Proceedings of the 4th International Conference on Civil Engineering for Sustainable Development (ICCESD 2018), 9~11 February 2018, KUET, Khulna, Bangladesh (ISBN-978-984-34-3502-6)

EFFECTIVENESS OF SAND COLUMN AS A GROUND IMPROVEMENT TECHNIQUE

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ABSTRACT

Soil strata is highly varying in nature and it is a challenging task for Geotechnical engineers to come up with the most suitable foundation system that is safe during static and dynamic loadings. In this paper, a case study on ground improvement using sand columns at a selected site of South-West region of Bangladesh is discussed. Ground improvement by granular piles is considered as one of the versatile and cost effective ground improvement method. This technique is suitable for very soft cohesive soil to loose deposits. Granular piles have already been installed in the soft soil regions of Bangladesh for the improvement of marginal sites. There is a record of successful application of rammed-displacement method in the installation of granular piles in the soft ground of Bangladesh. In this study, load tests were conducted on 0.30 m diameter plate resting a depth of 0.90 m from the existing ground surface on both the natural and improved ground. The plate load test was conducted on the natural ground at the foundation depth and on the top of sand piles after one month and one year of installation of granular pile. The results express that the bearing capacity of the normal ground was increased significantly by the installation of granular piles significantly. Comparing the natural ground, the bearing capacity of improved ground was increased by 200% and 250% for sand piles, respectively. The sub soil bore hole shows that the N-values increased by 2-3 fold than of natural ground. Thus this paper will include the soft ground improvement using granular piles technique which is a fast, economical and an efficient method to improve weak soil.

Keywords: *Sand column, rammed-displacement, soft ground, bearing capacity, improved ground.*

1. INTRODUCTION

This study deals with a particular improvement technique, namely granular piles, used to improve the soft ground condition. Amongst the various ground improvement techniques, construction of granular piles is considered as one of the foundation solution for its proven records of effectiveness in improving soft soil deposits. At the present time, more granular pile projects in the U.S.A have been constructed in silty sands rather than cohesive soils. World wide the reverse is true. Improvement of soft cohesive soils for construction purposes by means of vibro-displacement i.e. granular piles have been established for the last few decades (Engelhardt and Golding 1975, Barksdale and Bachus 1983, Shin et al. 1991, Okiawa et al. 1992, Bergado and Miruia 1994 and Alamgir 1996). Granular piles such as stone columns, sand compaction piles etc, have been used as a ground improvement technique to increase the bearing capacity, reduce settlement, increase the rime of consolidation, improve stability and resistance to liquefaction of soft ground. Granular piles with different types of granular materials were constructed in a typical soft ground of south western region of Bangladesh. Load tests were done over the constructed granular piles and the results show that the bearing capacity of the improved ground increased by 1.44 to 1.77 times than that of the natural ground. So it is termed as an essential component of ground improvement method. The main objectives of this research work is to study the improvement of the ground along the depth by comparing strength profiles of the ground before and after improvement and evaluate the response of ground improvement with elapsed period after the construction of sand pile. It can also evaluate the effectiveness of

locally available installation method for the condition of sand compaction pile in soft soil condition and determine the degree of improvement of the bearing capacity of soil due to the installation of granular piles by comparing the load settlement response obtained in the natural and the treated grounds.

2. METHODOLOGY

The granular piles were constructed here by vibro-displacement method in dry process. The dry method is frequently used to construct columnar inclusions through weak soils in developed areas because of the problems associated with the acquisition, retention and disposal of significant amount of water. The dry technique is suited for partially saturated soils that can stand unsupported, especially those that will density as a result of lateral vibration.

A 1500rpm traditional rig machine and a two end open casing pipe 8mm thickness and 300mm in diameter and 7m long with a vibro-hammer of weight 1000kg. The vibro-hammer was 250mm in diameter and 3.00 m long. The construction sequences are described in the following statements. The schematic diagram is shown in Figure.1.

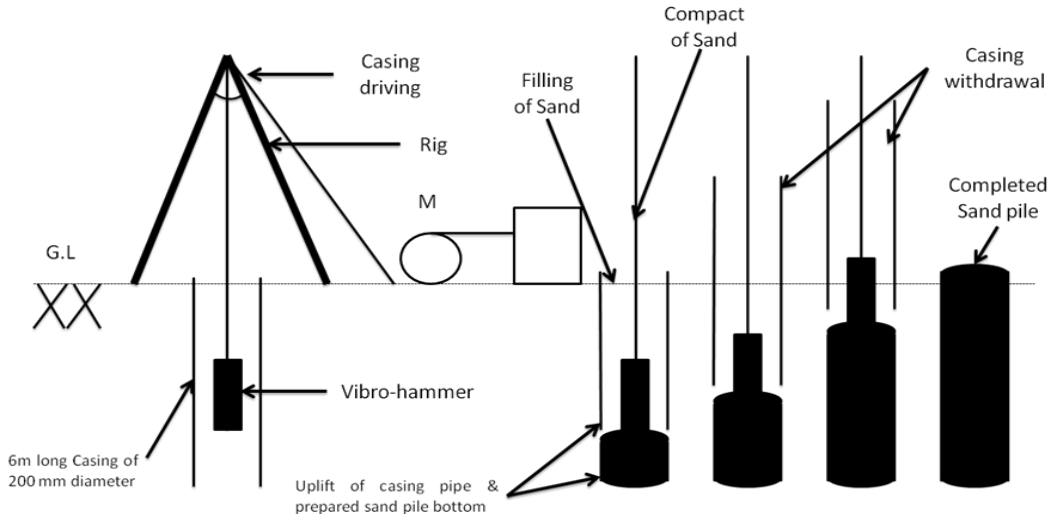

Figure 1: Schematic diagram of installation procedures of granular piles

i. A two end open casing pipe, 300mm in diameter and 7m long was placed vertically at the designed point on the natural ground surface for sand pile construction.

ii. The casing pipe was then inserted vertically into the ground about 300mm to 450mm depth at its own weight just by applying some pressure manually. At first a plug is made by the designated sand up to 750mm of casing pipe at bottom level.

iii. The vibro-hammer 250mm in diameter and 3.0m long, weighting 1000kg was placed inside the casing pipe. The vibro-hammer displaced the soil from beneath the casing pipe hence the casing pipe was driven by its own weight till reached the designated position (depth) into the ground. Here one casing pipe of 7m long was driven inside the ground.

iv. After reaching the designated depth, the sand plug is broken by providing excess energy then the vibro-hammer is withdrawn from the casing pipe.

v. Casing pipe was then lifted up by about 1m from its original bottom position. The designated granular materials were poured into the hole about 1m layer thickness measured from the bottom. The poured granular materials was then densified by vibro-hammer till the required compactness achieved.

vi. Casing pipe was then withdrawn from inside the ground that left the bottom portion of the hole unsupported and the top portion supported by the casing pipe. It was observed that the bottom portion of the hole standing safely without any lateral support.

vii. Then hole was poured by the selected granular materials in layers and hence 10 to 15 drops compacted each layer was densified by vibro-hammer till the designated compactness was reached.

viii. After the top of granular piles were reached about 1.0m to 1.5m below the ground surface the casing pipe was withdrawn and left the remaining hole unsupported.

ix. Then step five (v) was continued until the granular piles were constructed up to the ground level.

The plate load test was done on the natural ground at the project site to determine the load settlement response of the untreated ground. The ground improved by granular piles was also investigated by performing Standard Penetration Test. The effectiveness of granular piles in improving soft ground is justified by comparing N-values obtained for natural ground and improved ground.
Observations and recording system made a great contribution to ensure the quality control of the constructed granular piles. The careful site observation is the main requirement to construct the granular pile as per desire.

3. RESULTS AND DISCUSSIONS

3.1 Summary of The Plate Load Test Result

The plate load test reveal that the bearing capacity of the improved ground increased significantly due to the installation of granular piles. The arrangement of granular piles, installation pattern and the ratio of bearing capacity of treated (q_t) and natural ground (q_n) are shown in Table 3.1.

Table 3.1 Measured load carrying capacity of sand pile yields the largest increment of load carrying capacity which is 2.50 times than that of natural ground.

No. of Test	Description of granular piles	Load test after sand pile installation	Location of plate	q_t/q_n (Corresponding to 7mm settlement)
1	Sand piles	Immediately	Top of pile	2.00
2	Sand piles	After one year	Top of pile	2.50

3.2 Comparison of Result Obtained from SPT

Standard Penetration Test were performed on the improved ground for different conditions. There are (i) The boring immediately after sand pile installation and (ii) The boring one year after sand pile installation. The Standard Penetration Test results are given in the following sections for different improved conditions.

3.2.1 Immediately After Sand Pile Installation

Standard Penetration Test was performed in two bore hole of improved ground to depict the improvement of soft ground along the depth due to the penetration installation of granular piles. The penetration resistance i.e. N-values obtained in two boreholes are compared with those of natural ground before granular piles installation. The comparison is shown in fig. 2. This figure shows that N-values ranges 3 to 9. for the natural ground, while the values increases to 4 to 15 and 5 to 24 for the bore holes one and two respectively, in case of improved ground.

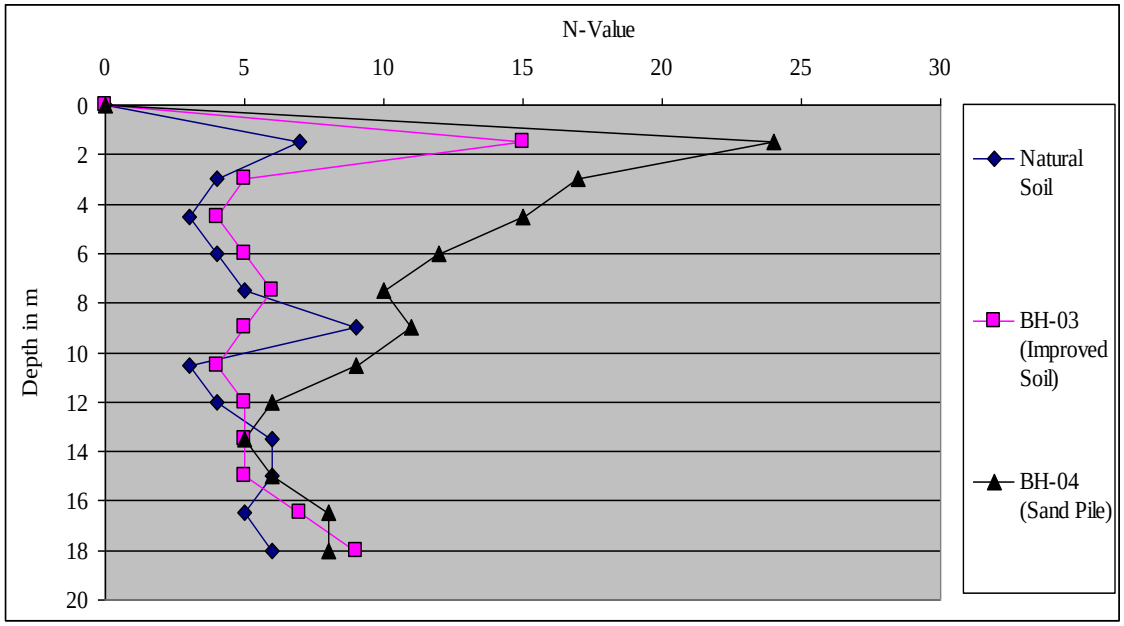

Figure.2 Comparison of SPT result, treated and natural ground (Immediately after sand pile installation

3.2.2 One Year After Sand Pile Installation

Standard Penetration Test was performed in two bore hole of improved ground to depict the improvement of soft ground along the depth due to the penetration installation of granular piles. The penetration resistance i.e. N-values obtained in two boreholes are compared with those of natural ground before granular piles installation. The comparison is shown in fig.3. This figure shows that N-values ranges 3 to 9. for the natural ground, while the values increases to 4 to 12 and 5 to 19 for the bore holes one and two respectively, in case of improved ground.

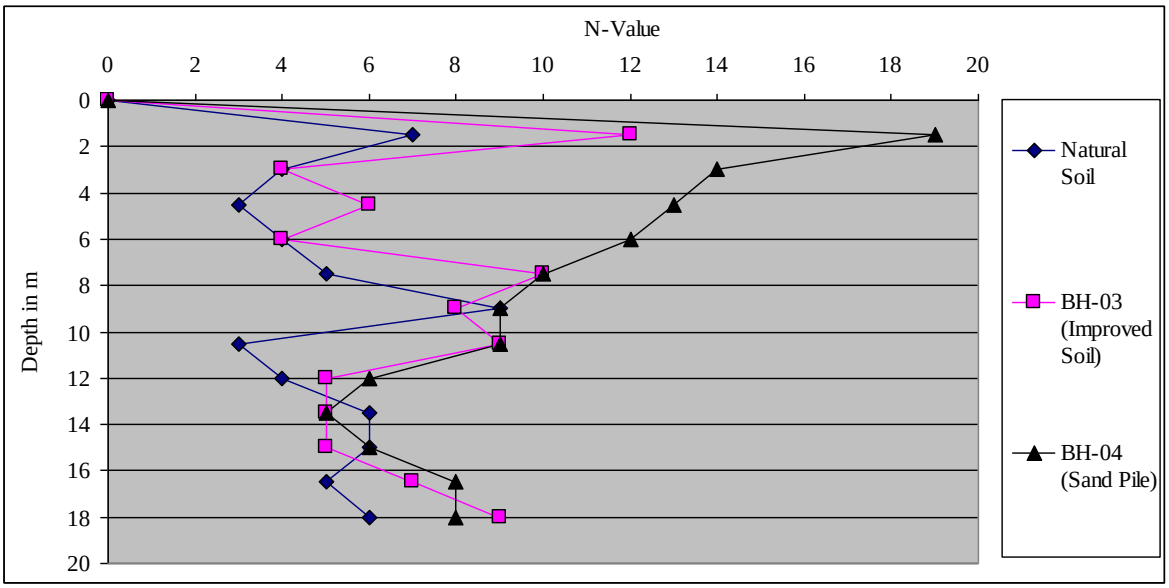

Figure.3 Comparison of SPT result, treated and natural ground (one year after sand pile installation)

4.CONCLUSIONS

Based on the construction of granular piles and the related test reported in this study, we can say that amongst the various ground improvement techniques for improving soft ground conditions, granular piles are considered as one of the most versatile and cost effective method. The simple construction procedures and the related equipment adopted in this project for the installation of the desired granular piles were found to provide high degree of effectiveness. The better increment of bearing capacity by granular pile are observed than that of natural soil. Standard Penetration Test (SPT) results also reveal that the significant improvement of the ground can be achieved along the depth due to the installation of granular piles. The practicing engineer can get help from this study and experience to improve the soft ground by the installation of granular piles.

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