Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 8, S. 426-431, 9, 2024

Araştırma Makalesi

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 8, pp. 426-431, 9, 2024

Research Article

https://as-proceeding.com/index.php/ijanser
ISSN:2980-0811

The effectiveness of Cement, Lime and CKD for improving the compressive strength of Sabkha soils.

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(Received: 24 October 2024, Accepted: 27 October 2024)

(4th International Conference on Engineering, Natural and Social Sciences ICENSOS 2024, 22-23 October 2024)

ATIF/REFERENCE: Khatrush, A. & Kezza, O. (2024). The effectiveness of Cement, Lime and CKD for improving the compressive strength of Sabkha soils, *International Journal of Advanced Natural Sciences and Engineering Researches*, 8(9), 426-431.

Abstract – Sabkha is a coastal sediment with high salt content and are characterized by low bearing capacities and high compressibility. It forms a large part of the geology of the city of Benghazi. It is of variable thickness between 4 and 10 meters. The increase in demand for land use as a residential and tourism development is rapidly expanding. This revealed the need for reliable and economical method of improvement for such soft soils.

The paper presents a laboratory experimental study to investigate the effectiveness of three different additives; cement, lime and cement kiln dust (CKD) for soil treatment . The potential improvement of the stabilized material is assessed using the mechanical strength characteristics and focus was made on the amount of mixing material and the curing time.

The results showed a significant improvement for the soil treated with cement. The use of lime was found ineffective, while the use of cement kiln dust can be relatively very promising especially when considering the economic factor.

Keywords – Sabkha Soils, Compressive Strength, Stabilization, Cement, Lime, CKD.

I. INTRODUCTION

The term Sabkha is an Arabic name that has long been in use to describe saline flat that are often encrusted with salt [1]. Sabkhas are characterized as being large flat, salt-encrusted evaporative terrains. It is an equilibrium geomorphic the surface level of which is dictated by the local water table [2]. Sabkhas are generally viewed as loose (or soft) with highly concentrated brines [3], and therefore characterized from geotechnical point of view as weak bearing soil which is usually a source of problems during construction [4].

Large parts of Benghazi city and adjacent coastal areas are covered with sabkha deposits (figure 1). The demand of land for future extension of the city which is planned to be included in tourism industry with various construction activities such as roads, buildings and other industrial activities. Improvement of strength characteristics with cost effective method and material become largely needed. Several investigations on stabilization of Sabkha soils, especially in Arabian Gulf were reported, although their main concern was in improving sub grade soils. For example, [5], [6].

The present study is a laboratory investigation aimed to asses the effectiveness of using different stabilizing material for improvement of shear strength of such weak soils. Three types of stabilizing materials were selected; cement, lime and cement kiln dust (CKD). However by considering the economic factor, more focus was put on the effectiveness of CKD which disposed in cement factories by large quantities on strength development of treated soil either when used alone or mixed with cement. . CKD properties can be found in detail elsewhere [7].

Fig. 1 Sabkha areas within Benghazi and adjacent coastal areas

II. MATERIALS AND METHOD

A. *Test material*

The soil used in this investigation was collected from Sabkha area, north of Benghazi city (figure 1). The shear strength of the deposit in its natural state was measured using field vane shear test up to a depth of 5.0 m and averaged as 20 kN/m2. The basic properties of the soil and brine water are given in Table 1

Three types of stabilizing materials were used; ordinary Portland cement, hydrated lime and cement kiln dust (CKD) denoted as C, L and K respectively. all cement product are obtained from Al-Hawary factory in Benghazi, manufacturing based on British standards BS12.

Stabilizing material content are kept low, hence not exceeding 7 % in all mixtures. Table 2 includes the amount and type of material used in all tests.

B. *Test method*

The treated soil was used in its natural state and its dry weight was estimated from water content and hence the required amount of mixing stabilizer is taken as a percentage of soil dry weight. Total natural water content is kept at approximately 50 % in all tests. All water are from brine and no fresh water was added. The required amount of stabilizing material is poured dry to simulate dry mixing technique. Mechanical mixing was used for approximately 5 minutes to ensure a homogenous blend. The content then placed in plastic tubes 42 mm diameter and about 120 mm in height, with slight hand pressing and tapping to obtain cylindrical specimens suitable for unconfined compression test.

The sample were then sealed and stored in special containers with a layer of water at half height but not in direct contact with the sample, to maintain high humidity inside the container during curing time. The specimens required for testing were trimmed to a height of twice their diameters and tested in unconfined compression at a rate of 1.0 mm/min. figure 3 shows typical specimen shape after testing

The initial assessment of strength of the untreated soil required for later comparison are made by laboratory vane shear apparatus (LVT). This also adopted for some specimens treated with 3 % lime for a short period of curing time of 3 days. The unconfined strength (UCS) is taken equals to twice the undrained strength obtained during (LVT) test.

Table 1 Some properties of test soils and brine.

Property	Value
Soil	
Water content (%)	50
Specific gravity	2.6
Fines (%)	53
Sand (%)	47
Gravel (%)	0.0
Liquid limit (%)	29
Plastic Limit (%)	6
Carbonate content (%)	36.2
Chloride content (%)	2.2
Sulfate content (%)	0.5
Undrained shear strength (kPa)	20
PH	8.2
Brine	
SO4 (%)	1.061
NaCl (%)	1.03
TDS (%)	23.98

Table 2 Stabilizer amount in tests

Symbol	Percentage stabilizing material amount by weight of soil	Total or mixture
C	3,5&7	100 % cement
L	3,5&7	100 % lime
K	3,5&7	100 % CKD
C/K	7	60 % cement + 40 % CKD
K/C	7	40 % CKD + 60 % cement

III. RESULTS AND DISCUSSIONS

The unconfined compression strength (UCS) is considered as the measure for the assessment of strength improvement of the treated soil. The relation between the amount of stabilized material and (UCS) are plotted in figure 2, for 7 and 28 days curing time. The results indicate clearly the general trend of improvement in strength with the amount of stabilizing material, which is very pronounced in case of specimens treated with cement, even at early age.

However, by comparing such behavior with that of specimens treated with lime and CKD, the results present large difference of the order of 2 to 5 times,

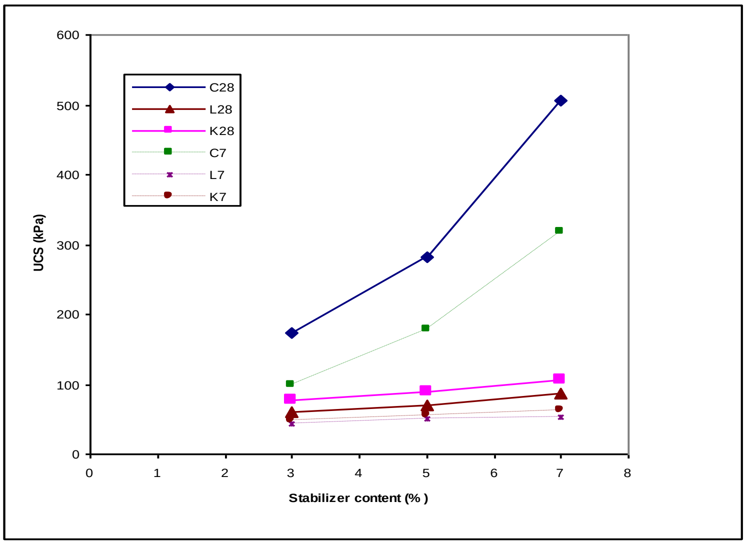

Fig. 2 UCS against Stabilizer content

As it has been discussed by Janz and Johansson [8], cement hydration begins as soon as it comes in contact with water and hence, immediately gain strength. Reactions with pozzolanic minerals in soil, take place in later and much slower than hydration. In the case of lime, the strength gain comes about by secondary pozzolanic reaction between aluminous and siliceous compounds in the soil and the Ca(OH)2 . However, in the lights of the results this could also be the case when using CKD as stabilizing additive.

Based on the above discussion the amount of lime or CKD does not seem to have very significant effect on strength in the short term. However, to further demonstrate this, the results again presented in the form of the ratio of total water content to stabilizer amount (W/A) previously suggested by Hassan and Ravaska [9], in which (W) is the soil total water content and (A) is the amount of stabilizing material initially used in the mixture. The results are given in figure 3, where it can be seen that the strength decreases with increasing (W/A) ratio.

For cement treated soil the behaviour is very similar to the effect of water/ cement ratio on concrete strength in which strength reduction happens with increasing water/ cement ratio. in the illustrated results higher strength could be achieved at W/A ratio below 10. For soils treated with lime or CKD, one can hardly observe clear change in strength with increasing W/A ratio. although the behaviour is generally similar. It can therefore be derived that the development of strength in the short term for the soils treated with lime and CKD is not very sensitive to the amount of stabilizing material,

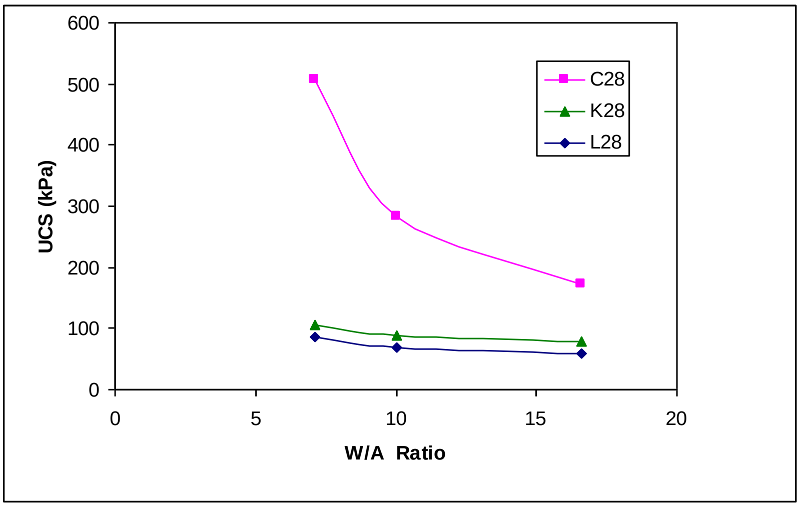

Fig. 3 Unconfined compressive strength against total water/addetive ratio after 28 days curing time

The effect of curing time on the development of strength can be seen clearly in figure 4 for all the three stabilizing materials. The data also show very significant increase in (UCS) when soil treated with cement, this pronounced change in strength appears at a very early curing time in approximately 7 days and then flatten with gentle reduction of strength. The increase of strength for soils treated with cement exceeds 21 and 38 times at 28 and 180 days respectively.

In case of soil treated with lime and CKD, the results are nearly exhibit similar trend, before 28 days of curing time . There are however a continuous development of strength up to 180 days for soils treated with CKD, which seems very promising since the developed strength is reaching (19) times the original strength for natural soil.

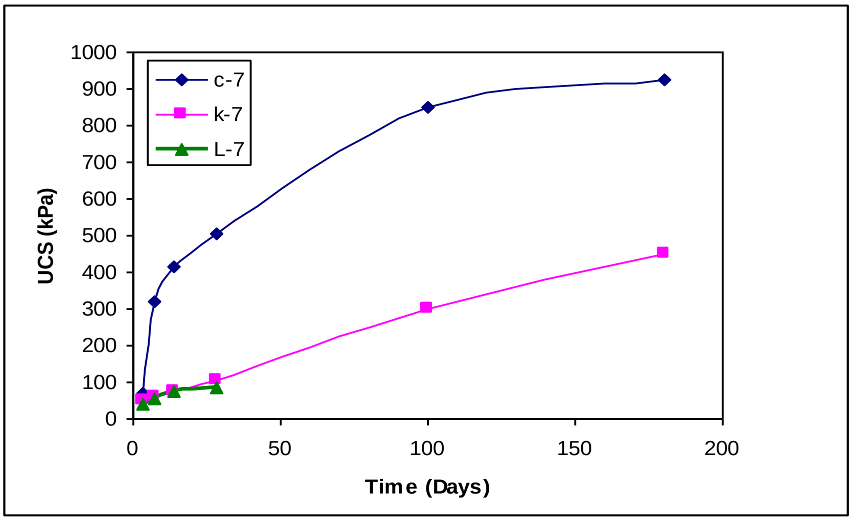

Figure 4 Unconfined compressive strength against curing time for 7 % amount of stabilizing material

Two extra series of tests were performed on specimens treated with mixture of cement and CKD with total amount of stabilizer of 7 %. The specimens were cured and tested at 7, 28 and 100 days .The results are presented in figure 5 which illustrates that the content of cement still controlling the development of strength .However , the resulting improvement of strength is very encouraging compared with the use of CKD alone . From economical point of view, the use of only 40% cement (45 kg/m3) with 60 % CKD could achieve good strength and reduction in the cost.

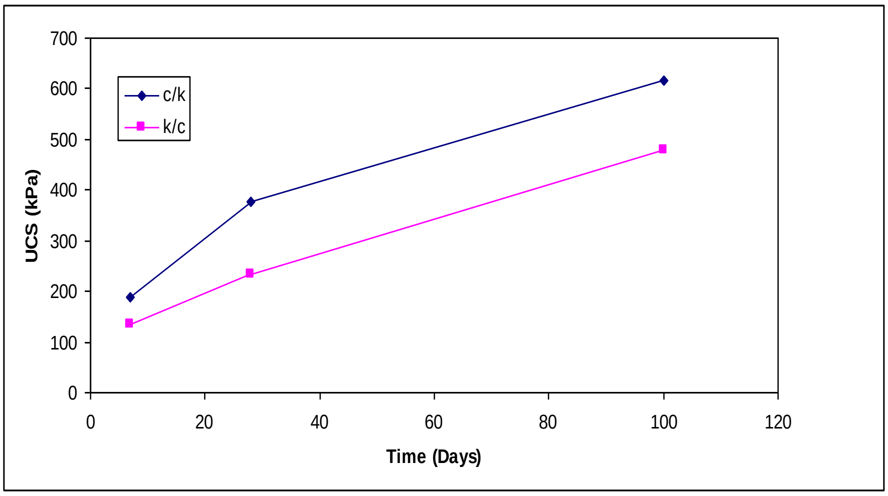

Fig. 5 UCS against curing time for 7 % amount of cement/CKD stabilizer

It is very important to notice that the soil used in this investigation contains large amount of salt and yet show adequate response to treatment, and in general manner of other normal soils with similar geotechnical properties. However, the resulting strength development may be considered insignificantly affected by the amount of salt which is not agreed with Naser [10], who claims certain relation between salinity and compressive strength.

IV. CONCLUSION

As a result of the present investigation, the following conclusions are derived;

- The Sabkha soils contains large amount of salts still having a general response to stabilization in similar manner to that exhibited by other normal soils.
- The development of strength in soils treated with lime and CKD in the short term is not very sensitive to the amount of stabilizing material.
- The addition of CKD to improve soil strength in the long term is very promising and mixing it with cement can give better strength improvement becomes more economical.

The main conclusions of the study should be summarized in a short Conclusions section.

REFERENCES

[1] R.B.C Russell. .Chemical and physical properties of Sabkha-type materials, TRRL supplementary report -79 UC, 1974.

[2] A. Sabatan, M. Al-Saify, and A. Kazi, "Moisture retention characteristics of coastal Sabkha," *Quaternary journal of engineering geology*, 1995,28, 37-4

[3] S.N. Abduljauwad and O.S.B. Al-Amoudi, "Geotechnical behavior of saline Sabkha soils", *Géotechnique* 45: 1995, 425-445.

[4] J. Newbery, and A.S, Subramanian, "Middle east sewerage project for coastal towns of Libya",: *Quaternary journal of engineering geology*,11 ,1978, 101-112.

[5] C.E Ellis, Arabian salt bearing soil (Sabkha) as an engineering material, TRRL report No. LR 523, 1973

[6] O.S.B. Al-Amoudi I,M. Asi and Z.R. El-Naggar , "Stabilization of an arid, saline Sabkha soil using additives" , *Quaternary journal of engineering geology*, 28; 1995, 369-379

[7] W.S. Adaska and D.H. Taubert, "Beneficial uses of cement kiln dust", *cement industries conference*, Miami, Florida, 2008

[8] M. Janz and S.E. Johansson The function of different binding agent in deep stabilization, Swedish deep stabilization research centre, Report No. 9, 2002

[9] M.M. Hassan and O.Ravaska, "Strength and permeability characteristics of cement stabilized soft Finnish clay", Géotechnics of soft soils, 2009, 227-233,London.

[10] A. M. A. Nasr, " Geotechnical Characteristics of Stabilized Sabkha Soils from the Egyptian–Libyan Coast " , *Geotech Geol Eng* (2015) 33:893–911