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Enhanced Characteristics of the Euphrates Riverbank Soils in the Marsh Area by using Different Salts

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Abstract

. Geotechnical engineering work becomes challenging when the sub-grade is revealed to be silt or silty clay soil. Clay-rich soils inflate when the moisture level in the soil is allowed to rise. Because of their geologic nature, textural qualities, and climatic conditions, most soils in the south of Iraq have a well-known diversity of formations among the world's soils. Because the soil particles are surrounded by molecules of chlorides, sulfates, or other species of salts, which act as link agents to fill in the gaps in the dry condition, most soils in the Marshes area of Thi-Qar Governorate can be classed as saline soils. The sort of salt in such soil determines how it is disposed of. Chloride salts, for example, are more common and more readily dissolve in water The goal of this research is to improve the geotechnical qualities of soil by using Portland cement and different chloride salt compounds. Salt concentrations of 2%, 4%, 8%, and 10% were applied to the soil to see how they affected compaction characteristics and consistency limits. According to the findings of the study, increasing the amount of each chloride component raised the maximum dry density while decreasing the optimum moisture level. As salt content grows, the liquid limit, plastic limit, and plasticity index all drop.

Keywords: Soil Stabilization, Silty Clay Soil, Consistency Limit, and Geotechnical Properties.

1. Introduction

Since ancient times, soil has been the most prevalent construction material used in engineering projects. Although virtually all structures are built on, in, or with soil, natural soil conditions are not always sufficient to complete the task at hand. As a result, enhancing the mechanical properties and behaviour of soil is frequently required for the safe construction and operation of a variety of structures. Densification, cementation, reinforcing, and drainage are the core elements for soil improvement. Soil stabilization is the process of improving one or more of a natural soil's qualities by adding a unique soil, a strengthening agent, or another chemical element. Any mechanical, hydrological, physicochemical, Ground improvement or ground modification refers to the application of a biological process, biological, or a mix of these approaches to change specific properties of natural soil deposits. The purpose of ground improvement is to strengthen the strength of existing soils and reduce settlement or change their permeability **[1].** The ground surface of saline soils is covered in hydrated gypsum (CaSO4.2H2O), SiO2, calcite (CaCO3), or sodium chloride (NaCl) salt. When there is a lot of moisture in the air, Due to capillary action and evaporation of water from the ground, the salinity of water increases for these soils to the limits of salt sedimentation, and the salinity of water grows for these soils to the limits of salt sedimentation. As a result, the presence of salty soil is influenced by the water table **[2,3].** With a chloride salt level of more than 3%, salty soil is a highly conductive system **[4].** Saline ions permeate the water as it moves. electric porous mediums and react with soil atoms **[5].** Chloride ions have a wider hydration range and are capable of absorbing water **[6, 7].** Due to physical and chemical difficulties such as salt expansion, dissolution, and distortion, such infill would not meet the required strength and anti-deformation standards for use in the building if not treated., and moisture absorption **[8].** The microstructures of treated soil are affected by chloride ions, as are the strength properties. **[9]**. In the short and long term, chloride ions have a significant impact on the strength of improved soil **[10, 11].**

Because the presence of considerable amounts of saline implies that the geotechnical properties of clayey soils may alter in the presence of infiltrating water, engineers investigated the plasticity index and unconfined compressive strength of clayey soils mixed with sodium chloride **[12].** The addition of chloride salt greatly enhanced the structure of the lime-soil mixture. The number of coarse soil particles rose while the overall surface area of the soil decreased. The degree of homogeneity was reduced by increasing the salt level, despite the fact that the salt amount had been reduced. The microstructure's features, such as bone area, appearance ratio, and roundness, have a linear relationship **[13].** Calcium chloride additions of up to 8% improved lateritic soil. Calcium chloride is ineffective as a standalone stabilizer, however it can be used as a modifier or additive in lateritic soil cement stability **[17].** The effect of salinity on the geotechnical qualities of fine grain soil was studied in Shatt Al-Arab. Limits of

Atterberg, conventional compaction consolidation, and soil shear strength are examples of testing in a laboratory Changes in the engineering properties of the soil can be caused by the presence of detectable levels of dissolved salts in water [**18].**

Table 1 geotechnical properties of the natural soil and chemical properties

Soil Property	Value	Specifications
D10 in mm	<0.0007	
D30 in mm	0.0023	ASTM D422
D50 in mm	0.0039	
D60 in mm	0.0045	
Liquid limit LL %	60	ASTM D4318
Plastic limit PL%	34	
Plasticity index PI	26	
Specific gravity Gs	2.5	ASTM D854
Maximum dry unit weight, γdry max (g/cm3)	1.51	ASTM 698
Optimum water content O.W.C %	22	
Undrained Shear Strength (Cu)	267a	ASTM D2166
Cl %	1.3	
O.M %	8.6	
T.D.S	8.4	BS. 1377
SO3	3.38	
Gyp	8.9	
pH	8.43	

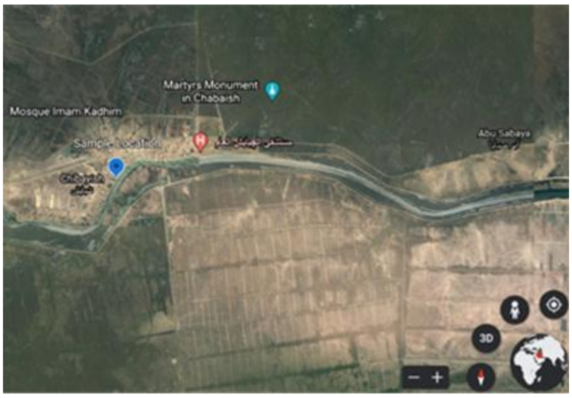

Fig.1 Satellite image of the location of the test points for samples extraction

the effect of magnesium chloride (MgCl2) emulsion on the geotechnical properties of clay soils was evaluated by different research. M. Turkoz, et al,.2014, explain that increasing the MgCl2 content reduced the consistency of the soil (Atterberg limits). [19]. The fact that the addition of NaCl, CaCl2, and MgCl2 filled the spaces between soil particles because the particle size of NaCl, CaCl2, and MgCl2 is smaller than the particle size of soil particles and can easily replace the voids Increases in chloride compound percentage resulted in lower compression and edema indexes [20].

2 Research Methodology

The method used in this study is to collect soil from the study area and run many traditional tests on it to assess its geotechnical properties. Second, to obtain saline soil samples, combine natural soil with a variety of salts at different concentrations. As stated in the experimental work section, various percentages were used. The samples will next be put to the test. After that, the data will be examined.

3 .Characteristics of soil in Marshes area in southern Iraq

Brownish silty to silty clay soils were brought from the south of Iraq representing a generally typical soil in the Marshes area in southern Iraq. Disturbed soil samples were collected from a depth of (20-100) cm from the Al-Chibayish District, located to the east of Al-Nasiriyah city in the south of Iraq (30°57'25.5" **N** 46°59'15.8"**E**). The study area was chosen to be nearby the bank of the Euphrates River, as shown by the blue mark in **Figure 2**. This site has a high potential for increasing salinization because of the drought exposed to the area. According to the standard specification ASTM D 2487-11, the soil can be classified as **MH** (Fine-grained soil) with silt content and clay content reaching 28% and 72% respectively. Geotechnical and chemical tests were conducted after transferring the samples to the laboratories of the Civil Engineering Departments in the College of Engineering at the University of Thi-Qar. **Table 1** summarizes the basic geotechnical properties of the natural soil and chemical properties.

4. Experimental Work

. The soil was oven-dried for 24 hours, with the earth placed in the oven at 60°C. The soil samples were prepared using Proctor test protocols in line with ASTM standards (D-698).

5. Engineering Tests of soil

5.1 Compaction test

According to ASTM, a proctor compaction examination was given to assess the moisture content–dry density connection (D 698). Three layers of earth were compressed into a 937 cm3 mould. The dry density–moisture content relationship for the soil and proctor compaction preparation is shown in Figure 2.

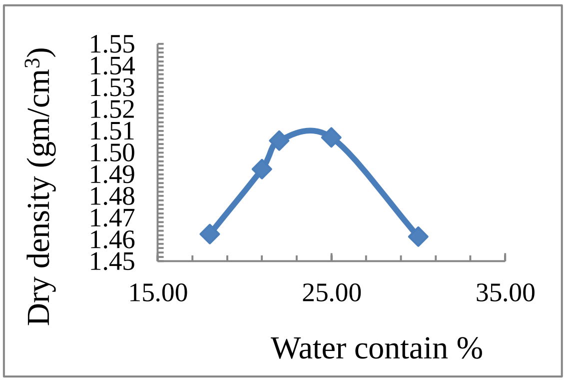

Fig.2 results of compaction test

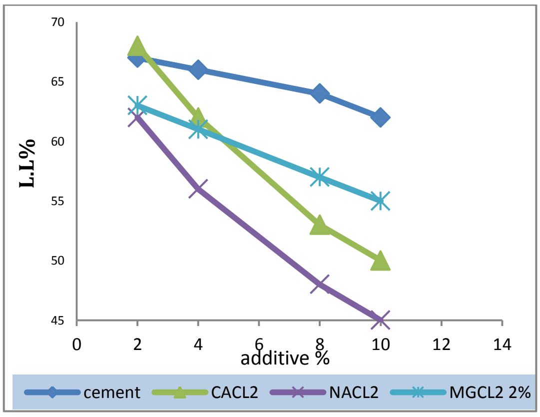

Fig.3 Variation of liquid limit (L.L) with increasing additive content

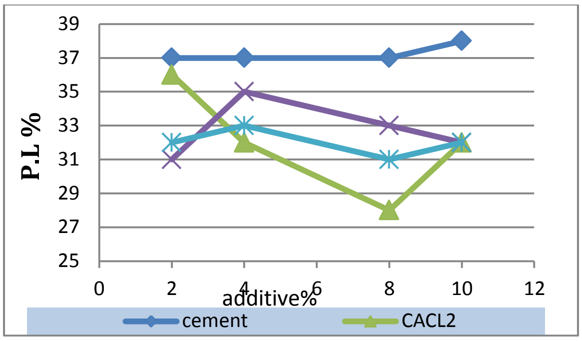

Fig.4 Variation of Plastic limit (P.L) with increasing additive content

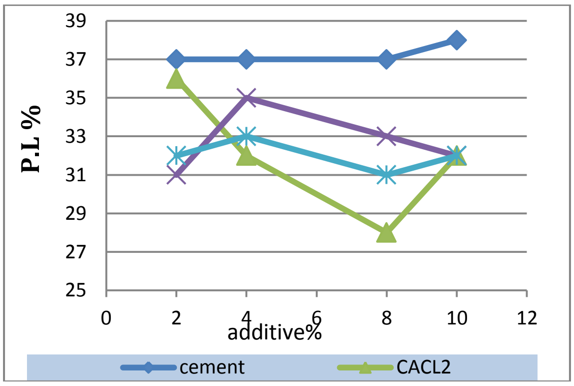

Fig.5 Variation of Plasticity Index (P.I) with increasing additive content

5.2: Atterberg limits

On the other hand, the all-values of the plasticity index decrease with adding the additive. The liquid limit test was carried out using Cassagrande equipment by ASTM standards (D423-66). The ASTM requirements were followed when conducting the plastic limit test (D 424-59). Each chloride compound was mixed with soil after being dissolved in water (NaCl, MgCl2.6H2O, CaCl2. 2H2O). The goal of these experiments was to see how adding salt to the consistency limits altered the results. Figures 3, 4, and 5 depict the effect of additive content on the Atterberg limits. The graphs show that as the number of additives increases, the liquid limits for all additives decrease. Although adding additives resulted in a significant change in soil behaviour and a decrease in the values of the plasticity limits, there was also a significant change in soil behaviour and a decrease in the values of the plasticity limits. by adding additions to the values of the plasticity limits

The physicochemical properties of salts alter as they dissolve in water and soil. Changes in the composition and concentration of the soil solution as a result of diverse interactions between the exchange complex and the soil solution. The behaviour of the soil in the presence of salty water is determined by its initial physical qualities as well as the adsorption capacity of ions, both of which influence its hydrophysical properties. The original chemical make-up of During water contact with the soil, the ion exchange activities are influenced by the soil. In addition to the accumulation of some elements, particularly sodium, which results in the deterioration of soil structure and a reduction in water and airflow, Finally, excessive salt induces flocculation and agglomeration of soil particles, resulting in a decrease in L.L. The findings reveal that as the salinity of the pore media rises, the liquid and plastic limits of the soil decrease. Shariatmadari et al., 2011 and Yukselen-Aksoy et al., 2008 [14] also found similar results.

5.3: Particle Size Distribution

According to the standard specification ASTM D 2487-11, the soil can be classified as MH (Fine-grained soil) with silt content and clay content reaching 28% and 72% respectively as shown in Figure 6

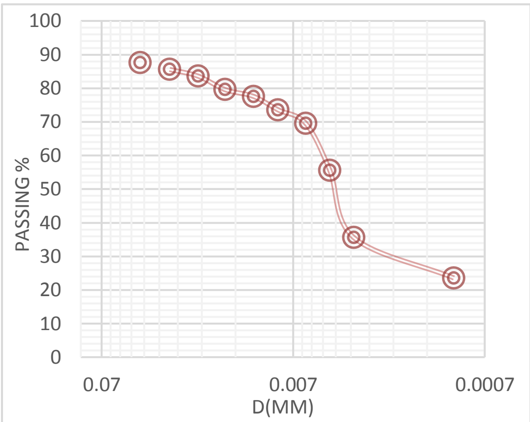

Fig.6 Grain Size Distribution

4.5: Shear Strength Results:

Unconfined compressive tests were utilized to measure the shear strength of soils treated with additives. The Harvard Miniature Compaction Apparatus was used to compress the sample into three layers to achieve the maximum dry unit weight and optimum water content.
The compacted specimen's diameter was 33 mm and 70 mm in length. The results of the unconfined

compressive strength of the Euphrates Riverbank soils in the Marshes area were treated by adding (NaCl, $MgCl_2.6H_2O$, and $CaCl_2$. $2H_2O$) under different percentages of additives (0%, 2%, 4%, 8%, and 10%) are shown in Table 2

To study the effect of salt content on the shear strength of soil, different groups of samples were tested under different amounts of salt to evaluate the soil cohesion. These groups are:

Table 2 The Unconfined compressive strength results for different additive contents for the Euphrates Riverbank soils in the Marshes area

Additive Percentage %	Unconfined compressive strength (kPa)				
	Natural compacted soil	NaCl	$MgCl_2.6H_2O$	$CaCl_2$. $2H_2O$	Portland cement
0		470	470	470	470
2		459	656	685	1104
4	470	495	512	571	1321
8		483	335	514	943
10		323	338	405	820

Conclusion

The effects of adding sodium chloride, magnesium chloride, calcium chloride, and Portland cement to the Euphrates Riverbank soils in the south of Iraq were explored in this study. From this analysis, the following conclusions may be drawn:

Generally, calcium chloride and Portland cement mostly act as active stabilizers because of their ability to alter material properties such as strength. Essentially, the act of this chemical is to lump fine particles together and join them together.

When compared to the other examples that included NaCl and MgCl2.6H2O, the addition of CaCl2.H2O and Portland cement to the soil results in hardening and increased strength.

Portland Cement increases the strength qualities of salty soils due to hydration; the higher the cement concentration, the more hydration products are produced.

Adding any of the chemicals (NaCl, MgCl2.6H2O, CaCl2.H2O, and Portland cement) decreased the liquid limit, plastic limit, and plasticity index of the soil.

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