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A Macro/Micro Structural Study of the Seawater Effect on the Process of Stabilizing Clay Soils with Lime and Nano-SiO2

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ABSTRACT: There is a large number of restrictions in the application of soil consolidation processes in many coastal areas due to the lack of fresh water. Besides, further studies are required on the effects of using saline water on soil improvement due to the widespread of saline water at the land surface. Therefore, in this paper, several macro/microstructural experiments were carried out to study the effect of ions in the seawater on the chemical stabilization process of clay soils with lime and nano-silica to stabilize kaolinite clay from varying amounts of lime, nano-silica, distilled water, and Persian Gulf water. A kaolinite clayey sample was cured with different amounts of lime and nano-silica. Accordingly, grain tests, Atterberg limits, pH changes, and changes in the uniaxial compressive strength over time were taken into account to evaluate the microstructures of X-ray diffraction analysis and to scan the electron microscopy images. Uniaxial compressive strength results indicated improvement in the samples without additives made with the seawater compared to the samples made with the distilled water. Additionally, the resistance of the samples mixed with the seawater increased by 4% compared to the samples mixed with the distilled water with 28-day curing, while the samples were modified with 6% lime.

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1. INTRODUCTION

Clay soils exhibit different behaviors with for their minerals and chemical constituents, and on the other hand, the chemical pore fluid causes a significant change in the clay engineering properties [1]. Also the change in the chemical quality of the pore water, or other words, the change in the amount and type of salts in the soil (decrease or increase), is a phenomenon that is unavoidable due to various human or natural activities [2].

The major cations and anions present in the seawater include sodium, calcium, and sulfate ions. Sodium chloride and calcium chloride salts act as stabilizers in the soil with lime as catalyst and accelerator. This reaction accelerates the uptake and hardening of the soil. The presence of sodium ions accelerates the decomposition process of silica in the soil-lime interaction. The effect of calcium chloride is similar to that of sodium chloride. But there are some different effects, such as increased permeability to soil consolidation [3-5].

In coastal areas, there are many restrictions for use in soil stabilization due to the lack of fresh water. Although studies have been conducted on the effect of pore water solutes on the characteristics of fine soils, there have not been many studies on soils stabilized with local salts such as seawater and the addition of lime mixed with nano-silica. In this study, different amounts of lime, nano-silica, distilled water as well as the distilled water of the Persian Gulf were used to stabilize kaolinite clay and were evaluated in the curing times 1, 3, 7, 14, and 28.

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2. MATERIALS AND METHODS

In this project, kaolinite clay was used for the experiments. This soil was prepared from the kaolin factory of Khorasan. Because 100% of the soil prepared passes through sieve #200, hydrometric testing (ASTM-D422-02) was used to determine its aggregation.

All the experiments in this study were conducted according to the ASTM standard. Table 1 presents the geotechnical and geo-environmental characteristics of the soil samples used in this study.

In addition to the physical and mechanical experiments on the soil, microstructural tests were also carried out to investigate the change of clay surface arrangement and soil mineralization due to the interaction with the additives. Fig. 2 presents the soil X-ray diffraction curve.

3. RESULTS AND DISCUSSION

Fig. 3 shows the uniaxial compressive strength curves for the lime-stabilized samples. As it can be seen in Fig. 1, when the stabilizer is not utilized, the resistance of the specimens in which the salt-containing water is used is greater than that of the distilled water. In this case, the uniaxial compressive

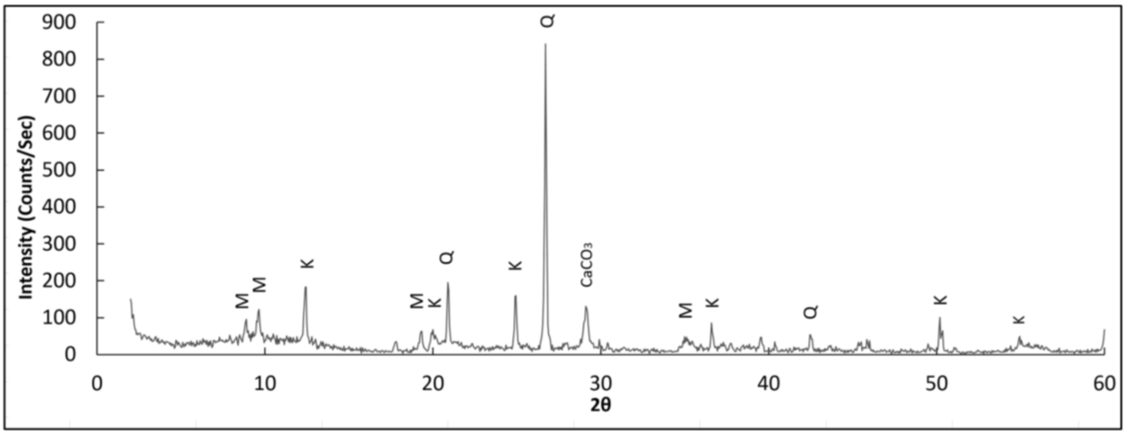

Fig. 1. X-ray diffraction curve of kaolinite soil sample (K: kaolinite, M: montmorillonite, Q: quartz, $CaCO_3$: calcite.)

Table 1. Geotechnical and Geo-Environmental Characteristics of Kaolinite Sample

Physical properties Soil	Quantity measured	References for method of measurement
Liquid Limit (%)	40	ASTM, D4318
Plastic Limit (%)	28	ASTM, D4318
Plasticity Index (%)	12	ASTM, D4318
Specific Gravity (G_s)	2.66	ASTM, D854, Method A
Maximum dry density (kN/m^3)	15.5	ASTM D698
Soil Classification	CL	ASTM, D3282
pH (Soil:water,1:10)	7.76	ASTM D4972
Ec (mS/cm)	0.0367	ASTM D1125-95

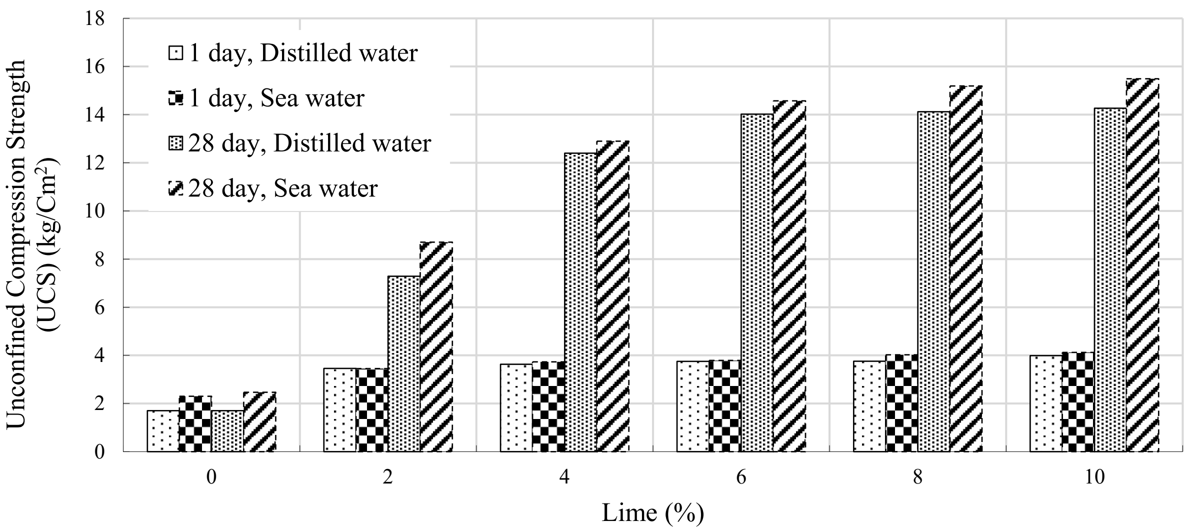

Fig. 2. Uniaxial compressive strength changes for the samples containing distilled water and seawater with varying percentages of lime through different curing

strength of the samples is 2.3 kg/cm2 for the seawater and 1.7 kg/cm2 for the distilled water, respectively. Given this, the seawater samples had a 35% increase in resistance to the distilled water without adding lime.

Fig. 4 shows the X-ray diffraction of kaolinite soil and kaolinite soil mixed with the seawater. In the soil-seawater mix, a very low cement structure is observed because the amount of Ca^{2+} is very low and insufficient for the pozzolanic reaction [3, 5].

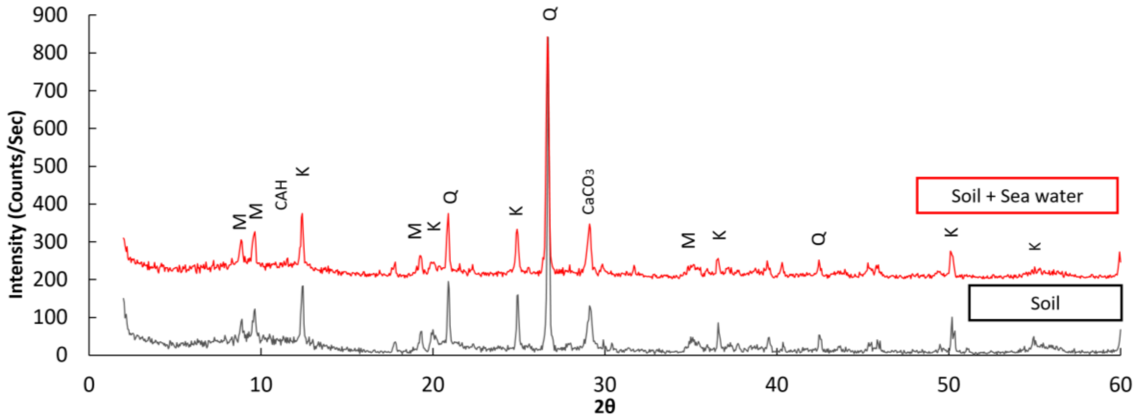

Fig. 3. X-ray diffraction curve of kaolinite and kaolinite-seawater mix (K: kaolinite, M: montmorillonite, Q: quartz, CAH: calcium aluminate hydrated, CaCO3: calcite.)

4. CONCLUSIONS

The experiments on the samples made with different amounts of lime as well as the use of the distilled water and the Persian Gulf Seawater revealed the following results:

1. When the samples were cured by 6% lime for 28 days, the difference between the samples made with the distilled water and the seawater was 2.45 units, a significant decrease in the pH of the samples containing the seawater.
2. In the samples without the lime additive, the soil-seawater mix accompanied by the soil-distilled water mix had a 35% increase in the uniaxial compressive strength.
3. The optimum percentage of 6% lime and 0.7% nano-silica had the highest increase in the uniaxial compressive strength.
4. The results of macro and microstructural experiments show that using a combination of kaolinite, lime, and nano-silica (especially in the presence of the seawater) can greatly reduce the use of the additives while intensifying the lime stabilization process.

REFERENCES

[1] Y. Yukselen-Aksoy, A. Kaya, A.H. Ören, Seawater effect on consistency limits and compressibility characteristics of clays, Engineering Geology, 102(1-2) (2008) 54-61.

[2] M. Esnaashari, E. Ahmadi, Effect of sea water on unconfined compressive strength of clayey soil stabilized with lime and pozzolan, Modares Civil Engineering journal, 17(5) (2017) 1-12.

[3] A.K.A. El-Aal, Effect of salinity of groundwater on the geotechnical properties of some Egyptian clay, Egyptian journal of petroleum, 26(3) (2017) 643-648.

[4] A.R. Goodarzi, Effect of curing temperature and SiO2-nanoparticles on the engineering properties of lime treated expansive soil, Modares Civil Engineering journal, 17(3) (2017) 132-144.

[5] V.R. Ouhadi, M. Amiri, S. Hamidi, Dispersive soil improvement with lime, special attention to the reduction of peak intensity of clay minerals in XRD analysis, Modares Journal of Civil Engineering, 14(2) (2014).

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