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Behavior of Single Pile Subjected to Dynamic Loading in Gypseous Soil

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

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بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ

﴿ وَقُلِ اعْمَلُوا فَسَيَرَى اللَّهُ عَمَلَكُمْ
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تَعْمَلُونَ ﴾

صدق الله العلي العظيم (التوبة 105)

Dedication

To my ideal life…………….. my father
To the light of my eyes....... my mother
To the candles that light my path… my brother and my sisters
To everyone who supported me to complete my thesis in the best form

Noor

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In the name of God, the Most Gracious, the Most Merciful, and prayers and peace be upon our Prophet Muhammad. I thank God who gave me the strength to complete my work.

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Noor D. Abd Al-tamimi

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We certify that we have read the thesis entitled (**Behavior of single pile subjected to dynamic loading in gypseous soil**) and we have examined the student (**Noor Deia Abd**) 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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Abstract

Behavior of Single Pile Subjected to Dynamic Loading in Gypseous Soil

By

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In this thesis, the dynamic response of single pile with a static load is studied under the dynamic load that were generated by use of an electric rotary motor with eccentric loading installed above cap pile, the tests are performed under dry and soaked states.

Many parameters are taken into consideration, including slenderness ratio (L/D) 12, 17, 22, 27 for solid steel pile with frequency 10 Hz and gypsum content 30%, different frequencies 10, 15, 20, 25 for solid steel pile with (L/D) 27, gypsum content 65% for solid steel pile, also (L/D) 27 and frequency 10 Hz, types of pile (concrete pile, hollow steel pile, rough steel pile, timber pile) with (L/D) 27 and frequency 10 Hz in all tests.

The results of the tests showed that the velocity of vibration, acceleration of pile, displacement amplitude and settlement decrease with an increase in slenderness ratio and decrease in soaked soil compared to the corresponding values in dry soil where velocity decreased when increasing the slenderness ratio from 12 to 27 in the dry and soaked states by 78.2% and 77.2% respectively. Acceleration decreased by 84% and 80%, respectively, while the displacement amplitude decreased by 66.67% and 61.4%, respectively. As well, settlement decreased by 31.25%.

The tests also showed that the velocity of vibration, acceleration, displacement amplitude of the solid steel pile with L/D 27 constant in all tests increased with increasing the frequency of the vibration source as the velocity decreased when the frequency is reduced from 25 to 10 Hz in the dry and soaked condition by 98% and 97.8% respectively, acceleration decreased by 98% and 97.8% respectively. While the displacement amplitude decreased by 84.7% and 80% respectively and the settlement is decreased by 31.25%.

In addition, the results of tests showed that the displacement amplitude, velocity of vibration and acceleration increased with an increase in the gypsum content in soil, as the velocity decreased when decreasing the gypsum content from 65% to 30% in the dry and soaked states by 58.85% and 50% respectively. Acceleration decreased by 29.4% and 20%, respectively. While the displacement amplitude decreased by 20% and 30.5%, respectively and settlement decreased by 12%.

The results also showed that the velocity of vibration, acceleration and displacement amplitude are differed according to the type of pile. The dynamic response showed that an increase in timber pile compared to other type due to low hardness, while the settlement is less than in other piles as a result of friction between pile and soil.

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LIST OF ABBREVIATIONS

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
Eo	initial void ratio
G.C%	Gypsum content of soil%
Gs	Specific gravity
L/D	Slenderness ratio of pile
N γ,Nq	factors for bearing capacity
Ø	Angle of internal friction of soil
S1	Soil one with 30% gypsum content
S2	Soil two with 65% gypsum content
Wc %	Water content of soil
γ_d	Dry unit weight of soil
Δ	Interface friction angle between pile and soil
Δe	void ratio changing in upon wetting
X	Gypsum content
Me	Rotating mass
Ωo	circular frequency of the system
T.D.S	Total Dissolved Salts
USCS	Unified Soil Classification System
L.L.	Liquid limit
P.L.	Plastic limit
O.M.C.	Optimum moisture content
O.M.	Organic matters

CHAPTER ONE
INTRODUCTION

1.1 General

Many countries in the world are suffering from gypsum soil. Gypsum is found in a form of ($CaSO_4 \cdot 2H_2O$) or ($CaSO_4$). Some countries in Europe and Australia are covered with gypseoues soil. The total area of the world is covered by 1.5% of gypsum soil (FAO, 1998). Gypseous soil is found in many area of Iraq from north to south with a percentage range from (10% - 70%) (Ismail, 1994); (AL-Saoudi et al, 2013).

Gypseous soil is very strong when it is dry. Problems can appear when gypseous soils are wet, the dissolution of gypsum content is the main problem of the gypseous soil. Dissolution causes immediate settlement, sudden collapse and reduces the strength of soil under the foundation of structure. Water is found in soil particles either from overflow, top such as rainfall or from the bottom when the level of ground water is rising (Noor et al., 2013). Many solutions are used to decrease the damage of a structure in gypseous soil such as improvement of the soil properties using chemical treatment, physical treatment or using piles.

Deep foundation (pile) is the most common type used in collapsible soils. A full scale is executed of pile load test in collapsible soil, results showed that there is a high reduction in the ultimate bearing capacity of piles due to the immersion of the soil by water (Grigoryan, 1997); (Fernandes and Cintra, 1997).

The experimental studies which are interested in investigating the performance of piles in gypseous soil show that there is a high reduction in bearing capacity and high settlement of piles when flooded after 24 hours, while, in case of dryness, there is a high bearing capacity of piles (Albusoda and Al-Rubaye, 2015; Abd-ullah, 2015).

1.2 Problems with Gypseous Soils

The presence of gypseous soil content under the foundation of a structure is a structural risk, especially when the structure is saturated and this problem makes crack, tilting and collapse of structure (Nashat, 1990). 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), as shown in plate (1.1).

Furthermore, many cracks are viewed in runway of the Air force college (Al-Neami, 2000). As well, there are a many problems of construction that respect to gypseous soils, such as: collapse, cracks, tilting and leaching (Mahdi, 2004). Additionally, excessive settlement and crack problems are also present in Habbaniya Tourist village, Al Anbar University site and some houses in Al Ramadi city (Tawfeeq, 2009).

Finally, the gypseous soils caused damages in many regions in the world also, in Iraq, such that Arabian countries, USA, Russia, Spain and Chine. The problem accures when water table or rainfall fractures and infiltrates into gypseous soils (Al-Soudi et al. 2013).

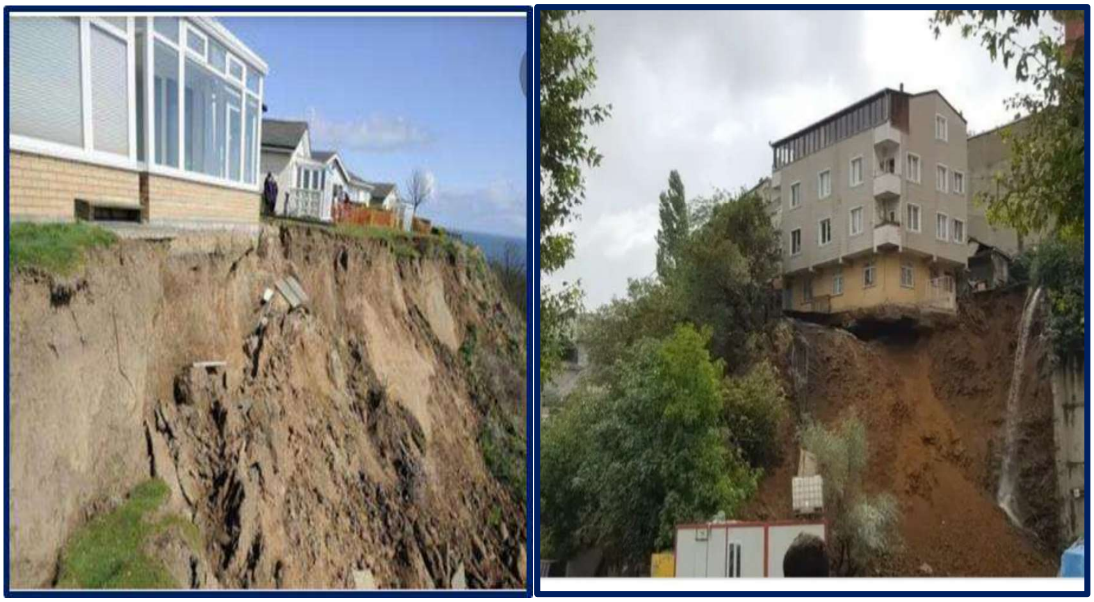

Plate (1.1) Failure of Buildings That are Built on Gypseous Soil (After Abid-Awn, 2010).

1-3 Dynamic Loading

The behavior of soils related to dynamic load has caused the problem, so problems appear when a genuine simulation of site condition is necessary to be investigated. Seismic activity, machine foundation, explosion, traffic and rail classified as a source of dynamic loading and these caused vibrations through the soil. Most of the soil properties are effected when exposed to vibration (Barkan, 1960).

It is important to investigate the effect of vibrated loading in soil properties, because most of the geotechnical engineer for designing a project of civil engineering such a building foundation, evaluating the stability of slopes and dams. In different cases, the soil that is stable under static load fails, when insecure to dynamically load.

There is numerous number of structure have a variable, such towers, pumping stations turbines on or underground surface, therefore foundation and under beneath soil are insecure to wide range of dynamic loading during different frequencies which are excited by nature of the structure, state loading may possibly diverge from large number of cycle with a low strain amplitude in state of vibration due to device to compare the small number of cyclic of huge strain amplitude from seismic activities (Silver and Seed, 1971).

Piles (deep foundation) used for hundreds of years, but in the last years or have seen a noticeable increase in an interest in pile dynamic. So piles are used widely in an important area of application have protrude, such, nuclear power plants and offshore towers, piles have frequently failed in earthquakes or were damaged, liquefaction, vibration effects and embankment movement caused damage in piles. Also piles damage during earthquakes in Japan given by mizuno 1987, it appeared also in Alaska earthquake of 1964 and Loma priera earthquake of 1989.

1-4 Types of Dynamic Loads

The resources of dynamic load that mentioned by Rao, (2011).

1- Earthquakes.

2- impact loads.

3- Forces generated by wind .

4- Vicinity to vibration environment .

5- Moving load.

6- Machines, which content unbalanced rotating and reciprocating parts and dynamic load and produce transient.

7- Periodic force and moments as an example due to mining and piling operation, sonic boom and drilling.

1.5 Types of Machines

Prakash and Puri (2006) classified the machines according to type of periodic forces created by these machines. The very important type are:

1- Impact machines: these impact loads created by machines such as forging hammers and the speed usually from 60 – 150 blows per minute in short internal and practically die out.

2- Reciprocating machines: these machines generat periodic unbalanced forces (such as steam engines). In these machines, the operation speeds usually less than (600 r.p.m).

3- Rotary machines or high speed machines such as the rotary compressions or turbo – generators and the speed, operation is more than (3000 r.p.m) and up to (12000 r.p.m).

1.6 Objective of the Study

The aim of this study is to explain the behavior of single pile subjected to dynamic load in gypseous soil. In this study different (L/D) from piles and different types are used of it and the all experiments tested in both cases (dry and soaked) condition.

1.7 Layout of the Study

Chapter one: includes the introduction and describing the soil that is used in experimental and piles also the dynamic load that affect piles and types of machine, object of study.

Chapter two: contains the literature reviews of the post student and researches that are in relation of dynamic response of pile under the effect of vertical vibration in dry and soaked state.

Chapter three: this chapter includes the experiment work such as material properties and the classification of soil that used and description of the model and testing program.

Chapter four: this chapter includes the results of tests and their discussions.

Chapter five: includes the main points concluded from this work and recommendation for future work.