Behaviour of Rectangular Footing Resting on Dune Sand Reinforced with Porcelain Insulator.

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Abstract **-Many researches have been made to increase the bearing capacity of Dune Sand by using shredded waste tyres ,different admixtures, geotextiles, reinforced earth, grouting etc. Here an attempt has made to investigate the potential benefits of using porcelain waste as reinforcement to improve the bearing capacity of dune sand. A series of load tests were conducted for three rectangular test footings resting on dune sand reinforced with varying percent of porcelain insulator waste. Results obtained indicate that bearing capacity of dune sand can be increased by using porcelain insulator waste as reinforcement.**

Keywords - Dune sand, pressure bulb, bearing capacity

1. INTRODUCTION

The Great Desert known as Thar Desert in the west of the Rajasthan bordering Pakistan covers over 61.3% of its area of Rajasthan state and 6.3% of area of the country as a whole. It covers an area of more than 2,00,000 sq.kms within the Indian state of Rajasthan, covering the districts of Jaisalmer, Barmer, and Jodhpur and some regions of the states of Punjab, Haryana and Gujarat. More than 60% of its area of Rajasthan is covered by wind deposited, non plastic, uniformly graded fine sand known as Dune Sand which possesses several geotechnical engineering problems. Utilization of this 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. There are hundreds of kilograms of broken insulators which are lying at every electric station of India. Although this waste is not hazardous still the bulky shape of it makes it difficult to manage. Porcelain insulators are made from clay, quartz or alumina and feldspar, and are covered with a smooth glaze to shed water. Properties associated with porcelain include low permeability and electricity, considerable strength, hardness, toughness, whiteness translucency and resonance and a high resistance to chemical attack and thermal shock.

2. MATERIAL USED

Dune Sand

No.	Properties of Dune Sand Used					
	Effective Particle Size (D_{10})	**Mean Particle Size(D_{50})**	**Coefficient of Uniformity (C_u)**	**Coefficient of Curvature (C_c)**	**Specific Gravity (G)**	**Maximum Dry Density (γ_{dmax})**
1	0.12 mm	0.177 mm	1.73	1.23	2.67	1.62 g/cc

The Dune Sand used in the present study was brought from location near Ossian, at about 45-48 km away from Jodhpur on Jodhpur-Jaisalmer road. Dune sand has zero cohesion and has low compressive strength and hence need stabilization. Particle size ranges between 75 μ to 1.0 mm, round to angular in particle shape i.e. fine coarse sand as per Indian standard classification system. The coefficient of permeability of dune sand is 2.0 x 10^{-4} cm/s.

Porcelain Insulators:

Table 2.

No.	Properties of Porcelain Insulator	
1	Density	2.8 g.cm^{-3}
2	Porosity	0%
3	Water Absoption	0.05%
4	Max. Operating Temp.	1150°C peak, 1100°C continuous
5	Thermal Conductivity	2.06 W/m.K
6	Thermal Expansion (20-800°C)	6.5 x 10^{-6} °C^{-1}
7	Hardness (on Mohr's scale)	7 to 8
8	Tensile Strength	48 Mpa
9	Bending Strength	82 Mpa
10	Compressive Strength	482 Mpa
11	Dielectric Strength	25 V/mm

3. TEST PROGRAM

Table 3.

No.	Test Program	
1	Size of the rectangular footing (BxL)	2.5x2.8 sq.cm, 3.5x4.2 sq.cm, 4.5x5.9 sq.cm
2	Particle sizes of the reinforcement	2 mm – 1.18 mm
3	Percentage of reinforcement (by volume)	2%, 4%, 6%, 8% and 10%
4	Placement of reinforcement	Uniformly mix with dune sand up to the depth of pressure bulb from the bottom of footing (3L)

The model footing were made of aluminum alloy. Three model footings were used in the study, they were rectangular in shape and having sizes equal to 2.5x2.8 sq.cm, 3.5x4.2 sq.cm and 4.5x5.9 sq.cm . The base of footing was made rough by pasting sand paper of zero grades. The footings were given a semi circular groove in the centre for resting a steel ball. A series of model loading tests were conducted inside a rectanglar tank having dimensions 100x50x50 (LxBxH) cm^3. The tank was made of sufficiently thick steel sheet to withstand lateral expansion under loads. The dimensions of tank were kept more than five times the largest dimension of footings so that it may not induce boundary effects.

4. LOADING AND MEASURING DEVICES

A dead load system was used to transfer the load to the footing through a leverage mechanism, so that load applied should remain constant till it was completely transferred to the soil. Loading system was designed to ensure that vertical load was applied to the centre of footing and no eccentricity was developed throughout the test. The footing was loaded at a constant load increment of about one tenth of the estimated ultimate bearing capacity until an ultimate bearing state was reached. The load was recorded through a proving ring of 2.5 kN capacity which had the least count of 312.5 g. The settlement was recorded through two dial gauges (least count = 0.01 mm) placed on two sides of the footing and mounted on their magnetic bases.

5. EXPERIMENTAL TECHNIQUE

The density of reinforced/ unreinforced sand was kept constant equal to 1.60 g/cc throughout the test program. For placing the reinforcements, the quantity of sand required with a certain percentage of reinforcements to maintain density of reinforced/ unreinforced sand as 1.60 gm/cc was calculated from the following equation:

Mp = % of Reinforcement x density of porcelain x V ...(1.1)

Ms + Mp = 1.6 x V ...(1.2)

where Ms = mass of sand in reinforced zone

Mp = mass of porcelain insulators in reinforced zone

V = volume of reinforced zone

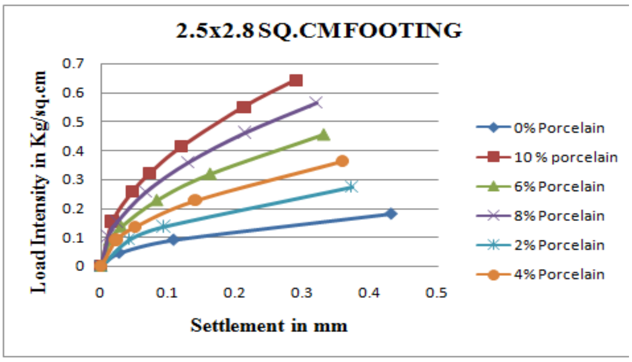
=cross section area of tank x 3L

Mass of sand (Ms) required maintaining density of reinforced sand as 1.60 gm/cc was calculated from equation (3.1). The calculated mass of dune sand, for particular percentage of porcelain reinforcement, was placed in tank in lifts and compacted with the help of tamping rod. Each lift was of 5 cm thickness. The predetermined amount of reinforcement for particular reinforcement content was uniformly mix with predetermined amount of dune sand in tank at desired depth below the footing.

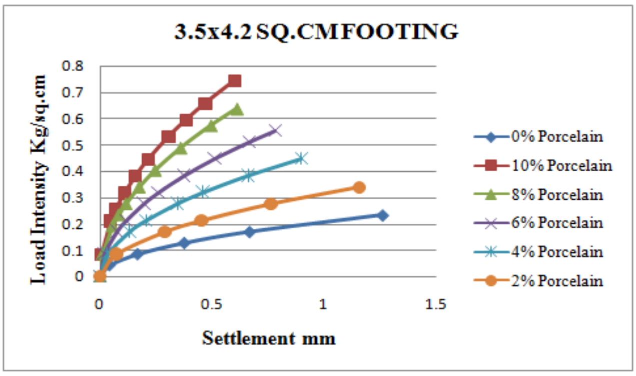
After filling the tank up to required depth, the top surface of sand was levelled. For compacting the reinforced sand, a steel rod with wider base was used as a tamper. The sand and reinforcement mixture can be compacted using tamper while vibratory compaction is ineffective Before starting new test, the sand in tank was removed (from previous test) up to a depth of 3L. The depth of reinforced zone for particular percentage of reinforcement was already marked each time before starting the new test. The proving ring was suspended from the loading arrangement. Footing was placed on the levelled surface of sand. A steel ball was placed on the central groove of the footing. An adopter was attached to lower end of the proving ring. Footing was adjusted to such a position that steel ball placed on it just gets fitted into the groove of adopter, so that vertical load was applied centrally over the footing and no eccentricity was developed. Two thick strips of iron was placed across the width of the tank to accommodate magnetic bases. Two dial gauges were mounted on the magnetic bases.A seating load of 70 g/cm2 was applied for about 10 minutes, which was released before the start of the test. The load was increased in an increment of about 10 percent of estimated ultimate load, and was recorded through proving ring. The resulting settlement was recorded through two dial gauges. The readings of dial gauges were recorded, when rate of settlement was reduced to 0.01 mm/10 minutes. The failure was assumed as that ultimate state at which settlement occurred continuously without application of further load.

6. TEST RESULTS

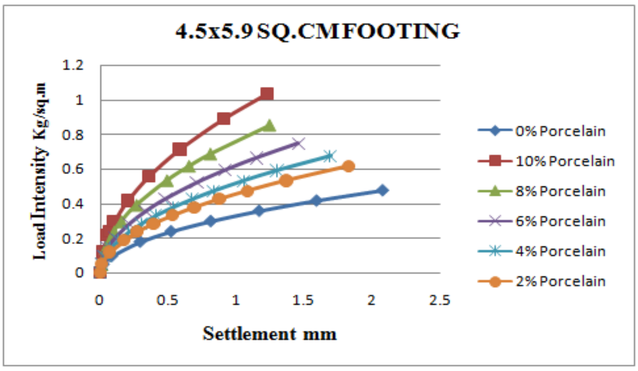
Load Intensity versus settlement graphs were drawn for each footing having different percentage of porcelain insulators.



Graph 1.

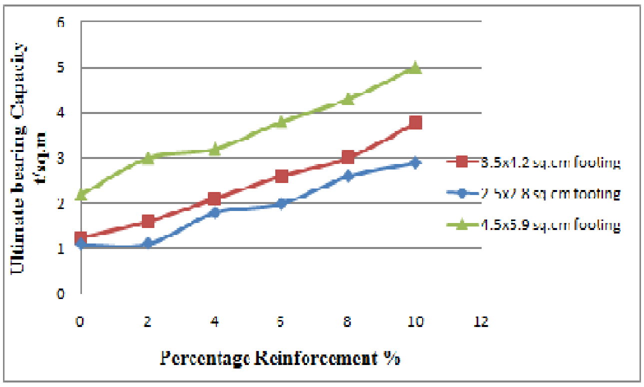


Graph 2.



Graph 3.

After plotting the load intensity vs settlement graphs Tangent Intersection Method was used to determine Ultimate Bearing Capacity for each graph. It was observed that with the increase in amount of porcelain Bearing Capacity also increased and it was maximum at 10% porcelain content for each footing.



Graph 4

7. CONCLUSIONS

The laboratory investigations were carried out to study the use of particles of porcelain insulator waste as a reinforcing material to increase the bearing capacity. The ultimate bearing capacity of a rectangular footing placed on dune sand reinforced with particles of porcelain insulators increases with increase in the porcelain reinforcement content. The bearing capacity of dune sand increases as the size of the footing increases. The settlement of a footing placed on dune sand reinforced with particles of porcelain insulators decreases with increase in reinforcement content

8. REFERENCES

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