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Use of salt compounds for the stabilizatıon of expansive soils

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ABSTRACT
The present research aims to study the influence of salts used at different concentrations: potassium chloride KCl and sodium chloride NaCl on the behavior of a swelling reconstituted soil. The molalities of the saline solutions are 0.5 mole / liter (M); 1 M and 2 M. In the first part, the materials were characterized from the point of view of their dimensions, their activity and their plasticity, which made it possible to establish a classification of the swelling potentials of each one. In the second part, the study focuses on the influence of different salt solutions on some geotechnical properties of expansive soils. The results obtained clearly show the reduction of the swelling potential which is influenced by the salt concentration and by the nature of the salts.

Key words: Clay, Swelling, Salts, Geotechnical tests.

1. INTRODUCTION

The geotechnical characteristics of soils, particularly clay soils, are affected by a number of factors, including density, porosity, structure, amount and type of clay minerals, plastic properties, and the amount and type of minerals in the soil pore water. Any modification of each of these features will alter the physical and mechanical characteristics of the soil and, therefore, structures built on the ground will be subject to change or modification [1, 2, 3, 4, 5]. Density, shear strength and plasticity are considered as soil engineering features that play an important role in the design of foundations for most structures.

Some clay soils subject to changes in moisture content may increase or decrease in volume. These cyclic swelling-shrinkage phenomena cause parasitic stresses in the structures and at the level of the foundations. Many research scholars have worked on expansive soils such as [6].

Many methods and equipment have been developed to determine the influence and effectiveness of a solution or product on the stabilization of cohesive, swelling soils [7, 8, 9, 10]. The estimation of the characteristics of the swelling requires the provision of standard tests, which are simple, well adapted and above all reliable. This article therefore presents the effect of concentration and the nature of salty compounds on the stabilization of swelling clays.

2. METHODOLOGY

For this study, we selected clay soil from the commune of Sidi Mezghiche in the wilaya of Skikda (northeastern Algeria). Sampling is done manually, these reworked samples were contained in the bags and then transported to the national laboratory LHC (Skikda unit, Algeria).

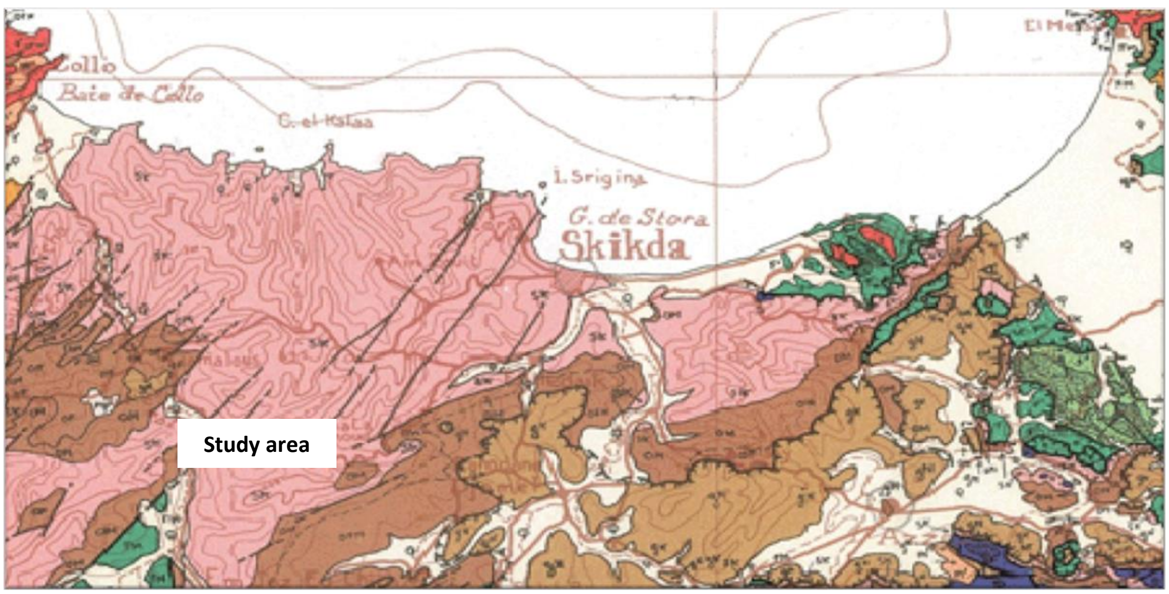

Figure 1 Geological map of Northeastern Algeria [11]

The properties of the soil and the results of the consistency limits were shown on table (1).

Table 1 Properties of soil

Water content (%)	< 80 µm (%)	Liquid limit(%)	Plastic limit (%)	Plasticity index (%)	Consistency index(%)	Methylene blue	Specific surface (m^2/g)
31,47	100	61,31	27,44	33,87	1,81	7	147

The soil is classified as a plastic clay (class A3) soil, according to the unified classification system. The methodology consists of mixing the bentonite with the tested soil (80% natural soil and 20% bentonite). Tow types of chloride compounds were used including (NaCl, KCl). Each one of these salts was dissolved in water and then mixed with soil.

3. EXPERIMENTAL STUDY

The basic properties of the reconstituted soil sample collected, from various laboratory tests are summarized in Table 2.

Table 2 Properties of the reconstituted soil sample

Property	**Results**
Particles < 80 μm (%)	100
Optimum water content W_{opn} (%)	14,2
Liquid limit (%)	80,02
Plastic limit (%)	31,93
Plasticity index (%)	48,09
Consistency index(%)	1,66
Methylene blue	9,4
Specific surface (m^2/g)	197,4
Cohesion (bars)	0,29
Angle of friction (°)	10,8
California Bearing Ratio	7,8
Compressibility pressure P_c (bars)	2,43
Compressibility coefficient C_c (%)	33,98
Swelling coefficient C_g (%)	8,99

Atterberg Limits

The tests were conducted using both salts to compare the values of different limits. The boundary graph is shown in Figure 2 and 3.

Table 3 Comparison of indices

Salt (mol/l)	**SB**	**NaCl**			**KCl**		
		0,5	**1**	**2**	**0,5**	**1**	**2**
Liquid limit (%)	80,02	67,28	66,01	60,86	74,18	68,43	56,28
Plastic limit (%)	31,93	33,66	36,12	39,22	41,7	39,7	36,86
Plasticity index (%)	48,09	33,62	29,89	21,64	32,49	28,72	19,41
Consistency index (%)	1,66	2,06	1,86	2,12	2,28	2,38	2,9

The results show that the added salts containing the Na + and K + cations develop exchanges with the ions in the double layer of the mineral clay and bring about various changes.

The liquid limit value of 80.02 for the control sample drops to 56.28 for 2 mol/l of KCl. This indicates that the particle size has increased. When the salts are added to the clay soil, the free ions such as Na+ and K+ present in the latter replace the cations of the hydrated layer surrounding the clay particles and reduce the net electric charge. This allows the leaves to come together forming blocks.

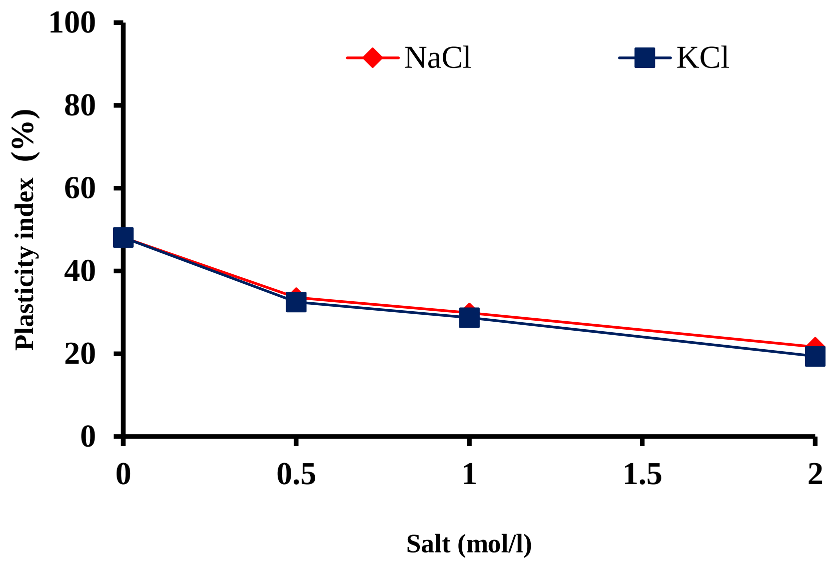

Figure 2 Effect of Salt compounds on Plasticity index of the Soil

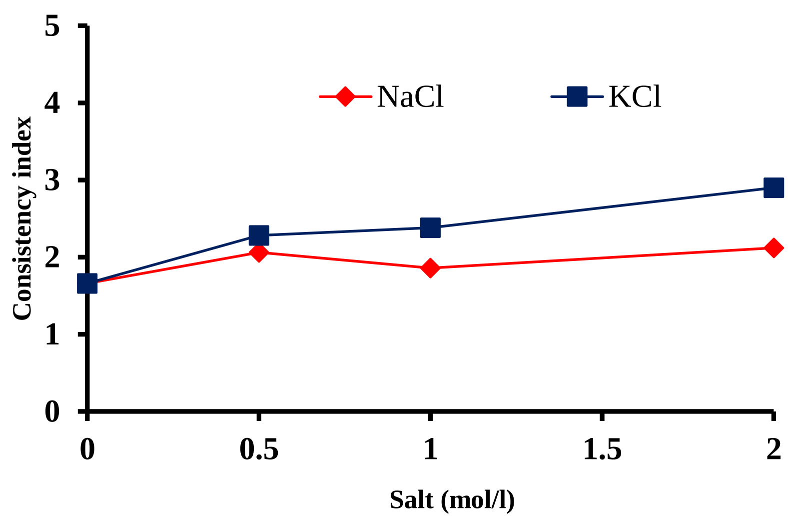

Figure 3 Effect of Salt compounds on Consistency index of the Soil

Compressibility Test

The compressibility test was performed using an odeometric apparatus for the control sample and the salts used. The compressibility coefficient for the control sample is 33.98 and that for the sample mixed with NaCl is 26.65. The various curves representing the variations of the compressibility pressure, the compressibility coefficient and the swelling coefficient are illustrated in Figure. 4, 5 and 6.

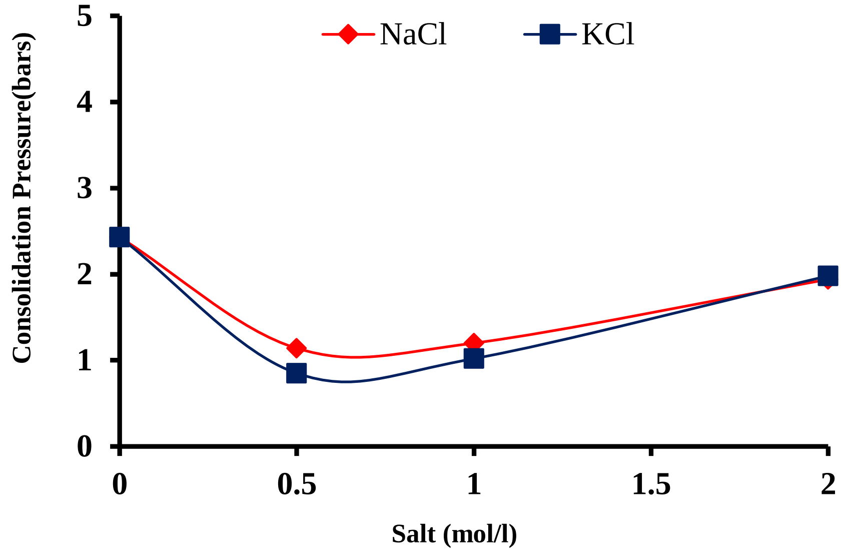

Figure 4 Effect of Salt compounds on Consolidation Pressure of the Soil.

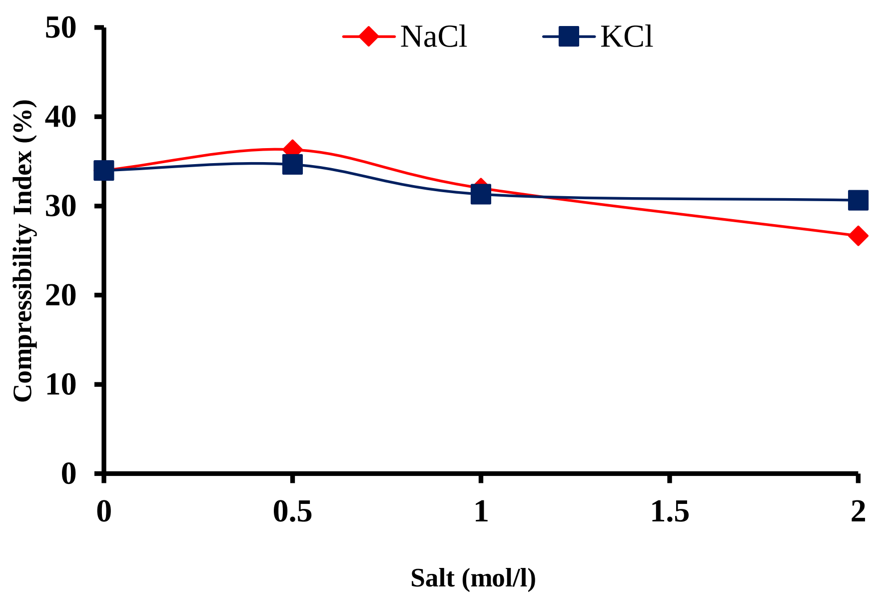

Figure 5 Effect of Salt compounds on Compressibility Index of the Soil

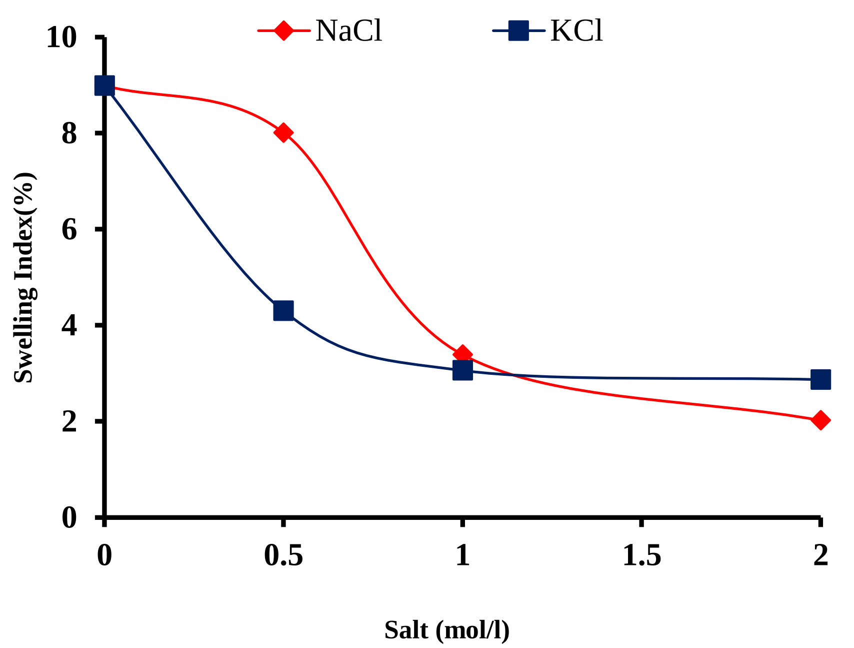

Figure 6 Effect of Salt compounds on Swelling Index of the Soil.

The Compressibility pressure has decreased from 2,43 bars for control sample to 0,85 bars for treated sample with 0,5 Mol/l of KCl, the coefficient of swelling has increased from 8,99 % for control sample to 2,02 % for treated samples with 2 Mol/l of NaCl. This can be contributed to increased size of the clay minerals. This decrease is interpreted by the effect of the sodium and potassium cations which favor the links between the layers of the clay. This gives a friable structure and therefore, the treated material becomes insensitive to water. These results are confirmed by those found in the literature [12, 13, 14, 15, 16, 17].

4. CONCLUSION

Through the tests carried out on the influence of the salts on the studied parameters of the clay: the plasticity, the pressure of consolidation, the index of compression and the index of swelling. Several conclusions can be drawn:

- The liquid limit decreases and the plastic limit increases slightly with the concentration of added salts. As a result, the plasticity index (PI) undergoes a very significant decrease with the increase in the concentration of the added salts.
- The compressibility index reduces when the concentration of the two added salts increases.
- The swelling index reduces when the concentration of added salts increases. This decrease is interpreted chemically by the effect of the added salt cations which favor the bonds between the clay leaves with the size of the clay minerals.

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