Ministry of Higher Education
and Scientific Research
University of Diyala
College of Engineering

RELATIONSHIP BETWEEN VOID RATIO AND PERMEABILITY FOR GYPSEOUS SOIL UNDER DYNAMIC LOAD

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

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February, 2018 IRAQ Jumada al-Thani-1439

بسم الله الرحمن الرحيم

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

صدق الله العظيم

سورة البقرة(32)

Acknowledgments

"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.

I would like to express my sincere thanks to my supervisor Assist. Prof. Dr. Waad A. Zakaria and Dr. Qasem A. Al-Janabe whose valuable advice, guidance, constructive criticism, cooperation and giving generously of their expansive time when help was needed through out the preparation of this study. I am greatly indebted to them.

Appreciation and thanks are also extended to the all staff of Civil engineering department, and the staff of Soil mechanics Laboratory.

Thanks are also due to all my friends, for their kindest help.

Finally, I would like to express my love and respect to my parents, my family, My brother, My sister, no word can express my gratitude to them.

Othman M. Ibrahem Al-Zuhairy

COMMITTEE DECISION

We certify that we have read the thesis entitled **(Relationship between Void Ratio and Permeability for Gypseous Soil under Dynamic Load)** and we have examined the student **(Othman Mohammed Ibrahem)** 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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I certify that the thesis entitled **"Relationship between Void Ratio and Permeability for Gypseous Soil under Dynamic Load"** was prepared by **"Othman Mohamed Ibrahem"** under my supervision at the Department of Civil Engineering-College of Engineering-Diyala University in a partial fulfillment of the Requirements for the Degree of **Master of Science in Civil Engineering.**

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SCIENTIFIC AMENDMENT

I certify that this thesis entitled "**Relationship between Void Ratio and Permeability for Gypseous Soil under Dynamic Load**" presented by **"Othman Mohamed Ibrahem"** has been evaluated scientifically, therefore, it is suitable for debate by examining committee.

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ABSTRACT

Relationship between Void Ratio and Permeability for Gypseous Soil under Dynamic Load

By

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The behavior of Gypseous soil under different frequencies encountered during a dynamic loading events like machine foundation, impact, explosions, seismic activity is very difficult to analyze, thus an attempt has been made to study the behavior of this type of soils subjected to dynamic loading.

In this research a parametric study is carried out to investigate the effect of applying a vibrated loading during leaching process. The work is carried out by using an experimental model, designed and manufactured for this purpose. Two representative samples of gypseous soil which contain different gypsum contents with (65%, 46%) are brought from a local source in Salah-Aldeen governorate, in north of Iraq.

The main objective of this research is to investigate the change in permeability of the samples with time (leaching), associated strains, dissolved salts and investigate the relationship between void ratio and the coefficient of permeability under static loading. Then after investigate these parameters under effect of wide range of vibrated loading to compare the results obtained with static state. Also the basic characteristics of vibrated loading have been measured during tests. They include, displacement amplitude, acceleration of motion, magnitude of dynamic force applied, and damping ratio.

The results show that some frequencies of loading have a slight effect in permeability by increasing with percentage not exceeding 10 % from original value. While there is a set of frequencies produce a significant

increasing in permeability coefficient by magnitude exceeds nearly (30%) for the first sample and (45 %) for the second. As a result, the rate of dissolution is increased during process due to increase in volume of water collected. But the high frequencies have a different effect on permeability, where it has led to a significantly decreasing in its value. The change in this coefficient depends mainly on basic characteristics of vibration, which are, displacement amplitude, acceleration, and amount of dynamic force applied.

Also the test results show that the vibrated loading leads to dangerous collapse, which increases strongly with increasing of frequency of loading. The collapse resulting from this loading reaches to 200 %, 210% from the soaking collapse for the two samples (S1, S2) respectively.

The damping ratio calculation is performed according to bandwidth method for the system. The results show that the damping ratio for the first sample is greater than second sample. Also tests are carried to evaluate the wall reflective characteristics of the test container and to assess the isolating property of the rubber isolator which is used as absorbing layer. The results indicate that there are a significant effect on the settlement occur due to wall reflectance when the test is conducted without using absorbing layer in model test. The reduction factor in value of settlement due to using the absorbing layer is ranged between (15 - 28) % for frequencies of vibrated loading between (30 - 100) Hertz.

Finally from the results, the relation between coefficient of permeability and void ratio is plotted with complex relation, the initially part of curve refers to increasing the permeability with decreasing of calculated void ratio, but the last part shows that the decreasing in void ratio led to decreasing in permeability of the soil samples.

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C.P.	Collapse potential
I.e	Collapse potential according to ASTM D5333, (2003).
e_o	Natural void ratio.
G.C.	Gypsum content
ϕ	angle of friction
c	Cohesion
Cc	compression index
Cr	rebound index
ε_v	volumetric strain
k	coefficient of permeability
i	Hydraulic gradient
Gs	Specific Gravity
Dr	Relative Density
γd	Density of the soil in its natural state field value
χ	Gypsum content
m_e	Rotating mass
ω_o	circular frequency of the system
e	eccentric distance of the rotating mass
TDS	Total Dissolved Salts
Az	vertical amplitude
USCS	Unified Soil Classification System
L.L.	Liquid limit
P.L.	Plastic limit
O.M.C.	Optimum moisture content
T.S.S.	Total soluble salts
O.M.	Organic matters

CHAPTER ONE

INTRODUCTION

1.1 General

Many parts of the world are suffering from many common soil problem, it is the presence of gypsum in soils. Its deposits possibly existing in shape of ($CaSO_4.2H_2O$) or anhydrate ($CaSO_4$). Many areas in countries such as Australia, Europe and Argentina are covered by gypseous soil, these soils occupy approximately 1.5 % of the total area of the world, and this ratio represent nearly 186 million ha. (FAO, 1998).

In Iraq, gypseous soil also found in considerable amount, huge area of land is covered by gypseous soil. These areas are valued to be about 30% of complete areas concentrated mainly in the west desert and extending to the southern parts and directed towards south west. (Al- Saoudi, et al., 2013).

Construction on gypseous soils may cause numerous engineering problems. The main reason of these problems is the softening of the existing gypsum when these soil are moistened. Theses soils may be exist in dry and semi-dry areas, in such regions, the annual amount of precipitation is insufficient to dissolve the gypsum present in these soils, (Pitrukhin and Boldyreve, 1978).

1.2 Gypseous Soil

Because of the complex and unpredictable behavior of this type of soil, it is classify as one of the collapsible soils. This is because that the gypsum existent among particles usually acts as cementing agent that strengthening the particles with each other. At moistening, the existing soil skeleton are missing progressively producing the breakdown problem.

The gypseous soils are commonly firm when they are dry, it reveal great bearing capacity, very low compressibility, but high reduction of volume, bearing capacity and rapid change in compressibility happen at any change in moisture content, (Dudly, 1970; Clemence and Finbarr, 1981).

Behavior of gypseous soil in the laboratory depends on whether the soil is originally gypseous or prepared in the laboratory, and whether the samples are disturbed, undisturbed or compacted. Also the gypsum content, coefficient of permeability, void ratio, and initial water content, have essential roles in the engineering behavior of such soils, (Al-Mufty, 1997).

1.3 Problems with Gypseous Soils

Existence of gypsum under foundations of structures consider the greatest difficult which is possible to encounter the specialist, because of its damaging effects, particularly when environmental fluctuations in saturation condition, (Nashat, 1990).

In fact, the main problem of gypseous soil is solubility of gypsum. This problem becomes more complicated due to increasing of water table or existence of hydraulic gradient producing percolating and migration of gypsum, also to dissolution, and decreasing in soil mass is take place. This produce a continual breakdown in the gypseous soil (Al-Mufty, 1997). The dissolution of gypsum out of soil causing damage to the physical and engineering characteristics of the soil, in addition to huge deformation, (Mikheev et al., 1973).

Significant difficulties have been observed when a foundations are erected on areas containing such soils in Iraq, such as gypsum dissolution in the foundation of Mousil dam has caused undesirable leakage (Nashat,1990), problems due to leaching of gypsum in Mendeli irrigation projects, and south Al-Jazirah irrigation project. Failure of different structures constructed on gypseous soils in another locations were recorded such as Samarra tourist hotel, Tikrit training center, Tikrit water storage tank, Kerbala elevated water tank, Dujail communication center and Habbaniyah tourist village, (Sirwan et al., 1989). Damages produced via gypseous soils have been investigated in numerous regions around the world in addition to Iraq, such as Arabian Peninsula, Russia, USA, and Spain.

1.4 Dynamic Loading

The behavior of soils subjected to dynamic loading is more problematic than static loading, so problems arise when a genuine simulation of site condition is necessary to be investigated. There are many activities can be classified as a sources of dynamic loading.

Seismic activity, explosions, traffic and rail, and machine foundation are considered as a main causative of vibrations which transfer through soil. Most of essential engineering characteristics of soil, such as void ratio, permeability, density, shear strength parameters, are liable to vary when exposed to vibration, (Barkan, 1960). There is a great importance for studying the effect of vibrated loading on basic properties of soil. Because that these basic properties are important to the geotechnical engineer in designing most of civil engineering projects, such as building foundation, dams, evaluating the stability of slopes, and determining the safety of these earth masses against failure.

In many cases, the soil that are stable under static load, fails when exposed to dynamic load. Huge number of structures have variable loads, for example pumping stations, turbines, towers, roadways and pipelines on or underground surface. Therefore the foundation and underbeneath soils are exposed to wide range of dynamic loading through different frequencies which are influenced by the nature of the structure. State of loading may possibly differ from large number of cycle with small strain amplitude in the state of vibration due to machine, to comparatively a small number of cyclic of huge strain amplitude in the case of seismic activities (Silver and Seed, 1971).

1.5 Objectives of Study

This work aims to research the effect of dynamic loading on behavior of gypseous soil during leaching. In this research a parametric study is carried out to investigate the effect of applying a wide range of frequencies of vibrated loading on two samples of gypseous soil with different gypsum content, during leaching process.

The main objective of this research is to investigate the permeability of the two samples with time (leaching), associated strains, dissolved salts and investigate the relationship between void ratio and the coefficient of permeability under static loading. Then investigate these parameters under effect of wide range of vibrated loading and compare the results obtained of two states.

1.6 Significant of the Study

A review of previous studies about behavior of gypseous soil revealed that most of them investigated this behavior under one dimensional static loading condition. But none of these studies investigated this behavior under the effect of any form of dynamic loading state. In addition, the fact that many of gypseous soil regions are opened up to industrial development, or may exposed to earth quack. It has become essential to study in depth the properties, behavior of such soils under different conditions. Due to the lack in research on this topic. Thus, this study will be an attempt to study the nature of this behavior under this type of loading.

1.7 Layout of Study

This thesis consists of five chapters. Chapter one presents a brief introduction and general information about gypseous soils and the target of the present study.

Chapter two covers a brief review of the available literature related to the gypseous soils. This include the properties of gypsum, influence of gypsum on engineering characteristics of soil. This chapter also presents a review about previous studies that deals with effect of harmonic vertical vibration on the soil.

Details of laboratory program that consists of conventional tests are covered in chapter three, also it contains a detailed description of the tests model manufactured to accomplish the work and the procedure for the testing program.

Chapter four includes presentation of test results and their discussions. Summary of the main conclusions and recommendations for future work are covered in chapter five.