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Stabilization of Dune Sand Mixed with Plastic (LDPE) Waste Strips for Design of Flexible Pavement in Construction of Roads

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ABSTRACT: *The objective of the present study is to develop a mix proportion that can be economically used for construction of flexible pavement by stabilizing of dune sand using cheap and locally available materials like waste LDPE (Low Density Polyethylene) strips. Dune sand is loose and cohesion less in its natural form. The construction as well as protection of flexible pavement for the purpose of approach roads, temporary roads and landing strips in desert region like western Rajasthan (India) has been a problem of great concern, which necessitates stabilization of dune sand with some admixtures to improve its strength property and reduce settlements. In this paper, waste LDPE strips of 5mm X 5mm are used so as a reinforcement to perform the CBR studies while mixing with dune sand for improving engineering performance of sub grade soil. The varying percentage 0%, 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1.0% LDPE waste strips content were mixed in dune sand. With these mix compositions, a series of California Bearing Ratio (CBR) tests and Variable Head Permeability tests were carried out at different dry densities arrived by Standard Proctor test as 1.57 gm/cc, 1.62 gm/cc and 1.66 gm/cc (M.D.D.). The results and conclusions were summed up which shows that use of LDPE waste in dune sand in an appropriate amount really aids in improving the strength of dune sand and also helps in modification of dune sand properties which might be in terms of strength of sub grade soil.*

Keywords: *Dune Sand, LDPE strips, CBR, Permeability.*

I. INTRODUCTION

The universal availability of soil at low cost and having basic construction properties offers great opportunity for skillful use as an engineering material. Soil is a highly variable material in terms of geotechnical properties. Dune sand is non plastic and uniformly graded fine sand. The particles are free to move relative to each other, which is responsible for their low mechanical properties. Stabilization of soil is technique for improving the mechanical and engineering properties of soil. Improvement of the engineering properties of soil using the technique of soil reinforcement involves introducing elements that increase its engineering strength characteristics in order to make up for the limited ability of soil to resist generated tensile load and shear stresses. A treated or stronger sub grade soil shall require relatively thinner section of a flexible pavement as compared to that of an untreated and weaker sub-grade resulting in significant cost advantage. 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 sub grade soils. Many researchers like Maher and Ho (1994), Lindh and Eriksson (1990), Ranjan et al. (1996), Rao and Dutta (2004), Ameta et al. (2008) Amol S. Bale (2011), S. K. Tiwari et. al. (2013), Pragyan Bhattarai et. al. (2013) and Akash Gupta et al. (2016) have conducted investigation on stabilization of soils using different types of admixtures.

II. MATERIALS USED FOR PRESENT STUDY

2.1 Dune Sand

Dune sand is found in abundance in western Rajasthan (India). The sand used in present study was brought from location near Osian town, about 65-70 km away from Jodhpur, Rajasthan on Jodhpur–Bikaner Highway. Dune 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 and round to angular in particle shape as per Indian Standard Classification System.

2.2 LDPE Sheets

Low density polythene sheet of black color which is used as canal liner is used in the present study which has a thickness of 175 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. Fig. 1 shows the plastic strip mixed with dune sand. Table 1 presents the properties of LDPE sheet which was used in this investigation.

Figure 1: Plastic Wsate Strips Mixed with Dune Sand

Table 1: Properties of LDPE

S. No.	Property	Value
1.	Aspect ratio of strip (l/b)	1.0
2.	Thickness	175 microns
3.	Density at 27°C (gm/cc)	0.923
4.	Melting point	199°C

III. TEST PROGRAMME AND PROCEDURE

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 dune 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 results of sieve analysis are shown in Table 2 and Table 3.

Table 2: Particle Size Distribution of Dune Sand

S. No.	IS Sieve	Mass Retained (gm)	Percentage Retained	Cumulative Percentage Retained	Percentage Finer
1.	4.75 mm	0	0.0	0.0	100
2.	2.0 mm	0	0.0	0.0	100
3.	1.18 mm	0	0.0	0.0	100
4.	600 μ	0	0.0	0.0	100
5.	300 μ	6	0.60	0.60	99.4
6.	150 μ	964	96.4	97.00	3.00
7.	75 μ	30	3.0	100.00	0.0
8.	PAN	0	0.0	100.00	0.0

Table 3: Properties of Dune Sand

S. No.	Property	Test Media Dune Sand
1.	Coefficient of uniformity (C_u)	1.43
2.	Coefficient of curvature (C_c)	0.88
3.	Mean Diameter (D_{50})	0.21 mm
4.	Effective size (D_{10})	0.16 mm
5.	Fine soil fraction (75 μ)	0%

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, pulverized soil samples were taken for the test. The soil is compacted by 25 blows of the rammer of 2.6 kg weight, 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 results show 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 increases 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 1.57gm/cc and 1.62 gm/cc were considered for the present study.

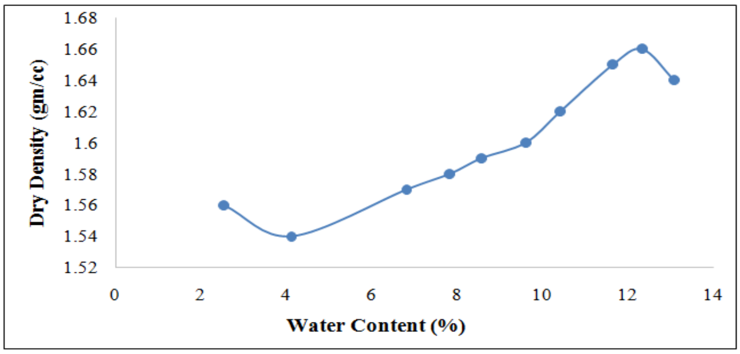

Figure 2: Dry Density v/s Water Content Curve

3.3 California Bearing Ratio (C.B.R.) Test

CBR tests were carried out to determine % CBR values of the dune sand with LDPE waste as per IS-2720, Part-16, 1979. In CBR test, 5 kg of sun dried soil sample was taken and mixed evenly with water. The LDPE waste was then distributed evenly and mixed with the wet soil uniformly and thoroughly. The mix was compacted in 2250 ml CBR (150 mm diameter and 127.3 mm height) using light compaction. The wet plastic-mixed soil was then compacted using light compaction in 3 equal layers by giving to each layer 56 uniformly distributed blows of 2.6 kg rammer. The specimen was then tested for penetration in the loading machine.

Penetration tests were done for obtaining the CBR values of unsoaked and soaked samples. For the soaked condition, the sample were kept in water for 24 hours. The mould, containing the specimen was mounted on the testing machine and two surcharge masses 2.5 kg each were placed on the top of specimen before starting the penetration test. After the penetration measuring dial gauge is corrected to read zero and the load was applied, the load readings were noted at every 0.5 mm penetration. The final CBR value is measured corresponding to 2.5 mm and 5.0 mm penetration whichever is greater.

3.3.1Comparative Study

1. According to test results, it can be seen that on increment of dry density, the CBR value of the mix composition increases. On increasing the percentage of LDPE waste content, the CBR value of the mix composition initially increases and then starts to decrease as we increase the percentage of LDPE waste content for both unsoaked and soaked conditions. The maximum results have been obtained at low percentage of LDPE waste content (0.06%) and minimum results at 1.0% LDPE content for all the three dry densities. Hence it can be concluded that to use the mix compositions in base and sub base construction, the CBR values can be increased or decreased as needed.
2. The test results also shows that the CBR value at different dry densities of dune sand with different percentage of LDPE waste content is more at unsoaked condition than that compared with soaked condition.

3. Comparative results for unsoaked condition for mix compositions of different all the three dry densities of dune sand and different percentages of LDPE waste content have been shown in Table 4 and Fig. 3. Comparative results for soaked conditions are tabulated in Table 5 and Fig. 4.

Table 4: CBR Value Variation in Mix Compositions in Unsoaked Condition

Dry Density (gm/cc)	CBR (%)						
	Mix Composition						
	0% Admixture	0.05% Admixture	0.06% Admixture	0.7% Admixture	0.8% Admixture	0.9% Admixture	1.0% Admixture
1.57	3.09	3.10	3.93	2.86	2.62	2.38	2.14
1.62	3.81	3.22	4.05	3.10	2.86	2.62	2.38
1.66	4.05	3.58	4.29	3.34	3.22	3.10	2.62

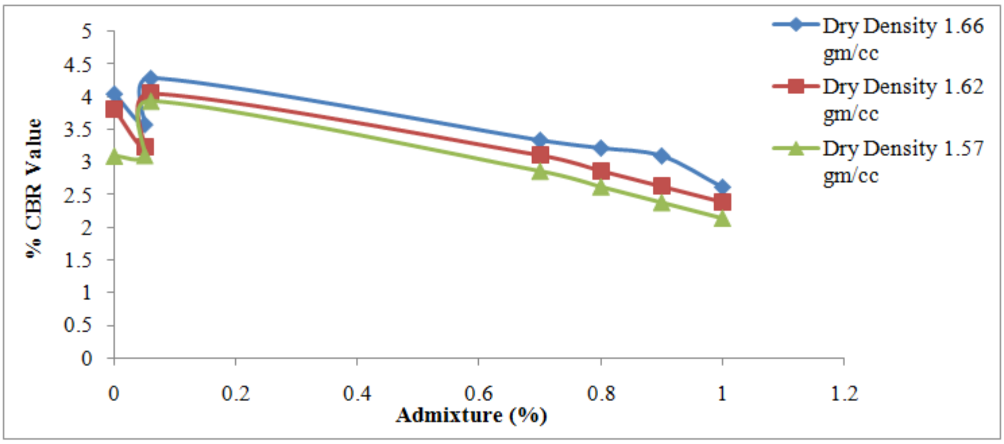

Figure 3: CBR Value Variation in Mix Compositions in Unsoaked Conditions

Table 5: CBR Value Variation in Mix Compositions in Soaked Conditions

Dry Density (gm/cc)	CBR (%)						
	Mix Composition						
	0% Admixture	0.05% Admixture	0.06% Admixture	0.7% Admixture	0.8% Admixture	0.9% Admixture	1.0% Admixture
1.57	1.90	1.67	2.38	1.67	1.19	1.19	0.95
1.62	2.38	1.91	2.62	2.14	1.79	1.67	1.43
1.66	2.62	2.14	2.86	2.14	1.91	1.79	1.43

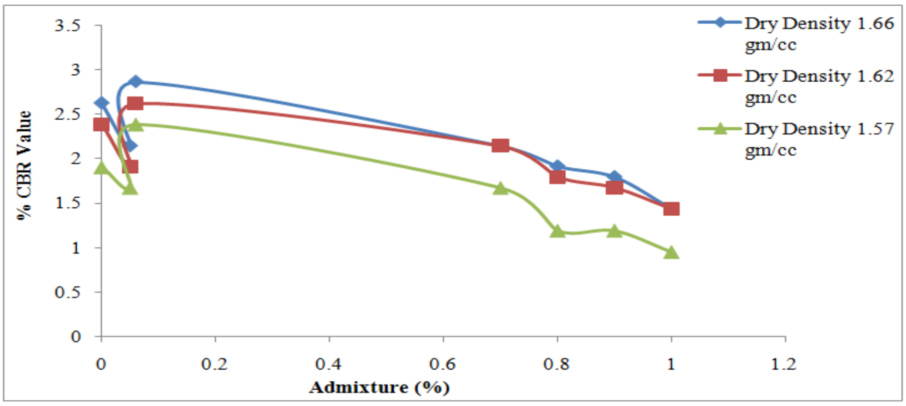

Figure 4: CBR Value Variation in Mix Compositions in Soaked Condition

3.4 Falling Head Permeability Test

The test was conducted in variable head permeameter according to IS 2720 (Part XVII). All the permeability tests were conducted on dune sand at MDD 1.66 gm/cc with LDPE waste content in varying percentage of 0%, 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1.0%. Canal lining sheet of LDPE obviously has some tremendous water barrier properties. Coefficient of permeability for dune sand mixed with LDPE waste strips was determined to access effect of size and proportion of strips. Test results have been shown in Table 6 and in Fig. 5.

Table 6: Falling Head Permeability Test at MDD 1.66 gm/cc

S. No.	LDPE Waste Content (%)	Coefficient of Permeability (k) (cm/sec)
1.	0%	2.42×10^{-3}
2.	0.05%	2.23×10^{-3}
3.	0.06%	2.18×10^{-3}
4.	0.7%	1.61×10^{-3}
5.	0.8%	1.50×10^{-3}
6.	0.9%	1.38×10^{-3}
7.	1.0%	1.27×10^{-3}

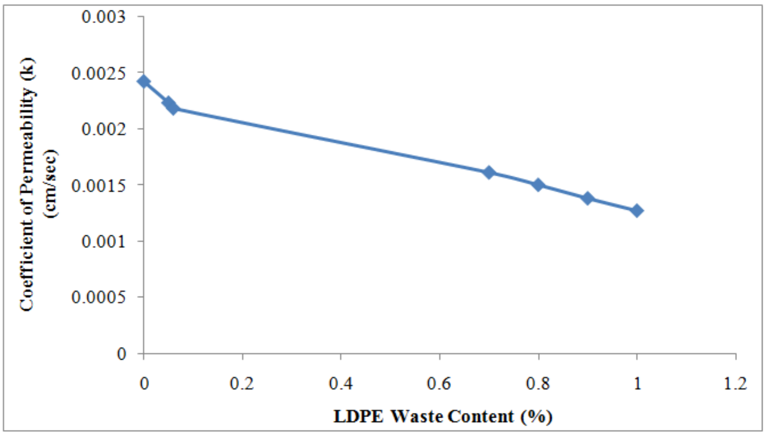

Figure 5: Variable Head Permeability Test at MDD 1.66 gm/cc

IV. CONCLUSION

The main objective of this investigation was to study improvement of various important properties of dune sand by replacing a part of it with LDPE waste strips and in addition to reduce the environmental pollution caused by the LDPE waste. Laboratory tests have been performed keeping dune sand and LDPE waste strip of size 5 mm x 5 mm in various mix composition as 0%, 0.05%, 0.06%, 0.7%, 0.8%, 0.9%, and 1.0%. The dune sand condition has been simulated by keeping the dry densities 1.66 gm/cc, 1.62 gm/cc and 1.57 gm/cc. The results of the testing program clearly show that the engineering properties of the dune sand improved considerably due to stabilizing using LDPE waste strips. After analysis of the test results presented in the tables and figures, the following conclusions are drawn regarding the performed experimental study:

1. The dry density of the dune sand at which the laboratory tests were conducted, played a major role in the improvement of the CBR values of dune sand. The laboratory test results clearly show that the CBR values of the dune sand mixed with LDPE waste strips vary with the dry density of the sand.
2. The best CBR values of LDPE waste strip reinforced dune sand were observed at the maximum dry density of dune sand i.e. 1.66 gm/cc. These CBR values are higher than obtained for the other two dry densities of dune sand. The CBR value in unsoaked condition is obtained greater than that of in soaked condition at same dry densities having same amount of admixture. Maximum increment in % CBR value is 27% for unsoaked condition and 25% for soaked condition at dry density 1.57gm/cc with 0.06% of LDPE waste. Thus, this study will helpful in reducing the thickness of flexible pavement in construction of roads.
3. The permeability of pure dune sand and LDPE waste strips mixed dune sand was determined. It can be concluded that the permeability reduces with an increase in the percentage of LDPE waste as the canal lining film has water barrier property. The value of k (coefficient of permeability) is decreased to 47%.
4. Results of tests demonstrated that inclusion of LDPE waste strips in dune sand with appropriate amounts improved strength and deformation behavior of sub grade soils.
5.

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