وزارة التعليم العالي
والبحـث العــلـمي
جـامـعـة ديــالــى
كـلـية الهـنـدســة

سلوك الركائز اللوحية في التربة الرملية المعرضة لقوى إهتزازية

رسالة مقدمة الى قسم الهندسة المدنية جامعة ديالى وهي جزء من متطلبات نيل درجة الماجستير في علوم الهندسة المدنية

من قبل

نورة جار الله موسى

(بكالوريوس هندسة مدنية/ 2017)

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شعبان/ 1444 هـ   العـــراق   آذار / 2023 م

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BEHAVIOR OF SHEET PILES IN SANDY SOIL SUBJECTED TO VIBRATING FORCES

A Thesis Submitted to the Council of the 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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March/2023 A.D. **IRAQ** **Shaban/1444 A.H.**

CHAPTER ONE

INTRODUCTION

1.1 Introduction

In today's society, the ground vibration caused by human activity is becoming a significant issue. Different types of man-made vibration can be characterized; including those caused by traffic loads, blasting for tunnels and foundations, the construction of new homes, etc. Infrastructure in metropolitan areas is expanded and developed as a result of rising population levels and rising infrastructure demand.

Sheet pile walls are the first methods of earth retention used in civil engineering projects. To withstand horizontal stresses, they are made out of constantly interconnected pile segments buried under soil. They can be described as flexible structures that rely on the soil's passive resistance inside the wall's confines in order to achieve stability.

Sheet pile can be anchored or cantilever. Cantilever walls can only reach wall heights of about 6 meters because they need to be sufficiently embedded into the stream channel or dredge line **(Craig, 2004)**. When the wall height is too high to be a cantilever wall, an anchored wall is usually necessary, 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 affected when exposed to vibration **(Barkan, 1960)**.

Steel, reinforced concrete, or timber are all acceptable materials for sheet piling. Steel sheet piling is the most popular type used for walls because it has many advantages over other materials, including: it is resistant to high driving stress developed in hard or rocky material; it is relatively lightweight; it may be reused several times; it has a long service life both above and below water; it is simple to increase the pile length by either welding or bolting; etc. (**Bowles, 1997**).

Steel sheet pile walls are frequently adopted as permanent or temporary earth support structures in a wide range of engineering problems, namely, quay walls, breakwaters, cofferdams, bridge abutments, underground structures, trenches, and flood protection. The majority of sheet pile walls require additional support at the top, which can be provided using walers and struts for bracing inside excavations, or connecting the top of the wall to a dead anchor **(ArcelorMittal, 2021)**.

1.2 Sandy Soils

Sandy soils are frequently thought of as having physical characteristics that are simple to define: a weak structure or no structure, poor water retention capabilities, high permeability, and a high sensitivity to compaction with numerous negative effects. This is particularly true for sandy soils in the tropics, which are exposed to a cycle of seasonal precipitation and drying.

Physical characteristics alter significantly depending on even slight compositional changes. The size distribution of the sand grains is one of the key soil features to consider. Greater porosity, water retention, and resistance to penetration are all caused by fine sand compared to coarse sand, which has lesser permeability. Porosity diminishes when the sand grain distribution becomes more heterogeneous, which raises the resistance to penetration and lowers permeability.

1.3 Problems with Dynamic Loads

Periodic and cyclical vibrations that affect the soil can be produced by heavy equipment, moving cars, trains, and earthquakes, which can cause the footings to react differently. Consequently, footings need to be designed effectively meet the requirements of a safe design by enduring dynamic loads and offer a longer lifespan and increased serviceability.

It is necessary to know that the most important categories of problems which soil dynamics plays a fundamental role in solving as summarized by **(Banerjee and Butterfield, 1987)** as 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.

These vibrations can upset both occupants and buildings with sensitive equipment, depending on the source of the vibration and the distance from the source **(Hong et al., 2014)**.

1.4 □y□es of Dynamic Loads

The following resources that have an impact on foundations as are outlined by **(□ao, 2011)**:

- Earthquakes.

- Impact loads.

- Forces generated by wind.

- Vicinity to vibration environment

- Moving load.

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

In order to analyze the dynamic response of sheet pile under dynamic loads, a number of studies offered several analytical and numerical methodologies. Additionally, soil-structure interaction issues under dynamic load were resolved using the finite element method, which has drawn a lot of interest in the previous three decades. Despite the presence of all these strategies and techniques, it is still important to undertake experimental research to confirm their efficacy.

In earlier investigations, trials, and testing, the behavior of sheet pile under dynamic load was investigated using small-scale model laboratory experiments are few.

1.□□y□es of □ achines

Prakash and Puri (2006) classified the machines according to type of periodic forces created by these machines, the very important types 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 generate 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.□□bjecti□es of □tudy

The objectives of the study are:

- Determining the safe distance between the source of vibration and sheet pile.
- Comprehending the procedure involved in the sheet pile walls' stability.
- investigating the effect of soaking the sandy soil.
- distinguishing the safe operating frequency of the machines.

1.7 Layout of the □hesis

This thesis is divided into the following five chapters:

- **Chapter One**: it contains a summarized introduction and general information about sheet pile, sandy soil, Problems with dynamic loads, types of dynamic loads and objectives of study the target of the present study.

- **Chapter Two**: it includes summaries of earlier analyses and studies that are pertinent to the dynamic behavior of sheet pile under the influence of harmonic vertical vibrations in both dry and saturated soils.

- **Chapter Three**: This chapter describes the experimental study, along with the model's description, material qualities, the soil's categorization that was employed, and the testing protocol.

- **Chapter Four**: This chapter contains a presentation of test results and a discussion of them.

- **Chapter Five**: it outlines the findings and recommendations for additional research and study.

Behavior of Sheet Piles in Sandy Soil Subjected to Vibrating Forces

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Abstract

In this thesis, the dynamic-vibration response of sheet pile resulting from vibration force is investigated. The source of vibration is generated by applying an electric-rotary motor with eccentric loading installed on a distance from sheet pile, the tests are performed under dry and soaked states. The experimental work is carried out by taking the following parameters into observance: the spacing between the sheet pile and the source of vibrations and operating frequency of the mechanical oscillator. All these tests are conducted by using a sandy soil which is taken from Karbala Governorate, central of Iraq. Twenty-eight tests are carried out for sheet pile, under three operating frequencies namely, 5, 10, and 15 Hz. The distance (D) between the sheet pile and the source of vibrations as follows: (D=0.5H, D=1H, D=1.5H), besides the displacement amplitude and velocity of vibrations, as well as acceleration, settlement and rotation of sheet pile are measured during tests. The displacement amplitude, acceleration, velocity of vibrations, settlement and rotation of sheet pile decreased at soaked conditions as compared with similar values of these parameters at dry condition. The reduction in displacement amplitude when the distance between the sheet pile and the source of vibrations increased from 0.5H to 1H at frequency of 5, 10, 15 Hz is

(46.67%, 21.74%, and 3.33%) at dry state. The velocity of vibration when the distance between the sheet pile and the source of vibrations increased from 0.5H to 1H from at frequency of 5, 10, 15 Hz is decreased by (21.1% , 17.97%, and 43.09%) at dry state. The acceleration value when the distance between the sheet pile and the source of vibrations increased from 0.5H to 1H from at frequency of 5, 10, 15 Hz is decreased by (0%, 20%, and 61.36%) at dry state. The settlement of sheet pile at frequencies of 5, 10, and 15 Hz decreased by (27.27%, 47.1%, and 41.71%) respectively when the distance increased from0.5H to 1H, the rotation of sheet pile at frequencies of 5, 10, and 15 Hz decreased by (59.2%, 61.84%, and 26.33%) respectively when the distance increased from0.5H to 1H. The results also showed that the velocity of vibration, acceleration, displacement amplitude, settlement and the rotation of sheet pile are increase with an increase in the operation frequency of the vibrated source and decreases with increasing distance between the sheet pile and the source of vibration.

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