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Response of Passive Footing on Gypseous Sandy Soil to the Dynamic Loading on Nearby Footing

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

By

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B.SC. Civil Engineering, 2008

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بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

﴿ يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنْكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ ﴾

صدق الله العظيم [المجادلة: 11]

Dedication

To my Father, who taught me the right path

To my mother, the light of my eyes

Remembers them, my brothers and sisters

To our teachers and professors who taught me the letters of gold. Who redefined my knowledge simply and from their ideas, made me a beacon to guide me through knowledge and the path of success.

Everyone, who wishes me success in my life I dedicate this humble work.

Saif

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Saif Kh. Ibrahim Al – Ezzi

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Abstract

Movement of Single Footing on Gypseous Sand Soil Subjected to Dynamic Loading

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In this thesis, the dynamic-vibration response of a single footing resulting from a nearby-close footing is investigated. The source of vibration which is called in this study the (active footing) is generated by applying an electric-rotary motor with eccentric loading on a square footing with dimensions of (100x100) mm, and it is considered are the source footing. Near the source footing another footing is placed, which is called (passive footing on which the vibration effects are to be investigated. Both footings are placed over gypseous soil. Two types of passive footings are investigated, a square of dimensions (80x80) mm and a rectangular with (160x40) mm. Tests are performed under dry and soaking conditions. The passive footing is with constant static weight, while the other footing (source of vibration) is with its self-weight.

The experimental work is carried out taking the following parameters into observance: shape of foundation (L/B =1, L/B =4), the spacing between the active footing (source of vibrations) and the passive footing (with static load), and operating frequency of the mechanical oscillator. All these tests are conducted on gypseous sandy soil which contain gypsum contents with 60%.

Forty-eight tests are performed. Half of them are carried out for square shape foundation, and the other half for rectangular foundation, under three operating frequencies namely, 10, 20, and 30 Hz. The spacing(S) between the two footings as follows: (S=1B, S=2B, S=3B, S=4B) for square shape footing and (S=2B, S=4B, S=6B, S=8B) for rectangular shape footing.

The reduction in displacement amplitude of square footing when the spacing between the two footings increased from 1B to 4B at frequencies of 10, 20, 30 Hz was (56.9 %, 37.3%, and 26.4%) at dry state and (72.54%, 27.5%, and 54.78%) at soaking state. For rectangular footing, the reduction was (53.03%, 38.8 % and 17.9%) at dry conditions and (55.5%, 50.72% and 37.6%) at soaked state, when the spacing between the two footings increased from 2B to 8B.

The settlement of square foundation at frequencies of 10, 20, and 30 Hz decreased by (29.3%, 34.5%, and 68.3%) respectively when the spacing increased from 1B to 4B. For rectangular foundation, the reduction in settlement value are (11.2%, 22.4%, and 35.6%) at the same frequencies (10, 20, 30) Hz, consecutively, when spacing increased from 2B to 8B. The differential settlement of foundation under the action of dynamic load resulting from adjacent foundation depends on the shape of foundation, and the spacing between the active and the passive foundation.

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LIST OF NOTATIONS	
C.P.	Collapse potential
C	Cohesion
Dr	Relative Density
e	eccentric distance of the rotating mass
G.C.	Gypsum content
Gs	Specific Gravity
I.e	Collapse potential according to ASTM D5333, (2003).
LL	Liquid limit
m_e	Rotating mass
O.M.C	Optimum moisture content
O.M.	Organic matters
PL	Plastic limit
TDS	Total Dissolved Salts
T.S.S	Total soluble salts
USCS	Unified Soil Classification System
ω_o	circular frequency of the system
ϕ	Angle of friction
γd	Density of the soil in its natural state field value

CHAPTER ONE

INTRODUCTION

1.1 General

Machines and equipment are considered as main sources of vibrations which transfer through soil and effect on their engineering properties, such as void ratio, density, and shear strength. So it is necessary to study and analyze the effects of these machines and equipment on nearby buildings and take precautions to prevent damages which are possible to take place. Therefore, it is important to study the dynamic response of foundations adjacent to foundations which are subjected to dynamic loads in different conditions.

The dynamic response of these foundations becomes more important when constructed on the gypsum soils that have been classified as collapsible soils .

1.2 Problems with Gypseous Soils

Different issues of gypsum soils are cavities brought about by the development of the Mosul Dam because the proceeded with the disintegration of the gypsum under the dam (Nashat, 1990). One of the issues brought about by the gypsum arrangement is the harm that happened at Anbar University in Ramadi, and splits in the Tigris Hospital, in Tikrit.

A number of studies have been conducted in Iraq to determine the behavior of foundations on gypseous soils under static condition. However, there is currently a lack of knowledge in understanding the behavior of the foundations under dynamic loading. With the development currently taking place, especially in the industrial field including factories, machinery, equipment and electrical stations, it is necessary to study the behavior of the foundations buildings adjacent to the foundations which are subjected to dynamic load in different conditions.

The problems encountered in the gypseous soil are summarized in the following points, as mentioned by (Saaed, 1990) and (Al-Abdullah, 1996):

1- Significant loss of strength under wetting.

2 - A suddenly increase in compression upon moisturizing.

3 - Continued deformations and collapsibility when filtering due to the movement of water.

4 - The presence of cracks because of seasonal changes.

5- The presence of sink holes in the soil because of the local melting of gypsum.

1.3 Problems of Dynamic Loads

Harmonic and periodic vibrations which affect in the soil can be generated mostly by heavy machines, vehicles or by running trains, and earthquakes causing the footings to behave in different mode. Therefore, footings must be designed properly to satisfy the requirements of safe design by resisting the dynamic loads and provide a greater longevity and serviceability.

Expertise in field the dynamic responsible of the soil under dynamic loads had been developed initiate from the simple spring-mass-dashpot system to the rigorous elastic half space model proposed by (Sung, 1953), (Lysmer and Richart, 1966), (Richart et al. 1970), (Gazetas, 1991) and (Kameswar Rao in 1998 and 2011) for single isolated footing.

However, when the footings are founded in groups, the effect of one on the other adjacent footings due to the dynamic load is likely to occur obviously. Hence, the importance of study cannot be ignored in the design of nearby footings which dynamic interaction is an influential factor in design.

It is necessary to know the most important categories of problems which soil dynamics plays a fundamental role in solving as summarized by (Banerjee and Butterfield, 1987) and they are shown below:

1- Machine foundation vibrations.
2- Pile-driving included settlements and vibrations.
3- Traffic and rail induced vibrations.
4- Densification by vibratory or impact loads.
5- Wave induced oscillation of offshore structures.
6- Effects of explosions.
7- Earthquake engineering.

Rao, (2011), mentioned the following resources which excite the foundations:

1- Machines, which contain unbalanced rotating and reciprocating parts and produce transient and dynamic loads.
2 - Impact loads.
3 - Vicinity to vibration environment.
4 - Earthquakes.
5 - Forces generated by wind.
6 - Periodic forces and moments as an example due to blasting, mining, and piling operations, drilling and sonic booms
7 - Moving loads.

A number of researchers presented several methods, analytical and numerical, to study the dynamic response of foundations under dynamic loads. Also soil-structure interaction problems under dynamic load were solved using finite element approach, which had received substantial attention in the last three decades. In spite of the existence of all these approaches and methods, the necessity to verify their validity by adopting experimental work remains essential.

In previous researches and studies, experiments and tests, both full-scale field tests or small-scale model laboratory experiments, to study the response of foundation under dynamic load, especially in saturated soil are few.

1.4 Design of Foundations Under Dynamic Loading

Rao (2011) offered a step-by-step procedure that meets the design of the sections in a dynamic environment that can be summarized as follows:

1- Dynamic forces and moments generated by operating machines are calculated.

2 -The appropriate design criteria shall be determined in terms of the allowable limits of response system

3 -Appropriate mathematical models are adopted to simplify and improve the physical system and its description, guided by the pertinent response mechanisms.

4- Based on field and laboratory investigations, appropriate system parameters are determined, in turn, to describe the elements of the ideal model above.

5- Analytical mode and system parameters are selected to estimate the system responses.

6 -The engineering design parameters are chosen for different system components, which produce acceptable response, to meet the design standards.

7- Finally, the design standards are improved.

Srinivasulu and Vaidyanathan (1990) stated that the manufacturers of machinery specified the permissible amplitudes. The allowable amplitude, of a machine is subject to two main criteria, active, the relative importance of the machine and the passive, the sensitivity of neighboring structures to vibration.

Where manufacturer's data does not involve the allowable amplitudes, the values of permissible amplitudes suggested by (Richart et al. 1970) and adopted for preliminary designs. However, the acceptable levels of vibration are related to:

1- Human observation.
2- Probable damage to machines or instruments and maintenance difficulties.
3- Possible damage of structural components.
4- Total failure prevention.
5- The dimensions of machine foundations.

1.5 Objectives of Study

Two closely spaced footings are placed on a gypseous sandy soil, the first (active footing) as source vibrations is subjected to vertical harmonic load. The second (passive footing) with static load only. The footings are placed at different clear spacing (S), see Figure (1.1).

The main objective of this study is the experimental investigating of behavior of passive footing under effects of dynamic loading nearby footing (active footing) subjected to harmonic vibration loads. Both footings are constructed on gypseous soil. Also, the effects of dry and soaking have been investigated.

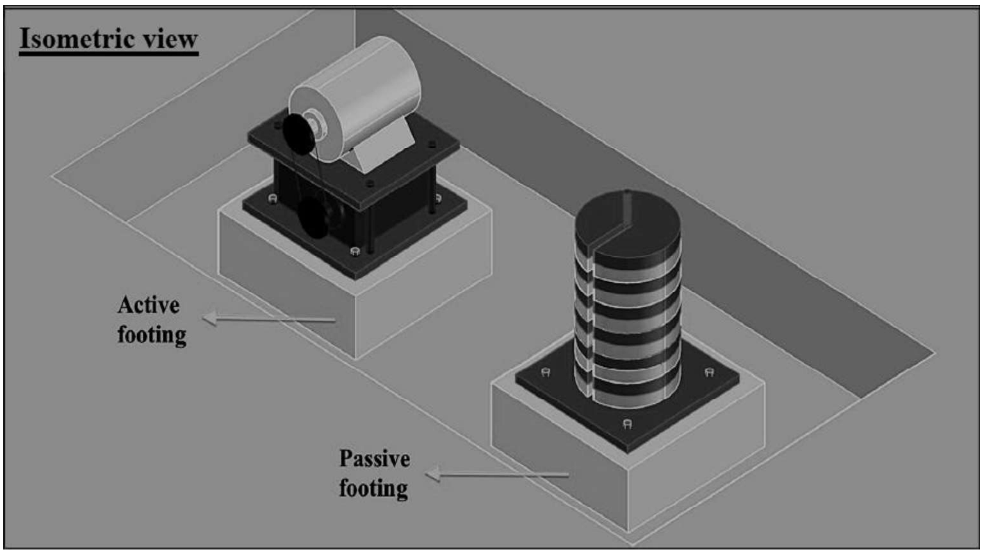

Figure (1.1) Definition problem

1.6 Layout of the Thesis

This thesis consists of five chapters as shown below:

Chapter One: includes the introduction, describing the dynamic response of foundations, the properties of both machine and type of the foundation, the design criteria, which affect the response of foundation under dynamic loads, objectives of the study**.**

Chapter Two: include reviews of the previous studies and researches that are relevant to dynamic response of foundation under effect harmonic vertical vibrations in dry and saturated soils.

Chapter Three: this chapter contains the experimental work, includes the description of the model, material properties, and the classification of the soil which used and the testing program.

Chapter Four: this chapter includes the presentation of results and their discussions.

In chapter five includes the conclusions and, the suggestions for future studies and researches