International Journal of Geography, Geology and Environment

P-ISSN: 2706-7483
E-ISSN: 2706-7491
IJGGE 2024; 6(1): 230-237
Received: 02-10-2023
Accepted: 07-11-2023

Aya Khaldoon Mohammed
Department of Geology and Environment, College of science Geology, University of Kirkuk, Iraq

Aomed Ahmed Mohammed
Department of Geology and Environment, College of science Geology, University of Kirkuk, Iraq

Corresponding Author:
Aya Khaldoon Mohammed
Department of Geology and Environment, College of science Geology, University of Kirkuk, Iraq

Evaluation of geotechnical characteristic of surface soil for compressed earth block industry in Shuwan area northern of Kirkuk

Aya Khaldoon Mohammed and Aomed Ahmed Mohammed

DOI: https://doi.org/10.22271/27067483.2024.v6.i1d.224

Abstract
The study and evaluation of geotechnical characteristics, which included tests of the, grain-size distribution analysis, Atterberg Limits and specific gravity, chemical and mineralogical analyses of samples from the shuwan, northern of Kirkuk, and the possibility of using them as raw materials in the compressed earth block industry, were all part of the research. The samples are composed of 28% clay, 47.2% silt, and 17.6% sand. The results of the soil consistency showed that the soil is of a low to medium plasticity type depending on the plasticity scheme within the standard classification of soils and that it can be formed and take suitable plasticity for the compressed earth blocks industry. Results were classified according to Picard's chart, showing that it is located within the clayey silt field, and this indicates an increase in the ability to form the compressed earth blocks industry. And the results of the specific weight ranged between (2.69 – 2.73), where the data of the results of this study showed the validity of these clays in the brick industry.

Keywords: geotechnical, soil, Shuwan, Kirkuk, earth

Introduction

Clay brick is considered one of the oldest construction materials used in construction in Mesopotamia. It was used in the form of stacked clay in primitive buildings. Then its manufacture developed into cut and dried shapes or mixed with other auxiliary materials such as plant stems (Hay) for the purpose of strengthening them and giving them a geometric shape and a degree of insulation. After that, regular bricks were produced by subjecting them to drying and burning in primitive ovens. Clay bricks are one of the building materials that are characterized by low production costs, their durability, not being affected by fires, and their good ability to thermal insulation.

Since ancient times, humans have been using clay bricks due to their abundance and ease of representation and formation in the required geometric shape. Most of the surface clays are suitable for use in making bricks.

The production of compressed earth blocks is one of the very important industries in the field of construction, especially since it has a very low cost, as the prevailing soil in each region is used in its manufacture, in addition to being environmentally friendly because it does not require burning or polluting the environment during its manufacture.

The study area is administratively located in Kirkuk Governorate and is located in the Shawan region, northeast of Kirkuk Governorate. It is 36 kilometers from Kirkuk Governorate's center. Which is situated between the longitudes (35°36 21) and (35° 36 56) and the latitudes (44°22 29) and (44° 22 19). Fig. 1. The goal of this research is to choose different sites in the study area to analyze the geotechnical qualities of the soil there, as well as the chemical and mineralogical properties of compressed earth blocks made from the study region's soil, In addition to studying the geotechnical and engineering properties of compressed earth bricks produced from the study area's soil, evaluating the geotechnical and engineering properties, drawing conclusions and making comparisons for the bricks produced, indicating the best and emphasizing the areas represented in the production of bricks with international specifications.

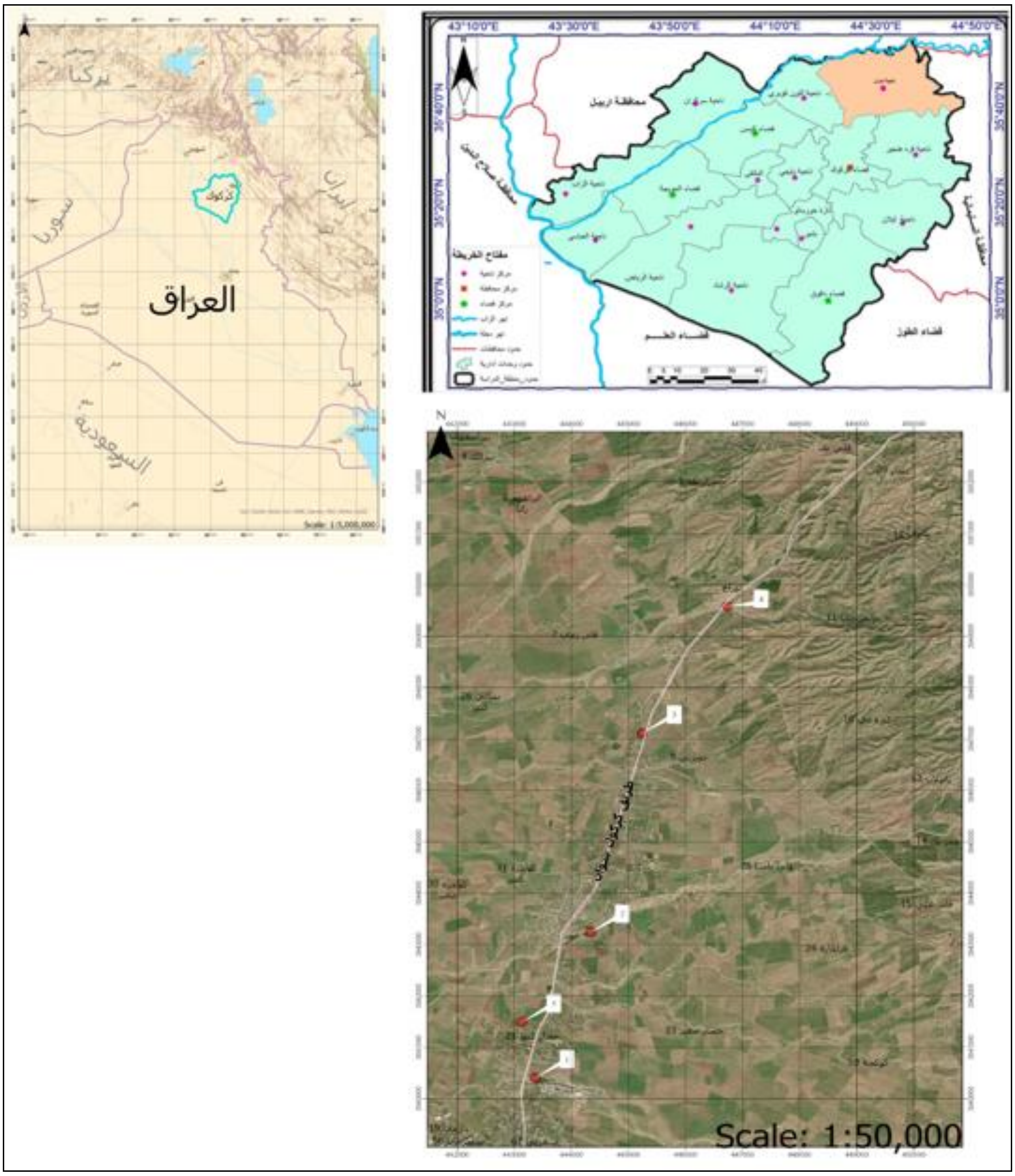

Fig 1: Location map of study area **.**Based on the administrative map of Iraq using the program ARC GIS10.8

Geology of the study area

Knowing the geology of the study area is especially important in understanding the general stratigraphic, compositional, geomorphological, and depositional conditions, as well as the changes affecting them, particularly tectonics, to enable the interpretation of any data obtained from the research, and from it we learn about the engineering characteristics of the rocks and soils spread throughout the region that are used in engineering projects, and determine the type of rock and soil. The nature of the existing soils and the geological environment in this location, anticipating probable soil effects, and determining exposed geomorphological shapes and characteristics. This study provided a detailed geological description of the studied area, including tectonic and compositional information. In terms of tectonics, the researcher Fouad (2015) [17] divided Iraq into two parts, one of which is located within the Arabian Plate and the other within the Eurasian Plate, with the part located within the Arabian Plate divided into flat lands (Inner Platform) and rugged lands (Outer Platform). The study region is located in the Low Folded Zone of the rough terrain, according to this categorization. The following geological formations are found in the study region, in order of age

Upper Miocene Injana Formation Busk and Mayo characterized this development for the first. According to (Jassim & Goff, 2006) [9], it was referred to as the Supreme Knight in Iran. Bellen and colleagues stated that its age is in the late Miocene, and it was known as the Injana Formation in Iraq (Al-Rawi *et al*, 1992) [6], and the thickness of this formation is 30 meters. It varies from region to region, with the thickness of this deposit reaching more than 2000 m in the Foot Hill Zone. This is due to geographical variances.

Lower Pliocene Miqdadiya Formation Busk and Mayo were the first to describe this formation. According to (Buday, 1980) [8], it was known as the Lower Bakhtiari Formation in Iran. The appearance of a typical piece of it in Iraq in the Muqdadiya region, north of Diyala Governorate, is linked to the Muqdadiya Formation, which constitutes the lower half of The Bakhitari Formation (Jassim | & Goff, 2006) [9]. It is made up of a series of sandstone rock strata, with pebble-sand deposits that range in color from gray to light green and range in size. It is medium to coarse granular, with a thickness ranging from (1-6 m) and a layer of coffee-colored mudstone rocks, Fatha Formation is one of the most common Miocene formations, and it is also economically significant in Iraq, as it contains evaporite rocks, which form cover rocks for many oil reserves. It is frequently exposed in northeastern Iraq near low folds and on the borders of high folds (Jassim *et al* 1984) [11]. The Bai Hassan Formation is similar to the Muqdadiya Formation in general, with the exception of geological age, as the Bai Hassan Formation is younger and has coarser grain sizes than the Muqdadiya Formation, with a thickness of more than 638 meters (Jassim *et al*. 1984) [11]. This Pliocene-Upper Miocene formation comprises of mudstone alternations with sandstone and siltstone and is frequently buried by current deposits. This formation's thickness surpasses (2000) meters.

Quaternary deposits differ in origin because they are formed from older clastic deposits, and the thickness of their deposits varies and can exceed 120 m in some wells drilled in the research area (Jassim and Goof, 2006) [9]. Because of their age, Quaternary deposits cover the majority of the study region. The ages of these deposits range from the early Pleistocene to the late Holocene. The Pleistocene age of the recent deposits is represented by lenses and layers of gravel, sand, clay, and dirt (Jassim and Goof, 2006) [9]. The modern deposits are taken into account. Good water storage configurations (Good aquifer)

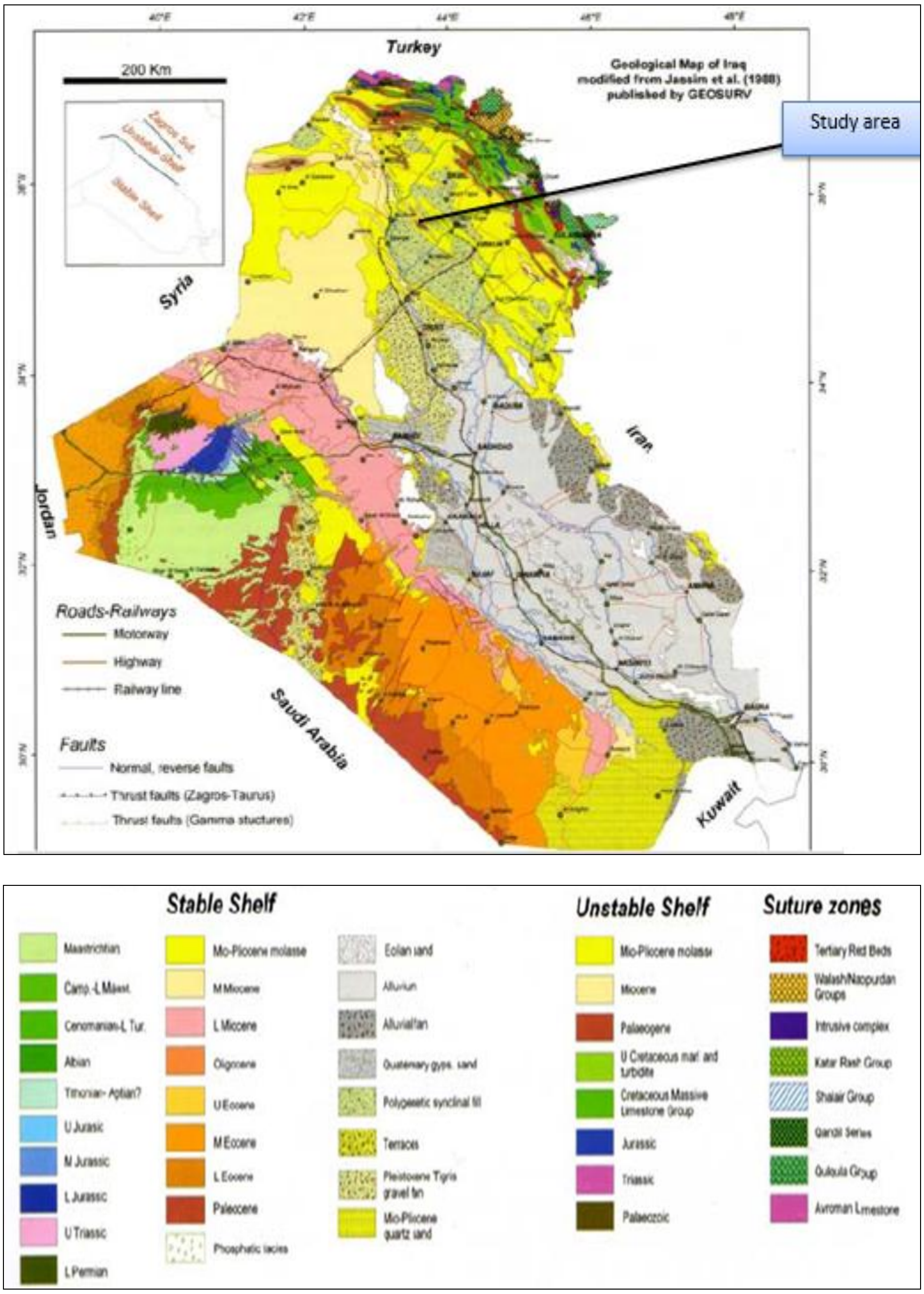

Fig 2: geological map showing the lithology of exposed formations, adapted from (Jassim and Goff, 2006) [9]

Materials and Procedures

Geotechnical tests of soils study area include specific gravity, grain-size analysis, and Soil consistency (Atterberg limits) is part of the laboratory activity. Which were carried out at Kirkuk construction laboratories in accordance with the American Society for Testing and Materials (ASTM) to determine the viability of these clays in the brick industry and their conformity with Iraqi specifications

The specific gravity o is the ratio between the weights of a certain volume of the substance to the weight of an equal volume of distilled water at the same temperature and is symbolized by the symbol (Gs). This test was carried out in Kirkuk construction laboratories on the soil of the research region in accordance with the American specification (ASTM-D, 854-02-2004). Das (1982) [7] found specific gravity values for each type of soil shown in table 1. The specific weights of the soil of the study area ranged between (2.69 - 2.73), and through the results of the specific weight it can be said that the soil of the study area is clay and silty clay soil. Shown in table 2.

Table 1: Represents the actual specific gravity ranges for various soil types. (Das, 1982) [7]

Soil Type	Specific gravity
Sand	2.63 – 2.67
Silt	2.65 – 2.7
Clay & Silty clay	2.67 – 2.9
Organic Soil	Less than 2

Table 2: Shows the specific gravity values of the research area's samples and their classification according to Das (1982) [7].

Soil's type according to (Das, 1982)	Specific gravity	Sample No
Clay & Silty clay	2.69	1
Clay & Silty clay	2.70	2
Clay & Silty clay	2.72	3
Clay & Silty clay	2.52	4
Clay & Silty clay	2.73	5

Grain size analysis one of the most essential physical parameters for defining the features of the product from bricks is grain size analysis (Al- Mallah, 2014) [15]. The size analysis seeks to categorize soil into aggregates based on the weight percentage of each content (gravel, sand, silt, and clay). Sieve examination the examination was completed at the Kirkuk Construction Laboratories in accordance with the American standard (ASTM-D, 422, 2004). Wet analysis is performed on fine soils with diameters less than 0.075 mm and passing through sieve No. 200. Soil samples were examined in Kirkuk construction laboratories in accordance with the American Standard (ASTM, D-422, 2004).

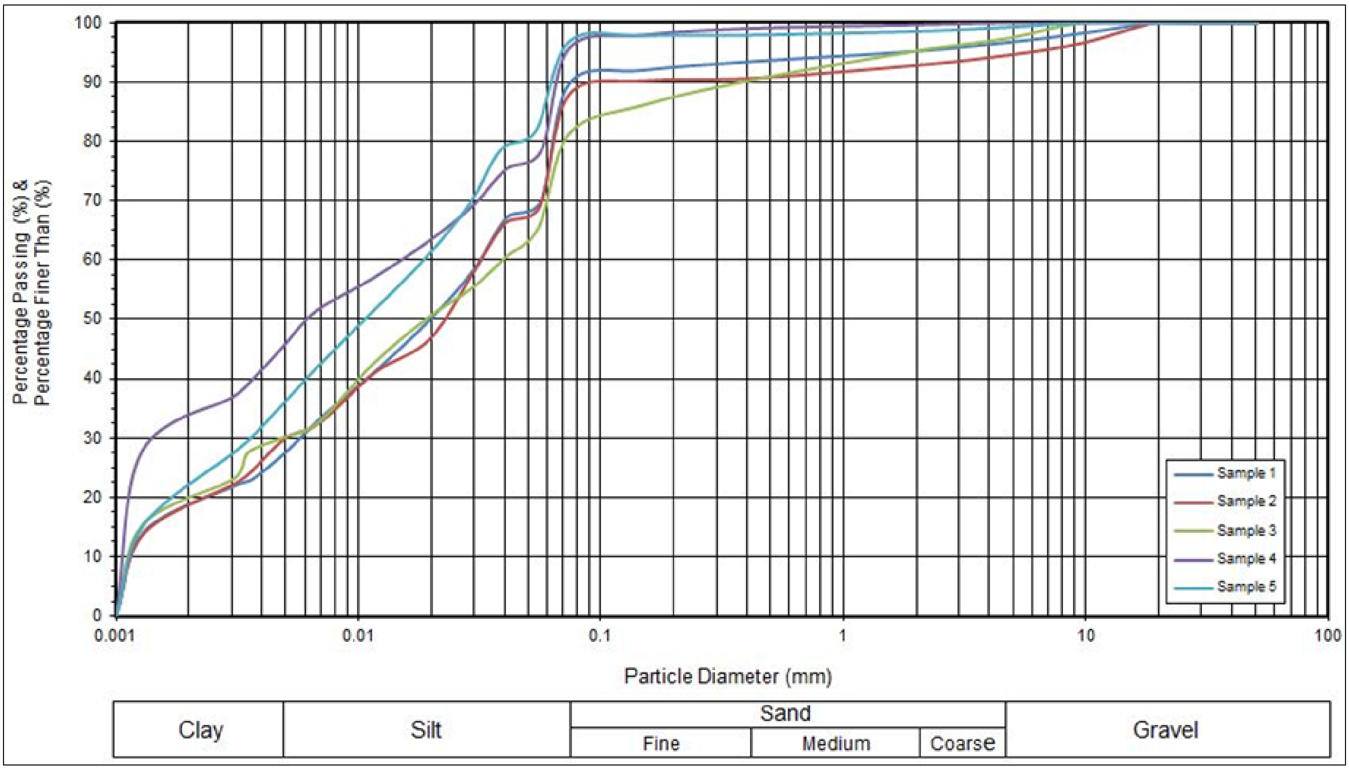

Fig 3: Curves grain size analysis of samples research area

Table 3: Shows the results obtained from the examination

Location No.	Grain size distribution			
	Clay %	Silt %	Sand %	Gravel %
1	26	64	6	4
2	5	7	60	28
3	29	52	16	3
4	45	51	4	0
5	35	62	2	1

To determine the textural classification, the relationship between the weight percentage of the basic components of clay, silt, and sand (Sand - Clay - Silt) for the models of the research region is represented by the Picard's classification triangle (1971). Because the components of clay sediments are so similar, this classification was used, and as a consequence, the models can be named. Fig 4, table 3

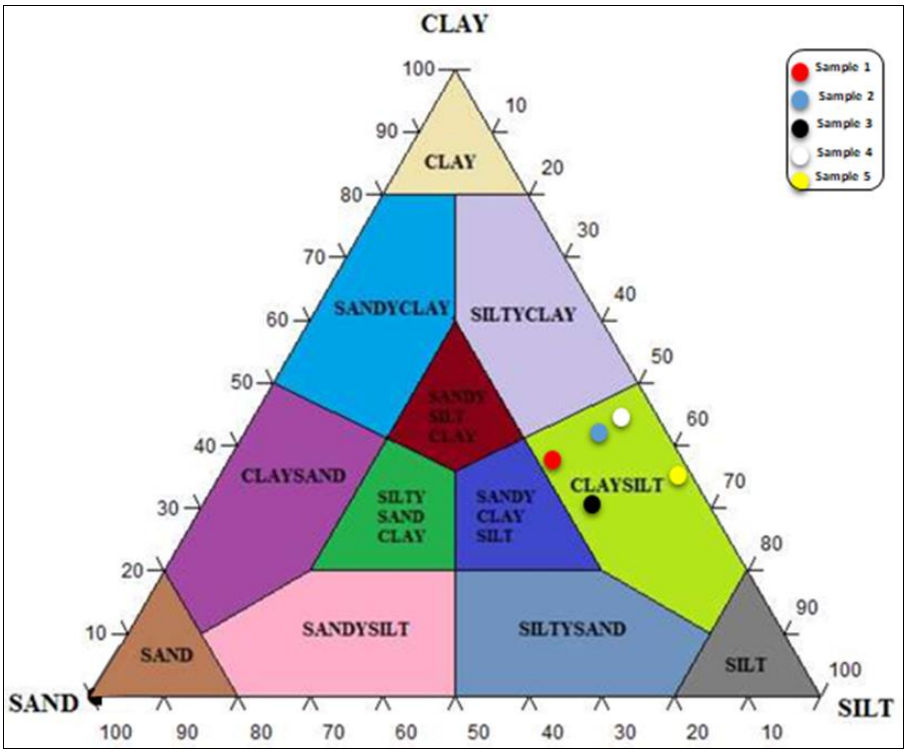

Fig 4: Textural classification of samples taken from the study area based on Picard, 1971)

Soil consistency (Atterberg Limits) Soil consistency (Atterberg limits) is a fundamental assessment of the nature of soft soils and one of the most significant soil consistency tests. The following limits indicate the soil texture: The liquid limit and plastic limit were tested in accordance with the American Standard (ASTM-D, 4318, 2004). The outcomes are shown in Table 4.

Table 4: Results of Atterberg limits for the soil of the study area

Plasticity index%	Plastic limit%	Liquid limit%	Sample No.
16.23	17.05	33.28	1
19.11	17.59	36.7	2
15.55	14.36	29.92	3
39.26	26.87	66.13	4
14.89	19.89	34.67	5

The plasticity scheme was used in this work inside the Unified Soil Classification System) USCS). Fig.5 depicts the distribution of the study area's samples on the plasticity diagram in order to classify soft soils within the unified classification and the decree between (plasticity Index, liquid limit) where the samples were projected within the fields in the figure and on the basis of which they are named and classified as low to medium plasticity (CL).

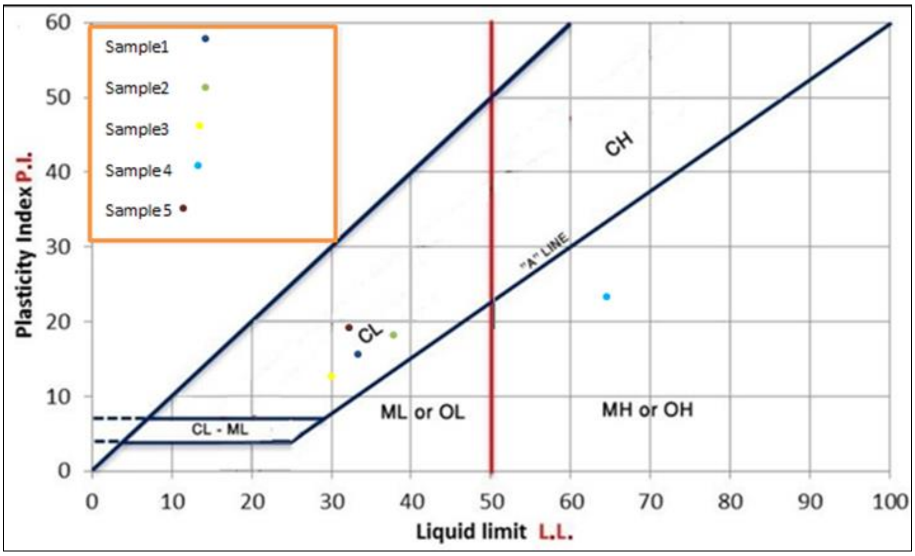

Fig 5: Shows the plasticity diagram for soils of the study area

Geotechnical properties of compressed earth blocks

Soil

It is the primary raw material used in the manufacture of compressed earth blocks. It is a mixed substance made up of various quantities of gravel, silt, clay and sand. Changes in moisture content and density have an impact on the engineering behavior of silt and clay. Before making compressed earth bricks, the soil must be examined to determine its salinity. To prevent using soil containing organic components and plants, the surface of the soil was excavated to a depth of 20-30 cm. Which is considered an unsuitable material in the creation of compressed earth bricks? The soil type of the research region is claysilt, (G. Minke, 2006) [18].

Moisture contain

It is a key material in the production of compressed earth blocks. It is mixed into the soil until it reaches a plastic condition within the range of the plasticity coefficient, making concrete processes easier. Because contaminants in the added water can interfere with the production of compressed earth blocks, water quality is critical. This may cause the bricks to break and damage the texture, or it may cause the surface of the bricks to split during drying, reducing the compressive resistance of the bricks. As a result, the compatibility of the water used in the production of compressed earth bricks must be considered. The stages of making compressed earth bricks started with (G. Minke, 2006) [18].

Compression process

This procedure is carried out utilizing equipment designed for the production of compressed earth bricks. Previously, a wooden stick was used to force the soil into molds specifically designed for this reason. There are currently various types of presses available for the process of pressing and manufacturing compressed earth blocks, whether mechanical or manual presses. There is one on the market (RAM CINVA).

This technology is affordable and does not consume a lot of energy to run. The presses (CINVA_ RAM) (BREPAK) are the most well-known in the world due to their low cost, light weight, and ease of operation. Preparing it, but one of its downsides is that it only has one mold, has a modest compression force, and has a lesser output rate than other presses.

Compressive strength was determined in this study, and (25) models of compressed earth blocks were produced for each of the five study sites using a device for manufacturing and examining compressed earth blocks, which is a device designed to produce compressed earth blocks that are 1/4 smaller than the original size common for producing bricks. According to international standards (ASR 674.1996), compacted earth has a compressive strength of around (15 MPa) as fig.6

Fig 6: A device (CINVA-RAM) for examining and manufacturing compressed earth blocks

Curing

This technique is critical in the manufacturing of compressed earth blocks because it affects the geotechnical and engineering qualities of the bricks. As a result, the bricks must be kept from weather elements and dried in shaded areas for at least four weeks. Because the models were made in the summer, they must be covered to avoid rapid drying due to the possibility of surface cracks.

Curing time is proportional to the compressive strength of the bricks. The longer the curing period, the greater the compressive resistance, because more of the water content of the bricks has time to evaporate. As a result, this process is required to improve the compressive resistance of the bricks, so it must be carried out carefully, and the bricks were dried below Tested temperature (i.e. natural drying type) as shown in Figure and over four time periods (7-11-21-28) days, before the examination process stage.

In this study, the compressive strength of compressed earth blocks made in the laboratory was calculated after seven days, fourteen days, twenty-one days, and twenty-eight days of curing using a device for analyzing and constructing compressed earth blocks, as illustrated in Fig 7

Fig 7: Shows the process of pressing blocks in a device for manufacturing and examining compressed earth blocks

Mineralogical Analysis of Raw Materials using XRD
X-ray diffraction (XRD)
The X-ray diffraction (XRD) instrument was utilized to diagnose and identify mineral components in the current study's samples. Its analysis speed and precision. The investigation was conducted out at the scientific research center -soran university in Erbil Governorate using deflecting X-ray equipment. Table 5 It shows the clay minerals that appeared in the soil of the study area

Table 5: It shows the percentages of presence of clay minerals in samples of the study area

Station	Quartz	Calcite	Enstatite	Kanoite	Zeolite	Clinopyroxene	Colusite	Berlinite	Dolomite	Ferroselite
1	36.6	32.7	30.7	/	/	/	/	/	/	/
2	32.7	31.7	/	31.7	/	/	/	/	/	4
3	28	14	/	/	36	22		/	/	/
4	24.8	26.7	/	/	/	41.6	1	5.9	/	/
5	36	34	25	/	/	/	/	/	/	5

Geochemical tests
Geochemical tests are focused with determining the distribution and spread of the major elements and oxides because they provide vital information on the conditions and environment of deposition and digenetic processes, as well as the geochemical weathering processes that affect the rocks.
In the Kirkuk laboratory, samples of raw materials utilized in the current study were chemically tested in the form of the principal oxides using an X-ray flash (XRF) equipment of the (X-Supreme) type, and the findings are shown in the table 6.

Table 6: Results of chemical analyses of study area Samples

Total SO_3 %	Total soluble Salts %	Organic matter	CL	$Caco_3$	Gypsum $caso_4.H_2o$	Ph	Sample No.
0.36	1.08	0.33	0.004	23.745	0.77	8.34	1
0.45	1.2	0.0133	0.013	23.395	0.97	8.53	2
0.38	1.6	0.14	0.010	24.496	0.817	7.66	3
0.37	1.35	0.09	0.010	23.745	0.817	7.61	4
0.34	1.35	0.43	0.014	24.42	0.73	7.52	5

Conclusions
The current study showed the following conclusions:
- The particle size ratios of the ground materials of the study area were appropriate for the production of compressed earth blocks based on international specifications (ARS 674: 1996, AS-1: 2007)
- The unconfined compressive strength values of compressed earth blocks produced from the soil of the study area are excellent in relation to the specifications of blocks produced by burning.
- The results of the geotechnical and engineering tests conducted on the soil of the study area showed that most of them are suitable for constructing low-cost buildings using compressed earth blocks.
- The results of the geotechnical and engineering tests for the produced compressed earth blocks showed that there is an inverse relationship between the water content and the number of drying days for the brick samples, whereas the curing days increases, the German content of the bricks decreases.
- An inverse relationship between the water content and the compressive strength of compressed earthen bricks, as the earthen brick with the lowest water content achieves the highest compressive strength**.**
- There is a direct relationship between the compressive strength and durability of the compressed earth blocks produced, as the higher the durability of the earth blocks, the better their sustainability.

References

1. ASTM International. ASTM-D.422-63. Standard Test Method for Soil Particle Size Analysis. West Conshohocken, PA: ASTM International; c2004.
2. ASTM International. ASTM D2487-06. Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System). West Conshohocken, PA: ASTM International; c2006.
3. ASTM International. ASTM D4318-14. Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. West Conshohocken, PA: ASTM International; c2014.
4. ASTM International. ASTM D-854; Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer; c2004.
5. ASTM International. ASTM D-422; Standard Test Method for Particle-Size Analysis of Soils; c2004.
6. Al-Rawi YT, Al-Sayyab AS, Al-Jassim JA, Tamar-Agha MY, Al-Samrrai AI, Karim SA, *et al*. New name for some of the Middle Miocene-Pliocene formation of Iraq (Fatha, Injana, Mukdadiya, and Bai Hassan Formation). Geo. Jour. Baghdad, Iraq: Mineral Investigation. 1992;1:1-18.
7. Braja, M Das. Soil Mechanics Laboratory Manual; c1982.
8. Buday T. The Regional Geology of Iraq, Stratigraphy and Paleogeography; c1980.
9. Jassim SZ, Goff JC. Geology of Iraq. Czech Republic: ISBN 80-7028-287-8; c2006.
10. African Organization for Standardization (ARS). African standard of compressed earth blocks. ARS 674:1996, ARS 671; c1996.
11. Jassim SZ, Karim SA, Basi MA, Al-Mubarak M, Munir J. Final report on the stratigraphy, Geosurv.int.ro1447. 1984.
12. AS-1. Standard of compressed earth blocks (Solid Environmental Solution); c2007.
13. Amin, Deriah Abdel Samad. Geotechnical evaluation of recent deposits for the purpose of producing

compressed earth blocks in the Laylan/Kirkuk/Iraq area. Unpublished master's thesis, College of Science, University of Kirkuk; c2018. p. 185.
14. Al-Futuhi ZR, Thabet M, Al-Jassar, SHM, Mustafa M. Engineering Geology and Site Investigation. Mosul, Iraq: Directorate of the Book and Publishing House, University of Mosul; c1989.
15. Al-Mallah IA. The Environmental and Hydrological Changes Resulting from the Operation and using of Iraqs Main Drain. Basrah, Iraq: College of Science, University of Basrah; c2014. p. 15-100.
16. Picard, MD. Classification of Fine-grained Sedimentary Rocks. J. Sed. Pet. 1971;41(1-4):179-195.
17. Fouad SFA. Tectonic map of Iraq, Scale 1:1000 000, 3rd edition, 2012. Iraqi Bulletin of Geology and Mining. 2015;11(1):8.
18. Minke G. Building with Earth, Design and Technology of a Sustainable Architecture. Boston, Basel, Berlin: Birkhauser publishers for architecture; c2006.