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IMPROVEMENT OF EXPANSIVE SOIL BY ADDING GEOPOLYMER MATERIAl

A Thesis Submitted to the Council of College of Engineering University of Diyala in Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering

BY

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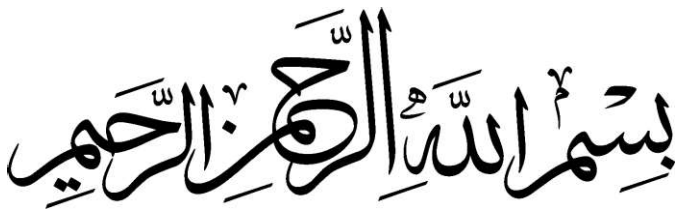

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Dedication

To the one who gave me everything he had to make my dreams come true
My dear father....
To the most precious person in this existence, to the one who came without limits to me, you are the fulfillment of some nights
Dear mother ....
To the one who encouraged me and supported me, my companion Dear husband ....
To whom I comfort myself and my eyes recognize their vision
my brothers and sisters....
To the candles that light my life
my children...
Everyone, who wishes me success in my life,
I dedicate this humble work.

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Improvement of Expansive Soil by Adding Geopolymer Material

ABSTRACT

Expansive soils are soils that have a tendency to undergo significant changes in volume due to variations in moisture content. The volume changes in expansive soils may result in heaving and cracking that lead to infrastructure damages worth several billions of dollars each year all over the world. In recent years, there has been a growing interest in chemical stabilization to treat the engineering characteristics of soil such as swelling, strength, and volume stability. It was used chemical material environmentally friendly, sustainable, and low-cost building materials that originate from various sources it's called Geopolymer. The present work's aim was to study the effect of adding five percentages of Metakaoline based-Geopolymer (MK) to expansive soil (0.3%,1%,2%, 4%, and 6%) with an activator ratio of 20% for the weight of dry soil at curing period (0day,7days, and14days). The expansive soil used in the present work was brought from the Governorate of Al-Anbar /Iraq. A number of laboratory tests have been carried out which were, including one-dimensional consolidation tests, shear strength tests, and physical tests. Additionally, Scanning Electron Microscope (SEM) and X-ray diffraction (XRD)tests were done. The swelling results showed that the addition of MK had an impact on the swelling reduction, which was reduced by about 91% with 4% MK at 14 curing days. Additionally, the optimum moisture content decreased from 23 to 18% with 4% Metakaolin, while the maximum dry density increased from 15.2 kN/m^3 to 16.9 kN/m^3. The peak value of unconfined compressive strength rises to (11) times the original soil for 4% MK with cured for 14 days. Moreover, the results of SEM and XRD illustrate the reaction of the clay with Geopolymer led

to the production of binder particles and the create of cementitious particle from interactions.

Finally, the stabilization of expansive soil with MK was a successful method and gave good results, it can be considered 4 % MK the best percentage of improvement expansive soil.

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List of Symbmbols

Symbol	Meaning
AAS	Alkaline Activator Solution
ASTM	American Society for Testing and Material
C_c	Compression index
CH	High Plasticity Clay
C_s	Compression Index
Cu	Undrained Shear Strength
C_v	Coefficient of consolidation
EI	Expansion Index
G. s	Specific Gravity
log σv	Logarithm scale of effective stress
kPa	Kilo Pascal
LL	Liquid Limits
LS	Liner Shrinkage
MDD	Maximum Dry Density
MK	Metakaolin

OMC	Optimum Moisture Content
PI	Plasticity Index
SEM	Scanning Electron Microscope
S_d	Strength development
SR	Swelling Reduction
Sp	Swelling Potential
UCS	Unconfined Compressive Strength
USCS	Unified Soil Classification System
Wc	Water Content
XRD	X – Ray Diffraction

Chapter One

1.1 Introduction

Generally, swelling soil speared in arid and semiarid regions **(Al-Rawas and Goosen,2006; Mishra et al., 2008)**. The material sources of expansive soils are coming from the weathering processes of different types of rocks like limestone and claystone as illustrated in Figure (1.1), which include a lot of silicate minerals and readily turn into clay minerals such as kaolinite, Illite, and Montmorillonite. Expansive soils have a large amount of the mineral Montmorillonite, which can absorb water molecules that lead to swelling. The Uniform variations in moisture content make expansive soils quite susceptible to expansion or contraction cycles **(Orabi, 1996; Talluri et al.,2013)**. In geotechnical engineering, these periodic changes in size lead to considerable issues to civil infrastructures constructed over this type of soil **(Pedarla et al., 2011).**

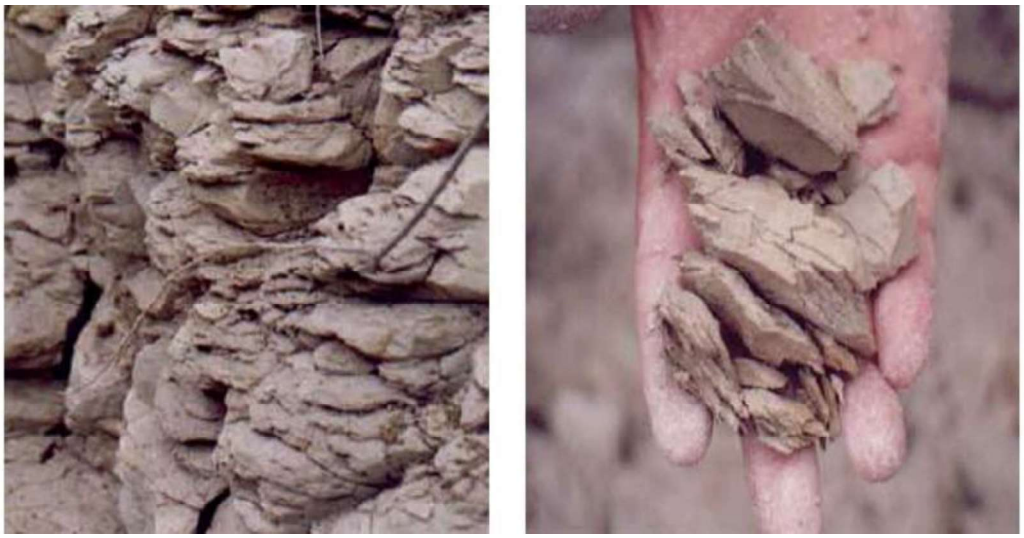

Figure 1.1: Claystone Deposits **(Al-Rawas and Goosen,2006)**

The swell-shrink properties can cause damage to structures on the soil such as; breaking up building foundations, tunnels, pipelines, sidewalks, and underpasses **(Calik and Sadoglu,2014; Pruska and Sedivý ,2015; Das ,2016).** Annual losses are rated between $2 - $9 billion and include intense structural damage **(Jones and Holtz ,1973; Puppala and Cerato,2009; Atahu et al., 2019).** Figure 1.2 shows images of some styles of damage caused by expansive soil of various kinds of structures built on it **(Abbas,2016).**

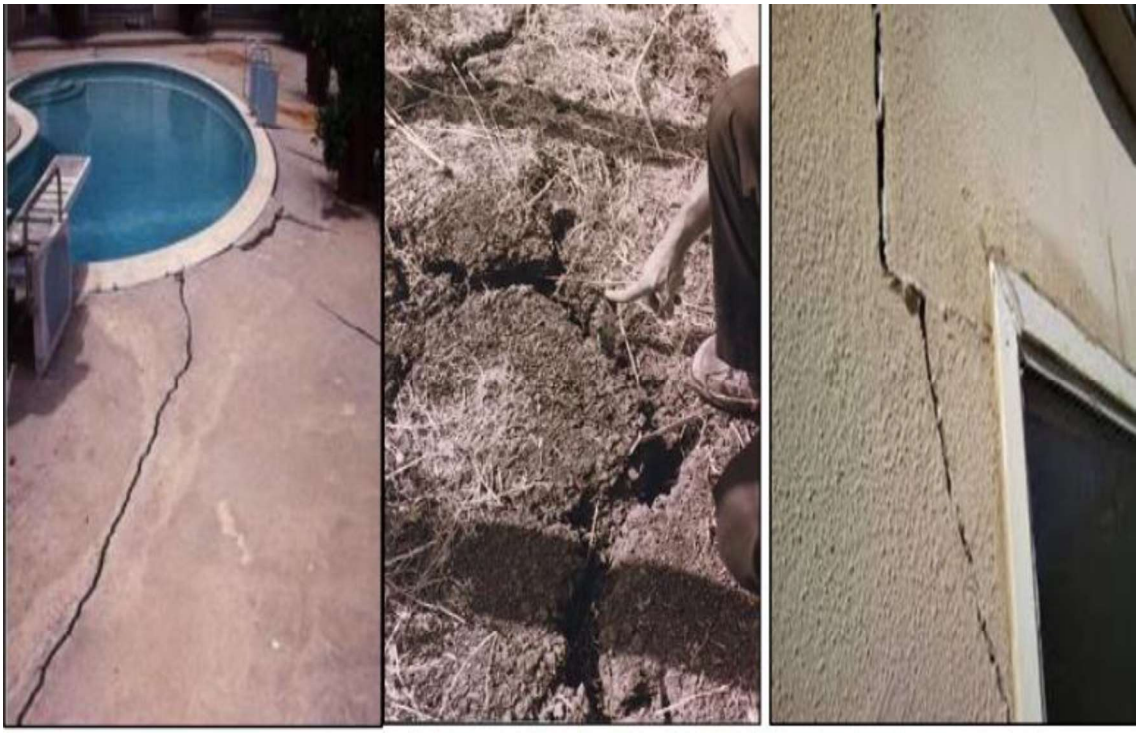

Figure 1.2: The damage of structures and cracks in expansive soil **(Abbas,2016).**

Geotechnical properties of expansive soils are treated by several methods that including prewetting, removal, replacement of soils, and chemical addition **(Sherwood, 1993)**. Therefore, soil improvement when using various stabilizers (such as treatment materials or chemical additives) is an active method to enhance the geotechnical properties of the expansive soil to minimize seasonal fluctuations over some time **(Nelson and Miller ,1992)**.

In recent years, the term sustainability receives increasing attention because a comprehensive sustainability approach involves economic development and environmental protection, therefore the use of binder materials known as (geopolymers) which is more sustainable and environmentally friendly than other stabilizers **(Presti, 2013)**.

1.2 Significance of This Study

Soil enhancement is a key role in civil engineering, in addition to its impact on cost and people's lives, so it is needful to use a new material that is environmentally friendly and low-cost. Many causes prompt the need for such research, such as reducing swell potential and swelling pressure that hence the settlement of structures.

1.3 Problem of the Study

Several techniques have appeared to treat soil such as chemical stabilizers by traditional materials. This is a well-known technique in the field of geotechnical engineering, but these materials are considered unwanted due to gas emissions CO2 for these reasons, a growing interest has arisen lately for low-cost sustainable eco-friendly construction materials known as Geopolymer **(Presti, 2013; Sheen et al., 2014)**

1.4 Aims of the Study

The main aims of the present work are to study the influence of adding the various percent of Metakaolin-based Geopolymer on the performance of expansive soil it can be summarized as follow:

1. Study the influence of adding Metakaoline on swelling potential, swelling pressure, and consolidation.

2. Assess the unconfined compressive strength and undrained shear stress for all treated samples.

3. To analyze the variation of maximum dry unit weight (kN/m3) and optimum moisture content with the addition of Metakaolin for five different dosages.

4. Carry out microstructural tests on treated soils to detect behavior in expansive soils.

5. To estimate linear shrinkage for different percentages of MK for curing periods of three hours of molding.

6. To analyze the results and make essential recommendations for optimum use in the future.

1.5 Layout of the Thesis

The contents of this research work are presented in five chapters as outlined below:

Chapter One: This chapter presents a summary of the swelling soil and its problems also the purpose of this study.

Chapter Two: gives a brief review of the concept of expansive soils and an introduction to geopolymers and their characteristics, as well as their use as soil perfect stabilizers.

Chapter Three: describes in detail the steps of experimental work that consists of physical and mechanical tests performed on control soil and treated soils by metakaolin based geopolymer.

Chapter Four: This chapter includes a presentation of the results of the test conducted and their discussions.

Chapter Five: Includes the summary, findings and conclusions from this study, as well as the necessary recommendations for the future.