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Mitigation of Machine Foundation Vibration on Nearby Footing in Agypseous Soil

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By

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بسم الله الرحمن الرحيم

(إِنَّمَا يَخْشَى اللَّهَ مِنْ عِبَادِهِ الْعُلَمَاءُ إِنَّ اللَّهَ عَزِيزٌ غَفُورٌ)

صدق الله العظيم

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The Researcher

CERTIFICATION

I certify that the thesis entitled **"Mitigation of Machine Foundation Vibration on Nearby Footing in Gypseous Soil"** is prepared by **"Ali Hadi Hussein"** 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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We certify that we have read the thesis entitled **(Mitigation of Machine Foundation Vibration on Nearby Footing in Gypseous Soil)**, and we have examined the student (**Ali Hadi Hussein**) 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

Mitigation of Machine Foundation Vibration on Nearby Footing in Gypseous Soil

By

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This study investigates the reduction of vibration effect between two footings by placing a trench between them . The first footing (designated as the source footing), on electric-rotary motor is fitted , it has dimension of (100x100) mm. Beside the source footing a second footing is placed and on this footing the reduction in vibration effects are to be investigated . Both the source footing , nearby footing and trench are placed over compacted gypseous soil in a steel tank having gypsum contents with (50%) . Single type of footing is investigated, a square footing with dimensions (80x80) mm. Tests are performed under dry and soaking conditions. The footing is loaded with static weight, while the source footing is with its self-weight. The experimental work is carried out taking the following parameters into observance: types of materials that it is used to fill the trench (PPR pipe with SBR rubber, SBR rubber, low density polyethylene and styropor) as for dimensions of the trench two depths for the trench are used (B and 2B when B is width of footing equal 80mm), and operating frequency of the mechanical oscillator.

Forty-eight tests are carried out for square shape foundation, under three operating frequencies namely, 8, 14, and 20 Hz. The spacing (S) between the

footing and trench is (S=2B) and the spacing(S) between the source of vibration and trench is(S=3B), as for dimensions of trench as follows (length=3B, width= 0.5B and depth=B, 2B). Displacement amplitude, velocity, acceleration and settlement of footing are measured during tests.

The reduction in displacement amplitude for footing when the depth of trench (depth=B) at frequency of 8 Hz is (91 % and 67 %) at dry state in each techniques (PPR with SBR and XPS) gradually, and (100 % and 70 %) at soaking state ,as for frequency of 20 Hz at same depth is (68 % and 60 %) at dry state in (PPR with SBR and XPS) gradually and (47 % and 30%) at soaking state. But at same frequency for depth of trench (depth=2B) is (84 % and 53 %) at dry state and (70 % and 1%) at soaking state.

The reduction in settlement value for footing when the depth of trench (depth=B) at frequency of 8 Hz is (85 % and 15%) at dry state in each techniques (PPR with SBR and XPS) respectively, and (70 % and 25%) at soaking state. As for frequency of 20 Hz at same depth is (58% and 45 %) at dry state and (60 and 5%) at soaking state in all from (PPR with SBR and XPS) respectively. But at same frequency for depth of trench (depth=2B) is (65 %) at dry state and (67%) at soaking state in (PPR with SBR). As for Styropor, it is give negative results.

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LIST OF SYMBOLS

Symbols	Meaning
C.P.	Collapse potential
G.C.	Gypsum content
ϕ	Angle of friction
c	Cohesion
Gs	Specific Gravity
Dr	Relative Density
γd	Density of the soil in its natural state field value
me	Rotating mass
LL	Liquid limit
PL	Plastic limit
O.M.C.	Optimum moisture content
T.S.S	Total of soluble salts
O.M.	Organic matters
e_o	Natural void ratio.
e	Eccentric distance of the rotating mass
SBR	Styrene-butadiene or styrene-butadiene rubber
XPS	Styropor or Rigid Foam (extruded Polystyrene)
PPR	Polypropylene Random Copolymer pipe
LDPE	Low Density Polyethylene

CHAPTER ONE

INTRODUCTION

1.1 General

The presence of gypseous in soils causes many engineering problems, especially in building engineering installations and important centers. Gypseous deposits possibly existing in shape of ($CaSO_4.2H_2O$) or anhydrate ($CaSO_4$). Many areas and countries covered by gypseous soil, these soils take up approximately 1.5 % of the total area of the world, and this ratio represents nearly 186 million hectare , (FAO, 1998) .In Iraq, gypseous soil cover about 30 % of land, these areas are evaluate 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 a lot of engineering problems. The main reason of these problems is melting gypseous when these soil are moistened . These soils may exist in dry and semi dry areas, in such regions, the annual amount of precipitation is insufficient to dissolve the gypseous present in these soils (Pitrukhin and Boldyreve, 1978).

1.2 Gypseous Soils

Because of the complex and uncertain behavior of this type of soil, it is classified as one of the collapsible soils and it is defined by (Clemence and Finbarr 1981) as "Any unsaturated soil that goes through a radical rearrangement of particles and great loss of volume upon wetting with or without additional loads". Gypsum, whether in huge or particular form, dissolves due to water table or water infiltration into gypseous soils manufacture cavities, causing deterioration of the gypseous soil structure, and therefore sudden settlements of buildings erected on them, and increasing hydraulic conductivity and flow rates in hydraulic structures (Al-Abdullah, 1995). Significant problems have been noticed when a foundations are stood up on areas containing such soils in Iraq, such as gypsum dissolution in the foundation of Mosul dam has caused unpleasant 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). Referring to (Saaed, 1990) and (Al-Abdullah, 1996), Problems can be summarize with Gypseous Soils:

1-A suddenly increase in compression when moisturizing.

2- Significant loss of strength when hydrating.

3- The presence of cracks because of seasonal changes.

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

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

1.3 Problems with Dynamic Loads

Harmonic and periodic vibrations which affect in the soil can be generated mostly by heavy machines, vehicles or by running trains, 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.

Depending on the source of vibration and the distance from the source, these vibrations can disturb both occupants and constructions containing sensitive equipment. (Hong et al., 2014).

Rao (2011) explained the following resources which effect on foundations

1- Impact loads.

2- Vicinity to vibration environment.

3- Earthquakes.

4- Forces generated by wind.

5- Periodic forces and blasting.

6- Moving loads.

A number of researchers presented several methods, analytical and numerical, to study the vibration isolation 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.

1.4 Vibration Isolation

Because of the effect of vibrations on engineering installations therefore, isolation techniques were used to reduce their effect using the fenders. Barkan (1962) and Dolling (1965) were the first to determination on survival field investigations for studying the effectiveness of wave barriers. Neumeuer (1963) and McNeill et al. (1965) discussed some effective applications of vibration isolation. Works on this topic were carried out by Woods (1967,1968), Richart et al.(1970)

and Dolling (1970a,b) who performed extensive field experiments to study the effectiveness of open trenches barriers .

Lightweight materials are used as bumpers to reduce the effect of vibration and can be summarized in the Table (1.1)

Table (1.1).Types of Lightweight Materials (after Miki. H. 1996)

Lightweight Material	Unit Volume Weight (tf/m^3)	Description
EPS Blocks	0.01 ~ 0.03	Ultra lightweight, expandable synthetic resins
Expanded Beads Mixed Lightweight Soil	0.7 approx. or more	Variable density; similar compaction and deformation characteristics to soil; can use excess
Air Foamed Mortar and Air Foamed Lightweight Stabilized Soil	0.5 approx. or more	Density adjustable; flow able; self-hardening; and can use excess construction soil
Coal Ash, Granulated Slag, etc.	1.0 ~ 1.5 approx	Granular material; self-hardening
Volcanic Ash Soil	1.2 ~ 1.5	Natural material
Wood Chips	0.7~ 1.0	Usually to be used below ground water level; anti leaching measures needed
Tire Chips	0.7~ 0.9	Usually used above ground water level; cover soil layer at least 0.9m is required

1.5 Objectives of Study

This study aims to investigated the effect of vibrations on nearby buildings (footing) resulting from a causative and near source and protection of the special equipment due to these effects as well to compare between the materials to choose the best material to reduce vibrations in terms of implementation, cost and availability, the most important is the ratio of reducing or limiting vibrations.

In general, the effectiveness of trenches filled with different materials is to reduce vibrations to an acceptable level and does not affect buildings and residents.

1.6 Layout of the Thesis

This thesis consists of five chapters as shown below:

Chapter One : contains a summarized introduction and general information about gypseous soils and the target of the present study.

Chapter Two: covers a summarize review of literature related to the gypseous soils. This include the properties of gypseous, influence of gypsum on engineering properties of soil. This chapter also presents a review about dynamic load in soil and mitigation of vibration.

chapter Three : contains the experimental work and laboratory tests.

Chapter Four: include the results tests and their discussions.

Chapter Five : summary of the main conclusions and recommendations for future work