal stress 150kpa	
	Peak shear stress(kPa)	Increase rate	Peak shear stress(kPa)	Increase rate	Peak shear stress(kPa)	Increase rate
0	49.35	1	109.11	1	139.41	1
0.5	65.14	1.32	147.30	1.35	181.23	1.3
0.75	78.96	1.6	178.94	1.64	209.12	1.50
1	93.27	1.89	204.03	1.87	237.0	1.7

Effect of relative density on shear strength

We have taken relative density as 30%, 50%, 70% so that we can cover loose sand, medium dense, highly dense sand in the experiment voids in the sand will be more in loose state

In the above graphs fiber content is kept constant i.e 0.5%, 0.75%, 1% and the enhancement in strength is attributed by mobilization of friction between fibers and sand and normal stress is also kept constant i.e 50kpa, 100kpa, 150kpa

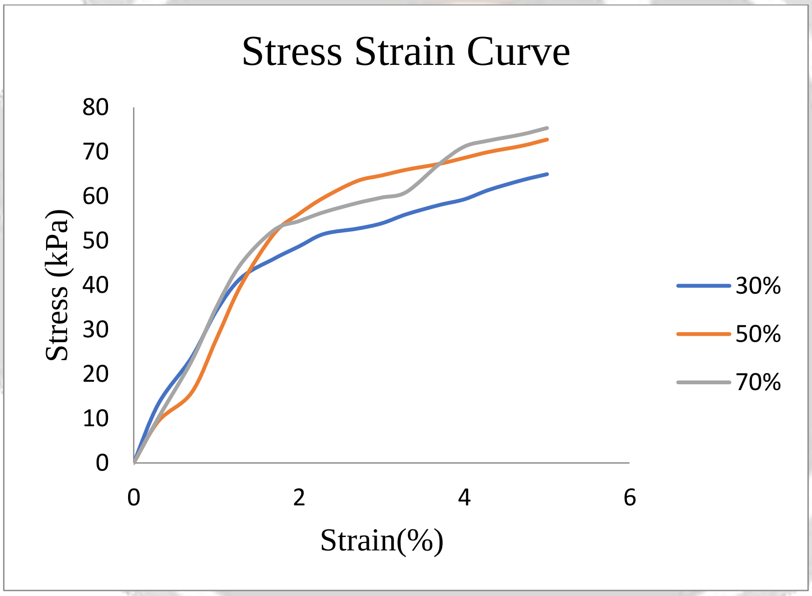


***Figure 5**: stress-strain graph for 0.5% fiber and 50kPa normal stress*

In the figure 5 fiber content is kept constant i.e 0.5% and the relative density is varied 30%, 50%, 70% and shear stress for 30% relative density is64.94 kPa for relative density of 50% shear strength is 72.73 kPa for 70% relative density shear strength is 75.33 kPa and the enhancement in strength is attributed by mobilization of friction between fibers and sand and normal stress is also kept constant i.e 50kpa

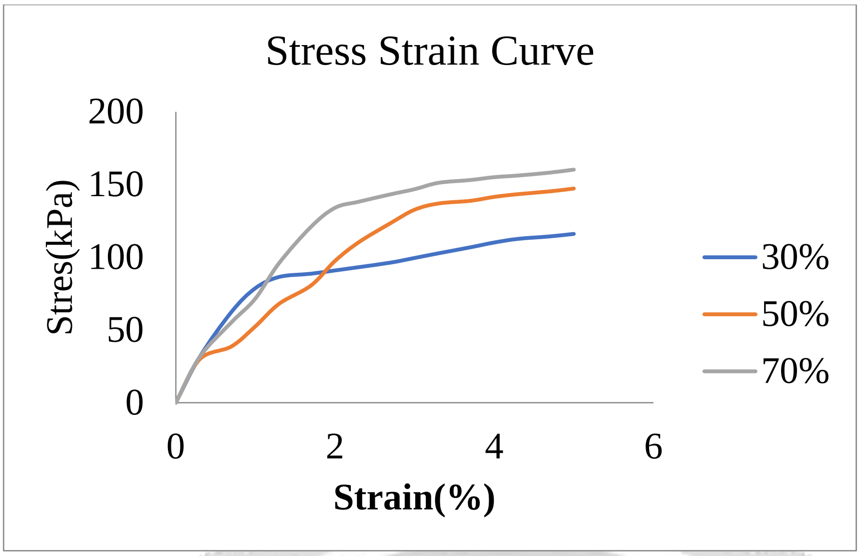


Figure 6 *: stress-strain graph for 0.5% fiber and 100kPa normal stress*

In the figure 6 fiber content is kept constant i.e 0.5% and the relative density is varied 30%, 50%, 70% and shear stress for 30% relative density is 116.03 kPa for relative density of 50% shear strength is 147.21 kPa, for 70% shear strength is 160.19 kPa and the enhancement in strength is attributed by mobilization of friction between fibers and sand and normal stress is also kept constant i.e 100kpa

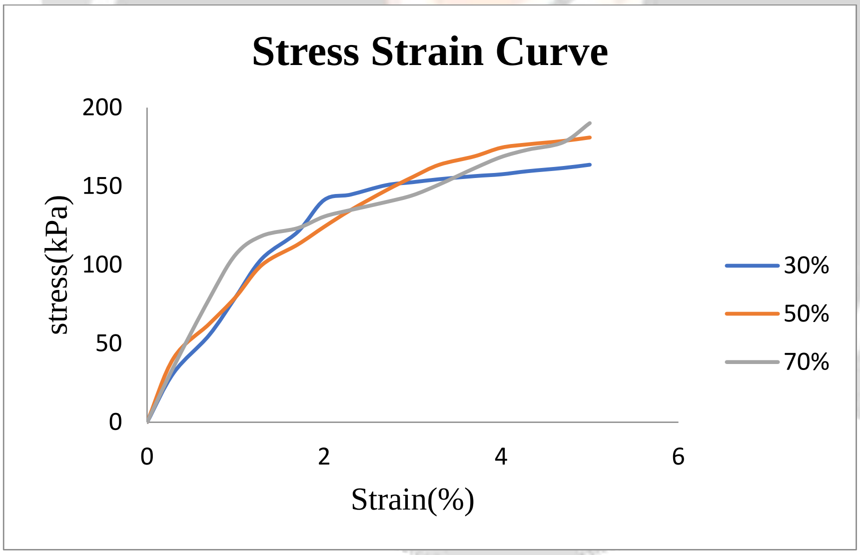


Figure 7 *: stress-strain graph for 0.5% fiber and 150kPa normal stress*

In the figure 7 fiber content is kept constant i.e 0.5% and the relative density is varied 30%, 50%, 70% and shear stress for 30%relative density is 163.66kPa for relative density of 50% shear strength is 180.98 kPa for 70%relative density shear strength is 190.11 kPa and the enhancement in strength is attributed by mobilization of friction between fibers and sand and normal stress is also kept constant i.e 150kpa

Relative density	Normal stress 50kpa		Normalstress 100kpa		Normal tress 150kpa	
	Shear stress(kPa)	Increase rate	Shear stress(kPa)	Increase rate	Shear stress(kPa)	Increase rate
30	64.94	1	116.03	1	163.66	1
50	72.73	1.7	147.21	1.35	180.98	1.10
70	75.33	1.18	160.19	1.55	190.11	1.25

Effect of fiber content on permeability

In the graph the fiber content is varied from 0%, 0,5%,0.75%.1% and relative density is taken as 30%, 50%, 70% and graph is plotted

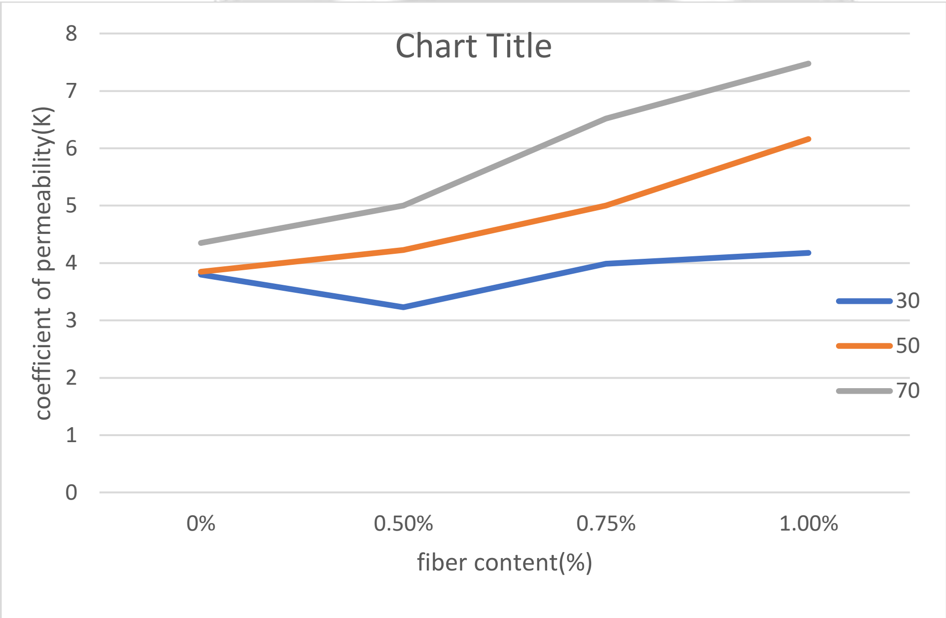


Figure 8 *:Varying fiber content vs coefficient of permeability*

In the figure 8 at loose state for 30% relative density initially the voids were bigger after the inclusion of fiber it resulted in a decrease in effective void ratio as a result the permeability of sand was found to decrease slightly. when the fiber content was 0.5% the fiber got in between the soil particles and resulted in creating the distance between them due to which effective pore size increased and led to increase in permeability

At medium dense state relative density of 50% here the sand is packed a little more tightly the void space is less and inclusion of fibers led to these fibers sitting in between the soil particles there by increasing the permeability

Fiber content	Coefficient of permeability(K) for 30%	Coefficient of permeability(K) for 50%	Coefficient of permeability(K) for 70%
0%	$3.88*10^{-3}$cm/s	$3.85*10^{-3}$cm/s	$4.35*10^{-3}$cm/s
0.5%	$3.23*10^{-3}$cm/s	$4.23*10^{-3}$cm/s	$5*10^{-3}$cm/s
0.75%	$3.99*10^{-3}$cm/s	$5*10^{-3}$cm/s	$6.52*10^{-3}$cm/s
1%	$4.18*10^{-3}$cm/s	$6.16*10^{-3}$cm/s	$7.48*10^{-3}$cm/s

Effect of fiber content on relative density for permeability

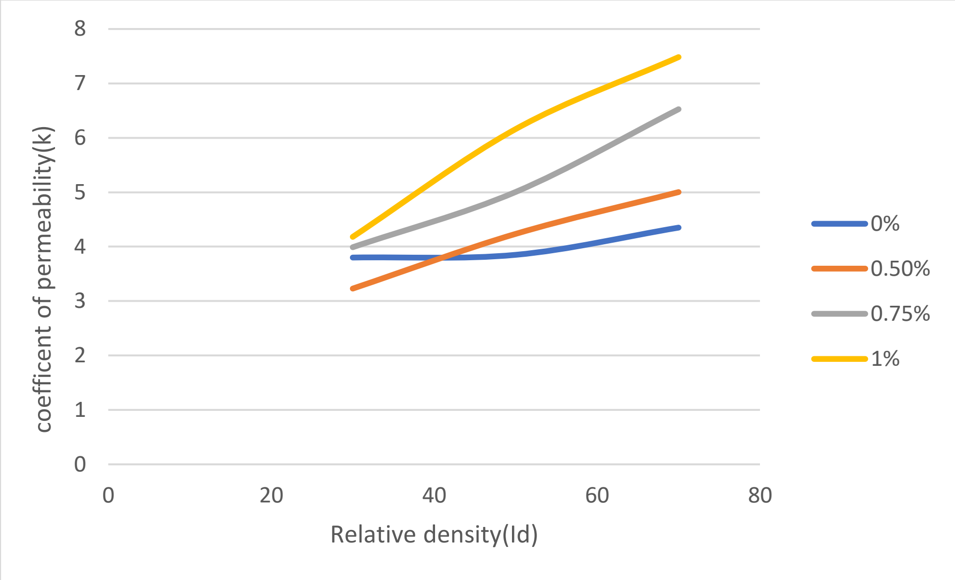


***Figure 9 :** Id vs coefficient of permeability*

In the figure 9 the relative density is kept constant and fiber content is varied for each relative density from graph it is observed that for 0% fiber content the permeability does not increase when there is inclusion of fiber and content of fibers is varied such as 0.5%, 0.75%, 1% for same relative density the permeability increases. For relative density 30% coefficient of permeability for 0% fiber content is $3.8*10^{-3}$cm/s for 0.5% fiber content K value is $3.23*10^{-3}$cm/s and 0.75% K value is $3.99*10^{-3}$cm/s for 1% fiber coefficient of permeability is $4.18*10^{-3}$cm/s The permeability increases with quantity of fibre and when relative density is taken as 50% K value is 3.85 for 0.5% K value is $4.23*10^{-3}$cm/s and for 0.75% K value is $5.05*10^{-3}$cm/s for 1% fiber K value is $6.16*10^{-3}$cm/s similarly for 70% relative density the values are for 0% $4.35*10^{-3}$cm/s and 0.5% $5.02*10^{-3}$cm/s for 0.75 % value is $6.52*10^{-3}$cm/s for 1% K value is $7.42*10^{-3}$cm/s by inclusion of fiber void ratio is reduced (i.e., aspect ratio). The value of K increases for different relative density i.e 30%, 50%, 70%

Relative density	Coefficient of permeability for 0%	Coefficient of permeability for 0.5%	Coefficient of permeability for0.75%	Coefficient of permeability for 1%
30	$3.8*10^{-3}$cm/s	$3.23*10^{-3}$cm/s	$3.99*10^{-3}$cm/s	$4.18*10^{-3}$cm/s
50	$3.85*10^{-3}$cm/s	$4.23*10^{-3}$cm/s	$5.06*10^{-3}$cm/s	$6.16*10^{-3}$cm/s
70	$4.35*10^{-3}$cm/s	$5.02*10^{-3}$cm/s	$6.52*10^{-3}$cm/s	$7.48*10^{-3}$cm/s

Conclusion:

The following conclusions are drawn from the results of this study:

- Rice Straw has Silica content which is about 87% (Cement Silica content : 22%) which help in increasing the strength and durability in construction
- Rice Straw can potentially increase the inter-particle cohesion of sand leading to enhanced mechanical strength
- Form the study the shear strength of sand increases as the fiber content increases when relative density is kept constant we observed that there is increase in shear stress
- The fibers inclusion increases the cohesion in the sand therefore there is increase in strength for 0% fiber shear stress was 48.49 at 50kpa when fiber was included for 0.5%shear stress was 72.74 and 0.75% shear stress was 82.43and for 1% fiber shear stress was 90.19 so we can observe that stress is increasing
- When the relative density is varied and fiber content is kept constant the values of shear strength are for 30% relative density 64.94 for 50% density 72.73 for 70% 75.33 and normal stress is taken as 50kpa
- When the normal stress is increased from 50kpa to 100kpa and 150kpa we observed increase in the strength
- For permeability at loose state voids are filled with inclusion of fibers leading to increase in permeability
- The increase in strength is attributed by mobilization of friction between fibers and sand

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