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The Unconfined Compressive Strength Properties of the Compressed Stabilized Earth Block

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Abstract

This research is carried out mainly to study the geotechnical properties of the compressed earth block which is produce from Injana's soil samples which were collected from three different locations near Kirkuk governorate. The local soils were blended to make a good soil mixture of gravel 0.09 percent, sand 82 percent and 17.43 percent of fine grain particles for manufacturing compressed earth blocks. The wet soil mixture compacted manually by manual press which is globally known as CINVA-RAM exerting high pressure estimated by 17.2 MPA to produce all soil blocks. Then the blocks were cured for 28 days and tested for unconfined compressive strength and moisture content. Based on the results, it was concluded that the compressive strength increases as the moisture content decrease, in the sense that it is increases as the age of blocks increases, where the highest compressive strength is recorded (55.5) MPA after 28 days of curing.

Keywords: Earth block, Compressive strength, Injana formation, Paris plaster

Introduction

Materials used for the compressed earth blocks production were collected from three different locations near Kirkuk in Shuraw area, since the deposits of Injana formation are widely exposed in the Shorau area in order to examine the compressive strength properties of the blocks and determine the variables that affecting on it. And over the last few centuries, there has been an increasing concern about the use of compressed earth blocks for residential building [1]. Compressed Earth Blocks (CEBs) are one of the building materials that have been developed in most countries around the world, and used as a basic building materials when low cost and environmentally friendly buildings are required, and it is defined as masonry elements mainly made up of raw earth, which are small in size and have regular dimensions and confirmed characteristics that are acquired by static or dynamic pressure of soil in a humid state, followed directly by de-moulding [2]. CEBs owe their cohesion in wet and dry state especially to the clay fraction within the soil, These blocks provide many advantages which make it favourable in comparison with another conventional building material, as it increased the utilization and consumption of local materials, thus generates local economy instead of spending for import materials, reducing the cost of transportation since the production is in situ, which makes quality houses suitable for low income groups [1]. Other merits of these bricks are good strength and thermal insulation properties [3]. As posted that the global [1] interest about the environmental and ecological issues has increased the utilization of (CEBs) for building purposes which it is known as environmentally friendly, as it generates less carbon and consumes less energy during the production phase, as well as (CEBs) have the ability to absorb the moisture from the atmosphere, and thus reducing the rate of evaporation, creating a healthy environment inside building, and that's so important in urban and dry areas.

Study Area and Geological Setting

The studied area is located near Kirkuk in Shorau area (i.e, in the north-eastern part of Kirkuk) which is far (about 10 km) from the city center (Figure 1), geologically the studied area represented by deposits of late-Miocene age, that known as Injana formation, which observed in lowlands of concave folds and in some parts of the high folds. The formation consists of periodic alternating layers of claystone, sandstone and siltstone in sedimentary cycles, and the claystone forms the vast majority of the deposits of this sequence and is characterized by low hardness which break down into small pieces. This unit represent the transition phase of the shallow marine environment to form Fatha to the nearby environment to form Muqdadiya. The formation thickness is very heterogeneous due to the effects of weathering and erosion, which lead to formation of valleys and parallel to the direction of the stratosphere. However, the thickness of Inajana formation in the studied area reaches about 900 m. The sedimentary environment of the formation is return to the delta as a result to the gradual regression of sea water in the middle-Miocene age. The lower contact of the formation is sharp with fatha formation, which indicates that the upper surface of the last limestone layer exposed in the fatha formation represents the lower boundary of the formation.

Methodology

The soil samples used for this work were obtained at three different locations, and this was done after drilling few meters deep from the soil surface to ensure that all organic matter is not included in the sample and then, the samples were dried naturally in the air before all the necessary tests were carried out. The block specimens were prepared from the required quantities of the blended soil of each site, in addition to the mixture of all the soils and in equal proportions with the desired level of water content (10-15%) according to Vroomen [4]. Next, the soil mixture was blended with the recommended content of (15%) of paris plaster (gypsum) with the chemical composition of ($CaSO_4 2H_2O$) in according to Vroomen [4] and Carlos [5] and then, the soil mixture

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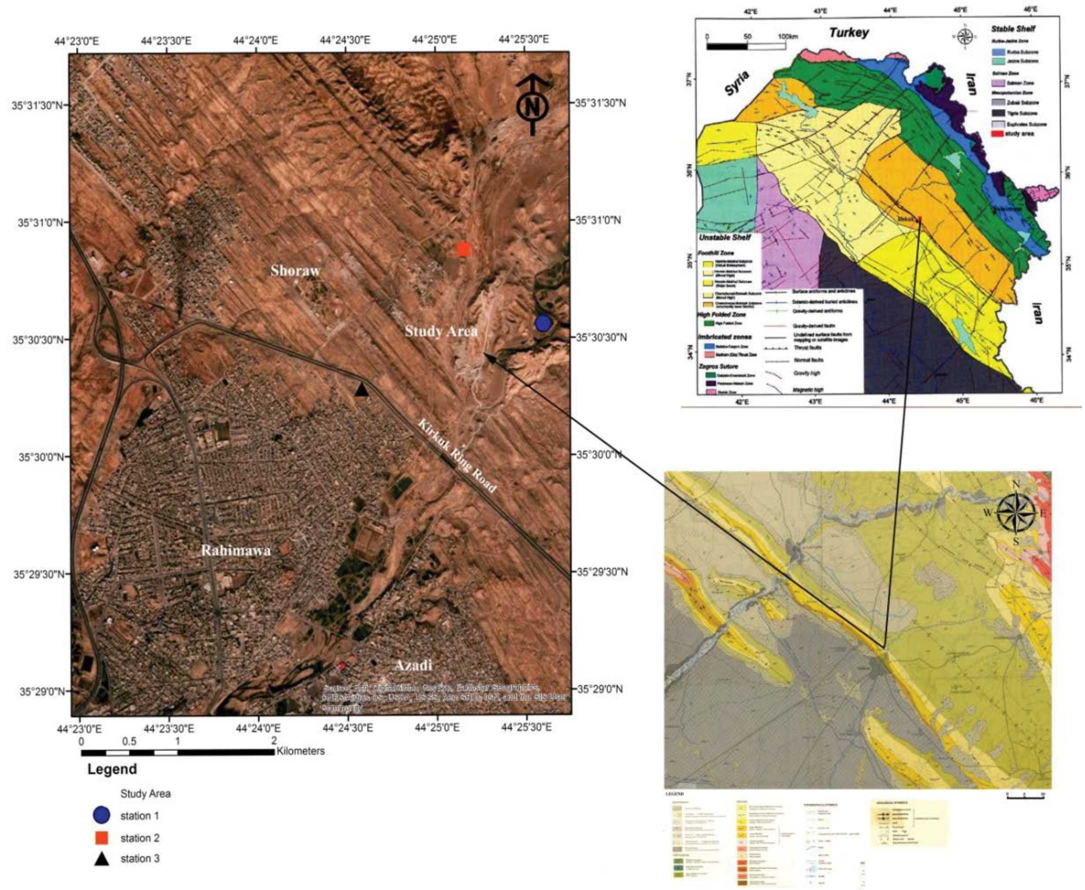

Figure 1: Regional geologic map of northern Iraq, Satellite image shows the Location of the studied area and the tectonic map.

was left for 24 hrs in order to be homogeneous. Then the blocks were moulded manually using the CINVA-RAM machine that's specially designed for (CEB) production as shown in (Figure 2). The machine essentially consists of two parts, the first one includes iron moulds and the second part contains an arm which works with an oil that push out the finished blocks of geometry (9 × 6 × 2.5 cm), then the blocks were cured for 28 days. And since, the compressive strength is so important in the production of (CEB), we tried to make this variable constant in (17.2) MPA in the production of the whole block samples in the current study. Finally the unconfined compressive strength and the moisture content tests were undertaken for the compressed stabilized earth blocks produced from the different soil samples at different curing ages.

Results and Discussion

Unconfined compressive strength

The compressive strength of compressed earth blocks (i.e. the amount of pressure that can resist without collapse) is considered one of the most important mechanical properties, since it's the most universally accepted value for determining the quality of blocks [6]. However, it is intensely related to the soil type, the amount of stabilizers used, as well as it is essentially related with the curing age of the produced blocks [7]. Therefore, we have taken this into consideration when the compressive strength test for the produced blocks were performed, by drying the specimens at different curing ages of (7, 14, 28) days respectively (Table 1). The result for compressive strength against curing ages for three soil samples are presented in Figure 2. The result shows that there is a positive relationship between the two variables (i.e. increasing compressive strength by increasing curing ages), and the highest compressive strength of 55.5 MPA was obtained from sample 2 with 15% content of plaster of Paris at the curing age of 28 days. According to Vroomen [4] the optimum gypsum content is the range of (10-15%).

CEB NO.	Unconfirmed Compressed Strength (MPA)		
	28 Days Curing	14 Days Curing	7 Days Curing
CEB 1	(43-45)	(30-34)	(25-28)
CEB 2	(49-55.5)	(38-43)	(35-36)
CEB 3	(46-54)	(36-37)	(32-35)
CEB 4	(48-52)	(38-40)	(30-37)

Table 1: Results of the average (UCS) for compressed stabilized earth blocks.

Moisture content

Moisture content of compressed earth block is expressed as the percentage of water that fills the voids or pores inside the block. And this percentage depends on the size and distribution of granules of earth materials involved in the formation and manufacture of compressed earth blocks. Moisture content of compressed earth blocks decreases over the time [8] as shown in (Figures 3 & 4), so it is important to determine the rate of moisture content of the compressed earth blocks, since that the high rate of moisture content may cause a swelling of compressed stabilized earth blocks, resulting in the loss of strength with

Figure 2: CINVA-RAM for compressed earth block production.

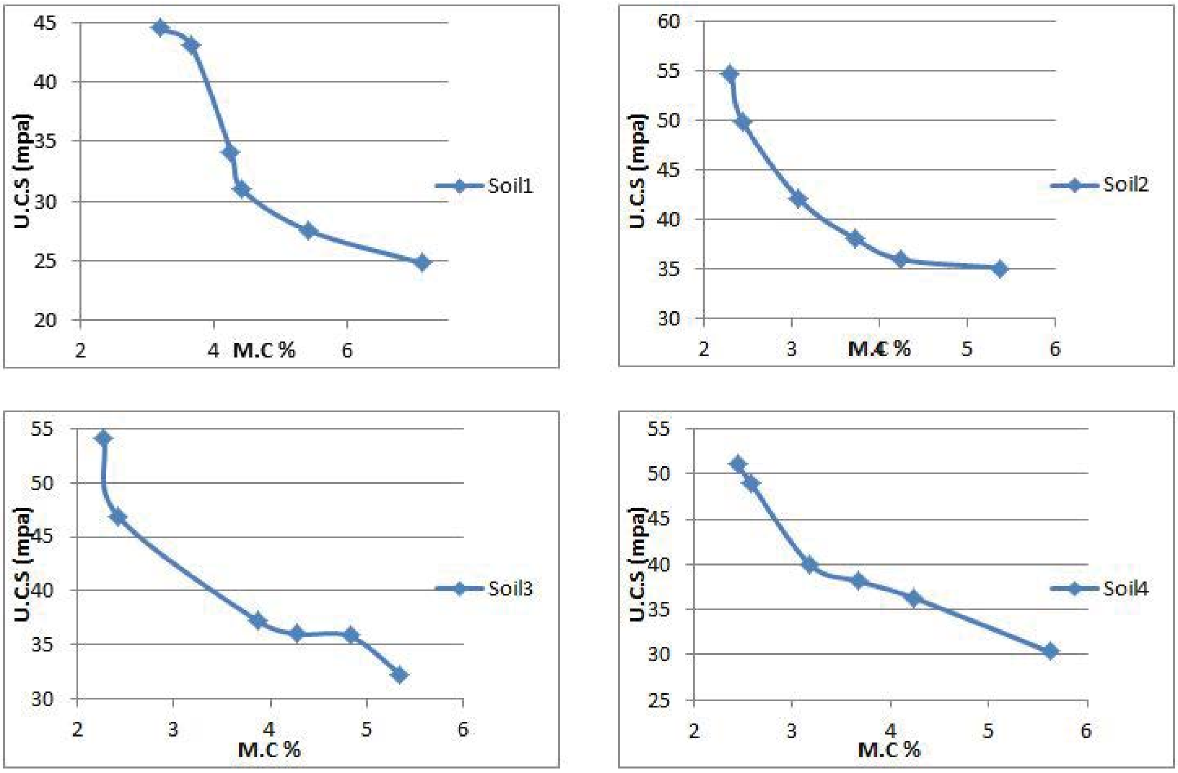

Figure 3: Variations of 28 days unconfined compressive strength with moisture content.

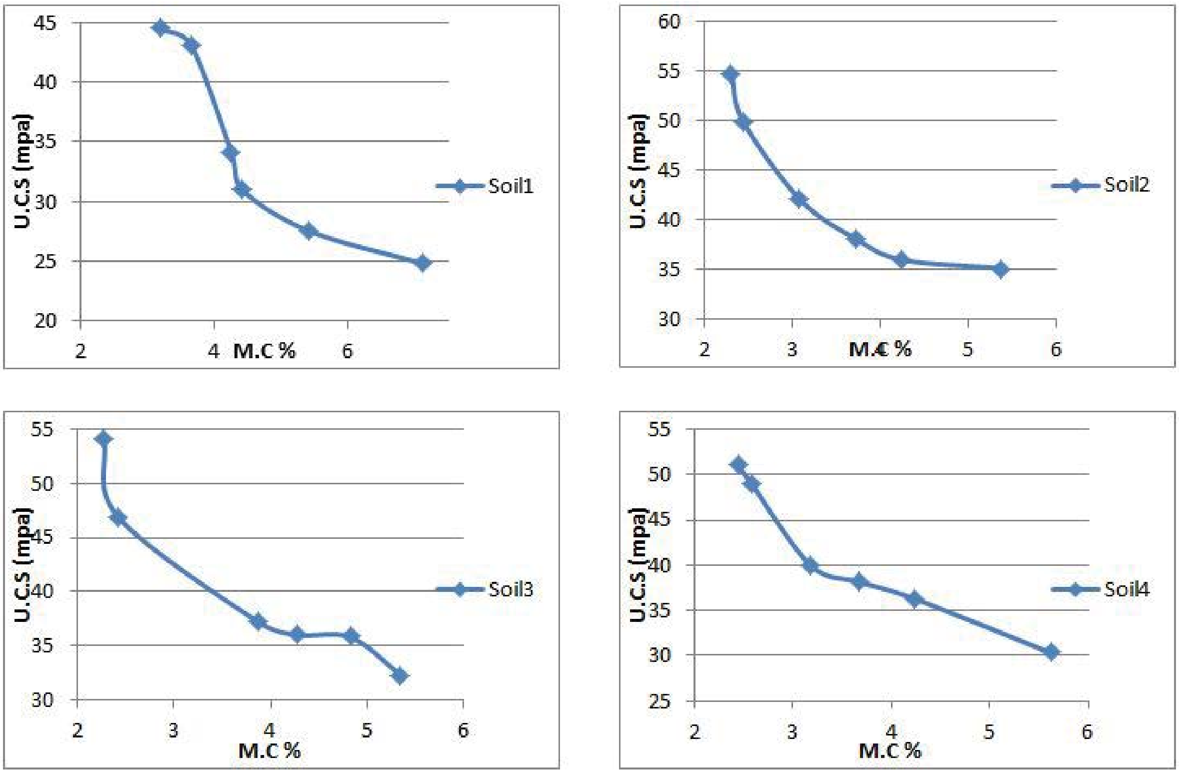

Figure 4: Variations of moisture content over drying days.

time. So, the moisture content of the produced compressed stabilized earth blocks has been calculated after pressing and moulding process due to the loss of a quantity of water content prior to pressing and this was done in accordance with the American specifications (ASTM D 558) mentioned in [8] and so by breaking the dried blocks and weighing it and then, put it in the oven at 150°C for 25 hrs, in order to weigh the dried sample to calculate the percentage of water lost, which represents the moisture content of the block samples.

Conclusions

From the results the following conclusions were drawn:

- The unconfined compressive strength increased by increasing in curing age.
- With the decrease in moisture content, the blocks strength increases and remains more or constant with age.
- The highest compressive strength of 55.5. MPA was achieved with 15% of Paris plaster of sample 2 at the curing age of 28 days.

Whole the samples exhibit acceptable geotechnical properties and are suitable for production of compressed stabilized earth blocks for walling in affordable low cost and environmentally friendly buildings.

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