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Evaluating the properties of Al-Faw soil and determining the extent of the effect of salts and organic materials on it

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Abstract

In this study, a hand auger was used to drill sixteen selected locations around AL-Faw city. Disturbed samples were gathered at 1.5 - 2.0 meters below the surface. This research aims to study the properties of the soil, find out the concentrations of salts and organic materials in the soil, compare them with standard specifications, and determine the extent of the influence of these compositions on the engineering behavior of the soil. Through the results, it was found that the soil of Al-Faw city consists of three types based on the Unified Classification System of soils: clayey silt low plasticity (ML), silty clay high plasticity (CH), and silty clay low plasticity (CL). While the results of chemical tests showed that the percentage of organic materials and total Soluble salts in the study sites is relatively influential in the engineering behavior of the soil, which creates a future engineering problem. As for

the percentage of gypsum and sulphate in the soil of the study sites is safe and has not exceeded the effective value in the engineering behavior of the soil. These percentages are subject to change with time as the area is affected by various geological and environmental factors.

Keywords: Chloride, Gypsum, Organic matter, Swelling soil, and Sulfate.

تقييم خواص تربة الفاو وتحديد مدى تأثير الاملاح والمواد العضوية عليها

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الخلاصة

في هذه الدراسة تم استخدام المثقاب اليدوي لحفر ستة عشر موقعاً مختاراً حول مدينة الفاو. تم جمع العينات المضطربة على عمق 1.5 - 2.0 متر تحت السطح. يهدف هذا البحث إلى دراسة خواص التربة ومعرفة تراكيز الأملاح والمواد العضوية في التربة ومقارنتها بالمواصفات القياسية وتحديد مدى تأثير هذه التراكيز على السلوك الهندسي للتربة. ومن خلال النتائج تبين أن تربة مدينة الفاو تتكون من ثلاثة أنواع حسب نظام التصنيف الموحد للترب: وهي تربة غرينة طينية منخفضة اللدونة (ML) وتربة طينية غرينية عالية اللدونة (CH) تربة طينية غرينية منخفضة اللدونة (CL). بينما أظهرت نتائج الاختبارات الكيميائية أن نسبة المواد العضوية والأملاح الكلية الذائبة في مواقع الدراسة لها تأثير نسبي في السلوك الهندسي للتربة مما يخلق مشكلة هندسية مستقبلية. أما نسبة الجبس والكبريتات في تربة مواقع الدراسة فهي آمنة ولم تتجاوز القيمة الفعالة في السلوك الهندسي للتربة. وهذه النسب قابلة للتغير مع الزمن حيث تتأثر المنطقة بالعوامل الجيولوجية والبيئية المختلفة.

الكلمات الدالة : التربة الانتفاخية، المادة العضوية ، الاملاح الذائبة

1.Introduction

Al-Faw, a port in Iraq, is situated south of Basrah and offers views of the Arabian Gulf. This city is recognized as a critical area of urban development in addition to its strategic, commercial, and tourism value. Thus, it is crucial to assess the local soil and determine any potential engineering problems.

The soil's stability is impacted by salt buildup, which causes the swelling index, liquid limits, and compression index to rise [1]. Because salts serve as cementing agents between soil grains, they have the reverse effect when subjected to solubility [2]. Thus, salty soil can have a detrimental effect on soil foundation and concrete by eroding organic matter, gypsum, sulfates, and chlorides. In concrete with a significant salt component, the restricted compressive strength dropped from 11% to 22% [3]. Enough gypsum is present in a soil gypsum to change or impact its engineering qualities; the sort and amount of gypsum in the soil, the surrounding environment, and the type of engineering problem under study are the main determinants of the influence [4]. It is rather robust and has good properties while it is dry, but these qualities gradually decrease as the moisture content rises [5].

The chloride salts have a major impact on the processes of hydration because of their high solubility in water. it dissolves some cement compounds, resulting in low density and a corresponding reduction in the concrete's ability to withstand external forces. Concrete is more able to absorb and dissolve sulphate due to the presence of chloride salts [6]. Clay soil becomes more cohesive when both sodium and calcium chloride concentrations are increased [7]. According to[8], higher chlorite salt

concentrations cause dry density, moisture content, swelling pressure, and plasticity index to all decrease.

The amount and rate of decomposition of organic matter in soil has an impact on its geotechnical characteristics [9]. Increasing the organic content and plasticity index of soil shows a greater tendency of soil to shrinks and expand , which may lead to significant adverse effects on buildings built on these types of materials [10]. The presence of organic materials in the soil leads to an increase in the percentage of soil voids, and after the decomposition of these organic materials, it makes the soil unsuitable for filling [11]. Soil strength and compressibility change when the percentage of organic matter ranges from 2-3% in the soil [12].

The purpose of this research is to quantify the salt and organic matter concentrations, compare them to standards specifications , and determine whether or not these concentrations have an impact on the soil's engineering behavior.

2. Location of the study area:

The southeast of Iraq is the location of the study area. The sixteen Basrah locales selected for this inquiry are exactly in Faw city between latitudes (48˚ 10′ 00" and 48˚ 40′ 00") east and latitudes (29˚ 50′ 00″ and 30˚ 20′ 00″) North. Al-Faw city's climate is distinct from the rest of the nation due to its proximity to bodies of water and the northern and northwest coasts of the Arabian Gulf. It is cold and humid in the winter and hot and dry in the summer. It also has a high percentage of solar radiation and little rain[13]. Fig.(1).

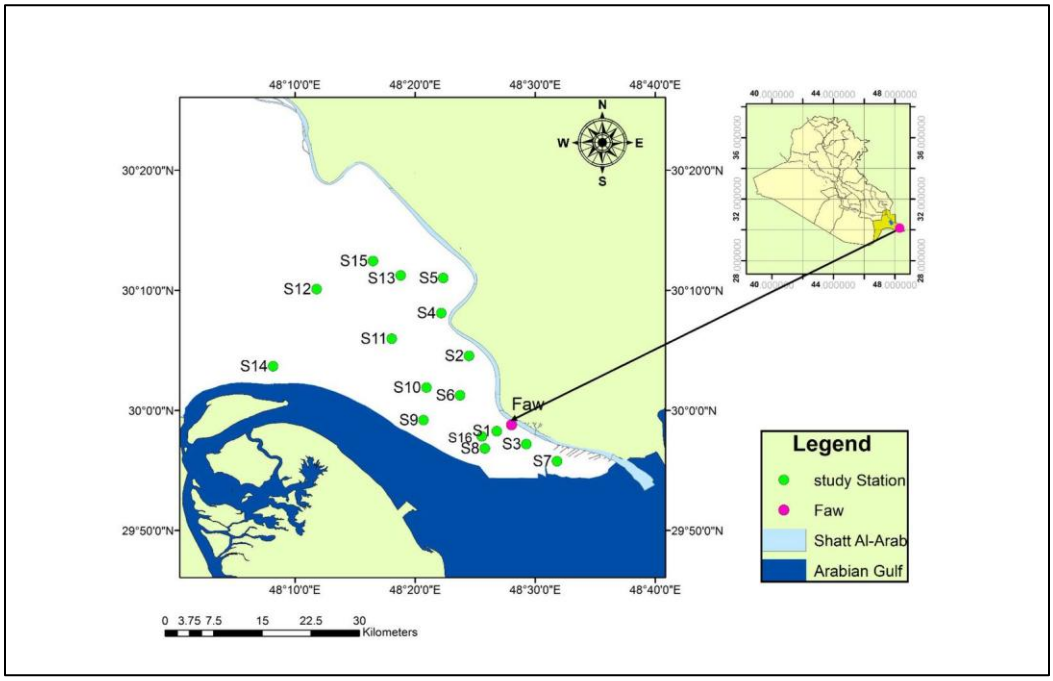

Fig.1: Location map of the study Area

3. Stratigraphic and Tectonic Setting

Al-Faw is one of the Quaternary deposits that cover the Mesopotamia Plain in Iraq [14]. Throughout the Pleistocene era, there were recurring changes in climate and sea level [15,16], which are extremely similar in nature, had a substantial impact on these deposits.

Al-Faw is situated in the southern region of the Mesopotamian plain, which is part of the Zubair subzone Fig. 2. It is characterized by a continuous composite structure that stretches from the northwest to the southeast, with underlying geological strata.

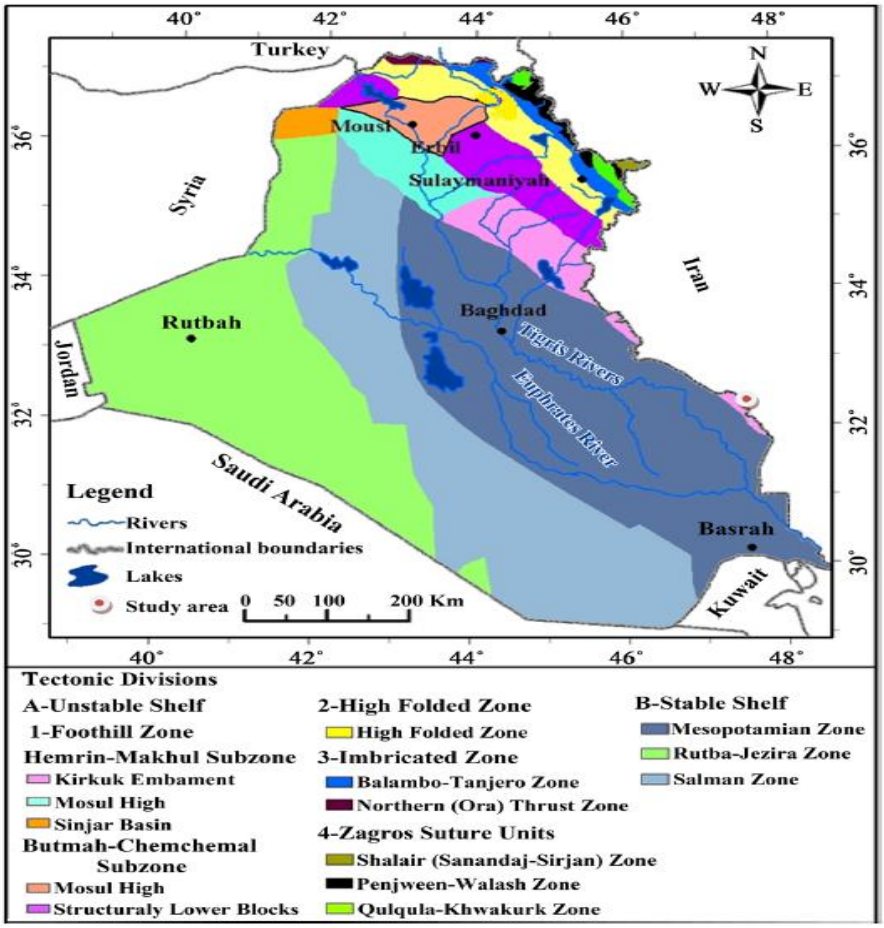

Fig.2 Iraq's tectonic map [17]

3. Materials and Methods

3.1. Field Work

Fieldwork was conducted in Al-Faw in November 2023 in order to understand soil behavior and select the best locations for this study.

3.2. Sampling

In order to identify their classification properties and ascertain the kind of soil, soil samples for this study were collected from sixteen places in Al-Faw city, at a depth of roughly 1.5–2.0 meters below the top surface.

3.3. Laboratory Test

3.3.1 Standard Penetration Test (SPT)

This test was conducted based on the British Standard [18]. The values of this test are used to classify cohesive soils according to their consistency.

3.3.2 Grain Size Distribution

The purpose of this test is to determine the size of the different particles that make up the research area, based on the method of analyzing the size of the particles explained in [19]. The Department of Earth Science at the College of Science / University of Basrah examined soil samples.

3.3.3 Atterberg' s Limits

These tests included measuring the fluid limit and plastic limit according to ASTM [20]. The Atterberg limits tests Conducted at Geological Laboratory- college of Science, Basra University.

3.3.4 Moisture Content test:

The drying method is used to determine it according to the American standard described in [21]. The test was conducted in the laboratories of the Geology Department in college of Science/University of Basrah.

3.3.5 chemical test

The objective of this test is to determine the percentage of some chemical substances present in the research area's soil that influence the soil's engineering behavior. The British Standard [22] was followed for administering the test.

4. Results and Discussion

4.1 Standard Penetration Test (SPT)

It is observed from the standard penetration test values in the study area shown in Fig.(3) that an average of 50 percent of sites have soft to very soft soil, an average 25 percent of sites have medium stiff soil, an average 19 percent of sites have a stiff soil , and an average of 6 percent of sites have very stiff soil. According to classification [23]. The lack of high pressure exposure for the surface soil during deposition is the cause of the soil's soft texture. It also results from the absence of human activity in soft soil areas and rainwater washing the top layer, dissolving the binding salts and minimizing particle compaction. The reason for the strength of the soil is the result of natural pressure due to human activity [24].

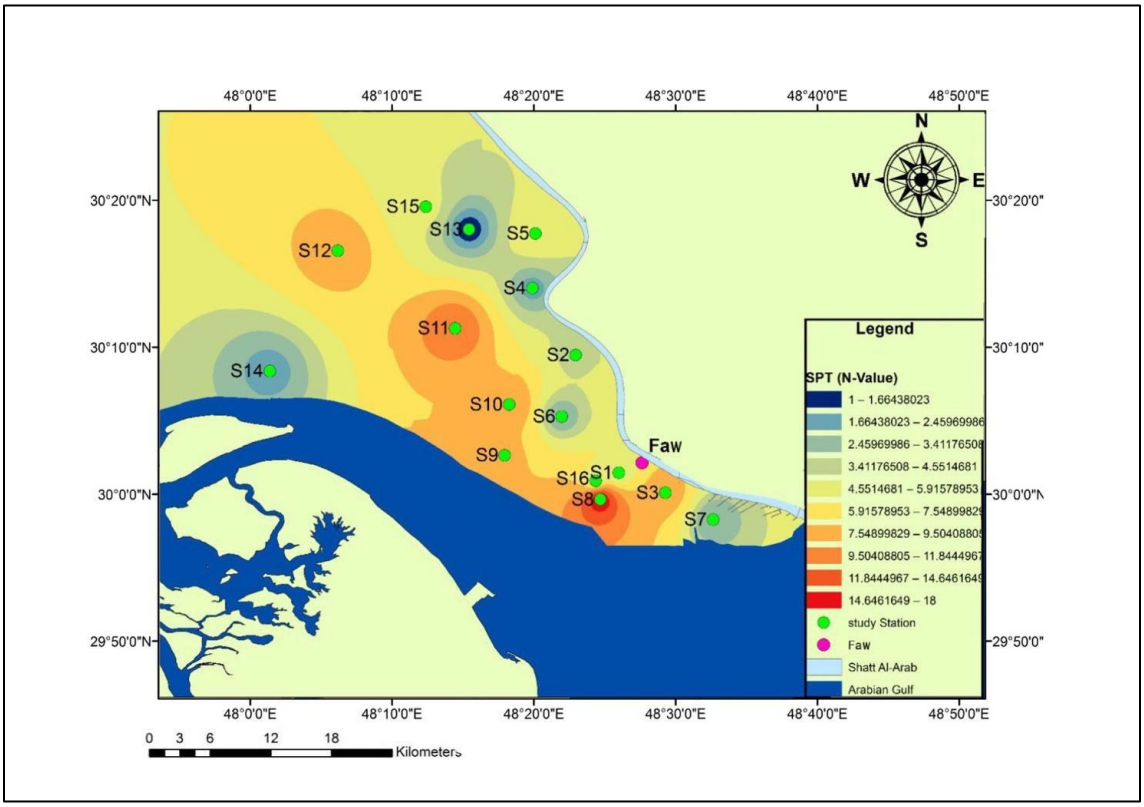

Fig.3 A research area's Standard Penetration test values (N-value) map

4.2 Grain Size Analysis

Showed Table 1 the results of the particle size analysis, and from it can be seen very clearly that there is variation in the proportion of clay, silt and sand particles in the soil of the study area, which causes different types of soils.

The soil's engineering behavior is greatly influenced by the proportion of clay. It diminishes soil permeability while increasing water mobility, primarily due to the capillary characteristic, and raises the soil's susceptibility to moisture, which results in the phenomena known as swelling [25]. Clay soils often have the most susceptibility to expansion and contraction, according to [26]. Clay's water content needs to be carefully controlled due to its modest compressibility. Water near the foundations will cause the soil to lose most of its carrying capacity as it will seep from the fractures and gather at the base.

Table 1: Results of grain size analysis for sites of study

Sit. No	Grain size analysis			Atterberg's limits			USCS
	Clay %	Silt %	Sand %	L.L %	P.I %	S.L %	
S1	53	46	1	49	19	11.5	ML
S2	66	31	3	34	12	6.5	CL
S3	64	35	1	63	31	23	CH
S4	57	38	5	48	19	11.75	ML
S5	61	37	2	37	14	8.25	CL
S6	58	38	4	36	13	7.25	CL
S7	54	44	2	42	15	8.25	ML
S8	56	43	1	49	25	19	CL
S9	53	43	4	55	28	21.25	CH
S10	54	44	2	48	24	18	CL
S11	56	43	1	55	26	18.75	CH
S12	57	44	1	45	20	13.75	CL
S13	56	43	1	40	16	10	CL
S14	61	35	4	44	18	11.5	CL
S15	59	39	2	45	24	18.75	CL
S16	55	42	3	43	13	5.5	ML

4.3 Atterberg's limit tests

Based on the plasticity chart and the Unified Standard Classification System (USCS), Atterberg's limit was used to classify soil samples in the study area. Fig (4) and Table (1) illustrate the results, which indicated that an average of 56% of the sites were of type silty clay low plasticity (CL), 25% of the sites were of type clayey silt low plasticity (ML), and 19% of the sites were of type silty clay high plasticity (CH).

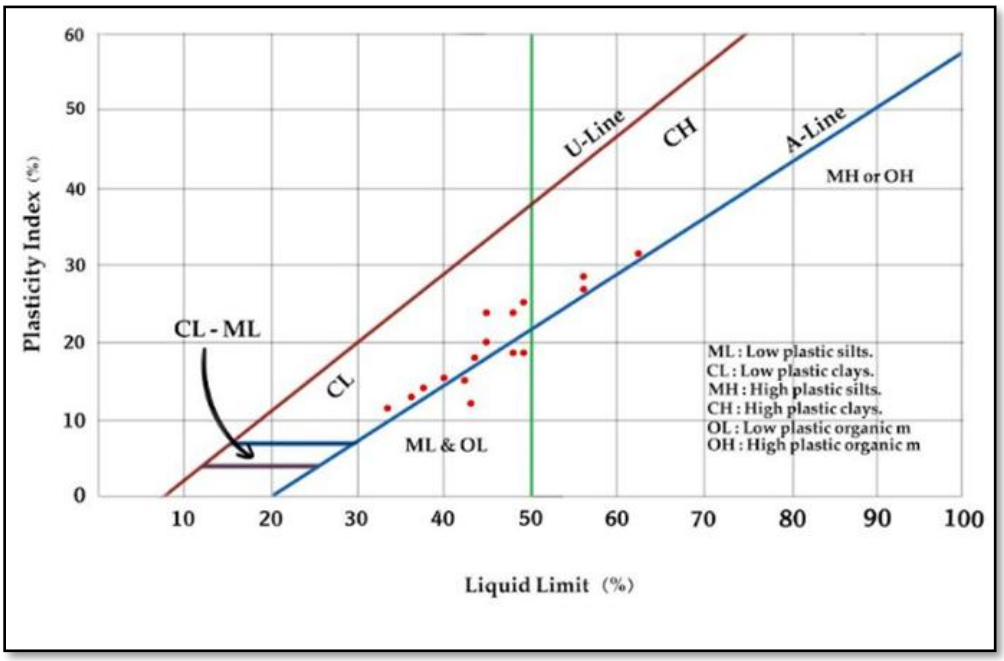

Fig.4. soil classification in the study area using the plasticity chart [27].

4.4 Moisture content (M.C%)

According to Fig.(5) results, the study's area's soil moisture content an average of 26% a rather high percentage .The causes are the high groundwater table, which lowers the carrying capacity of the shallow soil layers, and the close proximity of the Shatt al-Arab River to the area. Because an increase in moisture content reduces

cohesion, internal friction, layer load capacity, and foundation stability, it has a major impact on soil strength [28].

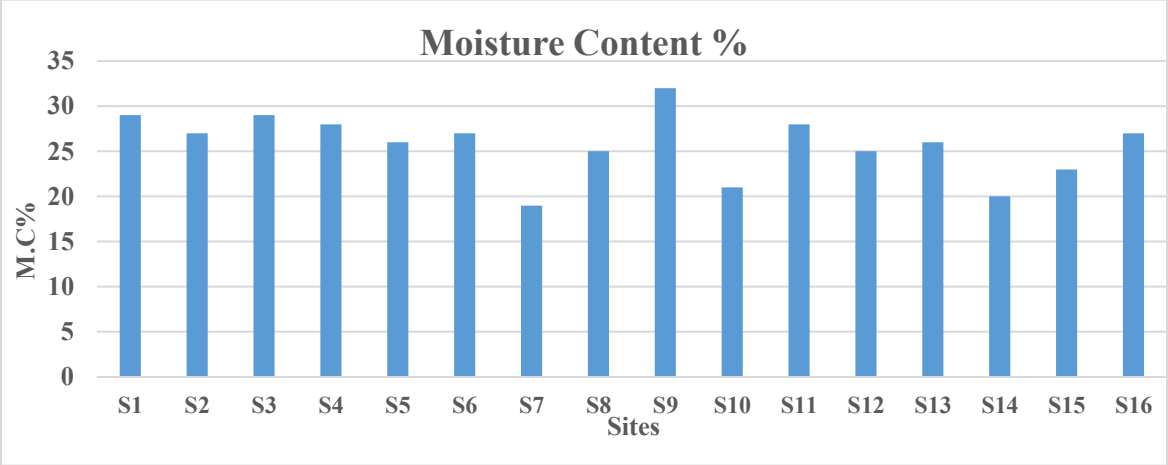

Fig. 5 : Results of moisture content for the sites in the study area

4.5 Chemical Test

According to Table (2) , the results indicate that the proportion of organic matter in study area is 1.06% in S1 to 2.93% in S3 with an average of 1.644%. When organic matter level is less than 0.5%, it has no effect on geotechnical stability. The percentage between 2-3% has a major influence on the strength and compressibility of the soil, according to [29]. [30] asserts that the percentage within the range of 0.5–2% is somewhat significant. Thus, the percentage of organic matter in the study area has a relatively significant impact on the soil's engineering behavior.[31] states that organic content increases Atterberg's limits and decreases the other geotechnical properties of the soil, while reducing cohesion, unconfined compression strength, and internal angle.

As for the percentage of Total Soluble Salt (T.S.S %) in cohesive soil, with an average of 2.235% and a range of 0.4% in S2 to 4.19% in S3. Iraqi soils include

various salts, such as sulphates, chlorides, and carbonates. and are deemed beneficial when their concentration is above 0.5% in the soil [32]. The existence of groundwater in the area is the cause of the salt content in this percentage. Salts in the soil of the study areas come from two sources: sewage water that seeps below the earth's surface due to poor drainage and salts deposited in the soil's surface layers that are dissolved by winter and spring rainfall and filter into the soil to mix with groundwater. Because dissolved salts of all kinds damage concrete foundations, particularly the cement material that makes up the foundation, they have an impact on the engineering behavior of the foundations [33]. In addition to some salt compounds' high solubility, this makes ions—particularly sulphur and chloride ions—more permeable to concrete. When sulphates and chlorides are combined in a solution, the chlorides cause the sulphates to become more soluble and penetrate the concrete more easily [6], which damages and corrodes the concrete.

Regarding the percentage of gypsum content of cohesive soil, it ranges from 0.25 in S6 to 2.32 in S2, with an average of 1.021%, and the British Standard [22] indicates that the percentage of gypsum in the soil should not exceed 2.5%. Therefore, the geometric behavior of the soil is not affected by the percentage of gypsum present in the study area.

In the research area, the average percentage of calcium carbonate is 8.728%. This is because carbonates are found in groundwater and seawater close to the location, and because high-carbon shells break down over time to release this material. Because it functions as a binder, calcium carbonate strengthens the soil's resilience to unconfined settling and cohesiveness [34]. It should be noted that higher than 30% calcium carbonate content may result in increased porosity, void formation, and decreased soil carrying capacity, among other engineering problems [35].

As for the percentage of sulphates (SO_3) in the soil samples selected from the study area is 0.399% , the results of sulfates percent in the study area did not surpass the effective value of the engineering behavior of the soil, which is 5%, according to [36]. While the results content of chlorides in the study area ranged between (0.05-1.6) % with an average of 0.628% , Because the percentage of chloride in the study area was higher than 0.1%, the reinforcing steel and foundations could be affected over time.

Table 2 : Results of chemical tests for the study area

Sit. No	ORG %	CaCO3 %	CL- %	SO3 %	T.S.S %	GYP %
S1	1.06	8.8	1.24	1.1	1.73	1.26
S2	2.58	7.4	1.42	0.14	0.4	2.32
S3	2.93	9.4	0.31	0.22	4.19	1.36
S4	1.52	8.21	2.2	1.12	2.25	0.38
S5	1.36	2.2	0.35	0.08	1.25	1.34
S6	2.6	8.3	1.6	0.1	0.4	0.25
S7	1.88	7	0.71	0.16	2.3	0.26
S8	1.65	6.7	0.36	0.22	3.12	1.82
S9	1.26	6.65	0.45	0.16	2.72	1.63
S10	1.48	15	0.38	0.54	3.63	0.59
S11	1.34	9	0.21	0.53	2.02	0.51
S12	1.13	12	0.38	0.44	1.99	1.78
S13	1.53	8	0.07	0.42	3.72	0.77
S14	1.33	5.2	0.21	0.47	1.97	0.62
S15	1.41	6.8	0.05	0.36	2.22	1.08
S16	1.25	19	0.12	0.33	1.85	0.38

5. Conclusions

1. Based on the results, al-Faw soil can be classified into three categories: clayey silt low plasticity (ML), silty clay high plasticity (CH), and silty clay low plasticity (CL).
2. The study site's soils are categorized as extremely compressive soils because of their high liquid limit, which results in a low bearing capacity and the necessity for treatment.
3. The amounts and types of clay vary, which affects how much the soils in the research region can swell.
4. In the study sites, organic materials and total Soluble salts are considered relatively influential in the engineering behavior of the soil, creating a future engineering issue.
5. The percentage of gypsum and sulphates in the soil of the study sites is safe and did not exceed the effective value in the engineering behavior of the soil and do not pose a danger to the concrete.
6. Over time, eating and ripping may occur as a result of chloride ions attacking the foundations and reinforcing steel in the studied region.

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