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EXPERIMENTAL STUDY OF ELECTRO-OSMOSIS ROLE ON BEHAVIOR A GYPSEOUS SOIL

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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بسم الله الرحمن الرحيم

قَالُواْ سُبْحَانَكَ لاَ عِلْمَ لَنَا إِلاَّ مَا عَلَّمْتَنَا
إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ

صدق الله العلي العظيم

سورة البقرة
(الاية ٣٢)

Dedication

To ...
God, The greatest truth in my life.
My father, who charted my path and supported me .
My mother, the light of my eyes, who supported and gave me strength, the cause of my success.
The candles that light my path, my brother and my sisters.
Our honorable teachers who taught and rewarded us their knowledge.
My close friends and everyone who supported me to complete my thesis in the best form.
Everyone, who wishes me success in my life,

I dedicate this humble work.

Methaq

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"In the name of Allah, the most beneficent, the most merciful"

First praise be to "Allah" who gave me the strength and health to work and enable me to finish this work.

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Thanks are also due to all my friends, for their help throughout my research work .

Finally, my sincere thanks and gratitude to my family, who have the greatest role of support.

Methaq Ali Talib

CERTIFICATION

I certify that this thesis entitled "**Experimental study of Electro-Osmosis Role on Behavior A gypseous Soil** " was prepared by "**Methaq Ali Talib**" under my supervision at the Department of Civil Engineering – College of Engineering- Diyala University in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering.

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Date: / /2021

In view of the available recommendation, I forward this thesis for debate by the examining committee.

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Chairman of the Department of Civil Engineering.

Date: / /2021

COMMITTEE DECISION

We certify that we have read the thesis entitled (**Experimental study of Electro-Osmosis Role on Behavior A gypseous Soil)** and we have examined the student (**Methaq Ali Talib**) in its content and what is related with it, and in our opinion it is adequate as a thesis for the **Degree of Master of Science in Civil Engineering**.

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SCIENTIFIC AMENDMENT

I certify that the thesis entitled **"Experimental study of Electro-Osmosis Role on Behavior A gypseous Soil"** presented by **(Methaq Ali Talib)** has been evaluated scientifically, therefore, it is suitable for debate by examining committee.

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Experimental study of Electro-Osmosis Role on Behavior A gypseous Soil

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Abstract

Actually, the gypseous soil is such type of soil that contains a considerable amount of gypsum which may cause dramatic negative changes in its engineering properties when water vary. More precisely, the problem behind gypsum is the solution ability which dictates caves formation and excessive settlement foundation deteriorations for the civil engineering projects that include this type of soil. The electro osmosis is such technique in which water and other positive charged ions are migrated through application of direct electrical field from the positive anode to the negative cathode. Such application have many successful applications in geotechnical engineering like dewatering, electro grouting, capacity enhancement in pile driving and contaminant retrieval.

The current study investigate the electro osmosis improvement behavior in gypseous soil through implementing an experimental program. Such program includes manufacturing a physical model to represent the foundation load application on a gypseous soil that experiencing a water rise and would be expected to collapse. The soil samples were prepared with dimensions of 30 cm x 30 cm x 25 cm and contained in 30 cm x 30 cm x 30 cm wooden box. This box was put in steel box of 50 cm x 50 cm by 35 cm to confine water. In addition, two soil of 30 % and 60 % gypsum contents were used in current study. Moreover, the role of applied voltage levels, electrodes

type, gypsum content, applied load and foundation dimensions were investigated through this program.

The results showed that the electro osmoses technique may improve the surfaces settlement response for both soils. It is observed that the best voltage level is between 15 and 20 Volt of DC voltage. The maximum reported degree of improvement for 15 Volt was 70 % while in 20 Volt, such level may reach 80 % in some stations within the testing time. Additionally, it is proved that the copper illustrate the best performance among the selected types of electrodes and about 78 % degree of settlement improve.

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k_e	The electro-osmosis permeability
kh	Hydraulic Permeability
C	Cohesion of soil
C.P.%	Collapse potential of gypseous soil
Cc	Coefficient of curvature
Cu	Coefficient of uniformity
D_{10}	Grain size at 10% passing
D_{30}	Grain size at 30% passing
D_{60}	Grain size at 60% passing
Dr	Relative density of soil
e	Void ratio
e_o	initial void ratio
G.C%	Gypseus content of soil%
Gs	Specific gravity
Ø	Angle of internal friction of soil
$\boldsymbol{\gamma}$d	Density of the soil in its natural state field value
Wc %	Water content of soil
L.L.	Liquid limit
P.L	Plastic limit
T.S.S	Total soluble salts
O.M.C.	Optimum moisture content
O.M.	Organic matters
S1	Soil one with 30% gypsum content
S2	Soil two with 60% gypsum content
USCS	Unified Soil Classification System

CHAPTER ONE
INTRODUCTION

1.1 General

In general, soil improvement techniques are the procedures that can be followed by geotechnical engineers to enhance the properties or behavior of soils that inherently have a considerable lack problem in its performance such as of gypseous soil .

gypseous soils are soils which have enough gypsum content to change or affect thier engineering properties. Gypsum (calcium sulphate dehydrate) is one of the moderately soluble salts that can have a detrimental effect on buildings, pavements, and earth structures. Gypsum dissolves with water and may produces caves and progressive settlements, acceleratin seepage flows and the accompanying deterioration of foundations (Subhi, 1987).

In addition, Gypseous soils are disturbuted in many regions around the world, especially in arid and semi-arid regions, where the annual quantity of rainfall is insufficient for leaching the gypsum form these soils (Al-Emami, 2007).

The gypseous soil is strong when it is dry, but loses its strength when exposed to water causing collapse and distortions, many attempts such as (field an laboratory investigations) have been made to understand the behavior and the characteristics of these soils due to problems detected when construction on such soils (Mansour et al., 2008)

There are many techniques used to improve gypseous soil properties, one of these electrical field (Electro-osmotic consolidation)

is a technique in which the pore water is migrated from anode under in the electric field of the existing soil. Such promising technique may be considered a good alternative to treat problematic soils and it is used in many applications like excavations, slopes / embankment stabilization, pile capacity increasing, strength of clays, dewatering sludge / tailings and controlling groundwater flow (Hu et al., 2013).

This study is trying to investigate and improve gypseous soil by using electro osmoses technique. Two gypseous soils were used as in this studyof percentages of gypsum (30 % and 60%).

1.2 Collapse of Gypseous Soil

Structures built on gypseous soils suffer from serious of engineering problems such as cracks or tilt, and sometimes may fall down (Al-Obaydi, 1992). The main problem of gypseous soils is that moving water, unsaturated with gypsum, can cause leaching of gypseous soils leading to the formation of serious cavities. The rise in groundwater table can cause serious softening resulting in the loss of shear strength and increase in settlement. The wetting or saturation of gypseous soil during the lifetime of structurse can cause a sudden settlement due to collapse (Razouki et. al., 1994). Civil engineers often face severe problems when constructing hydraulic structures on gypseous soils. Failure by excessive leakage may take place because of defects in structural arrangements of the underlying strata if they contain gypsum, which dissolves when exposed to speeding water.

In Iraq, many constructions have been built upon gypseous soils. As a result, there is a lot of damage threatening these constructions, as presented by (Razouki et. al., 1994). Moreover, the different structures that are built on the gypseous soils are failing in other places such as Tikrit training center, Samarra tourist hotel, Tikrit water tank,

Habbanya tourist avillage (Nashat, 1990; Razouki et al, 1994; Al.Mufty, 1997). furthermore, many cracks are viewed in runway of the Air force college (Al-Neami, 2000).

For the first glance, these types of soils should be avoided as much as possible in civil engineering projects, but in some cases, construction of buildings, highways and other structures may be dictated to be done over such type of soils.

1.3 Electro – Osmosis Technique

Electro osmosis is the process of water and other positive charged ion moving through application of direct electrical field from the positive anode to the negative cathode area. Such idea has many successful applications in geotechnical engineering like dewatering, electro grouting, capacity enhancement in pile driving and contaminant retrieval (Nichloson, 2015).

More precisely, some soils particles (like clay) have a negative charge due to thier chemical composition and / or the inherent physical nature. The result is that particles attract positive water dipolar molecules and other cations to form diffuse double layer. The application of electrical current is done with low electric potation by insertion of two conductive metal electrode rods, one is the positive terminal (Anode) and the other is the negative (Cathode) as shown in Figure (1.1). the result is that any free or loose water molecules will be drawn by the current towards the cathode to be removed usually by dewatering process. As a consequence, the water content of soil will be less and the mechanical strength / consolidation behavior will be improved.

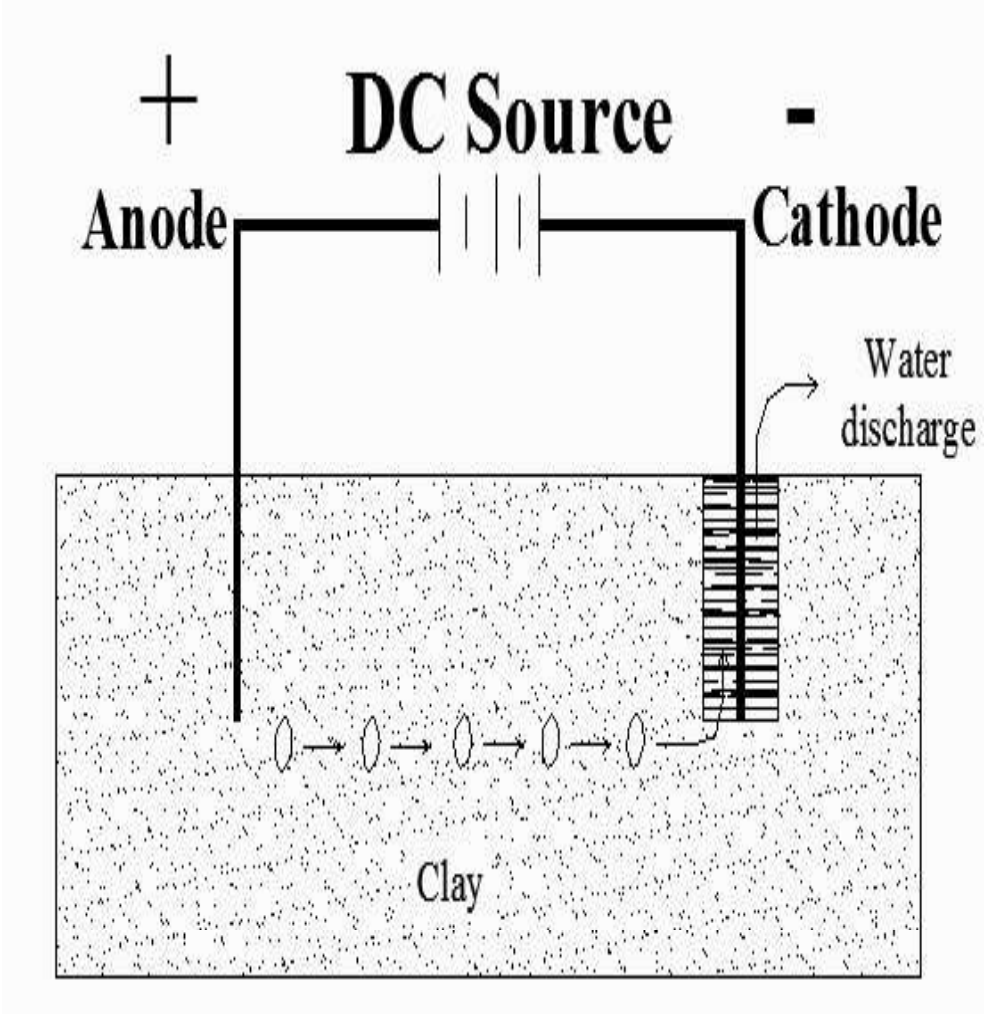

Figure (1.1) Electro osmosis scheme (after Nichloson, 2015)

1.4 Factors Affecting Electro – Osmosis Process

In general, the application of electrical current and the relevant water flow through porous media involves usually a number of variables including (Nichloson, 2015), the horizontal coefficient of hydraulic conductivity of the existing medium (soil), The applied electric potential (Voltage), The coefficient of electro osmotic permeability, Ionic content of pore water, The activity of soil which is related to soil particles ability to interchange the attracting ions and levels of the existing water content.

1.5 Problem Statement

As a matter of fact, although electro osmosis is a promising effective, fast and sustainable alternative to the common soil improvement techniques for soils but it is expensive in this time , the case histories of such field indicates that the laboratory experience regarding the key elements of this application cannot be extended to the full scaled field directly. There for, this study is an attempt to improve the knowledge about electro osmosis consolidation by implementing an experimental program.

In fact, it is highly recognized throughout the literature that there is a considerable lack of information about the electro hydro mechanical behavior of gypseous soils. Therefore, there is a need for a framework to integrate a view of knowledge about such type of soils with reliable experimental data.

1.6 Objectives of the Study

This study aims to understand the electro osmosis efficiency and the electro mechanical behavior of gypseous soils. The following are the specific objectives of the current study which are proposed to do such aims:

1. To study and investigate the behavior of gypsious soils within electric field .
2. To predict the effect of electro osmosis method on two different percentages of gypsious soils using different materials of anode and cathode electrodes.
3. To study the effect of the role of the voltage levels, the type of electrodes used, the gypsum content, the applied loads and the effect of the foundation dimensions when applying the electric field.

1.7 Thesis Layout

The general layout of this study consists of five chapters as explained below:

Chapter one: Presents a brief introduction of the problem and Electro osmosis demonstrating, aim and objectives of the study.

Chapter Two: Presents a background about electro osmoses history depending up on the literature review of the recent studies.

Chapter Three: Presents the experimental program of the current stuy.

Chapter Four: Shows the presentation of results recorded in this study and a brief discussion.

Chapter Five: Contains the conclusions and recommendations based on testing results.