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Research Paper

Stabilization of Dune Sand with Plastic (POLYBAGS) Waste as Admixture for the Construction of Embankments for Roads

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ABSTRACT ***:*** *India's western part, which is fully deserted is mostly comprised of dune sand. According to IS Classification System, dune sand has low plasticity characteristics and nil cohesion. It has less compressive strength. By stabilizing the dune sand, it will become very useful for the construction of embankments for roadways, helipad and airfield. Plastic waste like polybags can be used as admixture to reinforce the dune sand. This paper represents the experimental study and results on dune sand reinforcement with polybag waste. It may be a method of reusing polybag waste with stabilizing the dune sand. It will useful to manage the polybag waste. The size of polybags (plastic waste) used is 5 mm x 5 mm. Dune sand of dry densities 1.66 gm/cc (M.D.D.), 1.62 gm/cc, 1.57 gm/cc and different percentages 0%, 0.05%, 0.06%, 0.7%, 0.8%, 0.9%, 1.0% of polybag waste content were mixed and tested for study. For obtaining the desirable results, test which were conducted are particle size distribution test, standard proctor test, direct shear test and variable head permeability test.*

Keywords - *Dune sand, polybag waste, stabilization, direct shear, permeability.*

I. INTRODUCTION

The total load of superstructure is supported by foundation and foundation transfers the load to the soil. If the soil, that supports the structure like embankment, is weak then the construction of embankments are considered to be unsafe. There are chances of failure of embankments. Dune sand has weak properties and it has to be stabilizing to construct the embankments on it. There are many methods to stabilize the soil in civil engineering. By considering our measures we have tried to enhance the properties of dune sand. A huge amount of polybags is used every year and which is worth about 500 billion approximately. A very big amount of plastic waste (polybags) is damaging our environment. India is one of the biggest consumer of polybags. Many attempts have been made to reuse, recycle and dispose of polybags waste. This polybag waste is costly to dispose and takes a very long to photo degrade. It takes about 300 years to photo degrade. A very large amount of polybags is available in our world. It can be used to reinforce the dune sand. This method can provide low cost structure with removal of polybag waste. Many researchers like Dutta R. K. et. al. (2007), Ameta et al. (2008), Wayal A.S. et al. (2012), O. O. Ojuri et. al. (2015), S. K. Tiwari et. al. (2016) and Akash Gupta (2016) have conducted research on stabilization of soils.

II. MATERIALS USED FOR STUDY

2.1 DUNE SAND

All the tests have been performed on dune sand. Dune sand for testing was carried from Osian (Rajasthan) that is about 65 to 70 kms away from Jodhpur. Dune sand is mostly found in western part of Rajasthan. Dune sand has poor properties for large scale construction as it has low compressive strength and low cohesion. It is classified as uniform sand with varying particle size of 75 μ to 1 mm. It has nil plastic properties and good drainage. The values of coefficient of permeability vary from 10^{-4} mm/sec to 10^{-2} mm/sec.

2.2 PLASTIC WASTE (POLYBAGS)

The German chemist Hans Von Pechmann introduced polyethylene which was a result of a accident while investigating diazomethane in 1898. It was seen that it have long $–CH_2–$ chains and he termed it poly methylene. Polyethylene was found to bear very high frequency radio waves with very low destructive properties. It has softening point about 80°C (176°F) and melting point about 105 to 115°C (221 to 239°F). Most of the plastic grades have excellent chemical resistance. Which means that it is not affected by strong acids or strong bases, and perform as very resistible to gentle oxidizing agents as well as reducing agents. Crystalline samples do not possess the property to dissolve at room temperature. Polyethylene when come in contact with water, it appears that it is unable to absorb it. When it is exposed to sunlight it behaves as a brittle material. Carbon black is able to protect from UV. It burns slowly with a blue colour flame having a yellow tip. It gives an odour of paraffin (similar to candle flame). The material is able to burn continuously on removal of the burning source and produces a drip. Pretreatment is must before imprinting of polyethylene. Polyethylene is not a good conductor so it behaves as a better electrical insulator material. Plastic can be used for both rigid containers as well as plastic film applications such as plastic bags and film wrap. The density of LDPE is about 0.910-0.940 gm/cc. Plastic mixed with dune sand shown in Fig. 1.

Figrue 1: Polybags Mixed With Dune Sand

III. EXPERIMENTAL PROGRAM

The dune sand and polybag waste have been used for this study. The tests were performed on dune sand with polybag waste to find out results. Polybag waste was cut into 5 mm x 5 mm sized and used with dune sand.

3.1 EXPERIMENTAL PROGRAM

The tests performed on dune sand with mix compositions of dune sand with polybag waste are following:

1. Particle size distribution test.
2. Standard proctor test to determine different dry densities of dune sand.
3. Direct shear test (DST) to determine shear strength of dune sand with different mix compositions.
4. Variable head permeability test to determine coefficient of permeability for dune sand with different mix compositions.

The variables investigated are given in table 1.

Table 1: Variables Investigated

S. No.	Effect of	Variables	Range Investigated
1.	Curing environment on C.B.R value.	Type of curing	Soaked and Unsoaked
2.	Plastic waste strips (polybags) on different properties of sand	Strip size	5 mm x 5 mm
3.	Mix plastic waste content by weight of sand	Proportion Percentage	0%, 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1%
4.	M.D.D. and proctor density	Dry Density	1.66 gm/cc (M.D.D.), 1.62 gm/cc, 1.57 gm/cc

3.1.1 Particle size distribution test

The particle size distribution test is conducted with IS sieve size 4.75 mm, 2.00 mm, 1.18 mm, 600 μ, 300 μ, 150 μ, 75 μ and pan. A sample of 1000 gm is sieved. All sieves were arranged according to their decreasing opening size. Maximum sized sieve is placed on top. The sample is collected and weighted of every sieve and then percentage of retained sand was calculated.

$$\text{Percentage Retained} = \frac{W_{sieve}}{W_{total}} x100$$

Where W_{sieve} is the weight of sand in the sieve in gm and W_{total} is the total weight of the sand in gm. The percentage of finer was obtained by subtracting the percentage retained from 100%. The readings and results of this test have been tabulated in Table 2 and Table 3.

Table 2: Particle Size Distribution of Dune Sand

S. No.	Sieve Size	Weight Retained (gm)	% Weight Retained	Cumulative % Weight Retained	% Finer
1.	4.75 mm	0.0	0.0	0.0	100
2.	2.00 mm	0.0	0.0	0.0	100
3.	1.18 mm	0.0	0.0	0.0	100
4.	600 µ	0.0	0.0	0.0	100
5.	300 µ	6.0	0.6	0.6	99.4
6.	150 µ	964	96.4	97.0	3.0
7.	75 µ	30	3.0	100	0.0
8.	Pan	0	0.0	100	0.0

Table 3: Results of Particle Size Distribution

S. No.	Property	Test Results
1.	Coefficient of Uniformity (C_u)	1.43
2.	Coefficient of Curvature (C_c)	0.88
3.	Particle size D_{60}	0.23 mm
4.	Mean Diameter (D_{50})	0.21 mm
5.	Particle size D_{30}	0.18 mm
6.	Effective Size (D_{10})	0.16 mm
7.	Fine Soil Fraction (75 µ)	0%

3.1.2 Standard Proctor Test

Standard proctor test provides the different dry densities of dune sand corresponding to different moisture contents. The mould size is 100 mm diameter and 127.3 mm height with a capacity of 1000 ml in accordance with IS 27320 (Part VII). The soil was compacted in three layers into mould and each layer was compacted by 25 blows of 2.6 kg rammer with falling height of 310 mm.

The test results have been shown in Fig. 2. It shows that as we increase the moisture content, the dry density decrease but after then dry density start to increase. As it reaches on peak value dry density start to decrease again, it occurs due to bulking of dune sand. That is Maximum Dry Density (MDD). The tests were done on dry densities 1.57gm/cc, 1.62 gm/cc and 1.66 gm/cc obtained at moisture content 6.82%, 10.42% and 12.34% respectively.

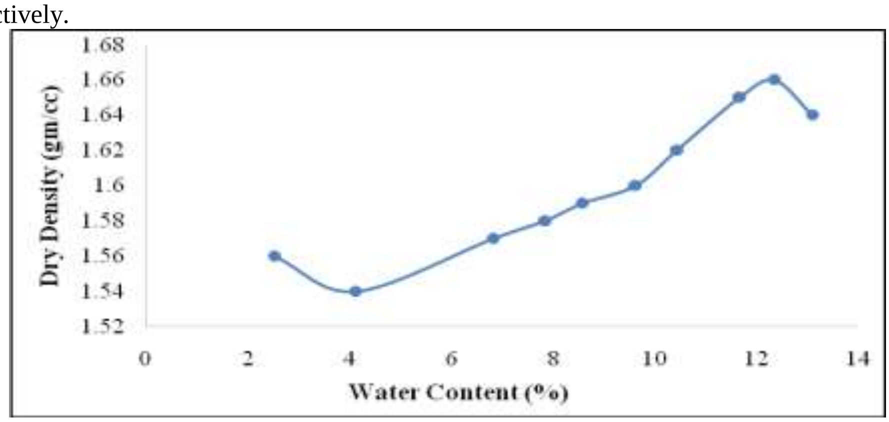

Figure 2: Variation of Dry Density with Moisture Content

3.1.3 Direct Shear Test

Direct Shear Test is conducted to find out the angle of internal friction and shear stresses in the soil. This test determines the shear strength of soil. Direct shear tests were performed on dune sand of three dry densities 1.66 gm/cc, 1.62 gm/cc, 1.57 gm/cc mixed with 0%, 0.05%, 0.06%, 0.7%, 0.8%, 0.9%, and 1.0% of polybag waste. The test was performed with a strain controlled shear apparatus and its rate of strain was 1.25 mm/min according to IS 2720 (Part XIII).

3.1.3.1 Comparative Study

A comparative study of variation of shear stresses and angle of internal friction has been shown in test results. In the graphs, shear stresses corresponding to dry densities 1.66 gm/cc, 1.62 gm/cc, 1.57 gm/cc with 0%, 0.05%, 0.06%, 0.7%, 0.8%, 0.9%, 1.0% of polybag waste content were plotted on Y-axis and normal stresses 0.5 kg/cm^2, 1.0 kg/cm^2, 1.5 kg/cm^2 were plotted on X-axis. The results have been shown in Table 4, 5 and 6 and graphically in Fig. 3, 4 and 5.

From the graphs it can be seen that the values of shear stresses corresponding to normal stresses increase as the dry density increases. The values of shear stresses increase initially with increase in percentage of polybag waste content increase. But on further increase of polybag waste content, the values of shear stresses decrease. From the results shown in Fig. 6, it can be seen that the angle of internal friction also increases initially and then start to decrease as the percentage of polybag waste content increase. The angle of internal friction increases for the higher dry density.

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

Normal Stress (kg/cm^2)	Shear Stress (kg/cm^2)					
	Mix Composition					
	0.05% Polybag Waste (S1)	0.06% Polybag Waste (S2)	0.7% Polybag Waste (S3)	0.8% Polybag Waste (S4)	0.9% Polybag Waste (S5)	1.0% Polybag Waste (S6)
0.5	0.513	0.559	0.495	0.476	0.504	0.586
1.0	0.962	1.054	0.980	0.935	0.925	0.980
1.5	1.430	1.530	1.439	1.375	1.356	1.384

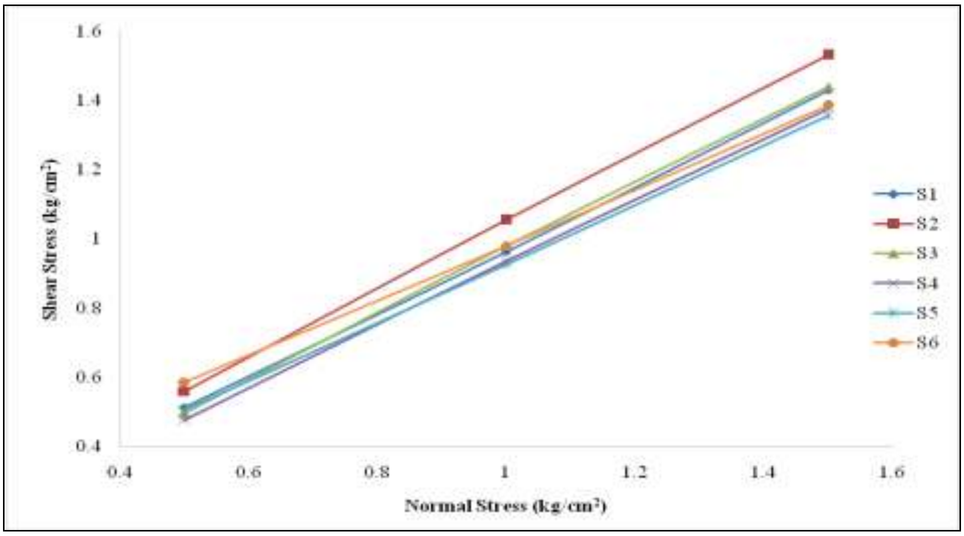

Figure 3: Variation of Shear Stress with Normal Stress for Mix Compositions at MDD 1.66 gm/cc

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

Normal Stress (kg/cm^2)	Shear Stress (kg/cm^2)					
	Mix Composition					
	0.05% Polybag Waste (S7)	0.06% Polybag Waste (S8)	0.7% Polybag Waste (S9)	0.8% Polybag Waste (S10)	0.9% Polybag Waste (S11)	1.0% Polybag Waste (S12)
0.5	0.504	0.559	0.522	0.485	0.513	0.449
1.0	0.935	1.026	0.953	0.898	0.889	0.843
1.5	1.393	1.475	1.402	1.301	1.292	1.219

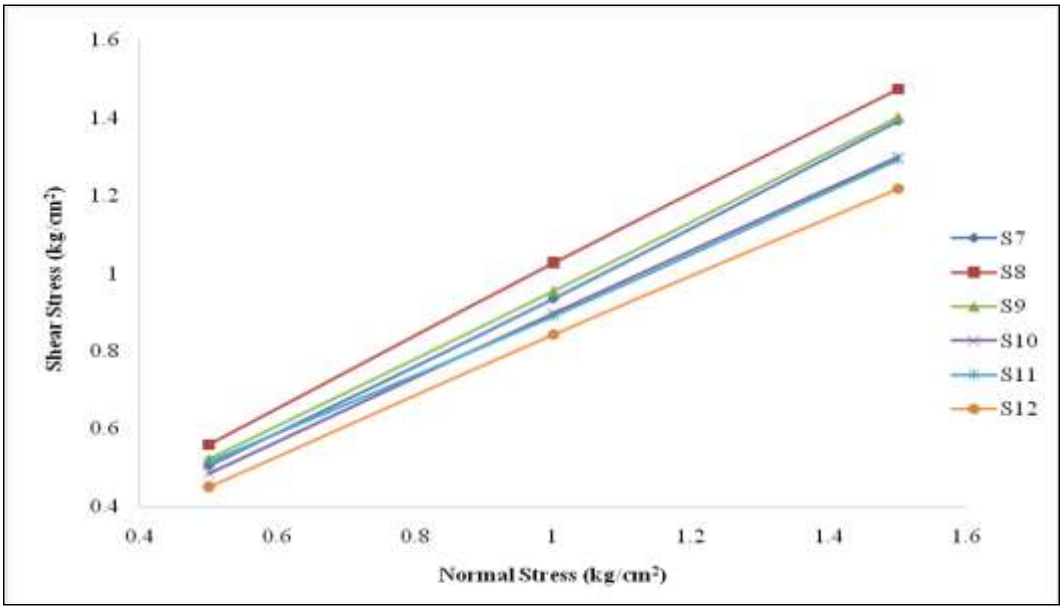

Figure 4: Variation of Shear Stress with Normal Stress for Mix Compositions at Dry Density 1.62 gm/cc

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

Normal Stress (kg/cm^2)	Shear Stress (kg/cm^2)					
	Mix Composition					
	0.05% Polybag Waste (S13)	0.06% Polybag Waste (S14)	0.7% Polybag Waste (S15)	0.8% Polybag Waste (S16)	0.9% Polybag Waste (S17)	1.0% Polybag Waste (S18)
0.5	0.522	0.586	0.540	0.513	0.495	0.467
1.0	0.944	1.026	0.962	0.916	0.870	0.834
1.5	1.384	1.475	1.393	1.329	1.265	1.219

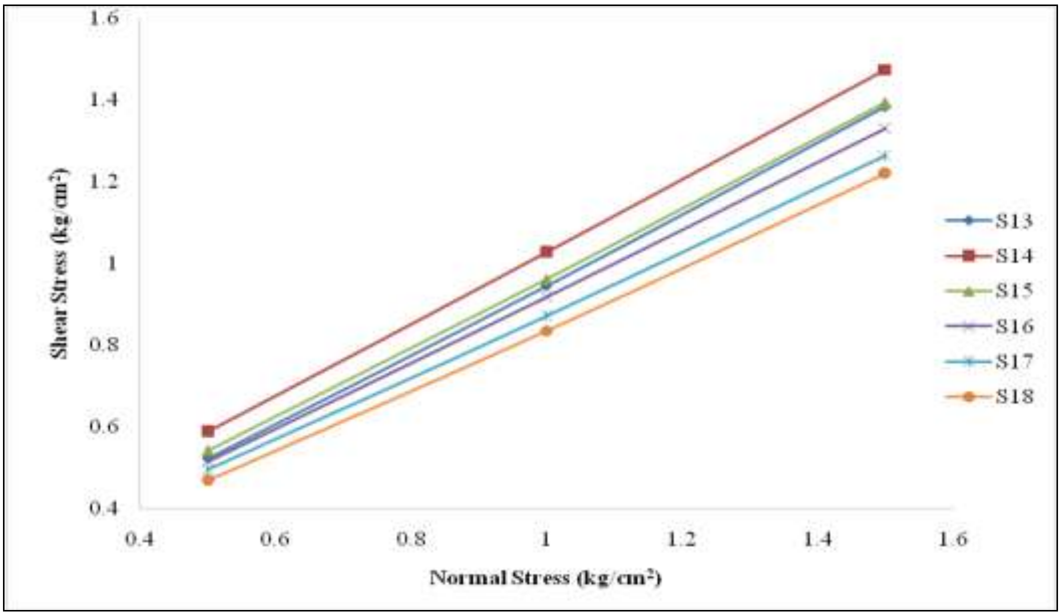

Figure 5: Variation of Shear Stress with Normal Stress for Mix Compositions at Dry Density 1.57 gm/cc

The values of angle of internal friction for all the three dry densities and different percentages of polybag waste content given in Table 7 and Fig. 6.

Table 7: Variation of Friction Angle for different Dry Densities with Different Percentages of Polybag Waste Content

Dry Density (gm/cc)	Angle of Internal Friction ϕ (Degree)						
	Mix Composition						
	0% Polybag Waste	0.05% Polybag Waste	0.06% Polybag Waste	0.7% Polybag Waste	0.8% Polybag Waste	0.9% Polybag Waste	1.0% Polybag Waste
1.66	33.43°	42.52°	44.16°	43.34°	41.98°	40.43°	38.59°
1.62	31.54°	41.64°	42.51°	41.35°	39.21°	37.92°	37.59°
1.57	30.02°	40.77°	41.63°	40.47°	39.22°	37.59°	36.95°

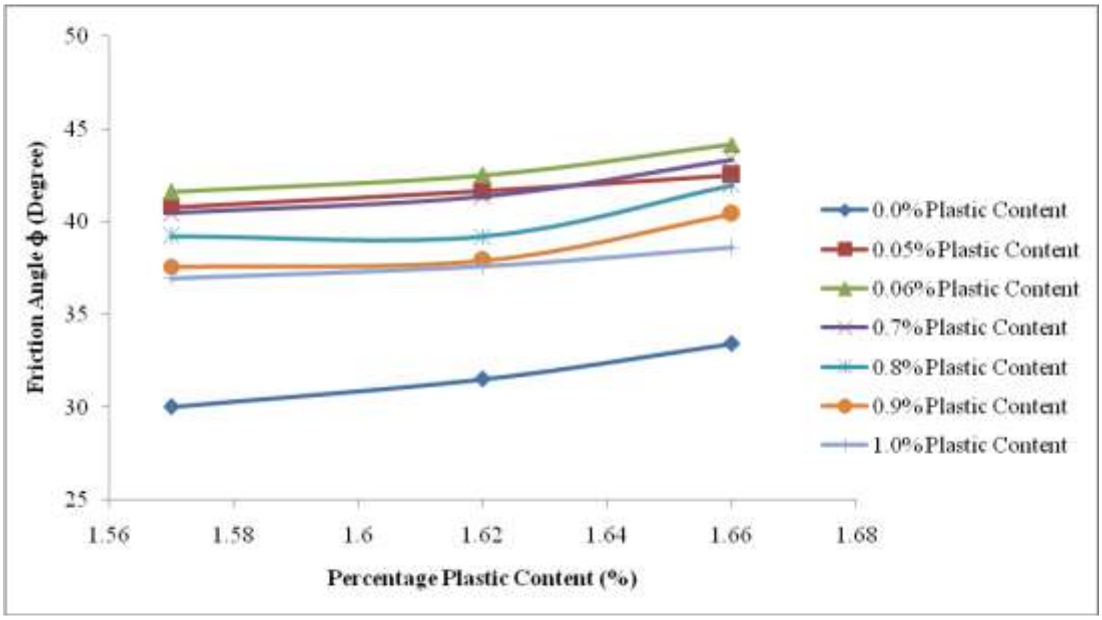

Figure 6: Variation of Friction Angle for different Dry Densities with Different Percentages of Polybag Waste Content

3.1.4 Variable Head Permeability Test

Permeability is defined as the property of a porous material which permits the passage or seepage of water through its interconnecting voids. It is a property of a soil which permits the flow of water. Variable head permeability tests were conducted on dune sand at maximum dry density 1.66 gm/cc with mix of 0%, 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1.0% of polybag waste. From the tests performed, it can be seen that values of coefficient of permeability decrease with increase in polybag waste. Results have been shown in Table 8 and graphically in Fig. 7.

Table 8: Variable Head Permeability Test at MDD 1.66 gm/cc

S. No.	Polybag Waste Content (%)	Coefficient of Permeability (k) (cm/sec)
1.	0%	2.42×10^{-3}
2.	0.05%	1.96×10^{-3}
3.	0.06%	1.65×10^{-3}
4.	0.7%	1.31×10^{-3}
5.	0.8%	1.03×10^{-3}
6.	0.9%	0.91×10^{-3}
7.	1.0%	0.87×10^{-3}

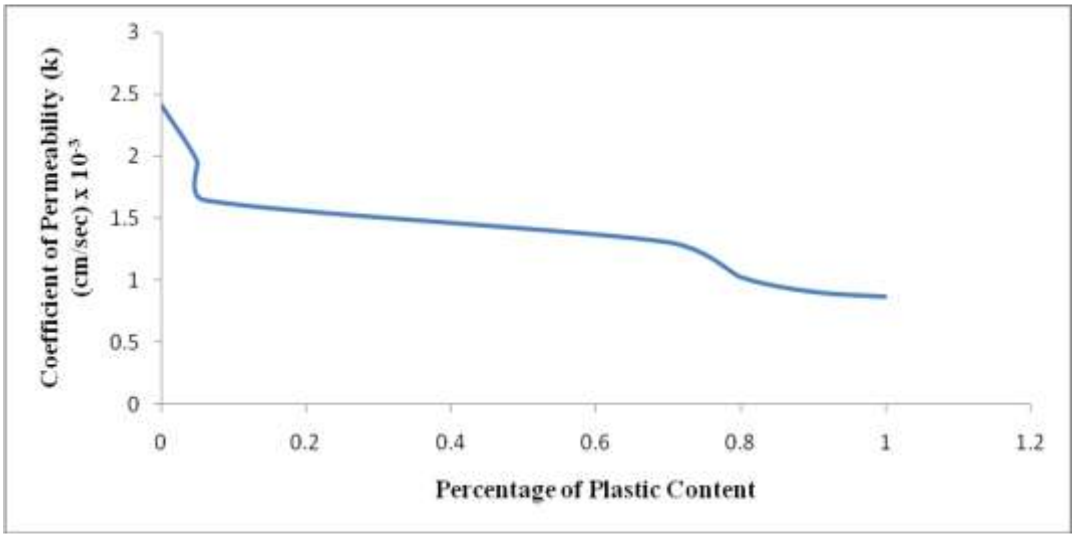

Figure 7: Variable Head Permeability Test at MDD 1.66 gm/cc

IV. CONCLUSION

In this study, we have used polybags as admixture to stabilize dune sand which was brought from Osian (Rajasthan). It can be clearly seen from this investigation that the geotechnical properties of dune sand can be improved by mixing polybags as admixtures.

The maximum values of shear stresses were obtained at higher dry density. Maximum value is obtained at 0.06% of polybag waste content when mixed with dune sand for each dry density. From the results it was observed that the initial void ratio was higher for plain dune sand and lower when polybag waste content was mixed. As the percentage of polybag waste content increased in dune sand, the density of polybag waste content being less, more voids were occupied with polybag waste content and resulted in overall reduction of void ratio. Here, we can see that the value of the angle of internal friction is maximum increased by 38% of pure dune sand at dry density 1.57 gm/cc with 0.06% of polybag waste.

In permeability test, values of coefficient of permeability decrease with increase in percentage of polybag waste content because the polybag strips act as a barrier for water seepage path. The value of coefficient of permeability is decreased by 64%.

A significant improvement has been found in the strength of dune sand with use of polybag waste content. This increase in strength of dune sand is due to increase in friction between dune sand and polybag waste content and development of tensile strength in the polybag waste content. So, it will helpful in reducing the cross section of embankment. Better results can be obtained by changing aspect ratio of polybag strips.

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