International Journal of Academic Engineering Research (IJAER)
ISSN: 2643-9085
Vol. 4, Issue 6, June – 2020, Pages: 1-4

Assessment of Sabkha Soil Improvement Upon Installation Vibro- Stone Column : A Case Study

Hassan. A. Abbas[1], Saad A. Aiban[2]

[1]Assistant Professor, Department of Civil Engineering, Prince Mugrin University, Al-Madinah Al-Munawarah, Saudi Arabia
H.Abbas@upm.edu.sa or hassankfupm@gmail.com

[2]Professor, Department of Civil and Environmental Engineering, King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia
saiban@kfupm.edu.sa

Abstract: Sabkha soils are widely distributed throughout Saudi Arabia, especially along the coastal areas. Typical problems encountered in foundations and structures built over Sabkha beds. The use of stone columns as a technique of soil improvement is frequently implemented in Sabkha soils. Besides, their use in Sabkha soils has been found to provide moderate increases in load carrying capacity accompanied by significant reduction in settlement. In this paper a case study chosen from the Eastern Saudi Arabia is studied in detail to investigate the performance behavior of ground improved with stone columns. The stone columns were constructed using the wet method. Comparison between Pre- and Post- Cone Penetration Test CPT was conducted in this study to discuss different methods that are used to assess the improvement of the soil layers upon installation of stone columns.

Keywords— Sabkha**;** stone columns; Cone Penetration Test

1. INTRODUCTION

The expression sabkha is originally an Arabic name, that has been use to describe saline flats that are underlain by sand, silt or clay, and often encrusted with salt [1] .Sabkha soils are widely distributed throughout Saudi Arabia, especially along the coastal areas. Typical problems encountered in foundations and structures built over Sabkha beds include excessive settlement, cracking, formation of huge potholes and rutting.

Stone columns improvement has been used on many construction sites to reinforce and densify weak soil layers by inserting stiff material and improve surrounding soils properties. Considering the changes that are occurring in the soil parameters surrounding stone columns will lead to better understanding of the performance of stone columns.

The performance of the stone column reinforced ground is evaluated through the changes achieved in the values of density, void ratio, and constrained modulus of the ground after installation [2]–[4] . The Cone Penetration Test (CPT) is most important tool for quality assurance and quality testing of ground improvement works through installation of stone columns, the CPT is more suitable and more preferable than normal Standard Penetration Test (SPT) [5].

The Cone resistance value is governed by many factors including soil density, in-situ stresses, stress history, soil type and soil compressibility [6]. Therefore Changes in these parameters can be documented with changes in measured cone resistance before and after installation of stone columns [7]. These tests generate full depth profiles against the design depth of stone columns and hence give a comparison of unimproved and improved ground conditions for the full depth.

The goal of this paper is to discuss different methods that are used to assess the improvement of the soil layers (including Sabkha) upon installation of stone columns. The study depends on published and field data collected from petrochemical project in Jubail industrial city - eastern Saudi Arabia

2. SUBSOIL CONDITION AND SOIL IMPROVEMENT WORK

Soil improvement by means of Vibro- replacement was used to improve the soil below the Early Water Tanks (EWT) in a Petrochemical Company Project – Jubail industrial city, in order to limit total and differential settlement, and to achieve the required bearing capacity.

A soil investigation program had been carried out in the area of the proposed plant; the stratigraphy observed from borings generally indicates the presence of top 2.7 m loose to medium dense sand layer followed by very soft compressible strata (Sabkha) up to 6 m depths. The strata below Sabkha layer is comprised of medium to very dense sand up to the maximum depth of exploration. The soil condition under tank is summarized in Fig. 1. The Ground water level is at an elevation of about EL= -1. 5 m.

The original soil conditions underneath the tank foundation was improved by the installing stone columns using wet method in a regular triangular grid 1.7 m x 1.7 m, which extends from existing ground level to the load bearing, medium dense sand layer at an approximate depth of 10 m.

International Journal of Academic Engineering Research (IJAER)
ISSN: 2643-9085
Vol. 4, Issue 6, June – 2020, Pages: 1-4

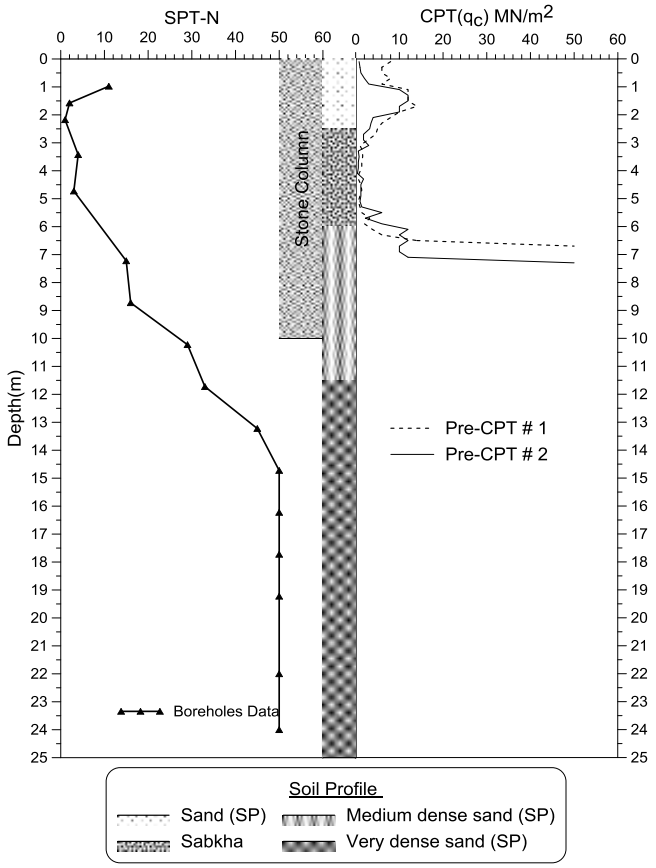

Fig. 1. Soil Profile, SPT and Pre-CPT in EW .

3. Results and Discussions

4.1 Comparison between pre and post- CPT

Three post-CPTs were carried out within the case study area. The first was in the center of the group of stone columns, the second in the center of two stone columns, and third was 60 cm away from the center of stone column. Comparison between pre and post-improvement CPT tests in the EWT are presented in Fig. 2 and Fig. 3. In general, there are slight improvements occurring in the top sand layer. There are several possible explanations for the non-improvement occurring in some points including lack of confinement on the surface and presence of some cemented materials in the sand before installation of stone columns. This cementation will break down as a result of vibrations accompanying the stone columns installation.

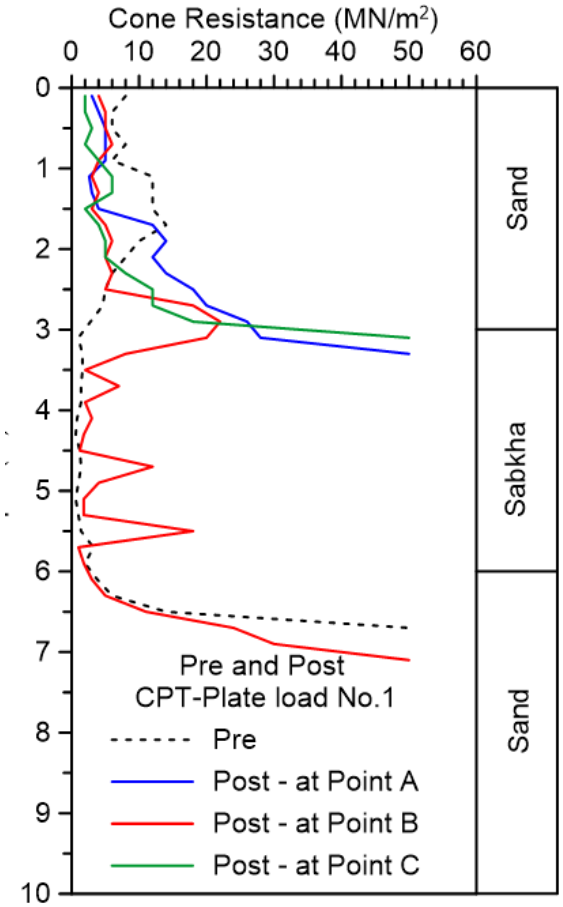

Fig. 2. Pre and Post- CPT within Plate Load Test No. 1, the EWT.

Significant improvement occurred in the Sabkha layer especially at the top 1 m to 1.5 m. The explanations for the improvement occurring in the Sabkha may be due to its sandy clayey nature with shell fragments mixed with sand from top layers. The value of CPT tip resistance in the sand layer below Sabkha (to a depth of 7 m) is approximately the same in pre and post installation of stone columns. The strength of this layer before inserting the stone columns is high. The Pre-CPT more than 20 MN/m^2 is at 6 m depth and refusal is at 7m. Therefore, the vibration accompanying the installation of stone columns may not cause significant improvement in this layer; assessment with CPT refusal is not possible.

International Journal of Academic Engineering Research (IJAER)
ISSN: 2643-9085
Vol. 4, Issue 6, June – 2020, Pages: 1-4

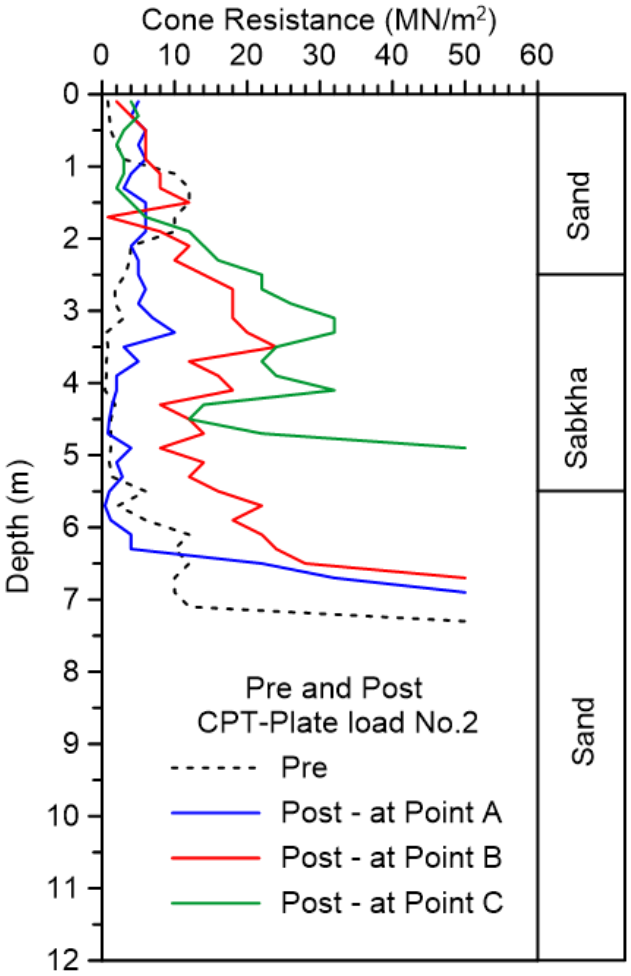

Fig. 3. *Pre and Post- CPT within Plate Load Test No. 2, the EWT.*

4.2 Assessment of Sand and Sabkha compactable due to Vibro- stone column

By assessing soil compressibility prior to the compaction work it is possible to determine whether, and to which degree, soil compaction will be required [2].Massarsch (1991) develop compactability criteria depend on CPT to evaluation ability of soil to compactable or not after vibration compaction. Massarsch (1991), suggested that soils subjected to Vibro compaction can be categorized as "*compactable*", "*marginally compactable*", and "*not compactable*" as shown Fig. 4. This approach based on the cone tip resistance and friction ratio [8]. This method uses in this paper to assessment ability of sand and sabkha soils to improve density after installation of Vibro- stone columns.

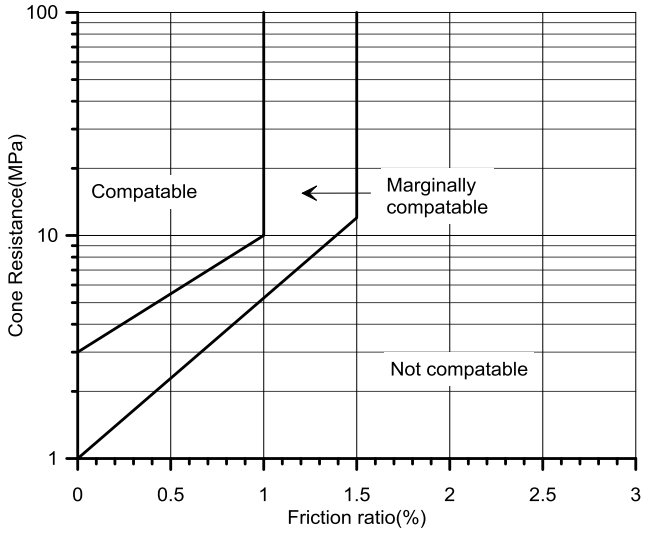

Fig. 4. *Soil classification for vibratory compaction(after [8])*

Relation between friction ratio and cone resistance in EWT are shown in Fig. 5 and Fig. 6. A visual review of the data points in tow Figure indicates that the upper layers locate in rang of compactable to the not compactable categories, the sabkha soils point concentrated in marginally compactable to the not compactable categories, and the sand with silt under sabkha exhibited compactable categories.

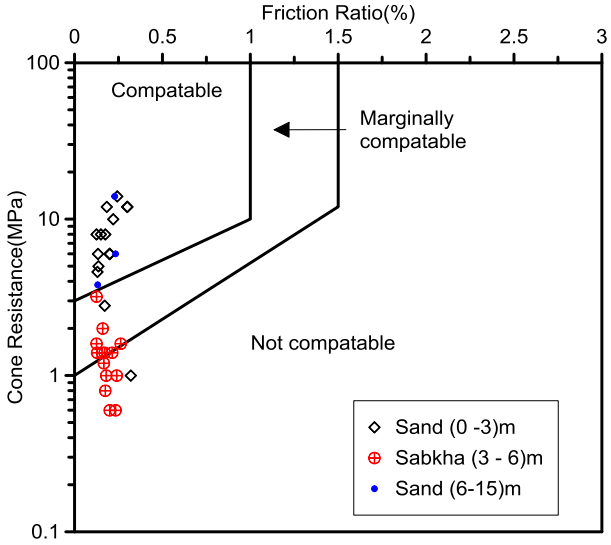

Fig. 5. *Evaluation of vibratory compaction at location test No.1 in EWT .*

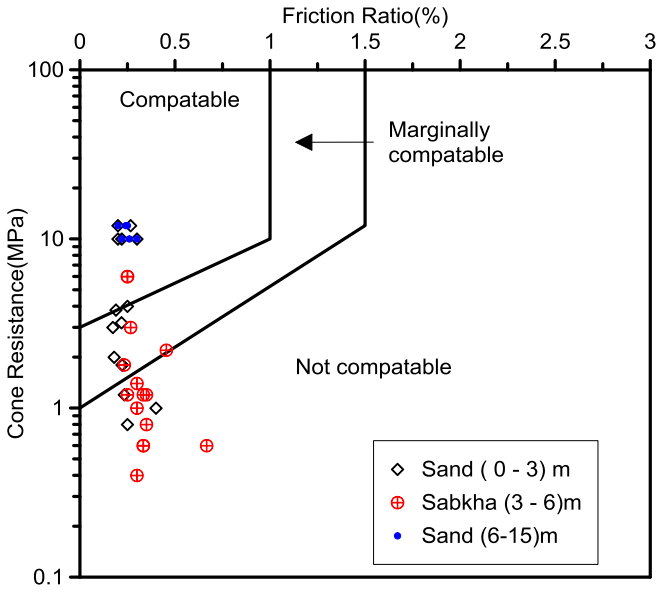

Fig. 6. *Evaluation of vibratory compaction at location test No.2 in EWT.*

4. CONCLUSIONS

The goal of this paper is to discuss different methods that are used to assess the improvement of the soil layers (including Sabkha) upon installation of stone columns. The study depends on published and field data collected from petrochemical project in Jubail industrial city - eastern Saudi Arabia

Cone Penetration Test (CPT) is a useful tool for quality assurance and quality testing of ground improvement works before and after stone columns installation.

There are several possible explanations for the non-improvement occurring in some points in top sand layer (within 3m depth) above sabkha including lack of confinement on the surface and presence of some cemented materials in the sand before installation of stone columns. This cementation will break down as a result of vibrations accompanying the stone columns installation. Significant improvement occurred in the Sabkha layer especially at the top 1 to 1.5m and the Sabkha soils point concentrated in marginally compactable (1 to 1.5 m) to the not compactable categories after 1.5 m.

The value of CPT tip resistance in the sand layer below Sabkha (to a depth of 7 m) is approximately the same in pre and post installation of stone columns, because the strength of this layer before inserting the stone columns is high. Therefore, the vibration accompanying the installation of stone columns may not cause significant improvement in this layer.

5. REFERENCES

[1] Al-Amoudi, O. S. B (1994). Chemical stabilization of sabkha soils at high moisture contents, Eng. Geol., vol. 36, no. 3, pp. 279–291,.

[2] Massarsch, K. R. and Fellenius, B. H (2014). Use of CPT for design, monitoring, and performance verification of compaction projects, , 3rd International Symposium on Cone Penetration Testing, Las Vegas, Nevada, , pp. 1187 - 1200.

[3]Murugaiah, S (2004).Numerical simulation of the performance of sand columns, Washington State University.

[4] Massarsch K. R. and Fellenius B. H (2002). Vibratory compaction of coarse-grained soils, Can. Geotech. J., vol. 39, no. 3, pp. 695–709.

[5] Mayne, P. W(2007). Cone penetration testing, vol. 368. Transportation Research Board,.

[6] Jacobs, P. (2004). Cone penetration testing (CPT), simplified description of the use and design methods for CPTs in ground engineering, Fugro Eng. Serv. Ltd Oxfs. UK,.

[7] Massarsch K. R. and Broms B. B (2001), New Aspects of Deep Vibratory Compaction, Proc. Mater. Sci. 21st Century JSMS 50th Anniv. Invit. Pap. Vol Soc. Mater. Sci. Jpn., pp. 172–179.

[8] Massarsch K. R(2014), Deep soil compaction using vibratory probes, ASTM Special Technical Publication, STP, 1991, vol. 1089, pp. 297–319.