Impact Factor (SJIF): 4.542

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 3, Issue 12, December - 2016

STABILIZATION OF FINE SAND MIXED WITH BOTTLE CAP STRIPS FOR DESIGN OF EMBANKMENT AND PAVEMENT IN CONSTRUCTION OF ROADS

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Abstract —***The object of the present investigations is to study the strength characteristics of fine sand of western Rajasthan stabilized with cheap and readily available material like plastic waste. Fine 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. As per Indian Standard Classification System of soils, the fine sand has nil cohesion. Due to very low compressive strength and high permeability, fine sand is not readily suitable for supporting flexible pavements as sub grade. This study discusses the possibility of stabilization of fine sand using plastic bottle cap waste as admixture. The varying percentage 0.15%, 0.25, 0.50%, 0.75%, 1% of square pieces of plastic waste were mixed with fine sand of different densities 1.66gm/cc, 1.62gm/cc and 1.57gm/cc (M.D.D.). All the Direct Shear Tests were conducted at different mix compositions of plastic waste bottle cap 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 bottle cap plastic waste as admixture improves the strength characteristics of the fine sand so that it becomes usable as construction of embankment.***

Keywords-Fine Sand, Direct Shear Test, Waste Bottle Cap Plastic.

I. INTRODUCTION

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.

Soil for a geotechnical engineer is the weathered material of earth crust, with or without organic matter. The bonding property of soil depends upon its particle size and is decreasing as the particle size increases. Fine sand has nil plasticity which means cohesion less, drainage fair with coefficient of permeability ranging between 10^{-4} mm/sec to 10^{-2} mm/sec. Fine sand is found in abundance in Western Rajasthan, India. Large parts of Rajasthan, covering about 500,000 sq. kms, consist of desert soils which are wind-blown deposits. The sand dunes have an average height of about 15 m. They are formed in highly arid conditions. Fine sand is non-plastic and uniformly graded fine sand. It poses many geotechnical engineering problems. There are numerous geotechnical problems associated with fine sand. The reinforcing elements absorb the loads that might prevent the soil to fail in shear or due to excessive deformation. The stability and reliability of geotechnical structures can therefore be achieved by reinforcing the soil. Towards this end, randomly reinforcing the soil by using low density polyethylene strips obtained from waste plastic containers 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 fine sand with pieces of bottle cap plastic waste. Many researchers like Ankit et al. (2016), Kapil et al. (2016), Punitetval. (2013), Purohit D.G.M. et al. (2009), AwadALKarni et al. (2012), jain O.P. et al. (1979), V. Mallikarjuna et al. (2016), Kevin M. (1978) and Wayal A.S. et al. (2012) Ameta et al. (2008), Awad ALKarni et al. (2012), Jain O.P. et al. (1979), Kevin M. (1978) and Wayal A.S. et al. (2012) have worked on stabilization of soils.

II. MATERIALS USED

2.1. Fine Sand

Fine sand is found in abundance in western Rajasthan (India). The sand used in present study was brought from location near from Luni town, at about 20-25 km away from Jodhpur, Rajasthan on Jodhpur–Pali Highway. Fine 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. Bottle Cap (LDPE)

Low density polythene Plastic Bottle Cap of Blue color which is used as cap of bottle liner is used in the present study which has a thickness of 275 microns. The extent of polymerization of LDPE varies from product to product. It was also taken care that the film shall be uniform in color, texture and finish, substantially free from pin holes and undispersed raw materials, streaks and particles of foreign matter, no other visible defects such as melt fracture, holes, tears or blisters. Table 1 presents the properties of plastic waste material.

Figure 1:- Plastic Waste Bottle Cap Strips Used In The Study.

Table 1:- Properties of LDPE Bottle Cap

S. No.	Property	Value
1.	Aspect ratio of strip (l/b)	1.5
2.	Thickness	275 microns
3.	Density at 27ºC (gm./cc)	0.950
4.	Melting point	199ºC

III. TEST PROGRAM AND PROCEDURE

The laboratory investigation on dune sand stabilization with waste plastics of bottle cap as admixture was performed. This work is done for beneficial utilization of waste plastic square pieces of Bottle cap 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 waste plastics of bottle cap as admixture. The present study has been undertaken with the following objectives:

1. Determination of particle size distribution of fine sand.
2. To study the effect of moisture content on dry density of fine sand.
3. Direct Shear Test to determine shear stress of fine sand and mix compositions with square pieces of plastic waste.

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 fine 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.

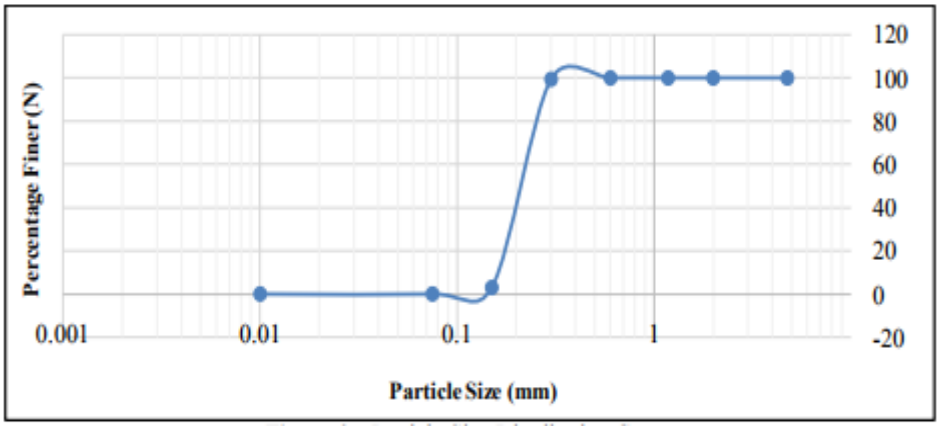

Figure 2:- Particle Size Distribution Curve

Table 2:- Properties of Fine Sand.

S. No.	Property	Test Media (Fine Sand)
1.	Coefficient of Uniformity (C_u)	1.33
2.	Coefficient of Curvature (C_c)	1.06
3.	Mean Diameter (D_{50}) mm	0.22
4.	Effective Size (D_{10}) mm	0.15
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 hold 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 1.66 gm/cc at O.M.C 12.34%. Two more dry densities as 1.57 gm/cc and 1.62 gm/cc were considered for the present study.

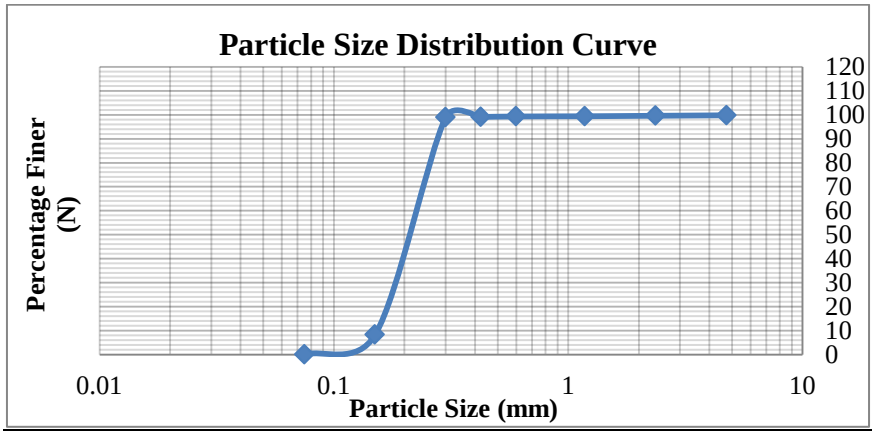

Fig 3:- Dry Density v/s Water Content Curve.

3.3. Direct Shear Test.

The value of cohesion (c) and the angle of internal friction (ϕ) of the soil are found by direct shear test. These are the soil shear strength parameters. Direct shear test was performed on dune sand and mix compositions with bottle cap plastic waste with a strain controlled shear apparatus at a rate of strain of 1.25 mm per minute in accordance with IS 2720 (Part XIII). The test was conducted by putting the dune sand at three different dry densities inside the shear box which is made up of two independent parts. A constant normal load is applied to obtain one value of c and angle of internal friction (ϕ). Horizontal load (shearing load) is increased at a constant rate and is applied till the failure point is reached. The equation to calculate the value of shear strength „τ" is as follows:

$$\tau = c + \sigma \tan(\phi)$$

After repeating the experiment for different normal loads we obtain a plot which is a straight line with slope equal to angle of internal friction (ϕ) and intercept equal to the cohesion (c). Cohesion for dune sand is zero, hence here (c) becomes zero. Direct shear test is the easiest and the quickest way to determine the shear strength parameters of a soil sample.

Comparative Study:-

From the results, it can be seen that the value of friction angle increases to a certain limit and then decreases as the value of bottle cap plastic waste content increases in the dune sand. Shear stress increases and then decreases in the same manner. The maximum values have been obtained at 0.06% of LDPE waste content. To obtain better results in practice, the value of LDPE waste content should be low. That will provide more strength to dune sand. It has been found from the study that on keeping dry density as constant, the shear stress of the mix composition increases as the normal stress increases. The results of direct shear test are tabulated in Tables 3, 4, 5 and in Fig. 4, 5, and 6.

Table 3:- Variation of Shear Stress with Normal Stress for Mix Composition at MDD 1.66 gm/cc

Normal Stress (kg/cm²)	Shear Stress (kg/cm²)					
	Mix Composition					
	0% Admixture	0.15% Admixture	0.25% Admixture	0.50% Admixture	0.75% Admixture	1%Admixture
0.1	0.1050	0.1456	0.1714	0.1717	0.138	0.1453
0.2	0.2042	0.268	0.265	0.2504	0.196	0.2045
0.3	0.3165	0.3894	0.3566	0.332	0.2634	0.2665

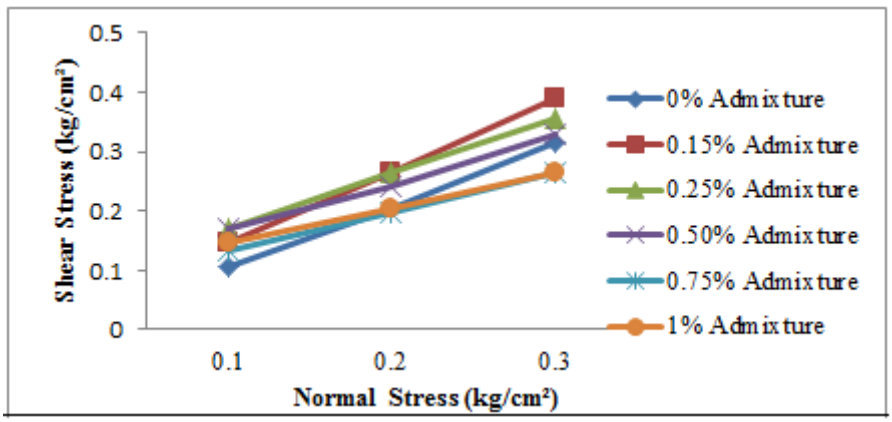

Figure 4:- Variation of Shear Stress with Normal Stress for Mix Compositions at MDD 1.66 gm/cc.

Table 4:- Variation of Shear Stress with Normal Stress for Mix Compositions at Dry Density 1.62 gm/cc

Normal Stress (kg/cm²)	Shear Stress (kg/cm²)					
	Mix Composition					
	0% Admixture	0.15% Admixture	0.25% Admixture	0.50% Admixture	0.75% Admixture	1%Admixture
0.1	0.1054	0.1126	0.1187	0.1386	0.1458	0.2244
0.2	0.1917	0.2238	0.2244	0.264	0.2245	0.2904
0.3	0.2816	0.3435	0.3231	0.396	0.3039	0.366

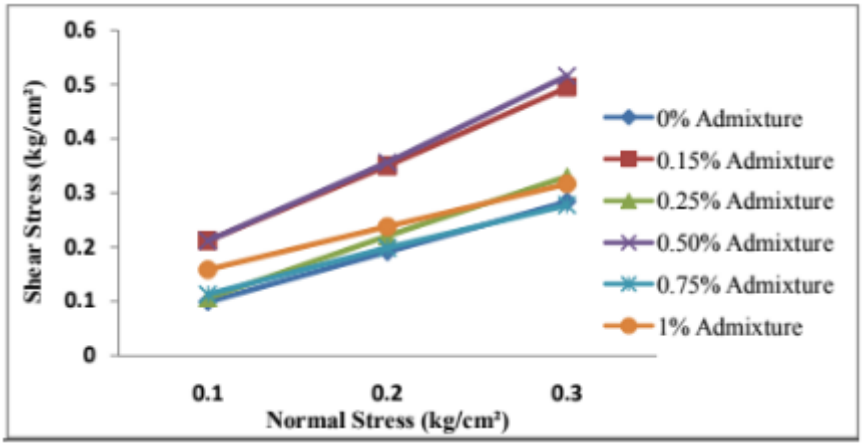

Figure 5:- Variation of Shear Stress with Normal Stress for Mix Compositions at Dry Density 1.62 gm/cc

Table 5:- Variation of Shear Stress with Normal Stress for Mix Compositions at Dry Density1.57 gm/cc

Normal Stress (kg/cm²)	Shear Stress (kg/cm²)					
	Mix Composition					
	0% Admixture	0.15% Admixture	0.25% Admixture	0.50% Admixture	0.75% Admixture	1%Admixture
0.1	0.0991	0.2115	0.1058	0.2113	0.1122	0.1584
0.2	0.1917	0.3494	0.222	0.3568	0.198	0.2376
0.3	0.2836	0.4951	0.332	0.517	0.2772	0.3164

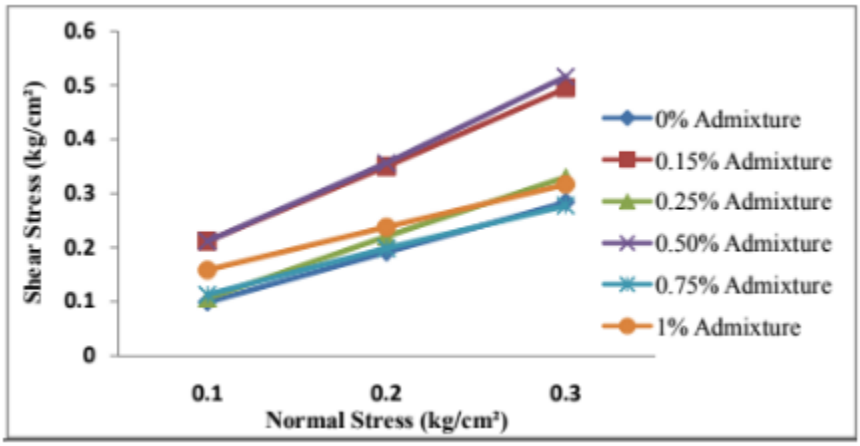

Figure 6:- Variation of Shear Stress with Normal Stress for Mix Compositions at Dry Density 1.57 gm/cc.

Values of friction angle for different dry densities and values of different percentages of LDPE waste content are given in Table 6 and Fig. 7.

Table 6:- Variation of Friction Angle for different Dry Densities with Different Percentages of Plastic content

Dry Density (gm/cc)	Angle of Internal Friction ϕ (Degree)					
	Mix Composition					
	0% Admixture	0.15% Admixture	0.25% Admixture	0.50% Admixture	0.75% Admixture	1%Admixture
1.51	30.12°	33.18°	39.24°	43.42°	45.36°	51.42°
1.54	32.18°	34.24°	42.18°	44.36°	48.6°	52.6°
1.58	36.18°	37.3°	43.42°	49.18°	53.48°	54.42°

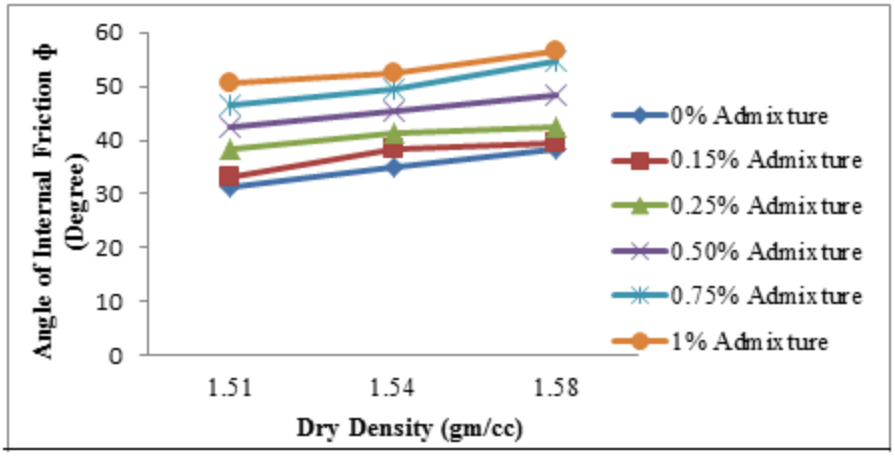

Figure 7:- Variation of ϕ with Dry Density of Sand and % Admixture.

IV. CONCLUSIONS

In this investigation we have used square pieces of plastic bottle cap waste 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 square pieces of plastic bottle cap waste.In the present investigation, as we are increasing the quantity of admixture of square pieces of plastic bottle cap waste, the angle of internal friction increases. So we have stopped the further increment of admixture. Further study can be done by addition of more amount of admixture.

The shear test were performed for mix compositions of fine sand of different dry densities 1.57 gm/cc, 1.62 gm/cc and 1.66gm/cc with square pieces of plastic bottle cap waste of varying percentage 0.15%, 0.25%, 0.50%, 0.75% and 1%. The angle of internal friction (shearing resistance) ϕ increases with increase in dry density of fine sand and quantity of the square pieces of bottle cap plastic waste. As the ϕis increasing, the required section for embankment is reduced.

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