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Study of some physical, chemical and engineering properties of the soil of selected sites/ Northwest of Tikrit

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Abstract

The research dealt with studying the physical, chemical and engineering characteristics of a soil site northwest of the city of Tikrit with the aim of identifying the characteristics of the soil of the region due to its importance in various construction designs. The moisture content of samples from the study area showed a relative decrease, ranging between (0.04%-1.49 %). While the results of the specific gravity values ranged between (1.83% - 2.73%), the results of the particle size analysis showed that the soil of the region is heterogeneous consisting of coarse (gravel and sand) and fine (silt and clay) grains. The percentage of gravel ranged between (0% - 40.37%), while the percentage of sand ranged between (39.82% - 90.84%) and the percentage of silt ranged between (7.93% - 33.92%). The percentage of clay is very small, ranging between (0.33% - 2.94%). Models of the study area showed a failure to examine plasticity limits. The direct shear examination also showed that the soil has a friction angle ranging between (41◦-45◦) and cohesion values ranging between (0-1). The results of the compaction analysis also showed different percentages in which the maximum dry density values ranged between (1.65-2 g/cm3). While the ideal moisture content values ranged between (10% - 18%), chemical analysis tests showed percentages of dissolved salts ranging between (3.22%-41.62%), while the percentage of gypsum ranged between (2.18%-38.74%). As for the organic materials, its percentage ranged between (0.013%-3.25%), while the pH ranged between (7.99-7.85). The percentage of chlorides ranged between (1.37%-0.19%).

Introduction:

The soil that we deal with was formed as a result of the influence of a group of physical and chemical factors on the layer of the earth's crust over the years, and as a result of the influence of these factors, the main soil properties were formed. During different periods of time, the soil was exposed to many influences and fluctuations in natural conditions, as new soil was constantly formed. Likewise, external factors such as wind, water influence, and temperature fluctuations played a significant role in the composition of the soil. Therefore, the physical, chemical and engineering properties of the soil were studied to identify the problems it is exposed to in order to reach a more accurate understanding of its engineering behavior when constructions are erected on it. In addition to projects that deal with different soil layers, by knowing the physical properties of the soil, the soil can be evaluated. Knowing the chemical properties helps determine the type of materials and treatments used in the foundations of buildings and facilities. As for the engineering properties of the soil, they determine the ability of the soil to bear the loads imposed on it and the extent of subsidence that occurs in it. Thus, the suitability of the soil for the purpose of constructing various buildings is determined [1] The construction of safe engineering facilities requires a comprehensive study of all the properties of the surface and subsurface soil to determine the extent of the tolerance of these soils to the changes that will occur during construction, as well as to estimate the bearing capacity of these soils and improve their engineering properties [2]. Weak gypsum soils and clay soils containing minerals that have the ability to swell expose buildings to the risk of collapse and cracking, which directly affects the foundations of the facilities and leads to cracks and slumps in roads, airport runways, and other important vital facilities [3]. When this type of soil is present, project engineers are forced to carry out several treatments, such as changing the type of soil by bringing in another soil with appropriate specifications. In most cases, this cannot be done, which forces the project engineer to choose foundation designs that suit the site conditions or work to improve the soil properties in order to obtain A resistant and solid foundation with the lowest possible economic costs [4]

Location of the study area:

The study area is located northwest of the city of Tikrit, located 180 km north of the capital, Baghdad. **Figure 1**, Site map of the study area models. **Table 1** shows the coordinates of the study area.

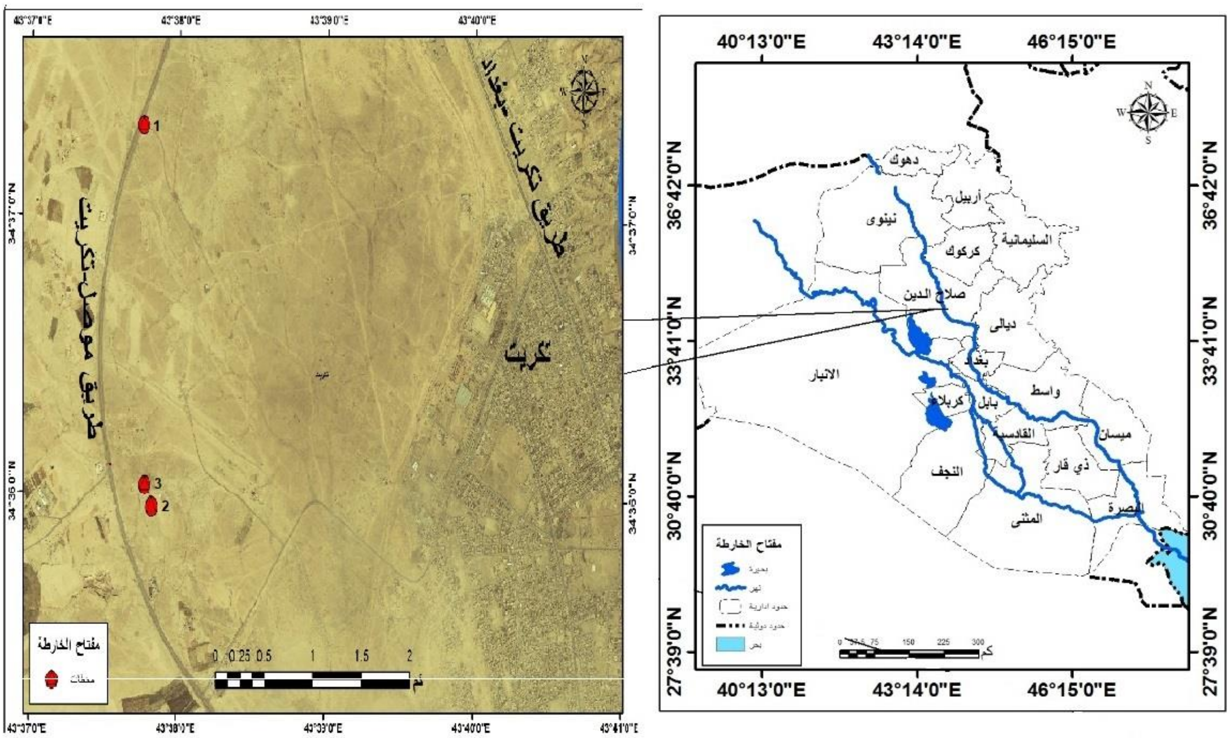

Fig. 1 : Iraq map and study area

Table 1. Coordinates of stations in the study area

Geographic coordinates		the site
Latitude	Longitude	
N˝ 19´ 37˚34	E˝45´ 37˚43	ST1
N˝57´35˚34	E˝49´ 37˚43	ST2
N˝01 ´36˚3	E˝46´ 37˚43	ST3

Aim of the research:

Study the physical, chemical and engineering properties of the soil Northwest of Tikrit and determine its suitability for constructing various buildings.

Search methods:

The laboratory work included conducting many tests of the soil of the study area, represented by physical tests, which included examining (moisture content) according to the American standard. [5], specific gravity according to the American standard [6] granular volumetric analysis according to the standard [7] and water perk limits according to the American standard [8]. These tests were carried out in the geological workshop of the Department of Applied Earth Sciences / Tikrit University. As for the engineering tests, they were a direct shear test according to the American Specification [9], which were conducted in the laboratories of the Civil Engineering Department / Tikrit University. The chemical properties tests included examining the percentage of gypsum, the percentage of soluble salts, the percentage of organic materials, pH and the percentage of chloride according to specifications [10]. The tests were conducted in the laboratories of the Chemical Engineering Department / Tikrit University. Simple excavation tools were used by choosing three sites, which consisted of taking four samples from different depths that ranged between (1-2.7) meters. Care was also taken that the models be undisturbed and representative of the soil of the study area, noting that the samples taken represent quaternary sediments.

First: Physical examinations included:

a. Water Content:

It represents the percentage of the weight of water present with in the soil model to the weight of solid particles for the same model [11]. It is labeled as % mc. **Table 2** shows the results of examining the moisture content of sites in the study area.

$$mc\% = \{(W2 - W3) / (W3 - W1)\} X\ 100 \qquad (1)$$

Where (mc%) represents the moisture content.

(W1) The empty weight of the container in grams.

(W2) Weight of wet soil + weight of container in units (gm)

(W3) Dry soil weight + container weight in units (gm)

Table 2 shows the results of examining the moisture content of sites in the study area

Moisture content %	Depth(m)	Model code	the site
0.99	1	D1	ST1
0.68	2.7	D2	ST1
0.04	1	E	ST2
1.49	1.5	F	ST3

b. Specific Gravity

The specific gravity represents average specific weights of soil particles, and it can be said that it is the ratio of the weight of a known sized quantity of dry soil to the weight of a quantity of distilled water equal to the volume of soil in the air at a certain temperature [12]. The specific gravity is calculated from the following equation, and **Table 3** shows the results of examining the specific weight of the sites in the study area:

$$Gs = W_3/(W_1 + W_3) - W_2 \qquad (2)$$

$$(GsT_{20}) = Gs\ T_1 . A \qquad (3)$$

Specific weight = GS

(W1) Bottle weight + water weight up to 500 ml.

(W2) Weight of water + weight of bottle + weight of soil mixture.

(W3) Weight of dried soil model at temperature (45°C).

(A) Temperature correction factor (represents the specific weight of water at a certain temperature divided by the specific weight of water at temperature (20).
(T1) Initial temperature.
(T_{20}) The temperature is at (20°C).

Table 3 shows the results of examining the specific weight of the sites in the study area

Specific weight	Depth (m)	Model code	The site
2.26	1	D1	ST1
2.33	2.75	D2	ST1
1.8	1	E	ST2
2.7	1.5	F	ST3

c. Grain Size analysis

The granular size distribution expresses the weight percentage of different size classes of soil particles [13**]**. The sieve analysis aims to classify the soil into different groups based on the weight percentages of its components of gravel, sand, silt, and clay according to classification [14**]**. The results of the sieve analysis and wet analysis are listed in the **Table 4**. From coarse to finer, the results were represented graphically by the particle size distribution curve, as shown in the **Figures 2 ,3 ,4 , 5**. **Table 4** shows the percentages of the particle sizes of the sediments of the study area.

Table 4 Percentages of grain sizes of sediments from the study area

Soil symbol	Clay%	Silt%	Sand%	%Gravel	Depth (m)	Model code	The site
SM	2.94	33.92	59.18	3.96	1	D1	ST1
GM	0.37	19.44	39.82	40.37	2.75	D2	ST1
SP-SM	0.5	10.3	81.2	8	1	E	ST2
SP-SM	0.33	7.93	90.84	0.9	2	F	ST3

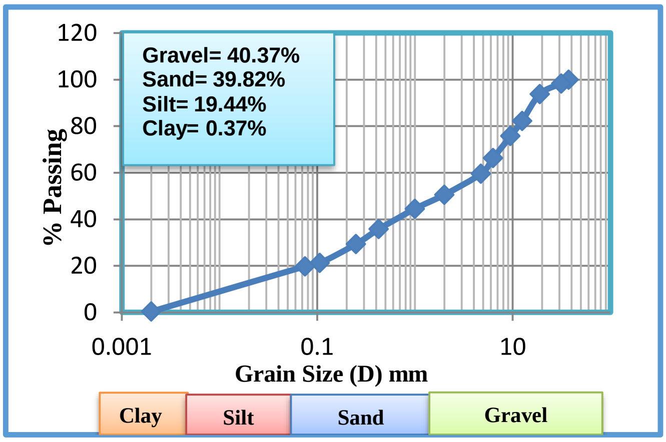

Fig. 3 shows the granular volumetric analysis site 1 sample D2

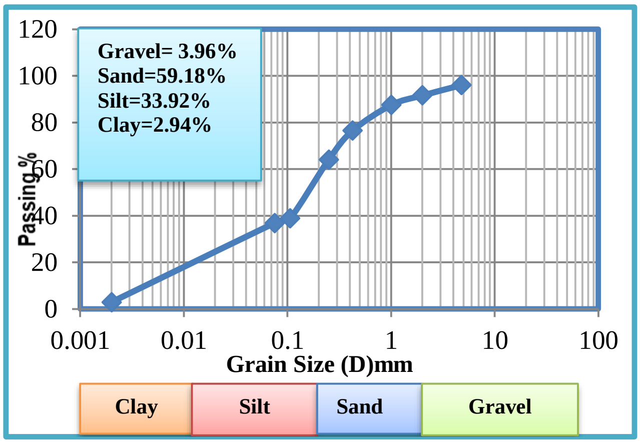

Fig. 2 shows the granula volumetric analysis site1 sample D1

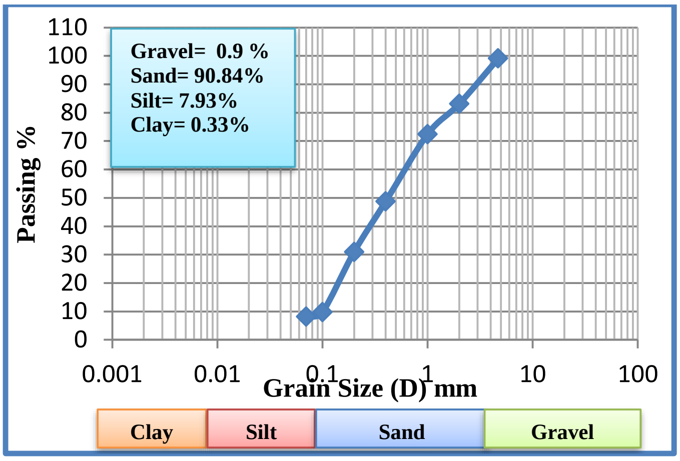

Fig. 4 shows the granular volumetric *Analysis Site 3 sample E*

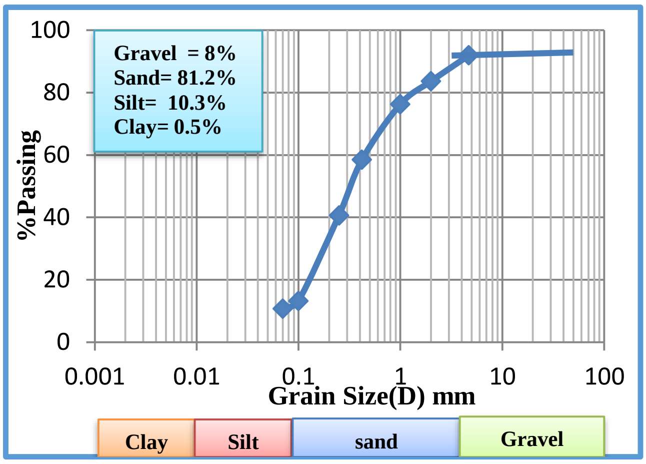

Fig. 5 shows the granula volumetric *Analysis site2 sample F*

d. Atterberg Limits

It represents the percentage of soil moisture at the limits of the change that occurs in its condition, as all types of soil show a clear effect and different behaviour when the percentage of moisture in it changes [11**]**. The Atterbury limit is of great importance in soil classification, as the Liquid Limit is known as the water content between the state of liquidity and the state of plasticity or it is the lowest water content that makes the soil in a liquid state but has little shear resistance against its flow. As for the Plastic Limit, it is known as it is the water content that separates the plastic state from the semi-rigid state [11**]**. From the limits of fluidity and plasticity, the plasticity index can be found. It is defined as the moisture content at which the soil remains in a plastic state.

The soil of the studied sites showed a difference in its types. The soil type of the first site, Model D1, was a sandy soil type with silty fines SM of low plasticity, while the soil type of the first site, Model D2, was a gravel soil with fine silts GM of low plasticity. The rest of the models showed failure in the plasticity test.

Engineering properties of soil:

The engineering properties of the soil in the study area were studied, where a direct shear examination of the soil was performed:

a. Direct shear test

Shear strength in soil is the largest stress that the soil can exhibit against sliding within the soil mass under the influence of external forces affecting it [15**]**. The sample to be examined is placed inside the shear box, and the vertical stress applied to each model is changed, so that the vertical weight applied for the first attempt is 2 kg, for the second attempt 4 kg, and for the third attempt 6 kg. The changes that occur to the model are read through a higher reading. The value Peak of the effect of the horizontal shear force, which appears on the screen of the device. The examination was carried out for models of the study area, and this was done for non-disturbed models. The models were placed in the examination cell of the device with a diameter of 6.4 cm and a height of 2 cm. Then readings were taken from the device and the Calculations and obtaining results. A relationship was drawn between the vertical stress and the shear stress for models of the area under study, as shown in **Figures 6, 7, 8, 9** and **Table 5** shows the values of cohesion and the angle of internal friction for of the study area.

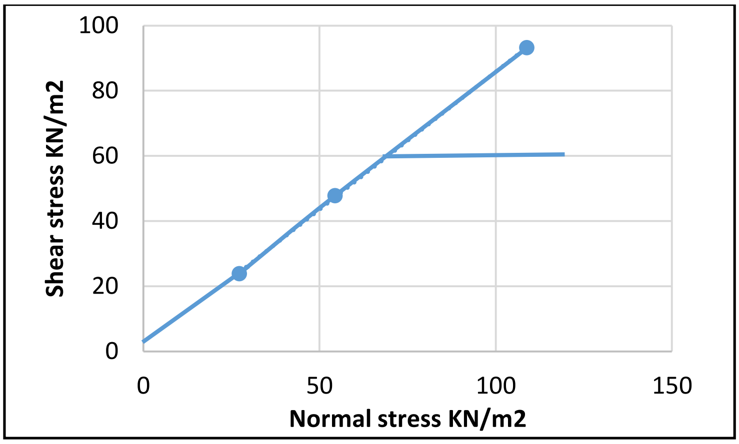

Fig. 6 shows the direct shear test of model D1

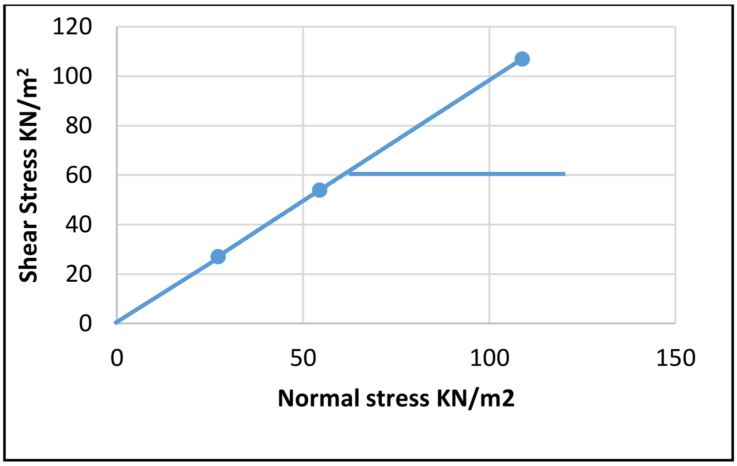

Fig. 7 shows the direct shear test of model D2

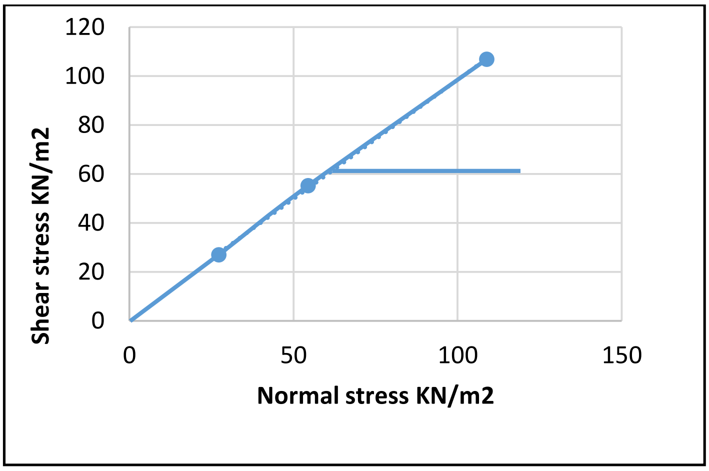

Fig. 8 shows the direct shear test of model E

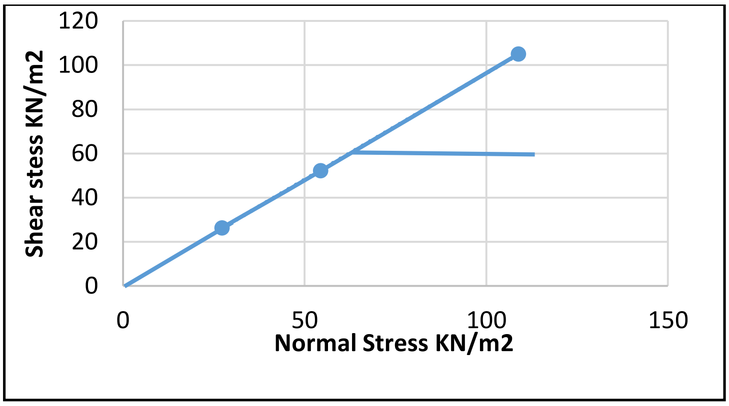

Fig. 9 shows the direct shear test of model F

Table 5 shows the values of cohesion C and internal friction angle ø for study area

C(KN/m^2)	(ø°)	Model code	The site
1	41	D_1	ST_1
0	45	D_2	ST_1
1	45	E	ST_2
0	44	F	ST_3

b. Compaction Test

compaction is defined as a process in which soil particles are rearranged using mechanical means in order to reduce the porosity of the soil and increase its dry density. With increasing the strength of the compaction, the maximum dry density is reached, and the maximum dry density obtained indicates the ideal water content [16]. The wet density, dry density and ideal water content are found from **Equation 5, 6** [17].

$P_{wet} = m_2 - m_1 / v$ (4)

P_{wet} = wet mass density of soil in units of gm/cm3.
m1= mass of the mold with the base in units of gm.
m2 = mass of the matrix with soil in units of gm.
v = mold volume in cm3.
The dry mass density is calculated from equation [18].
$P_{dry} = P_{wet} / 1 + W\%$ (5)
Pdry = dry mass density of soil in gm/cm3.
W%= Soil water content.
A steel test was conducted for samples of the study area in accordance with American specifications [19], and Table 6 shows the results of the compactness test for the site of the study area

Table 6 shows the results of the compactness test for the site of the study area

Maximum dry density	Ideal moisture content%	Depth (m)	Model code	The site
1.84	14.9	1	D1	ST1
1.65	18	2.75	D2	ST1
1.82	16	1.2	E	ST2
2	10	2	F	ST3

Chemical properties

Soil has several components and different phases: solid, liquid, gaseous and organic materials. Soil chemistry is mainly related to the solid phase, the liquid phase, and the interactions between them.

The liquid phase represents the soil solutions soil solution, while the solid phase includes the organic and inorganic components, and the major and secondary soil minerals, which directly affect soil properties and are usually present more than organic components, represent the inorganic components. As most soils contain large quantities of the main minerals that are formed when high temperatures occur when igneous and metamorphic rocks form, and sometimes from sedimentary cycles. As for the organic components, the plant and animal remains contained in the soil represent them, and they are few compared to the inorganic components [20]. **Table 7** shows the values of the results of chemical analysis of the soil of the study area.

Table 7 shows the results of chemical analyses of the soil of the study area

Station	Sample	GPYS	TDS	PH	Organic	Cl
		%	%	%	%	%
ST_1	D1	16.39	21.63	7.99	0.034	1.04
ST_1	D2	38.74	41.62	7.86	0.013	1.37
ST_2	E	32.68	38.66	7.96	0.21	0.96
ST_3	F	2.18	3.22	7.85	3.25	0.19

Discuss the results:

Through the various tests and chemical analysis conducted on soil samples the following conclusions can be drawn:

-The sediments exposed in the study area represent Quaternary sediments.

-The moisture content of the soil models of the study area ranged between (0.04-1.49), which is considered a relatively low percentage. The reason for this is the high temperatures, evaporation rate, and lack of rain in that region

-The granular volume analysis study, after comparing the percentages of clay, silt, sand, and gravel in the region, showed that there was a difference in the percentages, as it was observed that there was a predominance of coarse-grained sediments compared to fine-grained sediments. It was noted that there was a difference in the sizes of the sediments, as the soil of the region is not homogeneous in its properties and distribution, as it is considered uncohesive soil. (gravel, sand, green, clay) [7].

- The specific gravity values in the study area ranged between (1.83-2.73). The difference in the specific gravity values is due to the mineral composition of the soil particles, as the specific gravity values vary according to the types of soil [21].

- Direct shear examination showed that the soil of the study area has friction angle ranging between (41°-45°) and cohesion values ranging between (0-1). This is explained by the difference in the nature of the bonding material between the soil particles, the size of the particles, and the type of soil. Since most of the soil in the study area is of it is a sandy soil type, so it has a good angle of internal friction, but increasing water reduces the shear resistance factors, which include cohesion and the angle of internal friction [22].

-The results of the maximum dry density values for the models of the study area ranged between (1.65-2 g/cm(3), while the ideal moisture content values ranged between (10%-18%), where it is noted that there is a variation in the resulting percentages depending on the difference in the mineral compositions and grain sizes of the soil.

- Chemical analysis tests, represented by soluble salts, showed percentages ranging between (3.22% - 41.62%), as increasing the percentage of salts leads to a decrease in the soil's resistance to the stresses placed on it [23]. As for the percentage of gypsum, it ranged between (2.18% - 38.74%) and has an impact on soil properties, as the percentage of gypsum is considered dangerous on the foundations if it exceeds (5.0%) in the soil [24].' As for organic materials, their percentage ranged between (0.013%-3.25%), as the increase in the percentage of organic materials in it has a significant negative impact on the soil because the organic matter dissolves in water and forms organic acids that lead to the oxidation of organic carbon, which reduces the resistance of the soil [25]. As for the pH, its percentage ranged between (7.99-7.85) and indicates that the soil is neutral. To alkaline, as the PH value affects the soil, the higher the PH, the lower the soil salinity [26]. As for the percentage of chlorides, it ranged between (1.37%-0.19%). An increase in the percentage of chlorides in the soil is a negative factor for the soil that is used for purposes engineering, where increasing the percentage of chlorides leads to corrosion of the steel reinforcement of the foundations of buildings and facilities [27].

5- **Conclusions**

Of the results obtained from the tests conducted on the sites of the study area, we conclude that it is possible for engineering problems to occur for buildings and erected facilities because of the soil containing a high percentage of gypsum. When the soil is exposed to water, the gypsum will dissolve, leading to soil subsidence and then the collapse of the buildings. The soil in its current condition is not suitable for constructing facilities without treatment.

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