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Effect of Cement Kiln Dust on the Engineering Properties of Sabkha Soil

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Abstract:
Sabkha soil is a problematic soil and one of the many types of collapsible soils. Sabkha soil is strong in natural and dry conditions without changing in volume. But large and sudden reducing in volume (collapse) when the soils become wet. The main purpose of this research is to study a chemical stabilization of collected sabkha soil by using cement kiln dust (CKD). Many laboratory tests as grain size distribution; Atterberg limits, modified proctor test results and unconfined compressive strength were obtained. The results indicated that the increment of the curing time from 7 to 28 days led to an increase in unconfined compressive strength. Also, the maximum dry density decreases and optimum moisture content increases by using cement kiln dust.

1. INTRODUCTION

"Sabkha" is originally an Arabic expression (alternative spellings: sabkhah, subkha, sebkha, etc.) That used to describe the large, salty flat ground that is usually underlain with silt, sand or clay and often encrusted with salt. Sabkha soil is a problematic soil cause damage of buildings due to the change of volume. This type of soils is very strong in natural or dry conditions but a large sudden change in volume occurs in wetting condition (Al-Amoudi [1], [2]). Kinsman [3] divided Sabkha soils into two main types of sabkha: coastal and continental. Continental sabkhas are formed inside the land away from the sea and Coastal sabkhas are result and product of depositional off-lap at least in its seaward parts. This type of sabkha is usually stark, salt-encrusted, and virtually flat, except for possible scattered storm tide channels and small isolated sand dunes (Al-Amoudi et al. [4]). Generally, sabkha sediments were characterized by high void ratios, low dry densities, Very soft, Loses strength upon wetting, and Loses strength upon wetting (Alawaji and Mubarki [5]). According to the previous characteristics of Sabkha soil, it needs to be improved. The different methods used to improve the sabkha soil such as chemical stabilization, vibroflotation, stone columns, dynamic compaction and using Foamed asphalt. These methods depend on type, formation, and characteristics of sabkha soil. Al-Amoudi et al. [1], described the effect of five stabilizing agents, namely (limestone dust, marl, emulsified asphalt, cement and lime), on the properties of an arid, saline sabkha soil from eastern Saudi Arabia. Standard compaction and unconfined compressive strength tests were performed. He concluded that the use of sabkha brine as a wetting agent increases the unconfined compressive strength by about 50% in comparison with specimens wetted with distilled water. It is founded that additions of limestone dust or marl didn’t improve the unconfined compressive strength of sabkha soil. Emulsified asphalt brings about a decrease in the strength. Also, it is founded that the strength of the selected sabkha soil increases when cement or lime is used as a stabilizing agent, by about ten times that of unmixed sabkha. Abbas [6] studied two techniques to improve sabkha soil samples that were brought from Al-Khalis discrete at 1m depth of handmade borehole. The first treatment method was carried by addition fine gravel only with percentages (2%, 4.5%, and 6%). The second method of improvement was carried by using 3% of cement with fine gravel (4.5%, 6%) percentages. It is founded that there is no significant improvement after using the first method, but using the second method of treatment reduced the collapse settlement by 84%. Also effect of lime addition was used to improve the physical and compressibility of Jizan sabkha soil samples (that were taken from Jizan area). After applying different percentages of lime it is founded that the settlement of sabkha soil decreases when the lime content increases (Alawaji and Mubarki [5]). Asi [7] used foamed asphalt (FA) technique to stabilize and develop the sabkha soil to use it in asphalt structure as base or sub- base under high temperature conditions. He conducted the experimental works by using three methods to stabilize the sabkha soil: foamed asphalt (FA), emulsified asphalt, and sulfateresisting (type V) Portland cement. The results showed that using of foamed asphalt (FA) is the most effective method to improve the quality of sabkha soil from both strength and economical point of view. Also, in all the used asphalt treatment options, the addition of 2% cement resulted in generally improved strength properties of the mixed materials and improved resistance to water damages. Using of FAC (FA plus 2% cement) makes significant improvement in the strength properties, as compared with other techniques. Various disturbed sabkhas soils samples were collected from four different sites along the Egyptian–Libyan coast were mixed by different dosages (5, 10, 15, 20, and 25 %) of cement kiln dust (CKD). different laboratory tests such as chemical analyses, X-ray diffractometer, index properties, compaction, unconfined compressive strength, and consolidation tests were performed. The results presented that significant strength improvement of sabkhas with a low salinity when mixed with cement kiln dust than sabkha with high salinity. The compression index (Cc) reduced by about 17– 45 % after addition of 20 % (CKD) than non-mixed sabkha according to the type of sabkha and salinity concentration and the swelling index (Cs) for mixed sabkha soils are significantly lower than those of natural sabkha soils. Cement kiln dust treatment led to improvement in modulus of elasticity also, unconfined compressive strength rapidly increases by the addition of cement kiln dust for 7–14 days after compaction, and thereafter more slowly (Nasr [8]). Cement kiln dust (CKD) is a fine powdery material that products during the manufacture of Portland cement. It has same cementing characteristics, reacts with soil in a manner similar to Portland cement. Typically, CKD has approximately one-third of the amount of cement oxides (CaO, Al_2O_3, SiO_2, and Fe_2O_3) present in Portland cement. An environmental problem of cement kiln dust is a huge amount of (CKD) that daily produced from the cement factories disposed in landfills. Use of cement kiln dust as a chemical stabilization led to solve the environmental problem (Miller and Azad [9]). Cement kiln dust was used in many researches to improve the geotechnical characteristics of different types of soils. Carlson [10] used different dosages of Cement kiln dust (5, 10, 15, and 20% by dry weight of the soils) on soils that collected from the Aberdeen and Everett areas in the state of Washington to improve its properties. The results founded that Addition of CKD increased plasticity index initially, while higher percentages of CKD yielded in reduction of plasticity index. Also, the unconfined compressive strength of soils was developed. Modulus of elasticity increased for both Everett and Aberdeen soil. Ismail and Belal [11] used cement kiln dust stabilizer to treat the two disturbed samples which were collected from two localities in the Nile Delta. CKD was used in different percentages (5, 10 and 20 %). The results obtained that CKD led to increase the pH values and decreased the plasticity index in both samples of soils. Also, for soil A the optimum moisture content increased and maximum dry density decreased. On the other hand the optimum moisture content and maximum dry density decreased for soil B.

2 MATERIALS AND TESTS

2.1 Materials

2.1.1 Soil

Disturbed and undisturbed Sabkha soil samples used for experimental works in this paper were collected from Qeft-Quseir road, Red Sea coast, Egypt. Figure1shows the studied area and Figure2 shows the Geological map of the studied area.

2.1.2 Cement Kiln Dust

The CKD used in this research was obtained from Qena cement factory, Qeft, Qena, Egypt. Table 1 shows the chemical composition of CKD. The chemical analysis was determined by using the method of energy dispersive X-ray fluorescence (XRF). The portions of CKD that used were determined according to PH-test (Eades and Grim [12]). Table 2 shows the optimum values of CKD which used in this study.

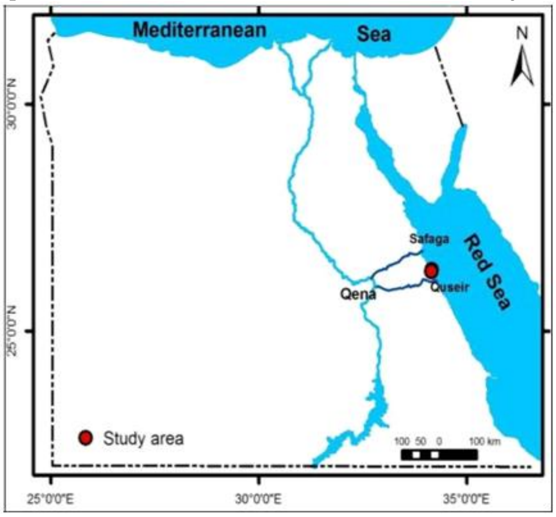

Figure.1. Location map of the studied area

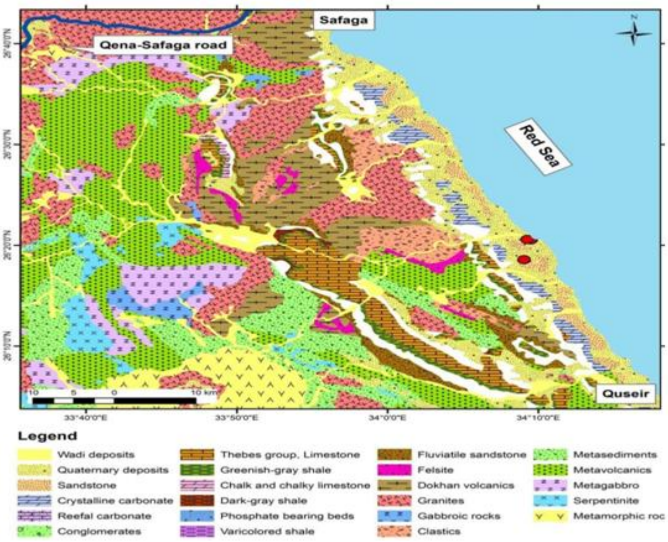

Figure.2. Geological map of the studied area

Table. 1. The chemical compositions (X-ray fluorescence) of CKD

Compound formula	CKD
Na2O	0.138
MgO	0.564
Al2O3	3.520
SiO2	7.332
P2O5	0.263
SO3	1.847
K2O	0.474
CaO	67.722
TiO2	0.320
Cr_2O_7	0.037
MnO	0.021
Fe2O3	3.543
NiO	0.014
ZuO	0.015
SrO	0.245
Cl	0.356
L.O.I (Los of ignition)	13.5

Table. 2. Relation between the pH-values and the optimum contents of the CKD

sample	Percent of CKD (%)	pH-value	Temperature =T (°C)
1	0	7.6	18
	2	10.30	18
	4	12.07	18
	6*	12.39	18
	8	12.46	18
2	0	7.8	18
	2	11.10	18
	4	12.23	18
	6*	12.41	18
3	0	7.88	18
	2	10.05	18
	4	11.07	18
	6	12.19	18
	8*	12.40	18
4	0	7.9	18
	2	9.84	18
	4	10.11	18
	6	11.57	18
	8	12.18	18
	10*	12.40	18

* = Optimum content

2.2 Laboratory tests

Laboratory tests were obtained to evaluate the main characteristics of natural and CKD mixed samples of studied soil according to American Society for Testing and Material (ASTM).To determine the maximum dry density ($\gamma_{d(max.)}$) and optimum moisture content Modified Proctor test was conducted on natural and CKD mixed soils. This test was carried out according ASTM D 1557 [13].To estimate maximum dry density and optimum moisture content (O.M.C), Curves between dry density and optimum moisture content were plotted. Also, The unconfined compressive strength tests (UCS) were conducted on four compacted natural and CKD mixed specimens with the values of optimum moisture content and maximum dry density according to ASTM D 2166 [14]. The mixed samples cured for 7 and 28 days.

3. RESULTS AND DISCUSSION

3.1 Properties of Materials

According the results of grain size distribution and Atterberg limits for natural four samples, the samples were classified according to ASTM D 2487 [15] for Unified Soil Classification System (USCS) and Massachusetts Institute of Technology (M.I.T). Figure 3 shows the grain-size distribution curves for studied samples; also table 2 summarizes the main properties of samples.

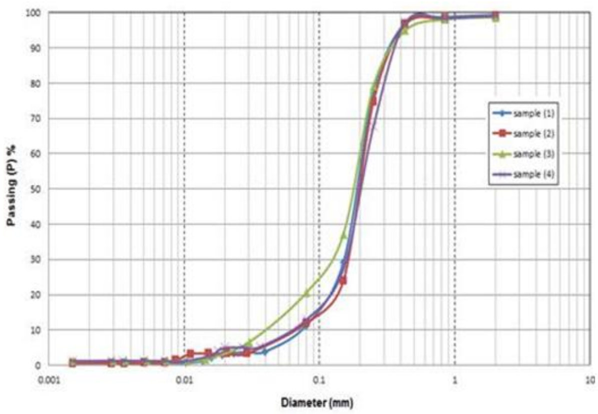

Figure. 3. Grain size distribution for studied s ample

Table .3. properties of studied samples

Sample	Gravel %	Sand %	Silt %	Clay %	USCS	M.I.T
1	0.6	92.4	6.4	0.6	(SW)	sand, some silt, trace of clay and gravel
2	0.9	90.1	8.4	0.6	(SW)	sand, some silt, trace of clay and gravel
3	1.2	82.8	14.8	1.2	SC	sand, some silt, trace of clay and gravel
4	1.0	90.0	7.8	1.2	(SC-SM)	sand, some silt, trace of clay and gravel

3.2 Compaction Characteristics

Curves between dry density and water content for natural and mixed samples were plotted in Figure 4 and figure 5. The figures show the relationship between dry density and water content. Also Table 3 gives the values of maximum dry density and optimum moisture content (O.M.C) for studied samples.

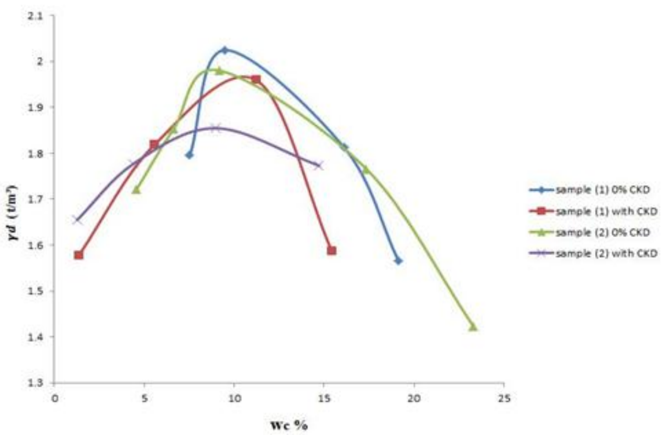

Figure 4 Dry Density-moisture content relationships for sample (1) and sample (2).

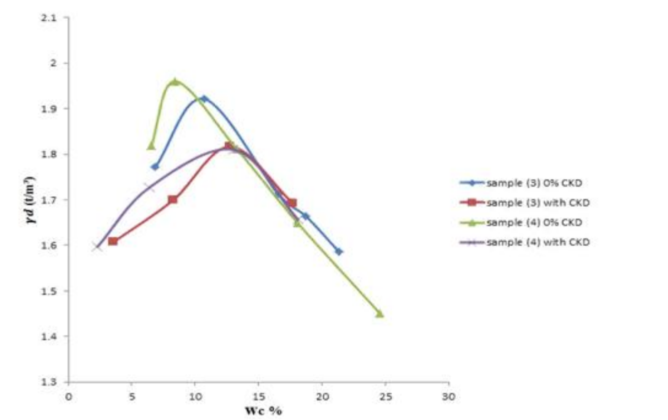

Figure 5 Dry Density-moisture content relationships for sample (3) and sample (4).

Table .4. values of maximum dry density and optimum moisture content for studied samples.

Sample	natural samples		mixed samples with CKD	
	$\gamma_{d(max.)}$ (t/m^3)	O.M.C (%)	$\gamma_{d(max.)}$ (t/m^3)	O.M.C (%)
1	2.03	9.5	1.97	10.6
2	1.98	8.6	1.85	8.9
3	1.92	10.4	1.82	12.8
4	1.96	8.4	1.81	12.6

3.3 Unconfined Compressive Strength

The unconfined compressive strength (UCS) results were obtained for each natural and mixed samples. The UCS values generally increased for CKD mixed samples by increasing curing time. The values of UCS tests summarized in table 5, also figure 5 and figure 6 show the effect of addition of CKD to the soil and effect of curing time for each samples.

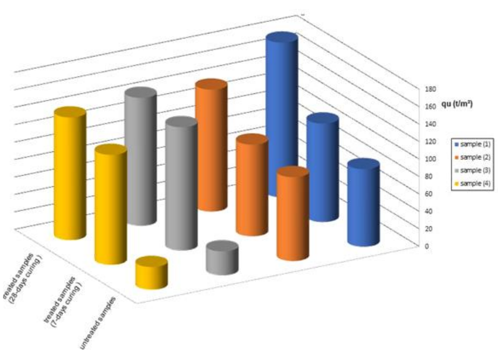

Figure. 6. Histogram shows the variation of qu for unmixed compacted samples; CKD stabilized sample (7- days curing); and stabilized sample (28- days curing).

Table. 5. Test results of unconfined compression strength (UCS) for unmixed samples and CKD mixed samples

sample	(q_u) for natural soil	(q_u) for CKD mixed soil (7 days curing)	(q_u) for CKD mixed soil (28 days curing)
1	89	113	177
2	96	105	140
3	27	141	147
4	26	126	141

4. CONCLUSIONS

The main conclusions obtained from this study are as follows:

•The maximum dry density decreases and optimum moisture content increases by using optimum cement kiln dust stabilizer.

•The unconfined compressive strengths of the cement kiln dust mixed sabkha soils were higher than that of the unmixed sabkha soil.

• The addition of cement kiln dust rapidly increases unconfined compressive strength for 7days after compaction, but the UCS increase more slowly for 28 days.

• CKD can be beneficially used to improve the unconfined compressive strength of sabkha soil.

5. REFERENCES

[1].Al-Amoudi, O.S.B., Asi, I.M., and EI-Naggar, Z.R. (1995), “Stabilization of an.Arid, Saline Sabkha Soil Using Additives”. Quarterly Journal of Engineering Geology, Vol. 28, P.369-379

[2].Al-Amoudi, O.S.B. (1994), “A state-of The Art report on The Geotechnical Problems in Sabkha Soils and Methods of Treatment”. Proceedings, ASCE-SAS First Regional Conference and Exhibition, Bahrain, P.53-77

[3]. Kinsman, D.J.J., (1969), “Modes of Formation, Sedimentary Associations and Digenetic Features of Shallow-Water and Supratidal Evaporates”. American Association of Petroleum Geologists Bulletin, Vol. 53, P. 830-840

[4]. Abduljauwad, S. N., Rasheeduzzafar, Al-Amoudi, O.S.B. (1992), “Studies on Soil-Foundation Interaction in the Sabkha Environment of Eastern Province of Saudi Arabia”. Faculty of the college of graduate studies King Fahd University of petroleum and minerals.

[5].Alawaji, Hosain, and Mubarki, A. M. “Improvement of Jizan Sabkha Soil by Using Lim”. King Saud University, College Of Engineering, Civil Engineering Department.

[6]. Abbas, Hassan O. (2011), “Effect of Adding Fine Gravel and Cement on Settlement of Sabkha Soil”. Eng. &Tech. Journal, Vol. 30, No. 1

[7]. Asi, Ibrahim M. (2001), “Stabilization of Sebkha Soil Using Foamed Asphalt”. Journal of materials in civil engineering, Vol. 13, P. 325-331

[8]. Nasr, Ahmed M.A. (2015), “Geotechnical Characteristics of Stabilized Sabkha Soils from the Egyptian–Libyan Coast”. Geotechnical and Geological Engineering, Vol.33, P.893–911

[9]. Miller, Gerald A., and Azad, Shahriar. (2000), “Influence of Soil Type on Stabilization with Cement Kiln Dust”. Construction and Building Materials, Vol. 14, P. 89-97

[10]. Carlson, K., Sariosseiri, F., and Muhunthan, B. (2011), “Engineering Properties of Cement Kiln Dust-Modified Soils in Western Washington State”. Geotechnical and Geological Engineering, Vol. 29, P. 837–844

[11]. Ismail, A. I. M. and Belal, Z. L. (2016), “Use of Cement Kiln Dust on the Engineering Modification of Soil Materials, Nile Delta, Egypt”. Geotechnical and Geological Engineering, Vol. 34, P. 463– 469.

[12]. Eades, J. L. and Grim, R. E. (1996), “A Quick Test to Determine Lime Requirements for Lime Stabilization”. Highway Research Board, National Research Council, Washington DC, No. 139, P. 61-72.

[13]. ASTM D 1557-00 (2000), “Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3))”. Annual Book of ASTM Standards, Vol.04.08, ASTM International, West Conshohocken, PA

[14]. ASTM D 2166-00 (2000), “Standard Test Method for Unconfined Compressive Strength of Cohesive Soil”. Annual Book of ASTM Standards, Vol.04.08, ASTM International, West Conshohocken, PA

[15].ASTM D 2487-00 (2000), “Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)”. Annual Book of ASTM Standards, Vol.04.08, ASTM International, West Conshohocken, PA