Stabilization of Dune Sand with Porcelain Waste as Admixture

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Abstract *The stabilization of Dune sand is of high prominence since it can be used for various building works and highways, airfields etc. The dune sand has nil cohesion and thus a low compressive strength. The analysis reported herein presents a study of stabilization of dune sand with Porcelain Waste as admixture. All the California Bearing Ratio tests were piloted at maximum dry density and optimum moisture content as attained from Standard Proctor Test. Direct shear tests were also executed. The main objective of this experimental study was to obtain an cost-effective stabilized mix of Porcelain waste and dune sand so that largely and cheaply available dune sand be sand be used for various construction purposes.*

Keywords — *Porcelain, Dune Sand, Stabilization, C.B.R., shear, Jodhpur, soil*

I. INTRODUCTION

With the growing population and rapidly developing economies, the need for resources has led to even quicker depletion of the same. On the other side, many resources which have been neglected due to some of the unsolicited engineering properties. One of them is dune sand, the giant mass remained disregarded, untouched from centuries, where life itself obliges 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 chemical or mechanical methods to improve strength, robustness and to avert erosion.

The properties of soil may be transformed in many ways. Stabilization is used for a variety of engineering works such as construction of all-weather roads and airport runways. The 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 Porcelain wastes. The test specimens have been prepared in laboratory by direct mixing of the crushed porcelain solid in dune sand.

The Porcelain wastage is easily available from various sources where broken parts are rejected and flung in yards. These sources include tableware, laboratory equipment industry, another major source is electrical panels where porcelain is used as electrical insulators.

II. MATERIALS USED FOR STUDY

Dune Sand Thar Desert in Rajasthan, covering about 500,000 sq. km., consists of desert soils of India. These are windblown deposits commonly present in the form of sand dunes with an usual height of about 15 m. The deposits are formed under arid conditions and the dune sands are primarily of non-plastic uniformly graded fine or silty sands. Some of the complications associated with the soil are soil stabilisation for roads and runways and scarcity of water for any construction activity.

Jodhpur District is a part of Thar Desert. The Dune sand used in the present reading was brought from location near Uchiyada village, at about 15-20 kms away from Jodhpur. 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 75u to 1.0 mm i.e., fine coarse sand, round to angular in particle shape as per Indian Standard Classification System.

Porcelain is a ceramic solid made by heating materials, generally comprising kaolin, in a kiln to temperatures between 1200 and 1400 degree centigrade. The toughness, strength and translucence of porcelain, relative to other types of pottery, arises mainly from vitrification and the development of the mineral mullite within the body at these temperatures.

Porcelain has been defined as being "completely vitrified, hard, impermeable (even before glazing), white or artificially coloured, translucent and resonant. However, the term porcelain lacks a collective definition and has been applied in a very unsystematic manner to substances of diverse kinds which have only certain surface – qualities in common.

Kaolin is the primary material from which porcelain is made. The structure of porcelain is highly variable, but the clay mineral kaolinite is often a raw material.

Porcelain Wastes - A lot of Porcelain waste is made during formation, transportation and servicing of Electrical insulators or crockery. These leftovers or scrap materials are inorganic material and hazardous. Hence, its disposal is a difficult which can be removed with the idea of utilizing it as an admixture to stabilize sand, so that the mix prove to be very cost-effective and can be used as subgrade in low traffic roads or village roads.

III. TEST PROGRAM AND PROCEDURE

The laboratory examination on dune sand stabilization with porcelain waste as admixture was performed. The scraps was brought from nearby dump yard where rejected or broken electrical insulators were thrown. The dune sand had similar characteristics as found in various areas of western Rajasthan. Hence, sand from one location near Uchiyada village of Jodhpur District was brought for the study.

The aim of the present reading is to evaluate the use of dune sand as a construction material stabilizing it with porcelain waste bits as admixture. The present study has been commenced with the following objectives:

1. To study the outcome of porcelain wastage particles of variable size (4.75mm. 2mm, 1.18mm and 0.425mm) on Proctor density and OMC of dune sand.
2. To study the deviations in CBR value of dune sand by mixing porcelain waste of fluctuating size in different quantities in un-soaked and soaked environments.
3. To study the discrepancies in shear stress of dune sand diversified with porcelain wastage of varying size in different proportions.

IV. TEST PROGRAM

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

1. Determination of particle size spreading of dune sand.
2. Standard Proctor Test for determining maximum dry density and optimum moisture content. (For dune sand and mix arrangement with porcelain wastage).
3. CBR Test to define CBR values for dune sand and mix compositions by means of porcelain wastage.
4. Direct Shear Test to decide shear stress of dune sand and mix compositions with porcelain waste.

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				

Table 1: Particle Size Distribution of Dune Sand

Standard Proctor Test or Proctor Compaction Test

The outcome tabulated in the Table 1 shows that on increment of the porcelain wastage in the dune sand, the maximum dry density (M.D.D.) of the mix composition rises. On the other hand, on amassed particle size of the porcelain waste the maximum dry density (M.D.D.) surges. The optimum moisture content (O.M.C.) also amplified from 12 to 16 percent. The maximum dry density variations of mix compositions are shown in Figure1.

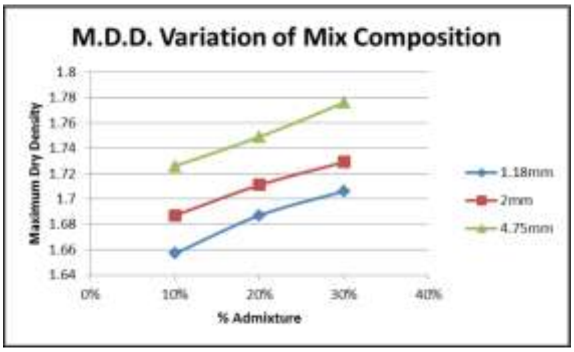

Figure 1: M.D.D. Variations of Mix Compositions

California Bearing Ratio (CBR Test) – The CBR value is an indication of the ratio of force per unit area that is required by the standardised piston to penetrate a soil mass at a rate of 1.25 mm/minute to that needed for the similar penetration in a standard material. To find the CBR values in soaked condition for the stabilized dune sand, various proportions of waste out of porcelain and dune sand were thoroughly mixed considering that the proportions of the porcelain leftovers and water are equivalent to the Optimum Moisture Content which has been determined by Standard Proctor Test already.

The mix of sand and porcelain waste was compressed in 2250 mL CBR mould (with a 150 mm diameter and height of 127.3 mm) by means of light compaction. He mix was thoroughly compacted in three equal stratums. Each strata was given 56 blows uniformly, with a 2.6 kg hammer. To perform the test, top surface of the specimen was evenly concluded such that it is suitable for the loading test. The samples were examined for the determination of CBR values in soaked conditions the day after.

The mould containing the specimen was mounted on the machine with a surcharge weight equal to 5 kg (2 spacer discs) was placed on the top of specimen before starting the penetration tests. Next step was to set the plunger on specimen surface and adjusting the load and the penetration measuring dial gauge as zero and after that the load was applied for obtaining the CBR values of soaked and un-soaked samples. Multiple penetration trials were done to examine the CBR value.

Load readings at an interval of 0.5 mm were noted and accordingly a graph was drawn between the Load (ordinate) and Penetration (abscissa). In most of the examinations the curve was either straight or curved upwards in the preliminary portion. In such cases, the test load corresponding to 2.5 mm and 5.0 mm were observed from the graph. 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 from the penetration axis. Test results obtained show that CBR value increases with rise in porcelain particle size. The CBR value for same size porcelain particles in mix composition surges with increase in percentage of porcelain particles. The tables and graphs are shown in the next pages.

Comparative Study

We have graphically represented the variations in C.B.R. values in the graphs for both un-soaked and soaked conditions. On the graph, at abscissa i.e., x-axis, Porcelain particles proportion of sand varying from 5% to 30% at an interval of 5% has been marked and on ordinance i.e., y-axis, C.B.R. values have been plotted for mix compositions of porcelain waste passing 4.75mm, 2.0mm, 1.18mm and 425u.

It can be evidently observed that with the increase of particle size of admixture, the C.B.R. value of the mix composition rises. Also as the quantity or percentage of admixture increases, the C.B.R. value of the mix composition increases. Therefore, it can be inferred that to use the mix compositions in base and sub base constructions, the C.B.R. values can be increased or decreased as needed.

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

Table 2: CBR Value Variation in Mix Compositions in Un-soaked Conditions

Variations in C.B.R. values at different percentages of mix composition at diverse size also show that rise in C.B.R. values is more at un-soaked condition than that compared with soaked condition.

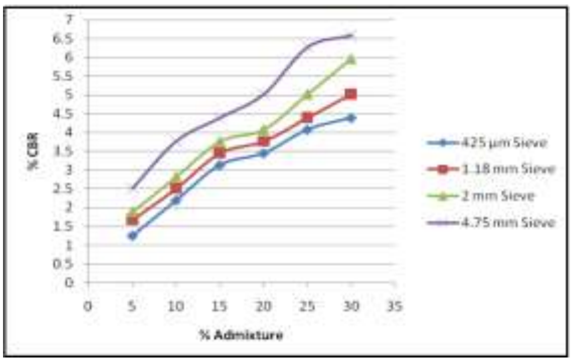

Figure2: CBR Value Variation in Mix Compositions in Un-soaked Conditions

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

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

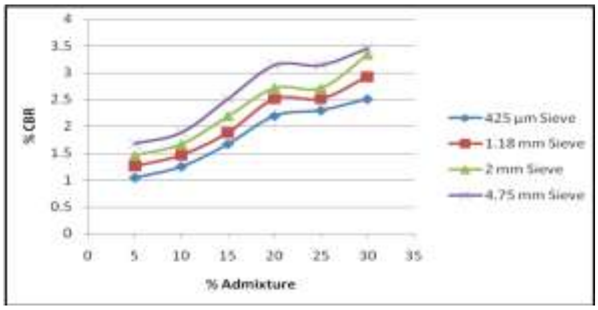

Figure 3: CBR Value Variation in Mix Compositions in Soaked Conditions

V. DIRECT SHEAR TEST

Direct shear tests were performed on the mix composition of porcelain particles of sizes passing sieve 4.75mm, 2.0 mm and 1.18 mm with 10%, 20% and 30% of sand. Tests were conceded out with a strain controlled shear apparatus made of brass. As we know, strain rate depends upon the type of soil used and for sandy soil the rate of 1.25 mm/minute is sufficient to determine failure stress and angle of internal friction (µ) of different mix composition. Proving ring fitted to the upper half to measure the shear force butts against a fixed support. Another dial gauge is fitted on top of the pressure pad which observes variations in thickness of the specimen.

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

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 rises as the normal stress rises.

Normal Stress (kg/cm^2)	Shear Stress (kg/cm^2)		
	Mix Composition		
	1.18mm pass sieve	2mm pass sieve	4.75mm pass sieve
0.1	0.1602	0.1786	0.2187
0.2	0.2315	0.2604	0.3170
0.3	0.2870	0.3645	0.4201

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

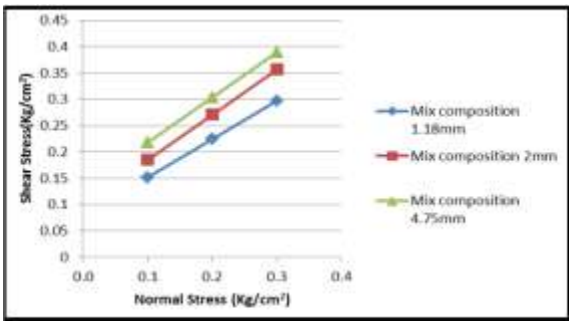

Figure 4: Variation of shear stress for 10% Admixture of 4.75mm, 2 mm and 1.18mm sieve.

Normal Stress (kg/cm^2)	Shear Stress (kg/cm^2)		
	Mix Composition		
	1.18mm pass sieve	2mm pass sieve	4.75mm pass sieve
0.1	0.2044	0.2358	0.2842
0.2	0.3102	0.3530	0.4237
0.3	0.4012	0.4614	0.5501

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

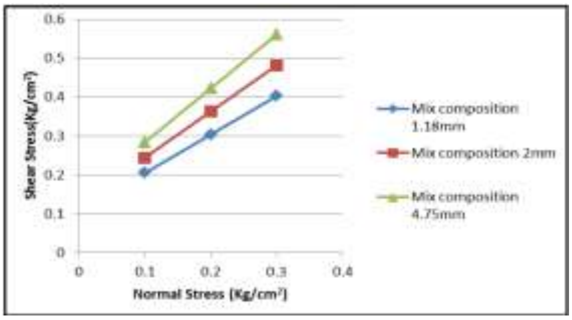

Figure 5: Variation of shear stress for 20% Admixture of 4.75mm, 2 mm and 1.18mm sieve.

Normal Stress (kg/cm^2)	Shear Stress (kg/cm^2)		
	Mix Composition		
	1.18mm pass sieve	2mm pass sieve	4.75mm pass sieve
0.1	0.2346	0.2840	0.3404
0.2	0.3561	0.4225	0.5017
0.3	0.4750	0.5634	0.6757

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

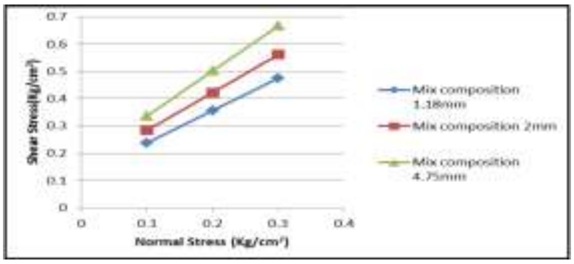

Figure 6: Variation of shear stress for 30% Admixture of 4.75mm, 2 mm and 1.18mm sieve.

VI. CONCLUSIONS

The investigations were carried out with the view of exploring the possibilities of stabilizing dune sand with porcelain wastage as admixture. Various investigations were executed on mix compositions of dune sand with porcelain waste as admixture and it was found that with growing percentage and particle size of admixture the stabilization of dune sand was accomplished.

The main inferences drawn from the investigations performed are:

1. The maximum dry density of mix-composition of dune sand and porcelain waste as admixture increases on incrementing particle size of admixture. Also for alike particle size of admixture the M.D.D. rises on increasing the quantity of admixture (increment from 10% to 30%).
2. A linear increment was observed in CBR values in both un-soaked and soaked surroundings. CBR tests were performed on mix compositions of dune sand and porcelain waste as admixture. Porcelain wastage passing sieve size 4.75 mm, 2.0 mm, 1.18 mm and 425 μ of fluctuating percentages 5%, 10%, 15%, 20%, 25% and 30% were mixed with dune sand. For un-soaked situation, CBR values are greater than that of soaked condition for same particle size and amount of admixture.
3. While performing the Direct Shear Test, angle of internal friction (shearing resistance) Φ rises with increase in size of porcelain wastage in mix composition. The Shear Tests were executed for the mix compositions of dune sand with porcelain 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 porcelain wastage.

4. On the basis of the trials performed it has been determined that loose dune sand transforms after stabilization into a robust rigid mass.

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