TO ENHANCE THE PROPERTIES OF FINE SAND BY USING SOIL STABILIZATION WITH CERAMIC TILES AND SANITARY WARE WASTAGE FOR CONSTRUCTION OF EMBANKMENT

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Abstract— ***Soil is the key element of this nature and all the basic needs of life such as food, house and cloths are fulfilled by the soil. Black Cotton soils with high potential for swelling and shrinking as a result of change in moisture content are one of the major soil deposits of India. Soil stabilization is the process which improves the physical properties of soil, such as shear strength, bearing capacity which can be done by use of controlled compaction or addition of suitable admixtures like cement, lime, sand, fly ash or by providing geo textiles, geo synthetics and waste materials etc. This investigation has been taken up by addition of 4.75 mm sieve passed and 2.36 mm sieve retained Ceramic tile and sanitary ware Wastage as admixture. The varying percentage 5%, 10%, 15% and 20% of ceramic tile and sanitary ware wastage were mixed with fine sand of different densities 1.50 gm/cc, 1.55 gm/cc and 1.58 gm/cc. All the Direct Shear Tests were conducted at different mix compositions of ceramic tile and sanitary ware wastage and fine sand of different dry densities as arrived from Standard Proctor Test. Falling-Head Permeability Tests were also performed on different mix compositions. On the basis of the experiments performed, it is determined that the stabilization of fine sand using ceramic tile and sanitary ware wastage as admixture improves the strength characteristics of the fine sand so that it becomes usable as construction of embankment also.***

Index Terms—***Ceramic Tiles and Sanitary Ware Wastage, Direct Shear, Fine sand, Permeability.***

I. INTRODUCTION

Soil deposits in nature exist in an extremely erratic manner producing thereby an infinite variety of possible combination which will affect the strength of the soil and the procedures to make it purposeful. Soil stabilisation is a technique introduced many years ago with the main purpose to render the soils capable of meeting the requirements of the specific engineering projects. In this work of the possibility of stabilising fine-grained plastic soils with waste materials and without cement is investigated.

Fine sand is scarcely suitable for sub grade which supports the sub base or base coarse in the pavement due to high compressibility. The properties of soil can be improved by soil stabilization. Stabilization is being used for a variety of civil engineering works, the most common application being in the construction of flexible pavements and airfield pavements, where the main objective is to increase the strength, erosion of soil and reduce the construction cost by making best use of locally available materials. The purpose of present research work is the beneficial and economical utilization of such wastages for improving properties of fine sand. Utilization of ceramic tile and sanitary ware waste for improvement of soil properties is a sustainable and cost-effective technique. Due to warping, a huge amount of broken ceramic tile and sanitary ware waste is produce every year from manufacturing unites. Hence it was thought to be utilized of ceramic tile and sanitary ware waste as an admixture with which fine sand can be stabilized. On the other hand, the problem of the disposal of Ceramic tiles and sanitary ware waste can be overcome by using it for stabilization of fine sand.

II. MATERIALS USED FOR PRESENT INVESTIGATION

Fine Sand

Fine sand is found in abundance in Western Rajasthan. The fine sand has similar characteristics which are found in various Towns of Jodhpur. Hence the sand used in present study was brought location near Dangiyawas-Banar villages, at about 30-35 kms away from Jodhpur on Jodhpur-Jaipur Road. Fine sand has nil cohesion and poor compressive strength and hence need stabilization. Fine sand is uniform clean sand as per Unified Soil Classification System. Particles size ranges between 75µ to 1 mm that is fine coarse sand, round to angular in particle shape as per Indian Standard Classification System.

Ceramic Tiles and Sanitary Ware Wastage

A Ceramic tile and sanitary ware is an inorganic, nonmetallic 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 tile and sanitary ware used in present work were of Kajaria Company. The ceramic tile and sanitary ware waste was bought from a manufacturing unit from Bikaner, Rajasthan (India).

Figure 1 Ceramic tile and sanitary ware Admixture

Table 1 Summary of the physical properties of the tested ceramic tile and sanitary ware waste material

	Physical and Engineering Properties	
	Ceramic tiles	Sanitary ware
Density	2.27 gm/cc	2.36 gm/cc
Water Absorption in 24 hours	4% by dry weight	3% by dry weight

III. TEST PROGRAM AND PROCEDURE

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

The objective of the present study is to evaluate the use of dune sand as a construction material after stabilizing it with waste ceramic tile and sanitary ware as admixture. The present study has been undertaken with the following objectives:

1. To study the effect of moisture content on dry density of dune sand.
2. To study the changes in shear stress of fine sand of different dry densities mixed with ceramic tile and sanitary ware waste in different proportions.
3. To study the changes in performance of permeability of dune sand mixed with ceramic tile and sanitary ware wastage in different proportions.

Test Program

The test program included the preliminary tests for dune sand and mix compositions of dune sand with waste plastic. Following tests were carried out:

1. Determination of particle size distribution of dune sand.
2. Standard Proctor Test (Proctor Compaction Test) for determining different dry densities for dune sand.
3. Permeability by Variable Head Permeability Test of dune sand and mix composition with ceramic tile and sanitary ware waste.

Table 2 shows the variables which are investigated in present study.

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 and sanitary ware waste on different properties of sand	Size passing sieve size	4.75 mm Passing and 2.36 mm retaining
3	Mix ceramic tile and sanitary ware waste by dry weight of sand	Proportion percentage	5%, 10%, 15% and 20%

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.

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

Where,

Wsieve is the weight of aggregate in the sieve in gm
Wtotal 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 and table 4, and fig. 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

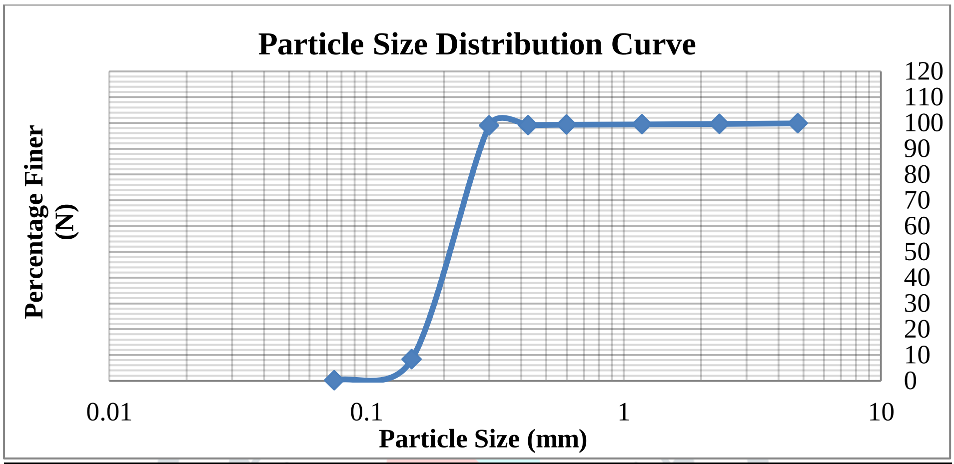

Figure 2 Particle Size Distribution Curve

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 (75 µ)	0.10%

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 tabulated 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 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.

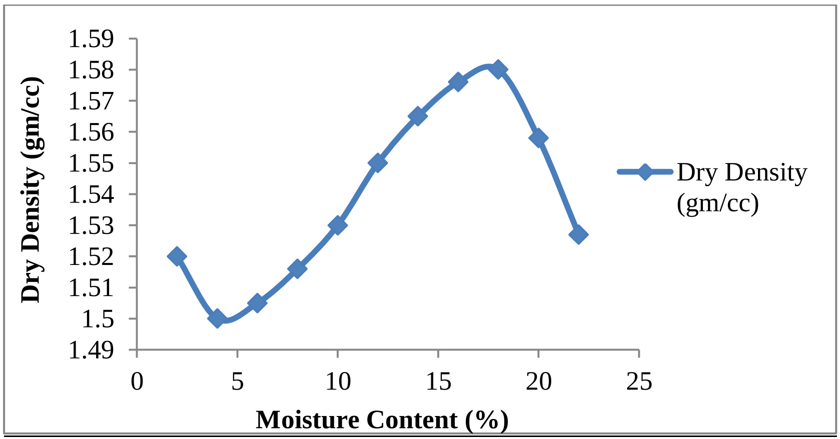

Figure 3 Dry Density v/s Moisture Content Curve

Direct shear Test

The Direct Shear Test is used to determine the shearing strength of the fine sand using the direct shear apparatus. Direct shear tests were performed on mix composition of fine sand of 1.50 gm/cc, 1.55gm/cc and 1.58 gm/cc density with ceramic tile and sanitary ware waste of 5%, 10%, 15% and 20% by dry weight 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 (ϕ) of different mix composition in accordance with ID 2720 (Part XIII).

Comparative Study

A comparative study of variation of stresses has been made from the test results. The variation of shear stress graphs, showing on X-axis corresponding normal stress 0.1 kg/cm2, 0.2 kg/cm2, 0.3 kg/cm2 and Y-axis corresponding shear stress at 1.50 gm/cc, 1.55 gm/cc and 1.58 gm/cc dry density sand mixed with 5%, 10%, 15% and 20% admixture have been tabulated in following tables and figures.

The value of shear stress linearly increases for different dry density, different percentage of admixture and different normal stress. It has been found from the study that on keeping dry density as constant, the shear stress value of the mix composition increases as the normal stress increases. Also for the same normal stress, as the quantity of the admixture increase, the shear stress value of the mix composition increases as the dry density increases.

From the results obtained it can be concluded that angle of internal friction (ϕ) increases with increase in dry density in mix composition. For the same dry density, the angle of internal friction ϕ increases with increase in percentage or quantity of ceramic tile and sanitary ware waste.

Table 5 Variation of Shear Stress for 1.50 gm/cc Dry Density Sand with 5%, 10%, 15% and 20% Admixture

Normal Stress (kg/cm²)	Shear Stress (kg/cm²) Mix Composition				
	0% Admixture	5% Admixture	10% Admixture	15% Admixture	20% Admixture
0.1	0.1188	0.1893	0.2013	0.2232	0.241
0.2	0.1782	0.2598	0.301	0.3256	0.3479
0.3	0.231	0.3378	0.3792	0.4192	0.4289

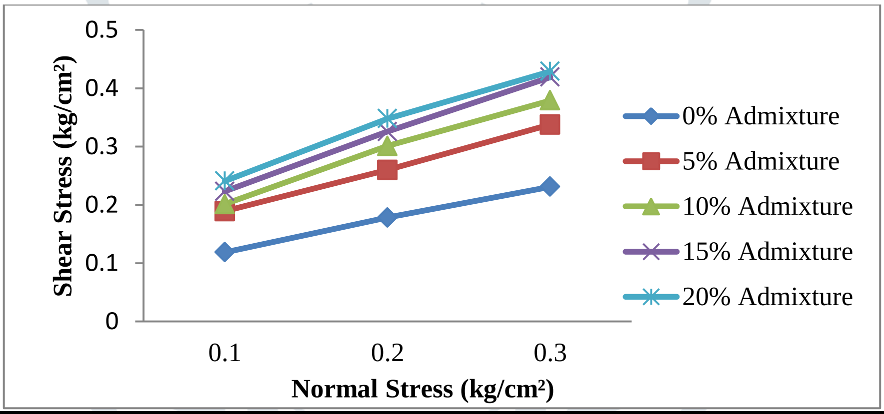

Figure 4 Variation of Shear Stress for 1.50 gm/cc Dry Density Sand with 5%, 10%, 15% and 20% Admixture

Table 6 Variation of Shear Stress for 1.55 gm/cc Dry Density Sand with 5%, 10%, 15% and 20% Admixture

Normal Stress (kg/cm²)	Shear Stress (kg/cm²) Mix Composition				
	0% Admixture	5% Admixture	10% Admixture	15% Admixture	20% Admixture
0.1	0.132	0.1913	0.2163	0.2403	0.2502
0.2	0.198	0.2646	0.3209	0.3412	0.363
0.3	0.2574	0.3502	0.3891	0.4258	0.4379

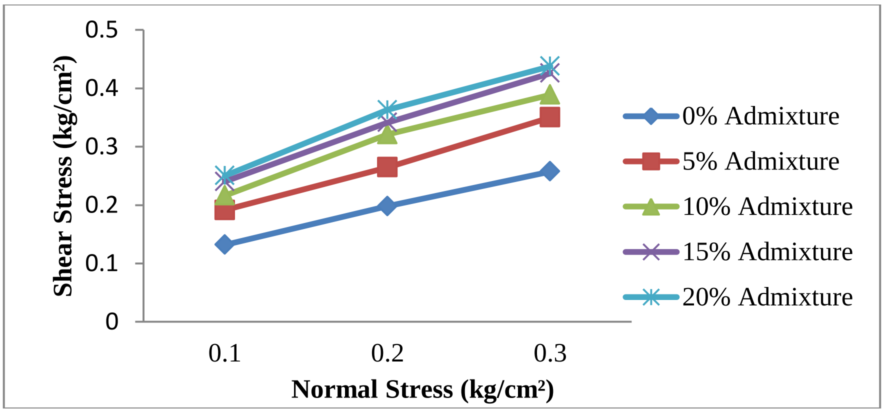

Figure 5 Variation of Shear Stress for 1.55 gm/cc Dry Density Sand with 5%, 10%, 15% and 20% Admixture

Table 7 Variation of Shear Stress for 1.58 gm/cc Dry Density Sand with 5%, 10%, 15% and 20% Admixture

Normal Stress (kg/cm²)	Shear Stress (kg/cm²)				
	Mix Composition				
	0% Admixture	5% Admixture	10% Admixture	15% Admixture	20% Admixture
0.1	0.1386	0.2072	0.2276	0.2566	0.2732
0.2	0.2112	0.2702	0.3302	0.3555	0.3798
0.3	0.2772	0.3586	0.401	0.4452	0.4532

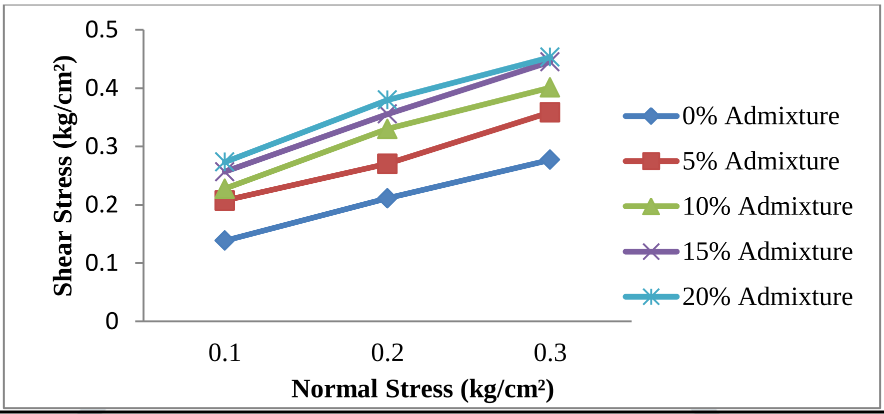

Figure 6 Variation of Shear Stress for 1.58 gm/cc Dry Density Sand with 5%, 10%, 15% and 20% Admixture

Table 8 Variation of ϕ with Dry Density of Sand and % Admixture

Dry Density (gm/cc)	Angle of Internal Friction ϕ (Degree)				
	Mix Composition				
	0% Admixture	5% Admixture	10% Admixture	15% Admixture	20% Admixture
1.50	29°17´	38°23´	42°42´	44°17´	46°27´
1.55	32°05´	43°11´	45°56´	47°37´	49°25´
1.58	34°43´	47°06´	47°59´	49°23´	51°37´

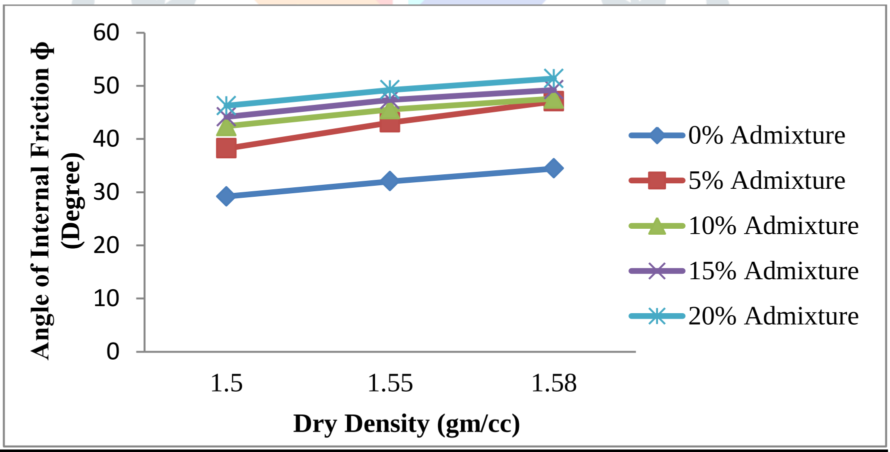

Figure 7 Variation of ϕ with Dry Density of Sand and % Admixture

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 and sanitary ware wastage in varying percentages of 5%, 10%, 15%, and 20%.

A conclusion from the test results obtained that coefficient of permeability (k) increases with increase in percentage of ceramic tile and sanitary ware waste as given in table 9 and fig. 8.

Table 9 Variation of Coefficient of Permeability k (cm/sec) with Mix Composition

S.No.	Percentage (%) Admixture	Coefficient of Permeability (cm/sec)
1.	5%	1.26×10^{-3}
2.	10%	1.43×10^{-3}
3.	15%	1.57×10^{-3}
4.	20%	1.61×10^{-3}

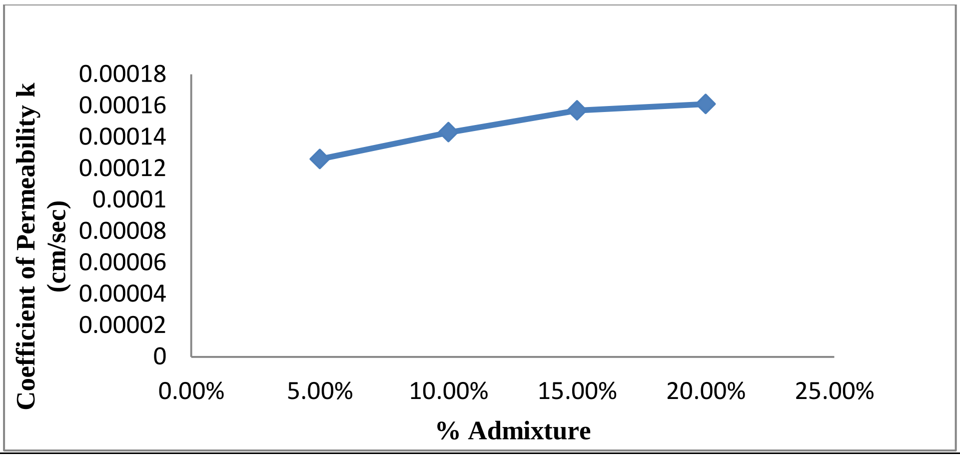

Figure 8 Variation of Coefficient of Permeability k (cm/sec) with Mix Composition

IV. CONCLUSIONS

In this investigation we have used ceramic tile and sanitary ware 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 and sanitary ware waste. In the present investigation, as we are increasing the quantity of admixture of ceramic tile and sanitary ware waste, the angle of internal friction 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. The shear test were performed for mix compositions of fine sand of different dry densities 1.50 gm/cc, 1.55 gm/cc and 1.58 gm/cc with ceramic tile and sanitary ware waste of varying percentage 5%, 10%, 15% and 20%. The angle of internal friction (shearing resistance) ϕ increases with increase in dry density of fine sand and quantity of the ceramic tile and sanitary ware waste. As the ϕ is increasing, the required section for embankment is reduced.
2. Permeability Tests were performed for mix composition of 5%, 10%, 15% and 20% of ceramic tile and sanitary ware 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 and sanitary ware waste mixed to fine sand. Greater the percentage of ceramic tile and sanitary ware 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 and sanitary ware waste can successfully be used as admixture for fine sand stabilization. It can be used for the making embankment for construction of road.

REFERENCES

[1] Ameta N.K. and Abhay Shivaji Wayal, "Effect of Bentonite on Permeability of Dune Sand". E.J.G.E., Vol. 13 – Bundle A, 2008.
[2] Ameta N.K., Purohit D.G.M. and Wayal A.S., "Behavior of Square Footing on Dune Sand Reinforced with Nylon Fibre", April 2009,International Journal of Geotechnical Engineering, Volume 3, Issue 2, pp 313-317.
[3] Laddha ankit and Purohit DGM "stabilization of fine sand using square pieces of waste plastic as a admixture for construction of embankment of road" Vol. 5, Issue 10, October 2016.
[4] Awad AlKarni, Sherif M. EIKholy, "Improving Geotechnical Properties of Dune Sands through Cement Stabilization", J.E.C.S., Vol. 5, No.1, pp 1-9.
[5] AwadAlKarni, Sherif M. EIKholy, "Improving Geotechnical Properties of Dune Sands through Cement Stabilization", J.E.C.S., Vol. 5, No. 1, pp 1-9.
[6] Dr. N.K. Ameta, Dr. Wayal A.S., PuneetHiranandani, "Stabilization of Dune Sand with Ceramic tile and sanitary ware Waste as Admixture", A.J.E.R., Vol. 02, Issue 09, pp 133-139.
[7] K.R. Arora, "Soil Mechanics and Foundation Engineering", Standard Publishers and Distributors, New Delhi.
[8] Wayal A.S., Ameta N.K., Purohit D.G.M., "Dune Sand Stabilization using Bentonite and Lime", J.E.R.S., Vol. III, Issue I, Jan-March 2012, pp 58-60.
[9] IS: 1498-1970 "Classification and identification of Soil for General Engineering Purposes", Bureau of Indian Standards (BIS), New Delhi.
[10] Jain, O.P. and Jain, B.K., "Earthwork Brick Properties", Nemi Chand and Brothers Publishing Company, Journal of S.M.F.D., ASCE, Vol. 105, GT1, Paper No. 14335, Jan 1979.
[11] K.R. Arora, "Soil Mechanics and Foundation Engineering", Standard Publishers and Distributors, New Delhi.
[12] Kevin M., "Micro Characteristics of Chemical Stabilized Granular Materials", Journal of GT, Proceedings of ASCE, Vol. 104, No. GT7, 1978.
[13] Manfred R., Hausmann "Engineering Principles of Ground Modification", McGraw Hill Pub. Co., 1990.
[14] Wayal A.S., Ameta N.K., Purohit D.G.M., "Dune Sand Stabilization using Bentonite and Lime", J.E.R.S., Vol. III, Issue I, Jan-March 2012, pp 58-60.