International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 08 | Aug-2016 www.irjet.net p-ISSN: 2395-0072

# EXPERIMENTAL STUDY OF IMPROVEMENT OF GROUND USING THE DISPLACEMENT TYPE SAND COLUMN

**Prof. Harish C[1], Sharanakumar[2]**

[1] *Assistant Professor, Department of Civil Engineering, East West Institute of Technology, Bengaluru, Karnataka, India.*
[2] *M.Tech Student, Department of Civil Engineering, East West Institute of Technology, Bengaluru, Karnataka, India.*

---

**Abstract -** The rapid growth of the big cities in the vertical direction leads to essentially of strengthening of low bearing capacity areas as the cost of land is very high, Stone columns are widely adopted to improve weak/lose ground to achieve adequate bearing capacity. Displacement type stone column /granular piles can densify loose sand/silty sand and strengthen the ground. In present a laboratory investigation has been made to investigate the improvement on the ultimate bearing capacity due to installation of a group of displacement type granular piles on loose sand bed. Effect of improving the surrounding region of the footing on the Ultimate bearing capacity has also been examined. Ultimate bearing capacity has been computed from Plate load tests results conducted on loose sand bed and also on improved sand bed. The material for sand piles is gravelly sand were used as granular pile material. Comparison has also been made between various load carrying capacity of sand column in term of changing the number of sand columns. A method also suggested for estimating the ultimate bearing capacity of the sand column improved ground which is supported by experimental result.

***Key Words***: **Bearing Capacity, Settlement, Soil Stability, Soft Soil, Square Footing, Sand Pile etc**

## 1. INTRODUCTION

Lack of suitable sites for construction forced the building industry to look for cheaper land for construction. Sand column method of ground improvement can be employed Successfully in both loose cohesion less soil and soft cohesive soil to improve its strength and deformation behavior. Many of researchers have studied about the behavior of soft soil deposit reinforced with sand column.

Various of the works reported in literature are reported to understand behavior and conclude the bearing pressure and compressibility characteristics of smooth soil stiffened along sand column. Very less column to improve/densified the loose cohesion less soil deposit. As it is not uncommon to encounter a loose cohesion less soil deposit up to shallow depth over a stiffer stratum where shallow foundation can deposit. In small project where using of vibroflot or dynamic compaction will not be economical and shallow foundation can be placed after improving/densifying the top loose soil affordable dynamic compaction will not be economical and be placed after improving/densifying the top loose soil affordable which brings the necessity to study the effectiveness of the stone column to improve the loose soil deposit and developed an approach to estimate the extreme bearing pressure of the improved soil strata which shall be employed in a subsequent design without details subsurface investigation.

### 1.1 Applications of Sand Column

Sand pile are widely adopted to improve weak/ lose ground to achieve adequate bearing capacity and displacement of type of stone columns/granular piles can densify loose sand/silty sand and strengthen the ground.

- Used in strengthening the loose and silty ground.
- Used in recharging the reservoir.
- They act like vertical drain.
- Used for stability increase and stone bulb.
- They provide strength reinforcement to the soil.

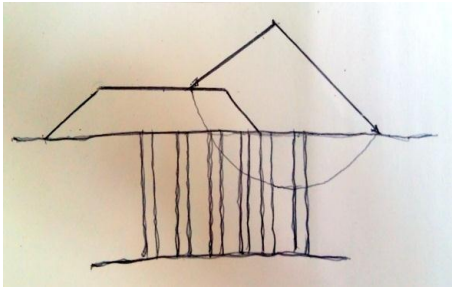

**Fig-1: used in stability of slopes.**

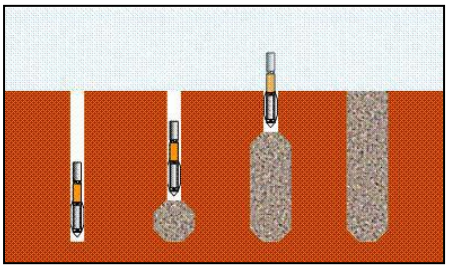

**Fig-2: used as stone bulb.**

## 2. LABORATORY TEST SETUP

1 – Loading direction

2 – Sand pile

3 – Model box

4 - Model Footing

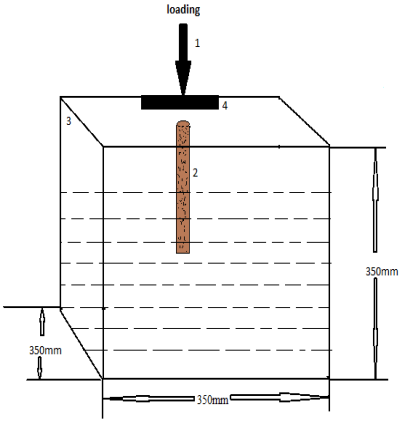


**Fig-3: Experimental setup.**

### 2.1 Model box and Model Footing

The above shown Figure 3 is the representative description of the experimental model setup utilised for this study.

The model box is having an inside dimension of 350 mm x 350 m and depth of 350 mm and the thickness of wall is 3mm. The box is fabricated to retain the plain strain conditions in all directions. The inner of the tank walls are painted to minimize the friction with the sand mass.

The model footing used for this study is a 15mm thick mild steel square plate of dimensions 70mm x 70mm as shown in Figure 3. The square plate was grooved and attached with a rod for the ease in the load transfer operations as indicated.

### 2.2 Material Used

#### 2.2.1 Loose Sand

The loose sand used in this study is collected from S. S. MARKETINGS, bangalore but it's brought from the Bellary coastal area, it's normally taken by layer as per availability at main site or plant.

Sand passing through 4.75 mm was used to prepare the sand bed. From grain size distribution curve the values of Coefficient of curvature (Cc) and Uniformity coefficient (Cu)are 0.9 and 2.86. Max.dry density= 16.17 kN/m3,Min.dry unit weight = 17.12 kN/m3, specific gravity=2.64. The angle of shearing resistance =37$^0$and Cohesion is zero. The material used for construction of sand pile is passing through 6mm sieve were used. From grain size distribution curve the values oCoefficient of curvature (Cc) and Uniformity coefficient (Cu) are 1.02 and 2.2. Max.dry unit weight= 18.02 kN/m3, Min.dry unit weight= 15.33 kN/m3, specific gravity=2.75.
Angle of shearing resistance is 41$^o$ and Cohesion is zero.

#### 2.2.2 Preparation of Loose Sand Bed

All the tests have been conducted on a square test tank of size 70m×70m×15mm. Loose sand bed was prepared by rainfall technique. Rainfall technique consists of filling the sand in test tank through a sieve from a fixed height to maintain constant density of filled sand bed. A specially designed sieve of same size as test tank having 3mm dia. hole @ spacing of 5mm c/c was used for thispurpose.

#### 2.2.3 Preparation of Granular Pile/Stone Column

Pipe having external dia 15mm has been used toprepare sand column. The sand columns were installedin loose sand bed by statically driving the pipe by a mechanical jack. pipes were attached with adetachable conical shoe at the tip to prevent entry of thesand into the pipe during driving. During the installationof pile two dial gauges were fixed just adjacent to pileposition to measure the heave which shows no heave duringthe installation. The length of the sand column (21cm)was two times the width of the footing. Special care has taken to maintain the verticality of the sand column/granular pile during installation. 4 no's(2 x2 group), 9 no's(3 x 3 group) and 16 no's(4 x 4group) of granular pile in square pattern at a c/c spacing of 1.5D, 3D and 4.5D times the diameter of granular pile were installed and load on single pile and load on sand bed also considered.

### 2.3 Test Procedure

5 no's of load test have been carried out, one on loose sand bed and other four test on groups of single sand column.
2 x 2, 3 x 3 and 4 x 4 gravelly sand as sand column material. load test was carried out on a square model footing of size

7cm×7cm. Load was applied in equalincrement (0.2kN) and each increment of load has been allowed until very little change(less than 0.002 mm/min)in settlement was observed. The details of arrangement of columns in group and their length, spacing are shown in Fig. 1and Fig. 2.

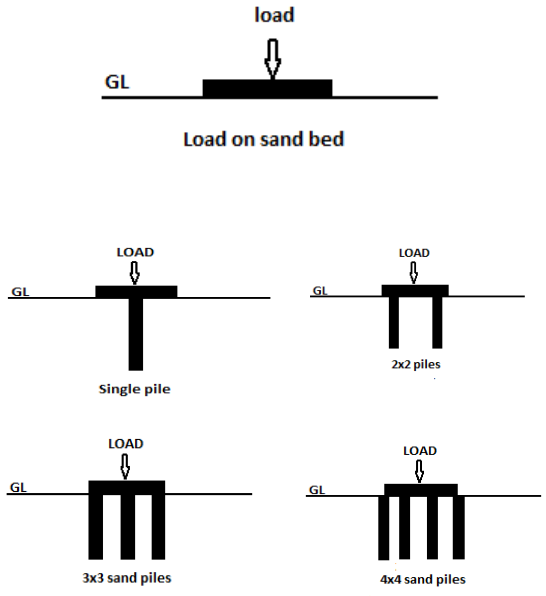


**Fig-4: sand columns installation**

## 3. RESULTS AND DISCUSSIONS

In this study work a total of eleven test were conducted on sand bed, single sand columns and 4 no's, 9 no's and 16 no's piles load-settlement curves. Maximum load was recorded for the settlement corresponding to 25mm for all the analyses.

**Case 1: The comparison is made for load and settlement of sand columns with respect different spacing's.**

The comparison made for the sand piles of four numbers with different spacing (1.5D, 3D and 4.5D). Here the graphs show that if we go on increasing the spacing the load taken by the sand piles will increase. The load taken by the sand piles with 1.5D spacing has taken less load compare to the load taken by the sand pile with 4.5D spacing with respect the same settlement, while sand pile with of spacing 3D has taken the intermediate place it shown in below graph.

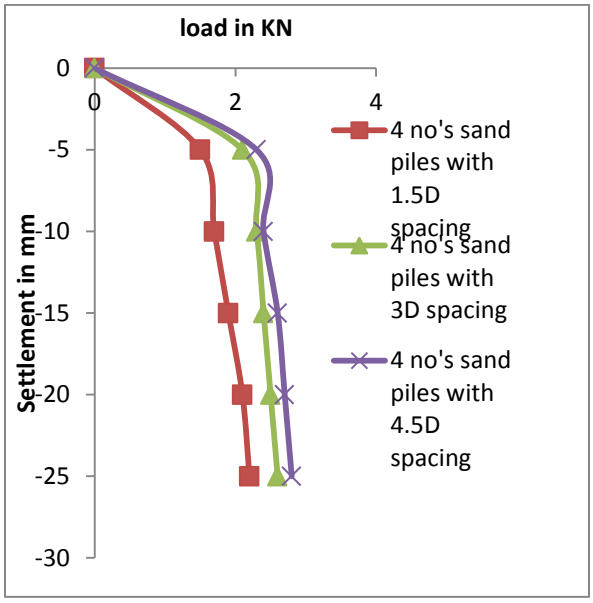


**Fig-5:** load and settlement graphs for sand piles with different spacing (4 no's piles, 2×2 pattern of spacing 1.5D, 3D and 4.5D).

The comparison made for the sand piles of nine numbers with different spacing (1.5D, 3D and 4.5D). Here the graphs show that if we go on increasing the spacing the load taken by the sand piles will increase. The load taken by the sand piles with 1.5D spacing has taken less load compare to the load taken by the sand pile with 4.5D spacing with respect the same settlement, while sand pile with of spacing 3D has taken the intermediate place it shown in below graph.

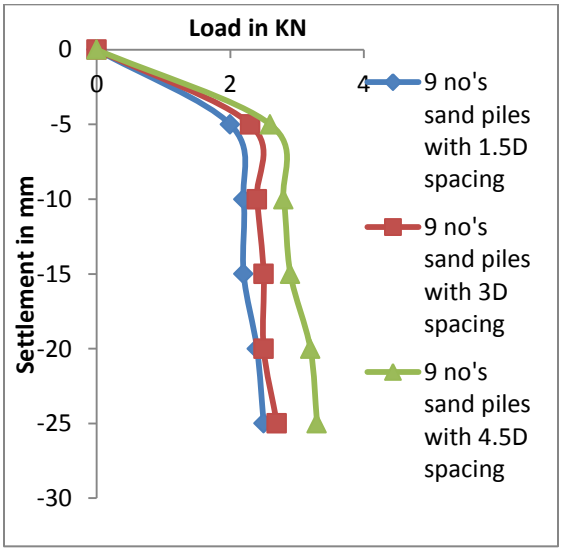

**Fig-6:** load and settlement graphs for sand piles with different spacing (9 no's piles, 3×3 pattern of spacing 1.5D, 3D and 4.5D).

The comparison made for the sand piles of sixteen numbers with different spacing (1.5D, 3D and 4.5D). Here the graphs show that if we go on increasing the spacing the load taken by the sand piles will increase. The load taken by the sand piles with 1.5D spacing has taken less load compare to the load taken by the sand pile with 4.5D spacing with respect the same settlement, while sand pile with of spacing 3D has taken the intermediate place it shown in below graph

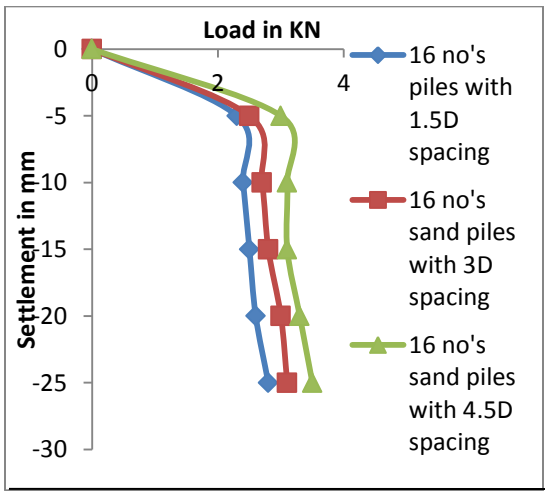


**Fig-7:** Load and settlement graphs for sand piles with different spacing(16 no's piles, 4×4 pattern with spacing 1.5D, 3D and 4.5D).

**Case 2: The comparison is made for load and settlement of sand columns with respect changing the numbers of sand columns with constant spacing's.**

The comparison made for the sand piles of 4 no's, 9 no's and 16 no's with different spacing 1.5D. Here the graphs show that if we go on increasing the number of sand piles the load taken by the sand piles will increase. The load taken by the 4 no's of sand piles with 1.5D spacing has taken less load compare to the load taken by the 16 no's of sand pile with 1.5D spacing with respect the same settlement, while 9 no's of sand pile with of spacing 1.5D has taken the intermediate place it shown in below graph.

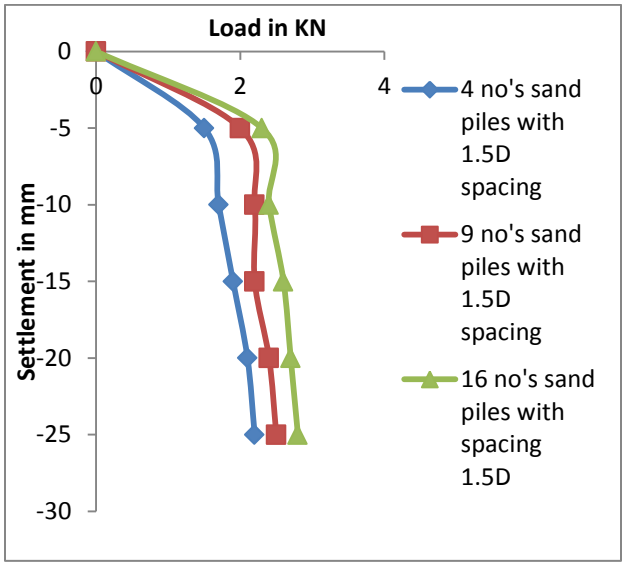


**Fig-8:** Load and settlement graphs for sand piles with 1.5D spacing's (4 no's, 9 no's and 16 no's pile).

The comparison made for the sand piles of 4 no's, 9 no's and 16 no's with spacing 3D. Here the graphs show that if we go on increasing the number of sand piles the load taken by the sand piles will increase. The load taken by the 4 no's of sand piles with 3D spacing has taken less load compare to the load taken by the 16 no's of sand pile with 3D spacing with respect the same settlement, while 9 no's of sand pile with of spacing 3D has taken the intermediate place it shown in below graph.

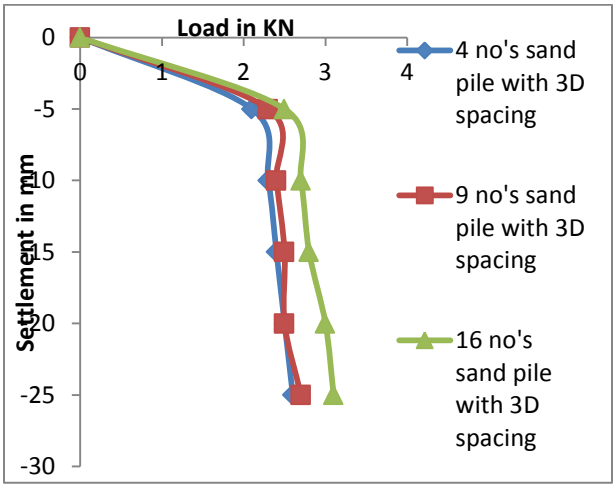


**Fig-9:** Load and settlement graphs for sand piles with 3D spacing (4 no's, 9 no's and 16 no's pile).

The comparison made for the sand piles of 4 no's, 9 no's and 16 no's with spacing 4.5D. Here the graphs

show that if we go on increasing the number of sand piles the load taken by the sand piles will increase. The load taken by the 4 no's of sand piles with 4.5D spacing has taken less load compare to the load taken by the 16 no's of sand pile with 4.5D spacing with respect the same settlement, while 9 no's of sand pile with of spacing 4.5D has taken the intermediate place it shown in below graph.

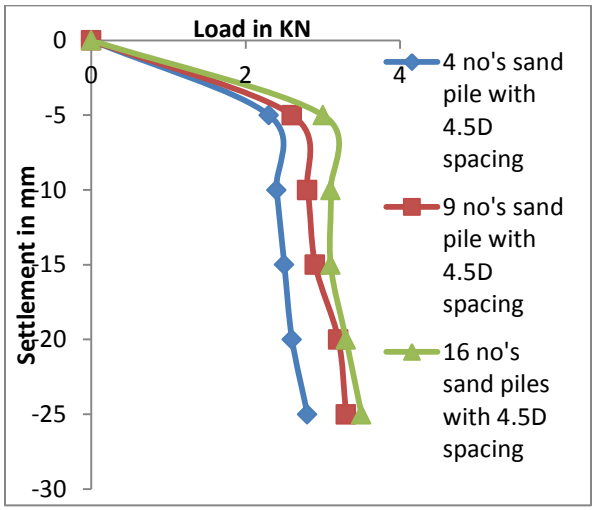


**Fig-10:** Load and settlement graphs for sand piles with 4.5D spacing (4 no's, 9 no's and 16 no's pile).

## 4. CONCLUSIONS

An experimental study is conducted on the sand bed with installation of gravelly sand piles and deal with to up-and-down load is investigate done on experiment analysis. A progression of tests were directed in a square test tank to assess the execution as far as change in bearing limit and decrease in settlement of square footing on the sand piles with different spacing (1.5D, 3D and 4.5D).
The following conclusion are drawn based on experimental results,

- Sand confinement by the sand piles with different spacing enhances the load carrying conveying limit of square footing lying on free sand bed.
- The load carrying capacity for the sand without sand piles is 1.5KN compared to in single sand pile condition is 1.7 KN for the 25mm settlement (i.e.0.2KN improvement).
- The load carrying condition for the 4 no's sand piles of 1.5D spacing is 2.2KN compare to the 9 no's sand piles of same spacing is 2.5 KN for the 25mm settlement (i.e.0.3KN improvement).
- The load carrying condition for the 4 no's sand piles of 1.5D spacing is 2.2KN compare to the 16 no's sand piles of same spacing is 2.8 KN for the 25mm settlement (i.e.0.6KN improvement).
- The load carrying condition for the 4 no's sand piles of 3D spacing is 2.6KN compare to the 9 no's sand piles of same spacing is 2.7 KN for the 25mm settlement (i.e.0.1KN improvement).
- The load carrying condition for the 4 no's sand piles of 3D spacing is 2.6KN compare to the 16 no's sand piles of same spacing is 3.1 KN for the 25mm settlement (i.e.0.5KN improvement).
- The load carrying condition for the 4 no's sand piles of 4.5D spacing is 2.8KN compare to the 9 no's sand piles of same spacing is 3.3 KN for the 25mm settlement (i.e.0.5KN improvement).
- The load carrying condition for the 4 no's sand piles of 4.5D spacing is 2.8KN compare to the 16 no's sand piles of same spacing is 3.5 KN for the 25mm settlement (i.e.0.8KN improvement)
- The load carrying condition for the 4 no's sand piles of 1.5D spacing is 2.2KN compare to the 4 no's sand piles of 3D spacing is 2.6 KN for the 25mm settlement (i.e.0.4KN improvement)
- The load carrying condition for the 4 no's sand piles of 1.5D spacing is 2.2KN compare to the 4 no's sand piles of 4.5D spacing is 2.8 KN for the 25mm settlement (i.e.0.6KN improvement)
- The load carrying condition for the 9 no's sand piles of 1.5D spacing is 2.5KN compare to the 9 no's sand piles of 3D spacing is 2.7 KN for the 25mm settlement (i.e.0.2KN improvement)
- The load carrying condition for the 9 no's sand piles of 1.5D spacing is 2.5KN compare to the 9 no's sand piles of 4.5D spacing is 3.3 KN for the 25mm settlement (i.e.0.8KN improvement)
- The load carrying condition for the 16 no's sand piles of 1.5D spacing is 2.8KN compare to the 16 no's sand piles of 3D spacing is 3.1KN for the 25mm settlement (i.e.0.3KN improvement)
- The load carrying condition for the 16 no's sand piles of 1.5D spacing is 2.8KN compare to the 16 no's sand piles of 4.5D spacing is 3.5 KN for the 25mm settlement (i.e.0.7KN improvement) Load carrying capacity is go on increase as per increasing the number of sand piles like 4no's, 9no's and 16no's.
- Load also will increase if we go on increasing the sand piles spacing like 1.5D, 3D and 4.5D.
- The load carrying capacity of 16 no's sand pile with 4.5D spacing is highest among the all load for 25mm settlement.
- Increasing the spacing and number of sand pile load will distributed and transfers to the deeper levels so enhances the strength of sand.

- These experiments shown that we are able construct the structure in the sandy located areas like coastal, marine etc
- The installation of sand pile we were used pipe as casing if we not removal of pipe means we can achieve more strength and load taking capacity.

## 5. REFERENCES

[1] Bou Lattouf H, Sadek S and Najjar S, Bolton & Omine [1998], Priebe's Improvement factor [1995] and Madhav, Poorooshasb, Miura and Alamgir [1996].

[2] Bergado, D.T; Singh, N; Sim, S.H; Panichayatum,B;Sampaco, C.L. and Balasubhramanium ,A.S. (1990) ,"Improvement of Soft Bangkok Clay using Vertical drains Compared to Granular Pi le" Geotextile i le and Geo membrane Journal.

[3] Ground Improvement Using Displacement Type Sand Piles- Indian Geotechnical Conference – 2010, GEO *trendz* December 16–18, 2010

**i)** IGS Mumbai Chapter & IIT Bombay.

**ii)** Hughes, J. M. O. And N. J. Withers (1974), "Reinforcing of Soft Cohesive Soils with Stone Columns," Ground Engineering, Vol.7,No.3, May, pp. 42-49.

[4] H. B. Poorooshasb and G. G. Meyerhof (1997) ,"Analysis of Behavior of Stone Columns and Lime Columns", Computers and Geo technics, Vol. 20, No. 1, pp. 47-70.

[5] Madhav, M. R. and P. P. Viktor, (1978), "Strip Footing on Weak Clay Stabilized with a Granular Trench or Pile", Canadian Geotechnical Journal, Vol. 15, pp. 605-609.

[6] Sand Piles for Shallow Foundations Pilotes de Arena para Cimentaciones Superficiales- Cintra, José Carlos A and Wilson Cartaxo Soares.

[7] The Comparison between to the Amount of Ground Water Debit in Recharge Reservoir using Sand Columns by international journal of engineering and technology Volume 3 No. 8, August, 2013.

[8] The Effectiveness of Sand Column Utilization in Recharge Reservoir as Seawater Intrusion Barrier by- International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 - 8958, Volume-3, Issue-2, December 2013.