

Stabilization of Fine Sand with Ceramic Tile Waste as Admixture for Design of Flexible Pavement of Road Construction

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ABSTRACT : This paper presents the study on the properties of fine sand from the Thar desert with ceramic tile waste as admixture. Fine sand is the unstable type of soil on which the designing and constructing any road for heavy load is very difficult and without any improvement in the properties of fine sand no construction has done. In India, Western Rajasthan is the area where fine sand is found in great quantity. At Western Rajasthan, the development of road is not easy because of nil cohesion and low compressibility of fine sand. In this paper, the properties of fine sand are improved by mixing different percentage of ceramic tile waste. The different percentage of ceramic tile waste is 2%, 4%, 8% and 12% along with the size range of admixture is between 2.36mm to 4.75mm for various densities of fine sand such as 1.50 gm/cc, 1.55 gm/cc and 1.58 gm/cc as arrived from Standard Proctor Test. On the basis of different compositions of ceramic tile waste and fine sand of different dry densities, California Bearing Ratio Tests and Falling-Head Permeability Tests were conducted and determine the improve strength characteristics of fine sand.

KEYWORDS: C.B.R., fine sand, permeability, ceramic tiles.

I. INTRODUCTION

Soil stabilization is necessary for the weak soil to improve properties such as compressibility, strength, permeability because foundation of all the structure is supported only by the soil, thus the soil stabilization is widely used in the construction of flexible pavement. If problematic soil is not properly stabilized then the failure of structure is occurred. Stabilization of fine sand from locally available materials is very important and reduces the construction cost of road. Fine sand is known to spread in huge areas throughout the Western Rajasthan (India). Fine sand is not suitable for sub grade which supports the whole structure, due to high compressibility. Mixing ceramic tile waste, which is cheaply available as admixture for stabilization of fine sand has broad scope. Thus the fine sand properties are improved along with utilizing of ceramic tile waste. Due to warping, a huge amount of broken ceramic tile waste is produce every year from manufacturing unites. The problem of the disposal of Ceramic tiles waste can be solving by using it for stabilization of fine sand.

II. MATERIALS USED FOR PRESENT STUDY

2.1 Fine Sand

The sand used in current study was brought from location near Dangiyawas-Banar villages, at about 30-35 km away from Jodhpur on Jodhpur-Jaipur Road. Fine sand is uniform clean sand as per Unified Soil Classification System. Particles size ranges between 75 μ to 1.0 mm i.e. fine coarse sand, round to angular in particle shape as per Indian Standard Classification System.

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2.2 Ceramic Tile Waste

A Ceramic Tile is an inorganic, non-metallic solid prepared by the action of heat and subsequent cooling. Ceramic material may have crystalline or partly crystalline structure, or may be amorphous, because most common ceramics are crystalline materials. 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 colored, smooth surface. The ceramic tiles used in present work were of Kajaria Company. The ceramic tile waste was bought from a manufacturing unit from Bikaner, Rajasthan (India). Figure 1 shows the ceramic tile waste and table 1 represent the physical and engineering properties of ceramic tile.



Figure 1 Ceramic Tile Admixture

Table 1: Summary of the physical properties of the tested ceramic tile waste material

Physical and Engineering Properties	
Density	2.27 gm/cc
Water Absorption in 24 hours	4% by dry weight

III. TEST PROGRAM AND PROCEDURE

The laboratory investigation on fine sand stabilization with ceramic tile waste as admixture was performed. This work is done for beneficial utilization of ceramic tile waste and a mix proportion that can be mixed with fine sand as a best stabilizer with limited detrimental effects.

The objective of the present study is to evaluate the use of fine sand as a construction material after stabilizing it with ceramic tile waste as admixture. The objectives of present study are given below:

1. To study the effect of moisture content on dry density of fine sand.
2. To study the CBR values of fine sand of different dry densities by mixing ceramic tile waste in different proportions in unsoaked and soaked conditions.
3. To study the changes in permeability of fine sand by mixing with ceramic tile waste in different proportions.

3.1 Test Program

The test program included the preliminary tests for fine sand and mix compositions of fine sand with ceramic tile waste. Following tests were carried out as shown in table 2:

1. Determination of particle size distribution of fine sand.
2. Standard Proctor Test (Proctor Compaction Test) for determining different dry densities for fine sand.
3. CBR Test to determine CBR value for fine sand and mix compositions with ceramic tile waste.
4. Permeability by Variable Head Permeability Test of fine sand and mix composition with ceramic tile waste.

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Table 2: Variables Investigated

S. No.	Effect of	Variables	Range Investigated
1	Moisture content in sand	Dry density	1.50 gm/cc, 1.55 gm/cc and 1.58 gm/cc
2	Ceramic tile waste on different properties of sand	Size passing sieve size	4.75 mm Passing and 2.36 mm retaining
3	Mix ceramic tile waste by dry weight of sand	Proportion percentage	2%, 4%, 8% and 12%

3.1.1 Particle Size Distribution or Gradation Test of Fine Sand

The particle size distribution test or gradation test was carried out with Indian Standard Sieve size 4.75 mm, 2.36 mm, 1.18 mm, 600 μ, 425 μ, 300 μ, 150μ, 75μ, pan and weigh balance in the laboratory.

A typical sieve analysis involves a nested column of sieve with wire mesh cloth (screen). A representative sample of 1000 gm is poured into the top sieve which has the largest screen opening of 4.75 mm. Each lower sieve in the column has smaller opening than the one above. The base is a round pan, called the receiver. The sample was shaken vigorously 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. Since percentage passing 75 μ is within 1% only, hydrometer analysis was not done. Calculated data for particle size distribution of fine sand shown in table 3, particle size distribution curve shown in figure 2 and results of particle size distribution shown in table 4.

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

where W_{sieve} is the weight of aggregate in the sieve in gm

W_{total} is the total weight of the aggregate in gm

The cumulative percentage passing of the aggregate is found by subtracting the percent retained from 100%.

Percentage (%) Cumulative Passing = 100% - Percentage (%) Cumulative Retained

The results of particle size distribution have been shown in table 3, table 4 and figure 2.

Table 3: Particle Size Distribution of Fine Sand

S.No.	Sieve Size	Weight Retained (gm)	% Weight Retained	Cumulative % Weight Retained	Cumulative % Weight Passing	% Finer
1.	4.75 mm	2.0	0.2	0.2	99.8	99.8
2.	2.36 mm	2.0	0.2	0.4	99.6	99.6
3.	1.18 mm	2.0	0.2	0.6	99.4	99.4
4.	600 μ	1.0	0.1	0.7	99.3	99.3
5.	425 μ	2.0	0.2	0.9	99.1	99.1
6.	300 μ	2.0	0.2	1.1	98.9	98.9
7.	150 μ	904.0	90.4	91.5	8.5	8.5
8.	75 μ	82.0	8.2	99.7	0.3	0.3
9.	Pan	3.0	0.3	100	0	0

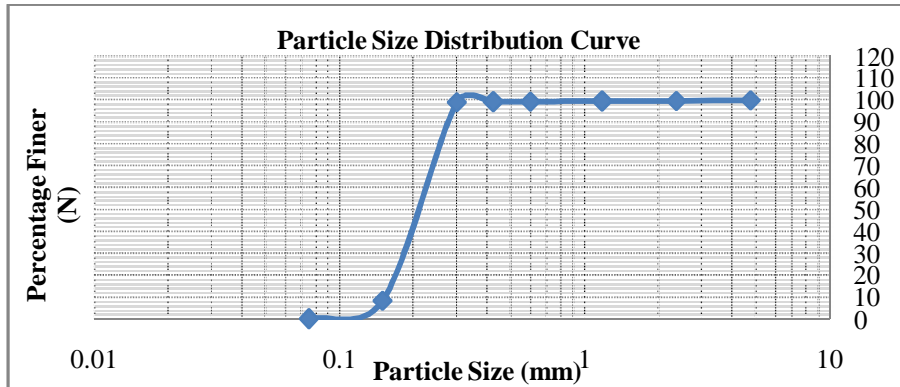


Figure 2: Particle Size Distribution Curve

Table 4: Results of Particle Size Distribution

S. No.	Property	Test Media (Fine Sand)
1.	Coefficient of Uniformity (C_u)	1.31
2.	Coefficient of Curvature (C_c)	1.08
3.	Mean Diameter (D_{50}) mm	0.20
4.	Effective Size (D_{10}) mm	0.16
5.	Fine Soil Fraction (75μ)	0.10%

3.1.2 STANDARD PROCTOR TEST

Standard proctor covers the determination of the relationship between the moisture content and density of soils. The standard proctor test was performed in accordance with IS 2720 (Part VII) on fine sand. In this test, a standard mould of 100 mm internal diameter and an effective height of 127.3 mm, with a capacity of 1000 ml are used. The mould had a detachable base plate and a removable collar of 50 mm height at its top. The soil was compacted in the mould in 3 equal layers; each layer was given 25 blows of 2.6 kg rammer falling through a height of 310 mm.

The result represented in figure 3 shows that on increment of moisture content, dry density first decrease and then increase. In the curve dry density first decrease due to bulking of sand. After reaching maximum dry density on optimum moisture content, dry density again decreases. The variation of dry density with moisture content shows that the required dry densities 1.50 gm/cc, 1.55 gm/cc and 1.58 gm/cc for the experiments occur at 4%, 12% and 18% moisture content.

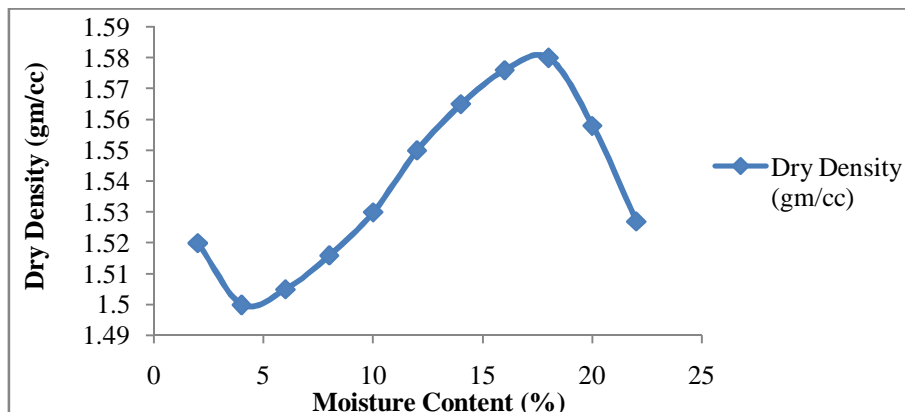


Figure 3: Dry Density v/s Moisture Content Curve

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3.1.3 CALIFORNIA BEARING RATIO (C.B.R.) TEST

In CBR test, 5 kg of soil was taken and mixed with water corresponding to required dry density and proportion of ceramic tile waste. The mix was compacted in 2250 ml CBR (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 hammer. Top surface of the specimen was finished properly to make it for even loading test. For the soaked condition, the samples were tested for the determination of CBR values on the next day.

For obtaining the CBR values of unsoaked and 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, setting the load and penetration measuring dial gauge to read zero, the load was applied. Load readings at every 0.5 mm penetration were noted and a graph was drawn between the actual 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. In the case of the initial upward concavity, the corrected zero is obtained by drawing a tangent to the curve at the point of the greatest curvature. The corresponding to 2.5 mm and 5.0 mm penetration are measured from the corrected zero.

Test results obtained show that CBR value increases with increase in dry density of sand. The CBR value also increases with increase in percentage of ceramic tile waste for same dry density sand. The test results are shown in tables and graph.

3.1.3.1 Comparative Study

The variation in CBR values have been tabulated and graphically represented in table 5, figure 4, for unsoaked condition and in table 6 and figure 5 for soaked condition. On the graph, at abscissa (X-axis) dry density of fine sand varying 1.50 gm/cc, 1.55 gm/cc and 1.58 gm/cc has been marked and on ordinate (Y-axis) CBR values in % have been plotted for mix compositions of ceramic tile waste of different percentage 2%, 4%, 8% and 12%.

It can be seen that on increment of dry density, the CBR value of the mix composition increases. The CBR value of the mix composition also increases as the percentage of admixture increases for both unsoaked and soaked conditions. 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.

The variations in CBR values at 1.58 gm/cc dry density and different percentage of mix compositions also show that increase in CBR values is more at unsoaked condition than that compared with soaked condition.

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

Dry Density (gm/cc)	CBR (%)				
	Mix Composition				
	0% Admixture	2% Admixture	4% Admixture	8% Admixture	12% Admixture
1.50	2.146	3.22	3.58	4.29	5.01
1.55	2.504	3.93	4.65	5.36	6.08
1.58	2.861	4.29	5.01	5.72	6.44

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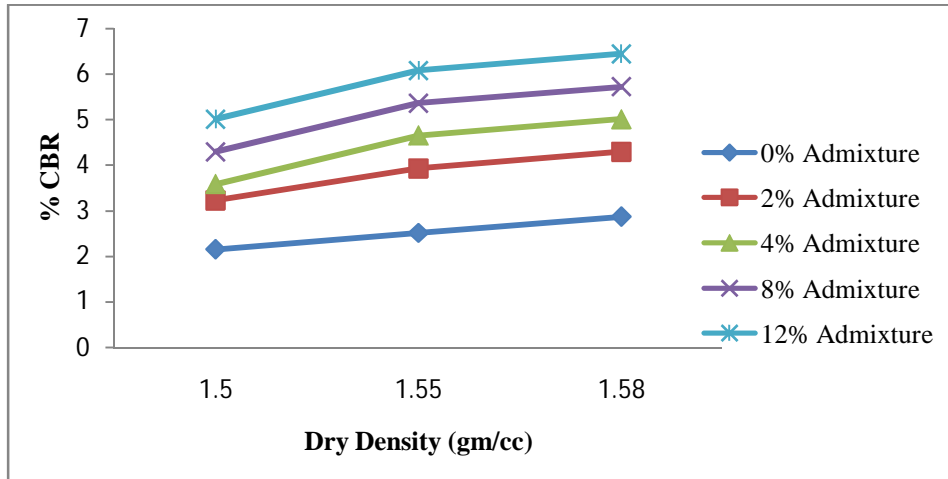


Figure 4: CBR Value Variation in Mix Compositions in Unsoaked Conditions

Table 6: CBR Value Variation in Mix Compositions in Soaked Conditions

S.No.	Mix Composition	CBR (%)
1.	1.58 gm/cc dry density sand mixed with 0% Admixture	1.07
2.	1.58 gm/cc dry density sand mixed with 2% Admixture	1.43
3.	1.58 gm/cc dry density sand mixed with 4% Admixture	1.79
4.	1.58 gm/cc dry density sand mixed with 8% Admixture	2.50
5.	1.58 gm/cc dry density sand mixed with 12% Admixture	2.86

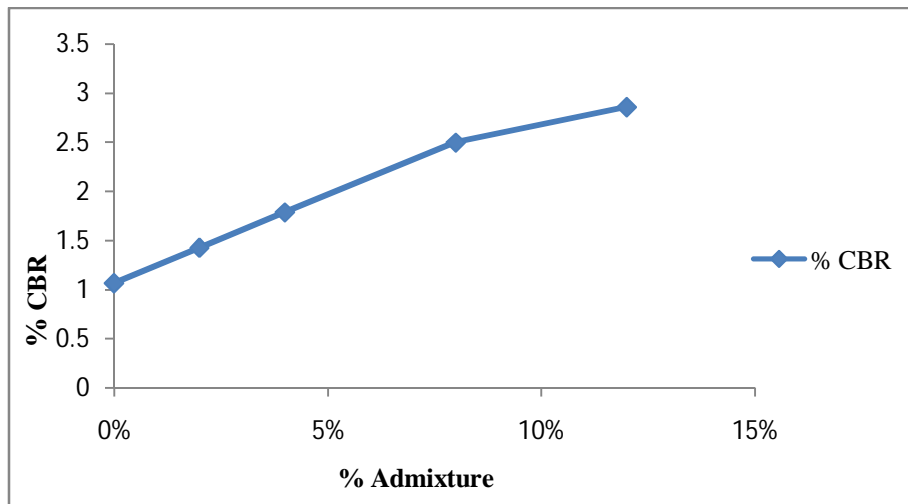


Figure 5: CBR Value Variation in Mix Composition in Soaked Conditions

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3.1.4 Variable Head Permeability Test

Permeability is the measure of the ease with which water can flow through a soil sample. The tests were conducted in variable head permeameter according to IS 2720 (Part XVII). Test investigations were carried out on variable head permeameter with mix compositions of 1.58 gm/cc dry density fine sand and ceramic tile waste in varying percentages of 2%, 4%, 8% and 12%.

A conclusion from the test results obtained that coefficient of permeability (k) increases with increase in percentage of ceramic tile waste as shown in table 7 and figure 6.

Table 7: Variation of Coefficient of Permeability k (cm/sec) with Mix Composition

S.No.	Percentage (%) Admixture	Coefficient of Permeability (cm/sec)
1.	2%	1.18×10^{-3}
2.	4%	1.24×10^{-3}
3.	8%	1.41×10^{-3}
4.	12%	1.54×10^{-3}

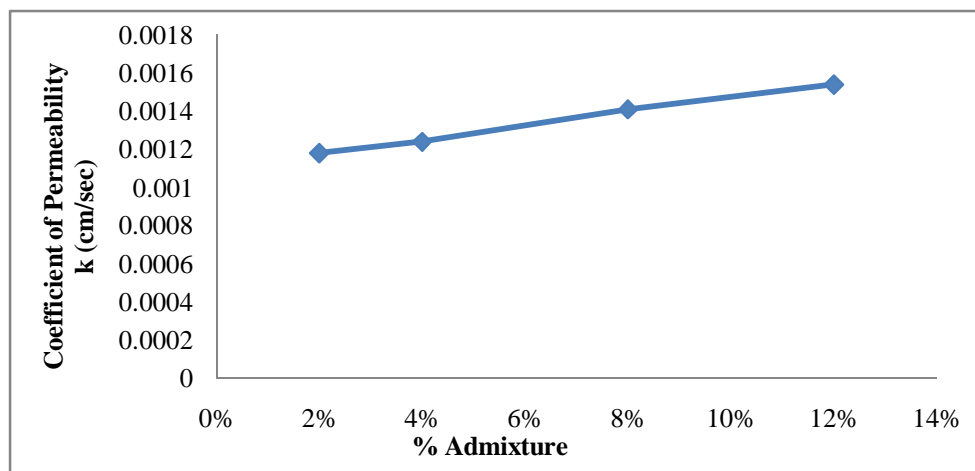


Figure 6: Variation of Coefficient of Permeability k (cm/sec) with Mix Composition

IV. CONCLUSIONS

In this investigation we have used ceramic tile in different proportions to study its effect on various geotechnical properties of fine sand of Western Rajasthan. The results of the testing program clearly show that the engineering properties of the fine sand improved considerably due to stabilizing with ceramic tile waste. In the present investigation, as we are increasing the quantity of admixture of ceramic tile waste, the CBR value increases. So we have stopped the further increment of admixture. Further study can be done by addition of more amount of admixture.

A few generalized conclusions are summarized below:

1. CBR tests were performed on mix compositions of fine sand and ceramic tile waste as admixture. Ceramic tile waste of varying percentage 2%, 4%, 8% and 12% were mixed with fine sand of different densities 1.50 gm/cc, 1.55 gm/cc and 1.58 gm/cc. A linear increment was observed in CBR values in both unsoaked and soaked conditions. For unsoaked condition, CBR values are greater than that of soaked condition for same dry density of sand and same quantity of admixture. As the CBR value is increasing, the required thickness for flexible pavement is reduced.

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2. Permeability Tests were performed for mix composition of 2%, 4%, 8% and 12% of ceramic tile waste and fine sand of 1.58 gm/cc dry density. The coefficient of Permeability k (cm/sec) increases with increase in the percentage of ceramic tile waste mixed to fine sand. Greater the percentage of ceramic tile waste more was the mix composition permeable. Hence, the impermeable material should be used in the mix composition to reduce the permeability.
3. After this investigation we conclude that ceramic tile waste can successfully be used as admixture for fine sand stabilization.

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