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Stabilization of Dune Sand with Ceramic Tile Waste as Admixture

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***Abstract:* -** The Dune-Sand has nil cohesion and thus has a very low compressive strength. The stabilization of Dune-Sand is of prime importance since it can be used for various construction works and highways, airfields and helipads projects. The investigation reported herein presents a study of stabilization of Dune- Sand with Ceramic Tiles Wastage as admixture. All the California Bearing Ratio tests were conducted at maximum dry density and optimum moisture content as arrived from Standard Proctor Test. Direct shear tests were also performed. The main objective of this experimental study was to obtain an economical stabilized mix of ceramic tiles wastage and dune sand so that largely and cheaply available dune-sand be used for various construction purposes.

***Keywords*: -** *Dune sand, Ceramic tiles, stabilization, C.B.R., Shear.*

I. INTRODUCTION

Utilization of immense reserve of dune sand, the huge mass remained unnoticed, untouched from centuries, where life itself requires courage to move ahead to survive, in the absolute scarcity of basic needs. Soil stabilization is the alteration of one or more soil properties, by mechanical or chemical means, to create an improved soil material possessing the desired engineering properties. Soils may be stabilized to increase strength and durability or to prevent erosion and dust generation.

The properties of a soil may be altered in many ways among which a few are chemical, thermal, mechanical and other means. Stabilization is being used for a variety of engineering works such as construction of all-weather roads and air-field pavements including helipads, where the main aim is to increase the strength or stability of soil by making best use of the locally available materials. Engineers are responsible for selecting or specifying the correct stabilizing method, technique, and quantity of material required.

There is a great scope of stabilization of Dune-Sand with the admixture of Ceramic Tiles Wastage for construction of pavements, airfields and helipads. The main aim of the present work is to develop a mix composition which can be economically used for stabilization of dune sand in any type of environment. The laboratory studies have been done on dune sand using ceramic tiles wastage. The test specimens were prepared in the laboratory by direct mixing of the ceramic tiles wastage in dune sand.

The ceramic tiles wastage can be easily available from various construction sites and manufacturing units. If this wastage can be used efficiently then we can obtain an economical mix of dune sand and ceramic tiles wastage as a construction material. On the other hand, the problem of the disposal of ceramic tiles wastage can be overcome by using it for stabilization of dune sand. Many researchers like Ameta et al. (2008), 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 FOR STUDY

2.1 Dune-Sand

The Great Indian Desert known as Thar Desert in the west of Rajasthan bordering Pakistan covers over 60% of its area and includes 12 of its 32 districts. The Thar Desert is one of the most densely populated desert environments in the world, occupying an area of 2,10,000 sq. kms., covering 61.3% of the Rajasthan State and

6.3% of the country as a whole.

Jodhpur district is a part of Thar Desert. The Dune Sand used in the present study was brought from location near Jajiwal-Banar villages, at about 20-25 km away from Jodhpur on Jodhpur-Jaipur road. Dune sand has nil cohesion and has poor compressive strength and hence need stabilization. Dune sand is coarse grained, uniform clean sand as per Unified Soil Classification system. Particles size ranges between 75 □ to 1.0mm i.e. fine coarse sand, round to angular in particle shape as per Indian Standard Classification System.

2.2 Ceramic Tiles

A ceramic tile is an inorganic, nonmetallic solid prepared by the action of heat and subsequent cooling. Ceramic materials may have crystalline or partly crystalline structure, or may be amorphous. Because most common ceramics are crystalline, the definition of ceramic is often restricted to inorganic crystalline materials.
The word "ceramic" comes from the Greek word (kermos) which means "potter's clay". The earlier ceramics were pottery objects made from clay, either by itself or mixed with other materials, hardened in fire. Later ceramics were glazed and fired to create a coloured, smooth surface. The potters used to make glazed tiles with clay; hence the tiles are called as "ceramic tiles".
The raw materials to form tile consist of clay minerals mined from the earth's crust, natural minerals such as feldspar that are used to lower the firing temperature, and chemical additives for the shaping process.

2.3. Ceramic Tiles Wastage

A lot of ceramic tiles wastage is produced during formation, transportation and placing of ceramic tiles. This wastage or scrap material is inorganic material and hazardous. Hence its disposal is a problem which can be removed with the idea of utilizing it as an admixture to stabilize dune sand, so that the mix prove to be very economical and can be used as subgrade in low traffic roads or village roads.

III. TEST PROGRAM AND PROCEDURE

The laboratory investigation on dune sand stabilization with ceramic tiles wastage as admixture was performed. The ceramic tile wastage was brought from some construction site. The ceramic tiles were of Kajaria Company. The dune sand had similar characteristics which are found in various areas of Jodhpur district. Hence sand from one location near Jajiwal-Banar Villages, at about 20-25 kms away from Jodhpur on Jodhpur-Jaipur Road was brought for the study.

The objective of the present study is to evaluate the use of dune sand as a construction material after stabilizing it with ceramic tiles wastage particles as admixture. The present study has been undertaken with the following objectives:

1. To study the effect of ceramic tiles wastage particles of varying size (4.75mm. 2mm, 1.18mm and .425mm) on Proctor density and OMC of dune sand.
2. To study the changes in CBR value of dune sand by mixing ceramic tile wastage of varying size in different proportions in unsoaked and soaked conditions.
3. To study the changes in shear stress of dune sand mixed with ceramic tiles wastage of varying size in different proportions.

3.1 Test Programme

The test programme included the preliminary tests for dune sand and mix compositions of dune sand with ceramic tiles wastage. Following tests were carried out :

1. Determination of particle size distribution of dune sand.
2. Standard Proctor Test for determining maximum dry density and optimum moisture content. (For dune sand and mix composition with ceramic tiles wastage).
3. CBR Test to determine CBR values for dune sand and mix compositions with ceramic tiles wastage.
4. Direct Shear Test to determine shear stress of dune sand and mix compositions with ceramic tiles wastage.

Table 1 : Particle Size Distribution of Dune Sand

S.No.	Sieve Size (mm)	Weight retained (gm)	% weight retained	Cumulative % weight retained	Cumulative % weight passing	% Finer
1.	2.0	8.0	0.8	0.8	99.2	99.2
2.	1.0	4.0	0.4	1.2	98.8	98.8
3.	.600	3.0	0.3	2.2	98.1	98.1
4.	.425	3.0	0.3	2.2	97.8	97.8
5.	.300	6.0	0.6	2.8	97.2	97.2
6.	.150	894.0	89.4	92.2	7.8	7.8
7.	.075	73.0	7.3	99.5	0.5	0.5
8.	Pan	5.0				

3.1.1 Standard Proctor Test Or Proctor Compaction Test

The result tabulated in the Table 1 shows that on increment of the ceramic tiles wastage in the dune sand, the maximum dry density (M.D.D.) of the mix composition increases. On the other hand, on increasing particle size of the ceramic tiles wastage the maximum dry density (M.D.D.) increases. The optimum moisture content (O.M.C.) also increased from 12 to 16 percent. The maximum dry density variations of mix compositions are shown in Figure1.

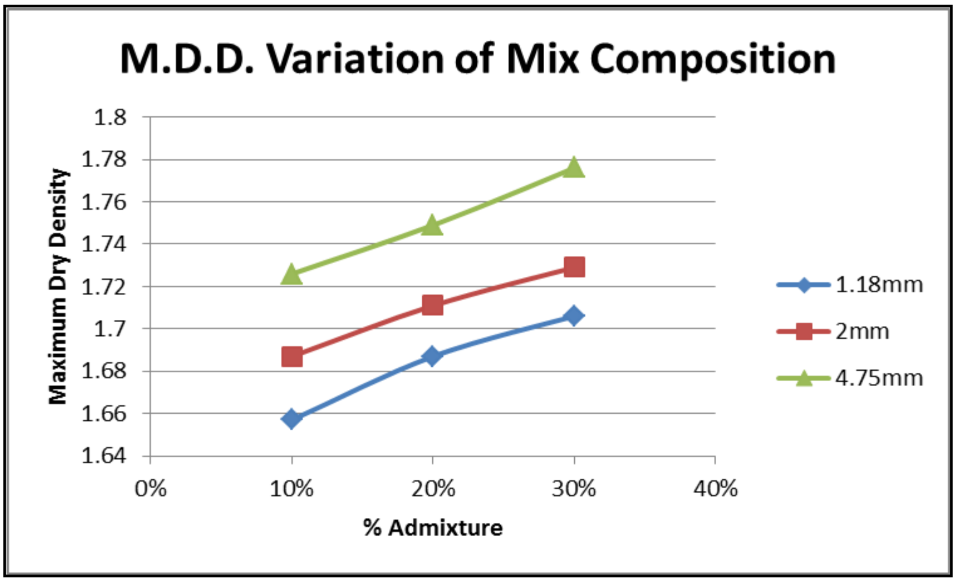

Figure 1: M.D.D. Variations Of Mix Compositions

3.1.2 California Bearing Ratio (CBR Test)

CBR Tests were conducted to determine CBR values of stabilized dune sand. Different proportions of ceramic tiles wastage were mixed in dune sand to perform the tests. 5 kg of soil was taken and mixed properly with proportion of ceramic tiles wastage and water equal to optimum moisture content obtained already by Standard Proctor Test.

The mix was compacted in 2250 ml CBR mould (150 mm diameter and 127.3 mm height) using light compaction. The mix was compacted in three equal layers; each layer being given 56 uniformly distributed blows of 2.6 kg rammer. Top surface of the specimen was finished properly to make it even for loading test. The next day, the samples were tested for the determination of CBR values in soaked condition.

For obtaining the CBR values of unsoaked & soaked samples penetration tests were done. The mould, containing the specimen was mounted on the testing machine and a surcharge weight equal to 5 kg (two spacer discs) was placed on the top of specimen before starting the penetration test. After setting the plunger on the surface of specimen and setting the load and penetration measuring dial gauge to read zero the load was applied. Load readings at every 0.5 mm were noted and a graph was drawn between the load (ordinate) and penetration (abscissa). In most of the tests the curve was either straight or convex upwards in the initial portion. In such cases the test load corresponding to 2.5 mm and 5.0 mm were read from the curve. If, in case the curve, in its initial portion comes to be concave upwards, in those cases the corrected origin point is to be shifted to the point of greatest slope with the penetration axis.

Test results obtained show that CBR value increases with increase in ceramic particle size. The CBR value for same size ceramic particles in mix composition increases with increase in percentage of ceramic particles. The tables and graphs are shown in the coming pages.

IV. COMPARATIVE STUDY

We have graphically represented the variations in C.B.R. values in the graphs below for both unsoaked and soaked conditions. On the graph, at abscissa (x-axis) ceramic particles percentage of sand varying from 5% to 30% at an interval of 5% has been marked and on ordinance (y axis) C.B.R. values have been plotted for mix compositions of ceramic tiles wastage passing 4.75mm, 2.0mm, 1.18mm and 425□ .

From graphs it can be seen that on increment of particle size of admixture, the C.B.R. value of the mix composition increases. Also as the quantity or percentage of admixture increases, the C.B.R. value of the mix

composition increases. Hence it can be concluded that to use the mix compositions in base and sub base constructions, the C.B.R. values can be increased or decreased as needed.
Variations in C.B.R. values at different percentages of mix composition at different size also show that increase in C.B.R. values is more at unsoaked condition than that compared with soaked condition.

Table 2: CBR Value Variation in Mix Compositions in Unsoaked Conditions

Admixture (%)	CBR(%)			
	Mix composition			
	425 µ Sieve	1.18 mm Sieve	2 mm Sieve	4.75 mm Sieve
5	1.255	1.674	1.883	2.511
10	2.197	2.511	2.824	3.766
15	3.138	3.452	3.766	4.394
20	3.452	3.766	4.08	5.021
25	4.08	4.394	5.021	6.277
30	4.394	5.021	5.963	6.591

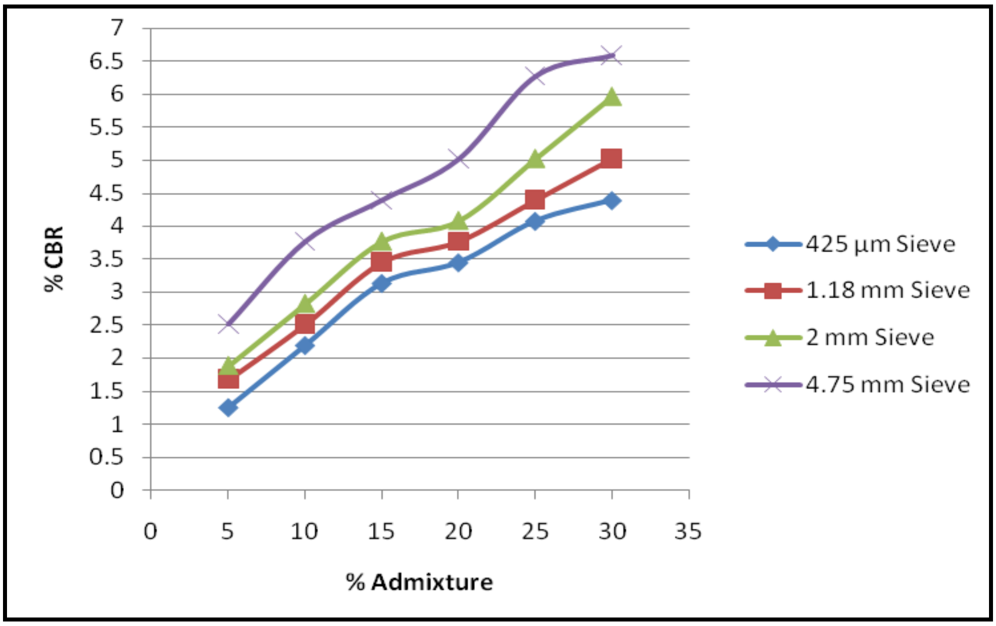

Figure2: CBR Value Variation in Mix Compositions in Unsoaked Conditions

Table 3: CBR Value Variation in Mix Compositions in Soaked Conditions

Admixture (%)	CBR (%)			
	Mix composition			
	425 µ Sieve	1.18 mm Sieve	2 mm Sieve	4.75 mm Sieve
5	1.046	1.255	1.464	1.674
10	1.255	1.464	1.674	1.883
15	1.673	1.883	2.197	2.511
20	2.197	2.511	2.72	3.138
25	2.301	2.511	2.72	3.138
30	2.511	2.929	3.347	3.452

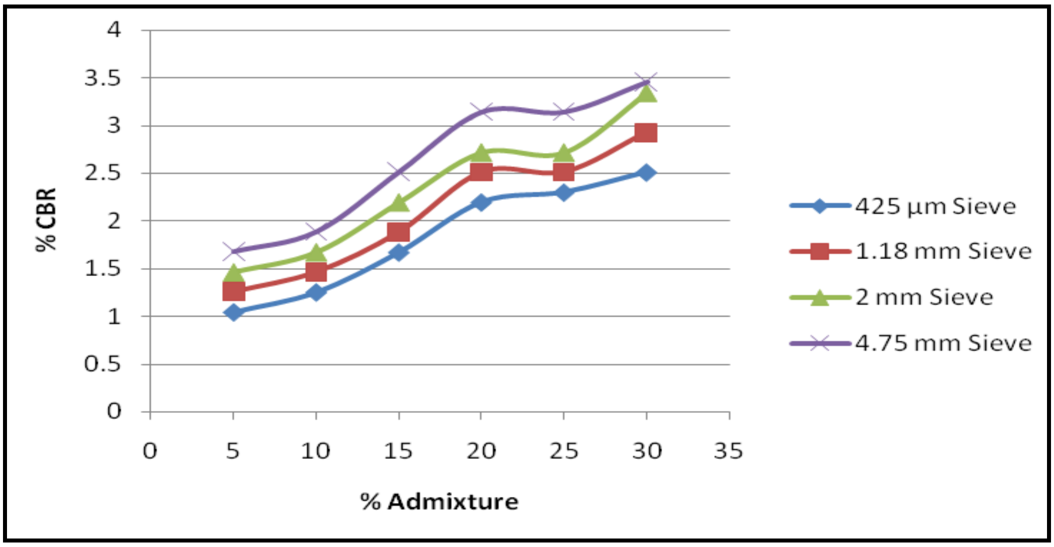

Figure 3: CBR Value Variation in Mix Compositions in Soaked Conditions

V. DIRECT SHEAR TEST

Direct shear tests were performed on mix composition of ceramic particles of size passing sieve 4.75 mm, 2.0 mm and 1.18 mm with 10%, 20% and 30% of sand. Tests were carried out with a strain controlled shear apparatus at rate of 1.25 mm/min to determine failure stress and angle of internal friction ( ) of different mix composition.

From the results obtained it can be concluded that angle of internal friction varies with increase in size of ceramic tiles wastage in mix composition. On the other hand for the same size of ceramic tiles wastage, the angle of internal friction increases with increase in percentage or quantity of ceramic tiles wastage. Variation of failure stress and angle of internal friction of 4.75mm, 2mm and 1.18mm sieve size at 10%, 20% and 30% admixture has been presented graphically and tabulated in following tables.

5.1 Comparative Study

A comparative study of variation of stresses has been made from the test results in preceding tables. For variation of shear stress graphs showing on x-axis normal stress 0.1 kg /cm2, 0.2 kg/cm2, 0.3 kg /cm2 and on y-axis corresponding shear stress at 10%, 20% and 30% admixture of 1.18 mm,2.0 mm and 4.75 mm sieve have been presented and tabulated in following tables .

It has been found from the study that on keeping normal stress as constant, as the particle size or the quantity of the admixture increases, the shear stress value of the mix composition increases. Also for the same particle size of admixture ,the shear stress values of the mix composition increases as the normal stress increases.

Table 4 : Variation of shear stress for 10% Admixture of 4.75mm, 2 mm and 1.18mm sieve.

Normal Stress(kg/cm2)	Shear Stress (kg/cm^2)		
	Mix composition		
	1.18mm pass sieve	2mm pass sieve	4.75mm pass sieve
0.1	0.1518	0.1848	0.2178
0.2	0.2244	0.2706	0.3168
0.3	0.2970	0.3564	0.4158

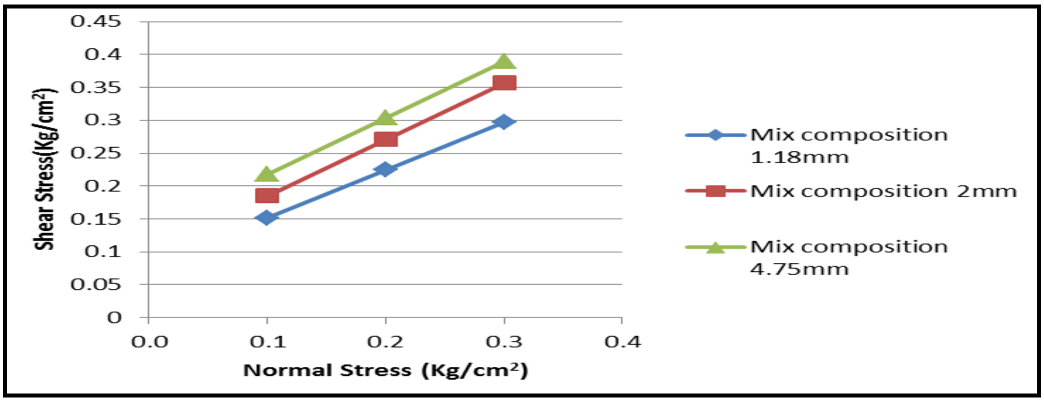

Figure 4 : Variation of shear stress for 10% Admixture of 4.75mm, 2 mm and 1.18mm sieve.

Table 5: Variation of shear stress for 20% Admixture of 4.75mm, 2 mm and 1.18mm sieve.

Normal Stress(kg/cm2)	Shear Stress (kg/cm^2)		
	Mix composition		
	1.18mm pass sieve	2mm pass sieve	4.75mm pass sieve
0.1	0.2046	0.2442	0.2838
0.2	0.3036	0.3630	0.4224
0.3	0.4026	0.4618	0.5610

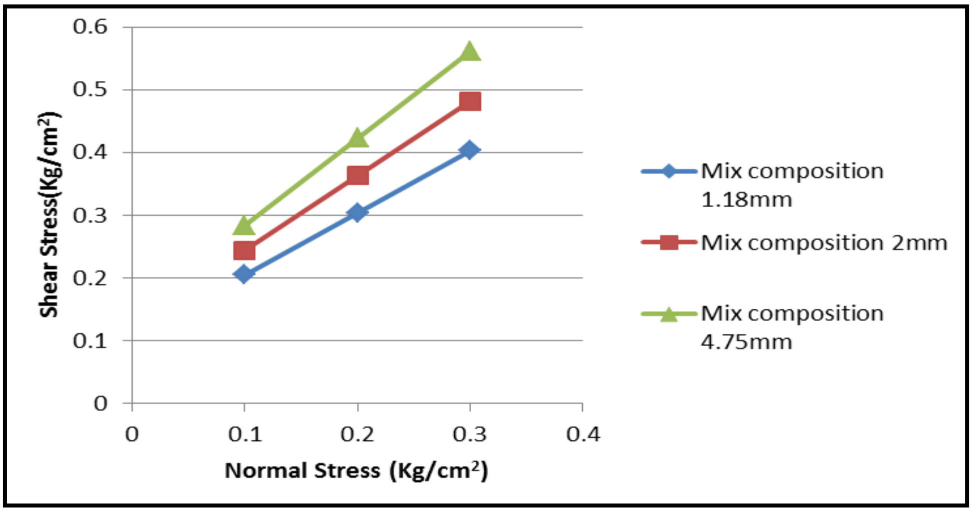

Figure 5: Variation of shear stress for 20% Admixture of 4.75mm, 2 mm and 1.18mm sieve.

Table 6 : Variation of shear stress for 30% Admixture of 4.75mm, 2 mm and 1.18mm sieve.

Normal Stress(kg/cm2)	Shear Stress (kg/cm^2)		
	Mix composition		
	1.18mm pass sieve	2mm pass sieve	4.75mm pass sieve
0.1	0.2376	0.2838	0.3366
0.2	0.3564	0.4224	0.5016
0.3	0.4752	0.5610	0.6666

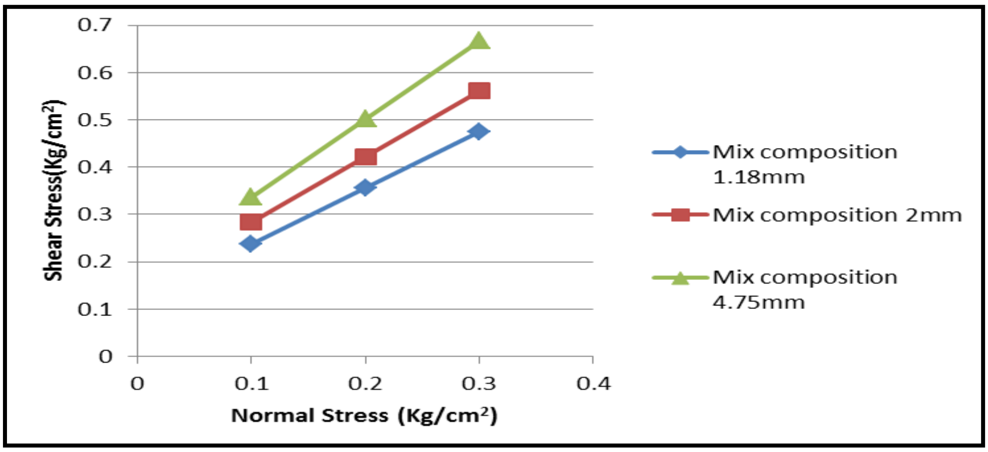

Figure 6 : Variation of shear stress for 30% Admixture of 4.75mm, 2 mm and 1.18mm sieve.

VI. CONCLUSIONS

The investigations were carried out with the view of exploring the possibilities of stabilizing dune sand with ceramic tiles wastage as admixture. Various experiments were performed on mix compositions of dune sand with ceramic tiles wastage as admixture and it was found that with increasing percentage and particle size of admixture the stabilization of dune sand was achieved.

The main conclusions drawn from the investigations performed are:

1. The maximum dry density of mix-composition of dune sand and ceramic tiles wastage as admixture increases on increasing particle size of admixture. Also for same particle size of admixture the M.D.D. increases on increasing the quantity of admixture (increment from 10% to 30%).
2. A linear increment was observed in CBR values in both unsoaked and soaked conditions. CBR tests were performed on mix compositions of dune sand and ceramic tiles wastage as admixture. Ceramic tiles wastage passing sieve size 4.75 mm, 2.0 mm, 1.18 mm and 425 µ of varying percentages 5%, 10%, 15%, 20%, 25% and 30% were mixed with dune sand. For unsoaked condition, CBR values are greater than that of soaked condition for same particle size and quantity of admixture.
3. In the Direct Shear Test, angle of internal friction (shearing resistance) Φ increases with increase in size of ceramic tiles wastage in mix composition. The Shear Tests were performed for mix compositions of dune sand with ceramic tiles wastage passing sieve size 4.75 mm, 2.0 mm and 1.18 mm of varying percentages 10%, 20% and 30%. The angle of internal friction (shearing resistance) Φ also increases with the quantity of the ceramic tiles wastage.
4. On the basis of the experiments performed it has been concluded that loose dune sand transform after stabilization into a strong rigid mass.

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