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Predicting the Settlement of Gypseous Soil Using Artificial Intelligence Techiniques

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 (Geotechnical Engineering)

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بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

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Dedication

To whom was her prayer the secret of my success, my mother.

To my biggest supporter, who keeps saying "I am proud of you" to my father.

To the one who always supported and encouraged me, my husband.

To those who supported me in times of need, my brothers and sisters.

To those who are not stingy with knowledge and kind words, my dear teachers.

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Abstract

The problem of estimating the settlement of the shallow foundation on the gypseous soil is very complex and not fully entirely understood. many methods have been developed to predict the settlement of the isolated and strip foundations. However, methods for such prediction that have the required degree of accuracy and consistency. In this study several artificial intelligent modeling method were applied, deep neural network (DNN), artificial neural network (ANN), support vector regression (SVR), and linear regression (LR). The parameters of predict shallow footing settlement are selected carefully based on previous studies. These were footing geometry, D_f/B ratio, gypseous soil properties like water content, gypsum content, dry unit weight, cohesion, angle of internal friction, and time of testing. effect of the adopted parameters on the prediction ability of the surface settlement like D_f\B, footing geometry, load, and time of testing. It is significant that they have assumed effect on the prediction ability of the surface settlement of the shallow foundation. A back propagation typed neural network was used in this study, where four artificial intelligent models has been adopted in this study, deep neural network model showed the most significant performance among the other model with the least mean absolute error and mean square error which were 2.9% and 3.87%. Deep neural network model recorded the highest coefficient of efficiency and variance account.

It has concluded that deep neural network model can be used to predict the settlement of the shallow foundation on a gypseous soil.

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LIST OF ABBREVAITIONS

Abbreviation	Term
G.C	Gypsum content
Wc	Water content
C	Cohesion
Ø	Angle friction
P	Applied load
T	Time
AI	Artificial intelligent
ANN	Artificial neural network
DNN	Deep neural network
SVM	Support vector machine
SVR	Support vector regression
LR	Linear regression
CE	coefficient of efficiency
VAF	variance account for
Cp	collapse potential
Δe	change in void ratio
eo	initial void ratio
Ij	activation level of unit j
Wij	the weight that binds between unit i and j
Θj	bias for unit j
Yj	value of output for unit j
f(Ij)	transfer function

Chapter One

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Gypsum soil is the soil that can collapse, causing major deformations in the buildings constructed on it. The term gypsum soil ($CaSO_4.2H_2O$) refers to the soil that contains gypsum in its components where the content of gypsum is more than the content of the soil (Ahmed,K.I, 2013). From the point of view of geotechnical engineering, gypsum soil can be defined when it contains a sufficient percentage of gypsum that can change the properties of the soil, (Ahmed & Ugai, 2011). Fact, gypsum soil is hard and dry, however, it loses its hardness and is compressible when wet.

Collapsible gypseous soil is unsaturated soils which shows the potential for large deformations and a complete change to the whole particle structure after wetting, with or without loading (Aswed et al., 2010). These soils are characterized by loose structures composed of silt to fine-sand-size particles. Considerable studies were dedicated to investigate the geotechnical characteristics of the gypseous soil (mohammed et al., 2019), (Al-Hadidi & Ibrahim, 2018), and (Alsafi et al., 2017).

The design of shallow foundations on the gypseous soil subject to undrained centric vertical loading is a routine task for the geotechnical engineering profession. To satisfy the ultimate limit state, the designer is required to ensure that applied loads remain far from the ultimate bearing capacity of the foundation (Nareeman, 2012). Design for the serviceability limit state requires that settlement of the foundation under working loads will be small enough to ensure satisfactory performance of the structure it supports. Foundation design therefore requires an ability to predict both the ultimate bearing capacity and settlements under working loads. many methods have been developed to predict the settlement of foundations on

loose soil (Mola-Abasi & Eslami, 2019). However, the methods for making such predictions have not been developed with of accuracy. Accurate predict of foundation settlement is essential as it is the one that controls the design of the foundations. Artificial intelligent is a useful techniques and may be suitable for this purpose.at the moment, this technique is being utilized successfully in a wide domain of the geotechnical engineering applications, (Raid et al., 2019).

Examples, it has been used in the prediction of the bearing capacity of footings and pile foundations and its settlement. Several investigators have utilized the artificial neural network in predicting the liquefaction potential of soils such as (Mola-Abasi et al., 2020), (Ardakani & Kordnaeij, 2017). Also, Artificial Neural Networks have been utilized with highly efficient in predicting compaction parameters, and in the estimation of the suction capacity (Eslami & Gholami, 2019). Moreover, the ANNs have been used successfully in the mapping of the soil layers. Therefore, this study was an early attempt to predict the settlement of the shallow foundation on gypseous soil using the artificial intelligence (AI) as linear Regression, support vector regression model, artificial neural network model, deep neural network model.

1.2 Research Problems and Justifications

Gypseous soil would prove problematic geotechnical engineering properties because they expand, collapse, disperse, undergo excessive settlement, has a distinct lack of strength, or are soluble (Al- Obaidi, 2015). Such characteristics may be attributable to their composition, pore fluids' nature, mineralogy, or fabric. The settlement quantity depends on the type of soil and on the amount of load applied. Generally, any soil under the load will settlement . However, after a certain time, such settlement will cease. However, in some types of soils, such as gypseous soil, which has a

metastable structure and its particles are bonded together by dissolvable minerals and with or without a small amount of clay. These soils are fairly strong when they are in the dry state (Bhamidipati, 2016).

However, when exposed to more wetting, the excess water will weaken or damage the bonds, causing shear failure and consequently an additional settlement. The problem of estimating the settlement of shallow foundations on gypseous soils is very complex and not yet entirely understood (Livneh, 2019). It can be attributed to the uncertainty associated with the factors that affect the magnitude of this settlement. Among these factors are the distribution of applied stress, the stress–strain history of the soil, soil compressibility, and the difficulty in obtaining undisturbed samples of gypseous soil (Tarawneh et al., 2017). Predicting the settlement of gypseous soil using AI appeared to be a viable solution since it has been successfully used in numerous applications in Geotechnical engineering.

1.3 Problem Statement

Covering many areas in Iraq, soils contain different types of gypsum percentage in their components depending on the amount of gypsum when the moist is present, the behavior and these soils' properties will be altered or influenced. Many problems such as loss of strength, increase in compressibility and precipitation may arise when building construction is carried out on these soils. Although there are many studies that have been conducted on this soil, but many and comprehensive studies are still needed to describe the behavior and characteristics of this soil in this research. Large database of files measured adjustments is used to develop and validate AI models.

1.4 Research Aims and Objectives

This study attempted to predict shallow foundations' surface settlement as isolated and strip foundations constructed gypseous soil. Using artificial intelligent (AI). To achieve this aim, the objectives of this study are addressed accordingly:

Building and validating the artificial neural model equations to compute the surface settlement of the shallow foundation on a gypseous soil as Linear Regression, SVR Model, ANN Model, DNN Model. Python programming language was used to build the code of the software.

Objectives:-

1- To valid the results accuracy by using mean square error and mean absolute error approaches as the performance indices.
2- To evaluate the benefits and limitations of the techniques used as a practical method for predicting the settlement behavior of surface foundations.
3- Conduct an analysis of the parameter used to build artificial intelligence models and identify their impact on the expected settlement of gypsum soil.
4- The factors that have been relied upon in the research are factors related to the foundation, such as dimension, applied load, in the addition to soil properties such as angle friction, cohesion, dry unit weight.

1.5 Dissertation Outlines

Chapter One

It exhibits the research introduction, problem statement research aims and objectives, research hypothesis.

Chapter Two

It exhibits the literature review on the effect of gypsum on the soil properties, Geotechnical properties of the gypseous soil, and the load settlement of the shallow foundation. The previous studies on artificial intelligent techniques were reviewed within the scope of geotechnical engineering.

Chapter Three

It involves historical data collection on the soil properties, soil stratum depth, and foundation dimension. Detailed explanations of the artificial intelligence technique used in this study was illustrated in this chapter.

Chapter Four

This chapter involved choosing the python language, selecting the types of models, and developing the models as linear regression, SVR Model, ANN Model, DNN Model. Furthermore, models for execution and training cycles was explained in this chapter.

Chapter Five

Conclusions based on the findings of this study were listed in this chapter. Future recommendations were also included.