Geotechnical Properties of Manufactured Sand And Shear Strength Improvement Using Plastic

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Abstract- *Sand is considered to be one of the most important type of soil as well as a construction material. But the indiscriminate mining of sand from riverbeds is posing a serious threat to environment such as erosion of riverbed and banks, triggering landslides, loss of vegetation, lowering the underground water table etc. Hence, sand mining from riverbeds is being restricted or banned by the authorities. Manufactured sand, obtained by crushing the rock, is emerging as a viable alternative to river sand. This material is in use for quite some time in developed countries. Use of scientifically produced Manufactured Sand as an alternative to river sand is the need of the hour and will provide a long-term solution to Indian Construction Industry. The main aim of this study is to understand the geotechnical properties of manufactured sand. A comparison of properties of m-sand with that of river sand is also prepared. The experimental study also aimed at studying the shear strength characteristic of manufactured sand reinforced with plastic powder. Thus, the disposal problem of industrial waste can be minimized. The samples were prepared by mixing the percentage of plastic powder and m-sand as 0.1%, 0.2%, and 0.3% by the weight of m-sand. Direct shear test was the main test carried out in this study to find shear strength along with other tests like specific gravity test to determine the specific gravity, sieve analysis to study particle size distribution, relative density test to determine dry density and permeability test to determine the coefficient of permeability.*

Keywords- M-sand, shear strength, plastic powder

I. INTRODUCTION

River sand is a widely used material all over the world for various engineering activities. Various Government, Non-Governmental Organizations and Research Institutes are striving to identify alternative materials to supplement river sand. Researchers are in continuous search for the alternatives to sand. Sand mining from rivers has become objectionably excessive. As natural sand deposits become depleted near some areas of metropolitan growth, the use of alternatives to sands is receiving increased attention. Some of the alternatives to River Sand which are commonly seen nowadays are manufactured sand, fly Ash/ bottom ash, copper slag, etc.

In this study, Manufactured sand is taken which popularly known by several names such as Crushed sand, Rock sand, Green sand, Pozzolan sand etc. IS 383-1970 (Reaffirmed 2007) recognizes manufacture sand as 'Crushed Stone Sand'. Crushed stone sand is produced by crushing boulders. Compared to river sand, m-sand has different advantages like, well graded in the required proportion, does not contain organic and soluble compound, does not have the presence of impurities such as clay, dust and silt, etc.

Experiments were done with plastic contents such as 0.1%, 0.2% and 0.3% with manufactured sand. Plastics are considered as one of the important inventions which has remarkably assisted in different aspect of life. But it is considered as one of the most hazardous pollutants of environment as well as it would not decay or can't be destroyed. So, the only way to reduce these hazards is to use it in different application in engineering field beneficially. The implementation of plastic waste as a reinforcing material is economic and eco-friendly. From literatures, the plastic wastes in the form of powder could be mixed with m-sand and it can improve the shear strength.

II. OBJECTIVES

The objective of the study is to understand the geotechnical properties of manufactured sand and to compare it with the properties of river sand. Also an attempt has been made to use plastic waste for improving the shear strength of m-sand by the addition of plastic in powder form in various percentages by its weight.

III. MATERIALS AND METHODOLOGY

A. Materials

1) River Sand

The soil used in the entire laboratory testing was locally available river sand. Sand was collected from Tirur - Ponnani River, Malappuram. It was easily collected from the bank of the river (Figure.1). The soil was initially air dried in open atmosphere prior before testing. The basic properties of sand were determined as per IS Code specifications. The soil was reddish in colour and was well graded.

Fig.1.River sand

2) Manufactured sand (M-sand)

M-sand is artificial sand produced from hard granite stone by crushing. M-sand used for this experiment is collected from Chittilappilly- Adaat Road (Figure 2). It was initially air dried in open atmosphere prior before testing. For finding the basic properties of m sand also, the same IS Code specifications for sand was followed.

Fig.2.Manufactured sand

3) Plastic Powder

Plastic powder was collected from a plastic recycling unit working at Kuranchery, Thrissur. It was white colored fine material as shown in figure.3. They were obtained by crushing of plastic during its recycling process. It was sieved trough 425mm sieve for the use. Experiments were done with plastic content of 0.1%, 0.2% and 0.3% by its weight.

Fig.3.Plastic waste

B. Methodology

Various laboratorial test experiments were conducted for sand and m-sand to determine their basic properties. This helps to compare the properties of both samples and found that the m-sand has poor shear strength. Thereafter, certain percentage of plastic powder was added to m-sand with plastic content of 0.1%, 0.2% and 0.3% by its weight to stabilize it, and the percentage at which the plastic powder produces the optimum shear strength was found out.

Shear strength of sand and m-sand were determined by using direct shear test. Then the test was again continued to find out the optimum plastic percentage. The tests were classified by varying initial soil conditions as loose, medium and dense.

IV. RESULTS AND DISCUSSIONS

The tests for index properties and engineering properties of river sand and m-sand were determined by conducting series of laboratory experiments. Properties of sand were tabulated in table 1 and m-sand in table 2.

Table.1 Properties of River Sand

Soil properties	Values
Specific gravity	2.672
Uniformity coefficient, Cu	2.57
Coefficient of curvature, Cc	0.716
Dry density (loose condition), g/cc	1.485
Dry density (medium condition), g/cc	1.527
Dry density (dense condition), g/cc	1.572
Permeability value, cm/s	1.468×10^{-4}

Table.2 Properties of M-sand

Soil properties	Values
Specific gravity	2.637
Uniformity coefficient, Cu	9.062
Coefficient of curvature, Cc	1.62
Dry density (loose condition), g/cc	1.716
Dry density (medium condition), g/cc	1.774
Dry density (dense condition), g/cc	1.835
Permeability value, cm/s	1.806×10^{-4}

The direct shear test was used to obtain the failure stresses for each composite of river sand and manufactured sand. The direct shear test was run based on IS 2720 part 13–1986. Three normal stresses of 50, 100 and 150 kPa were applied in each series of tests for all samples.

The test result is classified for different soil sample condition like loose, medium and dense condition of river sand and m-sand. Test result obtained for sand in loose initial condition is shown in the figure 4 under 50, 100 and 150 kPa loads. From the graph, maximum shear strength of 1.175833 kg/cm² was obtained at normal stress of 150 kPa.

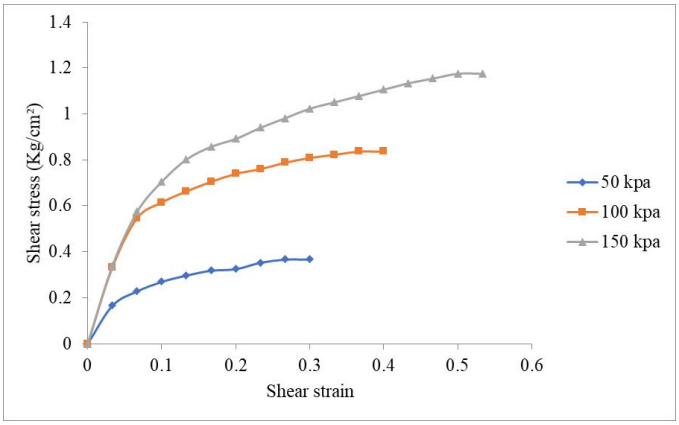

Fig.4.Shear stress v/s shear strain graph of sand in loose condition

Figure 5 shows the test result obtained for sand in medium initial condition. From the graph, the maximum shear strength of 0.97525 kg/cm² was obtained at normal stress of 150 kPa.

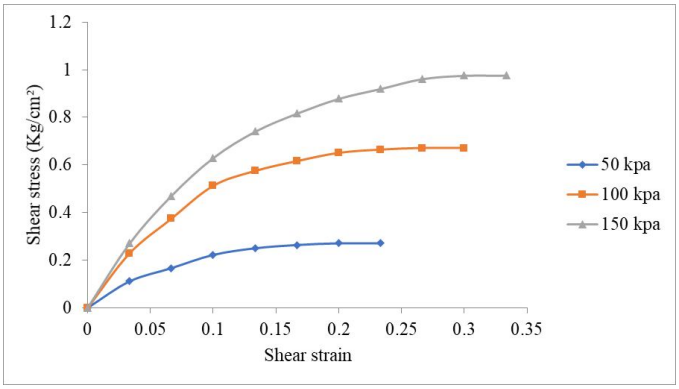

Fig.5.Shear stress v/s shear strain graph of sand in medium condition

Figure 6 shows the test result obtained for sand in dense initial condition. From the graph, maximum shear strength of 1.18275 kg/cm² was obtained at normal stress of 150 kPa.

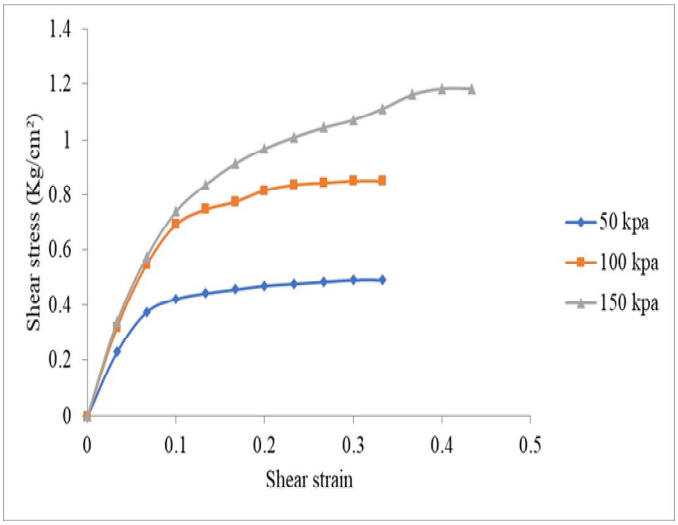

Fig.6.Shear stress v/s shear strain graph of sand in dense condition

Then the test was conducted on manufactured sand at loose, medium and dense initial condition under 50, 100 and 150 kPa loads. Test result obtained for m-sand in loose initial condition is shown in the figure 7 given below. From the graph, maximum shear strength of 1.155083 kg/cm² was obtained at normal stress of 150 kPa.

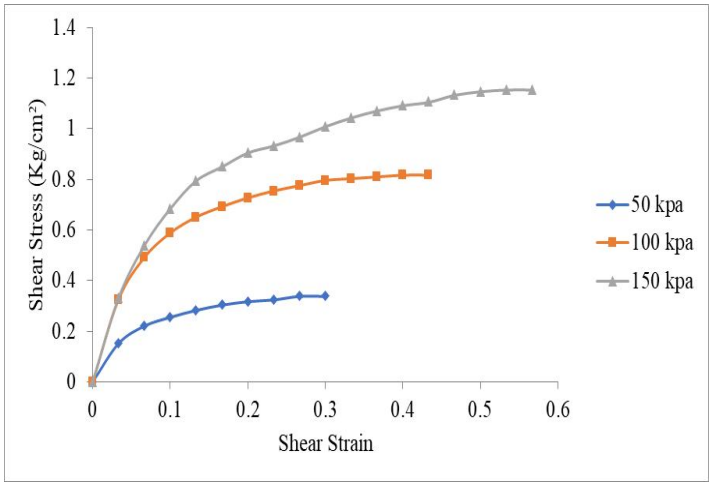

Fig.7.Shear stress v/s shear strain graph of m-sand in loose condition

Test result obtained for m-sand in medium initial condition is shown in the figure 8 given below. From the graph, maximum shear strength of 0.947583 kg/cm² was obtained at normal stress of 150 kPa.

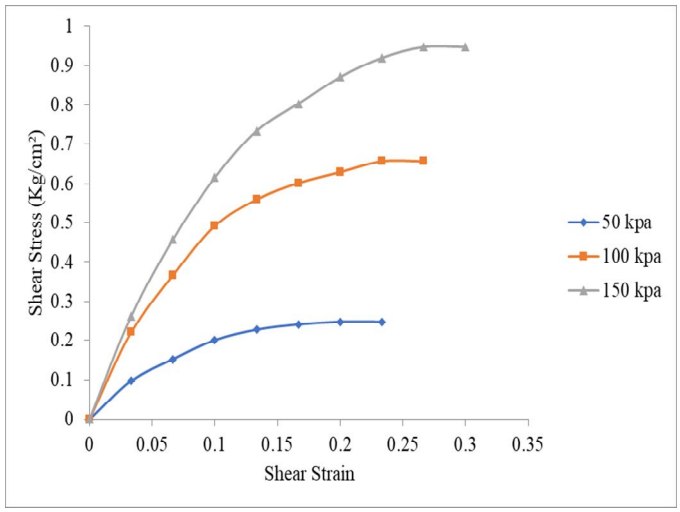

Fig.8.Shear stress v/s shear strain graph of m-sand in medium condition

Figure 9 shows the test result obtained for m-sand in dense initial condition. From the graph, maximum shear strength of 1.106667 kg/cm² was obtained at normal stress of 150 kPa.

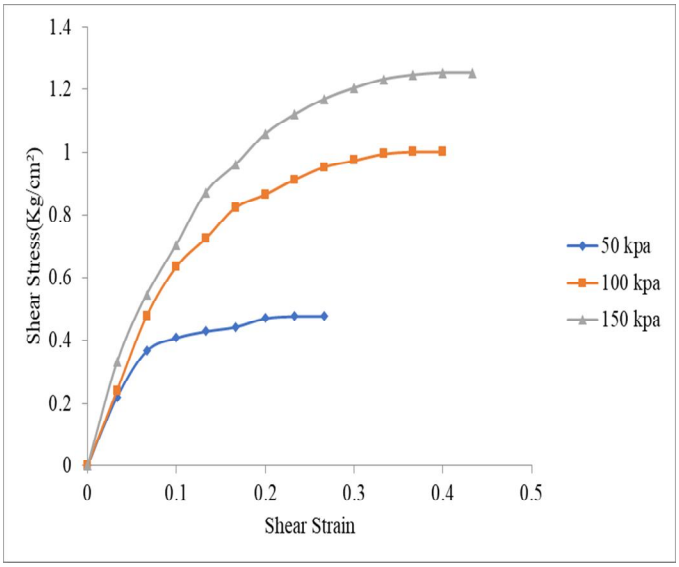

Fig.9.Shear stress v/s shear strain graph of m-sand in dense condition

By analyzing the test results, of direct shear test of both sand and manufactured sand implied that maximum shear strength was obtained for dense initial condition of the samples and at a normal stress of 150 kPa. A comparison of maximum shear strength obtained for sand and m-sand were shown in the figure 10 given below

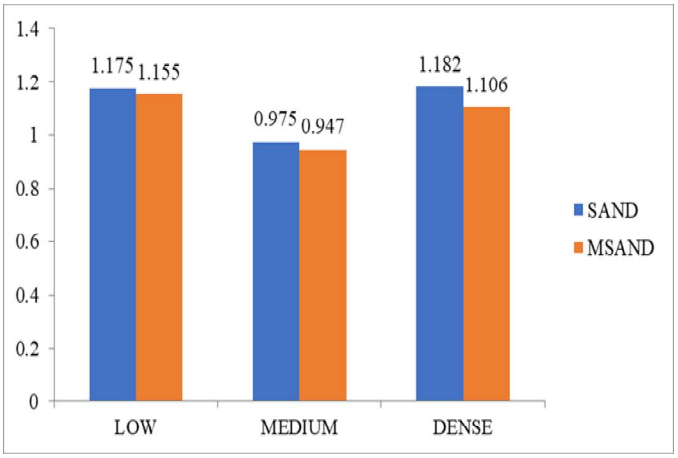

Fig.10.Comparison of maximum shear strength of samples

From the above results, shear strength of the manufactured sand is less than that of the sand. Therefore, as an attempt to increase the shear strength, plastic powder was introduced to manufactured sand. The percentages of plastic powder introduced were 0.1%, 0.2% and 0.3%. The test was conducted in medium initial condition.

The obtained values were plotted to show relationship between shear stress versus shear strain. The test result was classified for each percentage of m-sand- plastic

mixture. The maximum stress obtained was noted down in each load.

The test result obtained for m-sand mixed with 0.1% of plastic powder was shown by shear stress versus shear strain graph in the figure 11 given below. From the graph, maximum shear strength of 0.961417 kg/cm² was obtained at normal stress of 150 kPa.

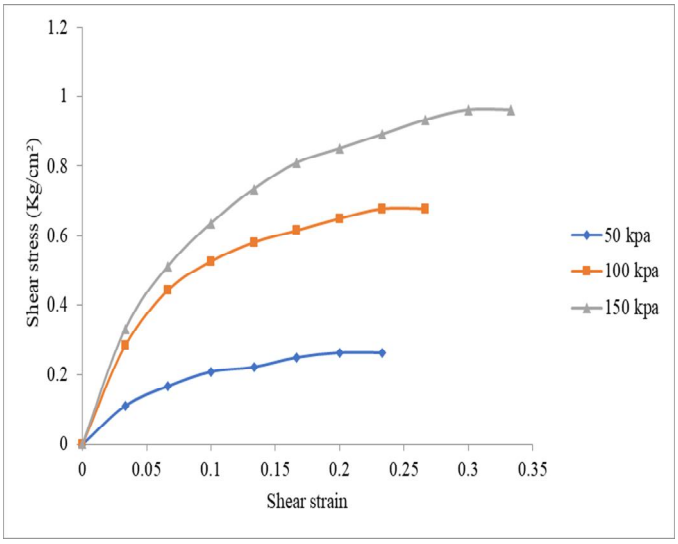

Fig.11.Shear stress v/s shear strain graph of m-sand and 0.1% plastic powder

Figure 12 shows the test result obtained for m-sand mixed with 0.2% of plastic powder. From the above graph, maximum shear strength of 0.982167 kg/cm² was obtained at normal stress of 150 kPa.

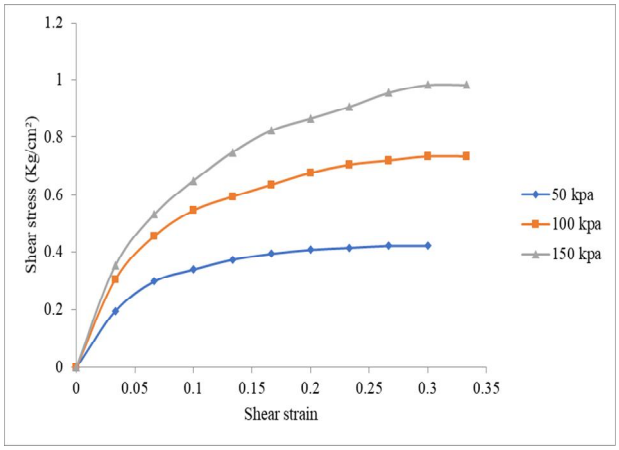

Fig.12.Shear Stress v/s shear strain graph of m-sand and 0.2% plastic powder

The figure 13 shows the test result obtained for m-sand mixed with 0.3% of plastic powder. From the graph, maximum shear strength of 0.97525 kg/cm² was obtained at normal stress of 150 kPa

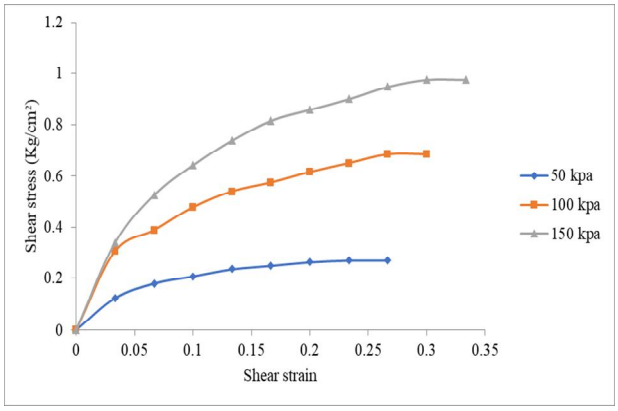

Fig.13.Shear stress v/s shear strain graph of m-sand and 0.3% plastic powder

A comparison of maximum shear strength was done for all the samples tested in this study as represented in the figure 14.

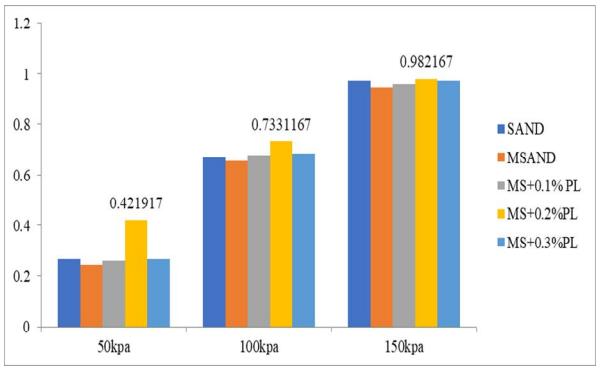

Fig.14.Comparison of maximum shear strength of parent samples and improved samples

The above comparison of maximum shear strength obtained by river sand, parent m-sand and reinforced m-sand with 0.1%, 0.2% and 0.3% of plastic powder by dry weight of m-sand is denoted by the above chart. It clearly notifies that the addition of plastic into manufactured sand has a good effect on improving the shear strength of m-sand. At 0.1% of addition, a slight improvement was shown in each normal stresses of 50 kPa, 100 kPa and 150 kPa. 0.2% of addition of plastic powder also resulted in the increment of shear strength of m-sand. But, for 0.3% of plastic powder, even though shear strength increased than the parent m-sand it shows a less value than the 0.2% of addition. That is, maximum shear strength was obtained at 0.2% of plastic addition at 150 kPa normal stress.

V. CONCLUSIONS

In this experimental study, the geotechnical properties of manufactured sand were found out. A series of laboratory tests were done on the manufactured sand. These test results proved to be very effective for further study on m-

sand. The same tests were also conducted on the collected river sand and properties were found out. A comparison is done with the properties of manufactured sand and river sand. It was noted that the shear strength of m-sand is less than that of the sand. Then the next aim was to improve this shear strength by adding any reinforcing material to the m-sand. From the literatures, plastic was seemed to be a proper reinforcing material for different soils. So, the effect of plastic with m-sand was also checked. The percentages of plastic powder added to the sand were 0.1%, 0.2% and 0.3%. Plastic powder appears to improve the shear strength performance of m-sand, when normal stresses of 50 kPa, 100 kPa and 150 kPa were applied. The following points were noted from the study.

- Specific gravity of manufactured sand is less than the river sand.
- From particle size distribution analysis, river sand was confirmed to poorly graded sample and manufactured sand was confirmed to well graded sample.
- Dry density of manufactured sand is greater than that of river sand in each initial condition of loose, medium and dense.
- Coefficient of permeability of manufactured sand is greater than that of the river sand.
- In case of direct shear strength of the samples, manufactures sand has less shear strength than that of river sand.
- The greatest shear strength for manufactured sand and river sand were noted, when 150 kPa of normal stress was applied.
- Addition of plastic powder in to m-sand improved the shear strength when compared to the parent m-sand and river sand.
- 0.2% plastic addition showed the maximum shear strength result under all normal stresses applied

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