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Dune Sand Stabilization Using Plastic (Polybags) Waste as Admixture for the Design of Flexible Pavement in Construction of Roads

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Abstract: *In India, western part is mostly deserted which have mostly dune sand. According to Indian Standard Classification System, dune sand has nil plasticity characteristics and nil cohesion. Dune sand has low compressive strength. Hence, by the stabilization of dune sand, we can use it for various constructions like highways, helipad and airfield constructions. We can use plastic waste like polybags as admixture to stabilize the dune sand. This paper presents the experimental results on dune sand mixed with polybags. This is also a way to reuse of polybag waste with reinforcing the dune sand. It will help in plastic waste removal and management. The size of polybag waste used is 5 mm x 5 mm. Different proportions 0%, 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1.0% of polybag waste and different dry densities 1.66 gm/cc (M.D.D.), 1.62 gm/cc and 1.57 gm/cc of dune sand were mixed and used for testing. Particle size distribution test, standard proctor test, california bearing ratio test and Variable head permeability test have been conducted to obtain results.*
Keywords: *Dune sand, polybag waste, stabilization, CBR, permeability.*

I. Introduction

Soil is the base material that bears all the load of superstructure. If the base is not strong enough to take such load, then construction of pavement is not possible and it will not stay stable for long time. Dune sand has low geotechnical properties and it has to be reinforcing to construct pavements on it. Various methods have been introduced in civil engineering to stabilize the soil and this is an attempt to improve the properties of dune sand. Every year, around 500 billion plastic bags are used worldwide. Hence, so many plastic bags are damaging our environment. India's plastic consumption is one of the highest in the world. Yet, precious little has been done to recycle, reuse and dispose of polybag waste. Polybag waste is difficult and costly to recycle and most end up on landfill sites where they take around 300 years to photo degrade. They break down into tiny toxic particles that contaminate the soil and waterways and enter the food chain when animals accidentally ingest them. A very big amount of polybag waste is available in world so it should be used as admixture for reinforce the dune sand. It has a wide scope of stabilization of dune sand with polybag waste for construction of pavement. Use of polybag waste for reinforcing the dune sand is a cost effective technique. On the other hand, problem of removal or disposal of polybag waste can be reduced with stabilizing the dune sand. Before this study, 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 worked on stabilization of soils.

II. Material Used For Study

2.1 DUNE SAND

Tests have been conducted on dune sand that is brought from Osian town 65-70 kms away from Jodhpur (Rajasthan). Dune sand has nil cohesion and it has poor compressive strength, hence need stabilization. It is uniform sand, particle size varying between 75 μ to 1 mm. Dune sand have nil plasticity characteristics and good drainage. It has coefficient of permeability from 10^{-4} mm/sec to 10^{-2} mm/sec.

2.2 PLASTIC WASTE (POLYBAGS)

Polyethylene was first synthesized by the German chemist Hans Von Pechmann, who prepared it by an accident in 1898 while investigating diazomethane. It contained long $-CH_2-$ chains and termed it poly-methylene. Polyethylene was found to have very low loss properties at very high frequency radio waves. Its softening point is 80°C (176°F) and melting point is typically 105 to 115°C (221 to 239°F). Most plastic grades have excellent chemical resistance, meaning they are not attacked by strong acids or strong bases, and are resistant to gentle oxidants and reducing agents. Crystalline samples do not dissolve at room temperature. Polyethylene absorbs almost no water. Polyethylene can become brittle when exposed to sunlight, carbon black is usually used as a UV stabilizer. Polyethylene burns slowly with a blue flame having a yellow tip and gives off an odour of paraffin (similar to candle flame). The material continues burning on removal of the flame source and produces a drip. Polyethylene cannot be imprinted or stuck together without pretreatment. Polyethylene is a good electrical insulator. Plastic is used for both rigid containers and plastic film applications such as plastic bags and film wrap. LDPE is defined by a density range of 0.910-0.940 gm/cc. Polybag waste shown in Fig. 1.

Figure 1: Plastic Waste (Polybags)

III. Experimental Program

All the experiments have been conducted on dune sand and polybag waste. Polybag waste was cut into pieces of size 5 mm x 5 mm and then mixed with the dune sand.

3.1 EXPERIMENTAL PROGRAM

The tests done on dune sand and 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. CBR test to determine CBR values for dune sand with different mix compositions with polybag waste in unsoaked and soaked conditions.
4. Variable head permeability test to determine coefficient of permeability for dune sand with mix compositions.

Table 1 show the variables which are investigated.

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.	Polybag waste strips on different properties of sand	Strip size	5 mm x 5 mm
3.	Mix polybag 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 and 1.57 gm/cc

3.1.1 Particle Size Distribution Test

The particle size distribution test is performed 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 was poured in top sieve. All sieves were placed according to their decreasing opening size. After shaking the sample on sieve shaker, the retained material of every sieve is weighted.

$$\text{Percentage Retained} = \frac{W_{sieve}}{W_{total}} \times 100$$

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 finer was calculated by subtracting the % retained from 100%. The results of this test have been shown in Table 2 and Fig. 2.

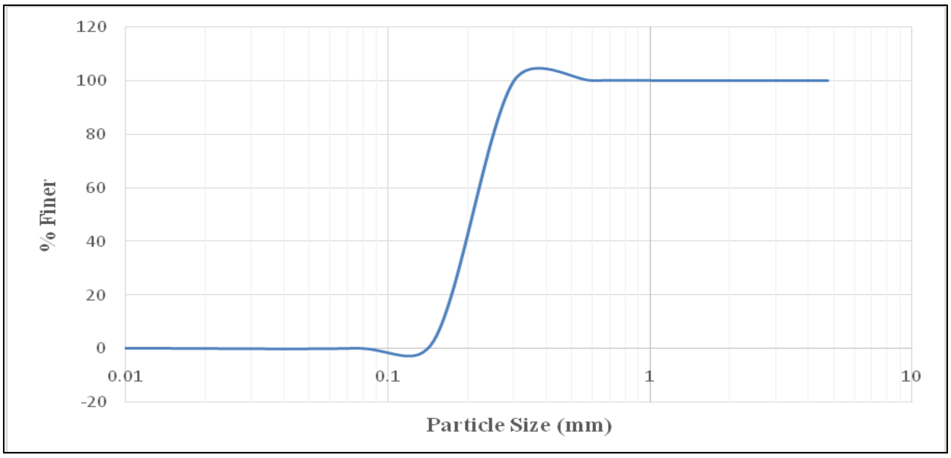

Figure 2: Particle Size Distribution Curve

Table 2: 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 is used to determine 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. 3. It shows that as we increase the moisture content, the dry density decrease but after then dry density start to increase and it occurs due to bulking of dune sand. As it reaches on maximum value, dry density starts to decrease again. The tests were done on dry densities 1.57 gm/cc, 1.62 gm/cc and 1.66 gm/cc (M.D.D.) on moisture content 6.82%, 10.42% and 12.34% respectively.

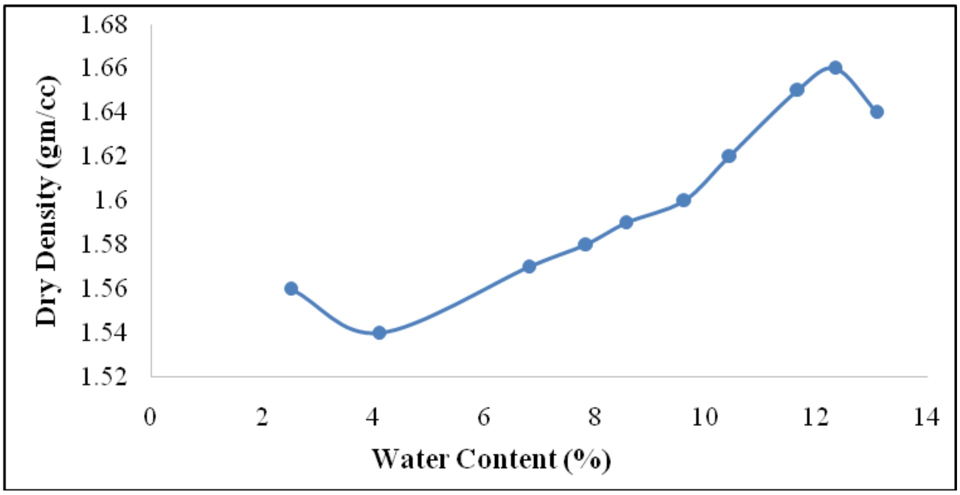

Figure 3: Variation of Dry Density with Moisture Content

3.1.3 California Bearing Ratio (CBR) Test

CBR test was conducted on a 5 kg dune sand sample and mix compositions of dune sand and polybages waste. The sample was mix to required dry density. The mould size was 150 mm in diameter, 127.3 mm in height and capacity of 2250 ml. Dune sand was compacted in three layers into mould. Each layer was compacted 56 times by a 2.6 kg rammer. The samples were placed into water for 24 hours to test in soaked condition.

3.1.3.1 Comparative Study

The results of CBR tests have been tabulated in Table 3 and graphically shown in Fig. 4 for unsoaked condition. For soaked condition, results have been tabulated in Table 4 and graphically shown in Fig. 5. In the graph, different percentage of polybag waste content 0%, 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1.0% have been plotted on X-axis and the different values of CBR for different dry densities 1.66 gm/cc, 1.62 gm/cc and 1.57 gm/cc have been plotted on Y-axis.

From the tests, it can be concluded that CBR value of dune sand increases with higher dry densities. As the polybag waste content in dune sand increases, initially, the CBR vlaue increase and then start to decrease. All the values of CBR for three dry densities were more in unsoaked condition than soaked condition.

Table 3: Variation of % CBR Values for Different Dry Densities with % Polybag Waste Content for Unsoaked Condition

Dry Density (gm/cc)	% CBR Value						
	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	4.05	4.76	6.91	4.05	3.57	3.09	2.14
1.62	3.81	4.53	5.48	4.04	3.33	3.09	1.90
1.57	3.09	3.33	3.81	3.57	3.21	2.62	1.66

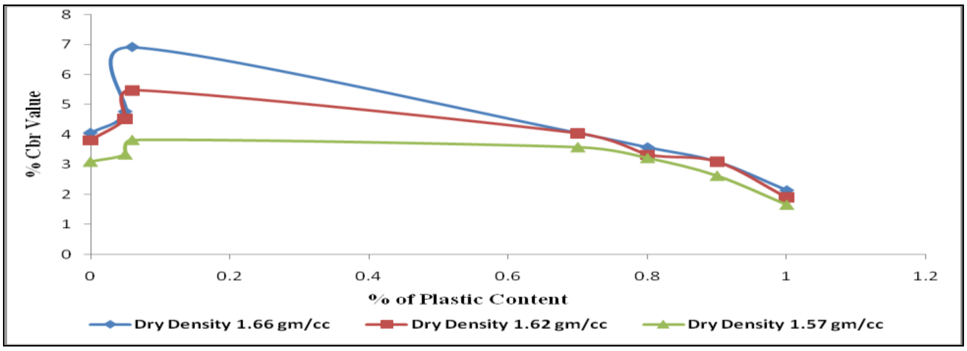

Figure 4: Variation of % CBR Values for Different Dry Densities with % Polybag Waste Content for Unsoaked Condition

Table 4: Variation of % CBR Values for Different Dry Densities with % of Polybag Waste Content for Soaked Condition

Dry Density (gm/cc)	% CBR Value						
	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	2.62	3.57	4.29	2.14	1.90	1.66	1.43
1.62	2.38	2.86	3.33	2.14	1.66	1.43	1.43
1.57	1.90	2.14	2.38	1.90	1.66	1.43	1.19

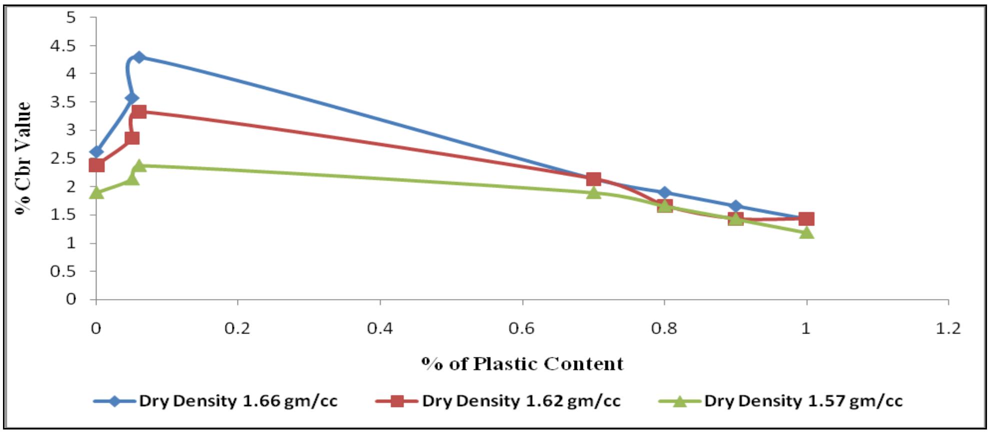

Figure 5: Variation of % CBR Values for Different Dry Densities with % Polybag Waste Content for Soaked Condition

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. Variable head permeability tests were conducted on dune sand at maximum dry density 1.66 gm/cc with all mix of 0%, 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1.0% of polybag waste content. From the test performed, it can be seen that value of coefficient of permeability decrease with increase in plastic content. Results have been shown in Table 5 and graphically in Fig. 6.

Table 5: 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}

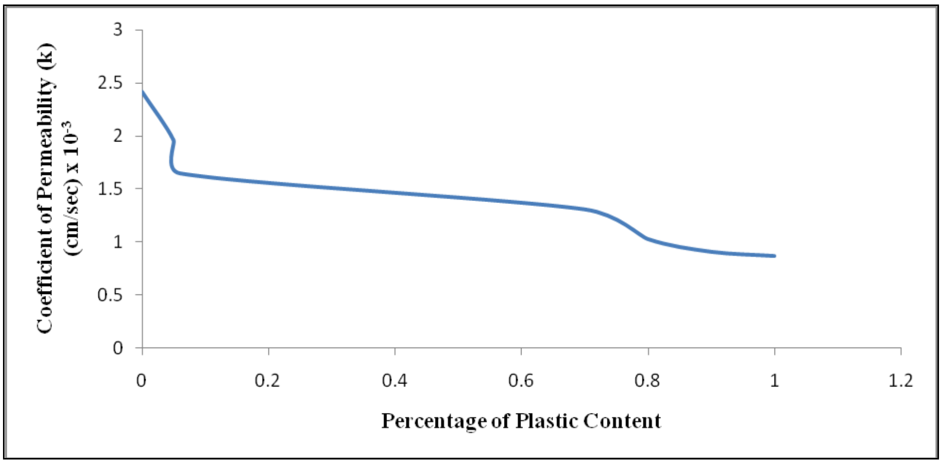

Figure 6: Variable Head Permeability Test at MDD 1.66 gm/cc

IV. Conclusion

In this study, we have used polybag waste as admixture to stabilize dune sand. This dune sand is collected from Osian (Rajasthan, India). It is clearly seen from this investigation that the geotechnical properties of dune sand can be improved by mixing polybag waste as admixtures.

The values of CBR, initially increases with increase in percentage of polybag waste content but further increase in percentage of polybag waste content will result in decreasing order of CBR values. The maximum values obtained for both unsoaked and soaked conditions were at 0.06% of polybag waste content mix with all dry densities of dune sand. CBR value depends on soil particle friction. As polybag waste content was mixed, friction among soil particle and polybag strips became more but as the percentage of polybag waste content was further increeased, soil particles started to slip and CBR value decreased. The maximum increment in % CBR value for unsoaked condition is 70% and for soaked condition is 63% at maximum dry density mixed with 0.06% of polybag waste content. The values for unsoaked conditions were more than soaked condition for all the three dry densities.

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%. As the value of % CBR is increased, thus by this study, we can conclude that dune sand with polybag waste can be used for pavement construction and can be improved by more work on size of strips or percentage of plastic wastage. Further, as a result, providing us with a stable pavement and the thickness of pavement can be reduced accordingly.

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