Ministry of Higher Education
and Scientific Research
University of Diyala
College of Engineering

RESPONS OF SCREW PILE GROUP TO LATERAL CYCLIC LOAD EMBEDDED IN TWO CLAY LAYERS

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

BY

Azhar Subhi Ibrahim

(B.Sc. Civil Engineering, 2010)

Supervised by
Assist. Prof. Hassan Obaid Abbas (Ph.D.)

May 2021 IRAQ Shawwal 1442

بسم الله الرحمن الرحيم

﴿ فَتَبَسَّمَ ضَاحِكًا مِّن قَوْلِهَا وَقَالَ رَبِّ أَوْزِعْنِي أَنْ أَشْكُرَ نِعْمَتَكَ الَّتِي أَنْعَمْتَ عَلَيَّ وَعَلَىٰ وَالِدَيَّ وَأَنْ أَعْمَلَ صَالِحًا تَرْضَاهُ وَأَدْخِلْنِي بِرَحْمَتِكَ فِي عِبَادِكَ الصَّالِحِينَ ﴾

صدق الله العظيم

سورة النمل (١٩)

CERTIFICATION OF THE SUPERVISOR

I certify this thesis entitled " **Respons of Screw Pile Group to Lateral Cyclic Load Embedded in Two Clay Layers** " was prepared by "**Azhar Subhi Ibrahim**" was made under my supervision in the University of Diyala in partial fulfillment of the requirements for the degree of master of science in civil engineering.

Signature: H. S.

Name: Assist. Prof. Hassan Obaid Abbas

(Supervisor)

Date: / / 2021

COMMITTEE DECISION

We certify that we have read the thesis entitled (**Respons of Screw Pile Group to Lateral Cyclic Load Embedded in Two Clay Layers**). We have examined the student (**Azhar Subhi Ibrahim**) 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.

Examination Committee		**Signature**
1- Assist. Prof. Dr. Hassan O. Abbas	**(Supervisor)**	**……………….**
2- Lec. Dr Qutaiba Gazi Majeed	**(Member)**	**……………….**
3- Assit . prof. Dr. Ahmed Al- Obaidi	**(Member)**	**……Al-Obaidi……**
4- Prof. Dr. Jasim Mohamed Abbas	**(Chairman)**	**……J.a.S…….**

Prof. Dr. Khattab S. Abdul Al-Razzaq (Head of Department)……………

The thesis was ratified at the Council of College of Engineering/ University of Diyala.

Signature……………………………

Name: Prof. Dr. Anees A.Khadom

Dean of College Engineering / University of Diyala

Date:

Dedication

To………

My father, who was the cause of my success

My mother, the sight of my eyes.

My wife, who supported me in the critical time.

My brothers and my sons whose love flows in my veins.

Our honorable teachers who taught and rewarded us their knowledge.

Everyone, who wishes me success in my life,

I dedicate this humble work.

AZHAR SUBHI

ACKNOWLEDGEMENTS

Thanks are to Allah for all things which led me into the light during the critical time.

I would especially like to express my deep appreciation and sincere gratitude to my supervisor Assist. Prof. Dr. Hassan O. Abbas for his supervision and his valuable guidance and assistance throughout conducting this work.

Appreciation and thanks to the Dean and the staff of the College of Engineering, University of Diyala and also the staff of Civil engineering department, and the staff of Soil mechanics Laboratory.

Thanks are also due to all my friends, for their kindest help.

AZHAR SUBHI

Respons of Screw Pile Group to Lateral Cyclic Load Embedded in Two Clay Layers

By

Azhar Subhi Ibrahim

Supervisor

Assist. Prof. Dr. Hassan O. Abbas, (Ph.D.)

ABSTRACT

Screw piles or helical piles are deep foundation elements used to resist forces exerted by tension, axial compression, and lateral loading. Despite the great development in the manufacture of the helical pile and the development of their use, especially in transmission towers and wind turbines, there is a little research on their lateral behavior.

In this study, the investigation of the behavior of screw pile group (1×2), (2×1), and (2×2) with the pile spacing to the helix diameter ratio (S/Dh =1.5, 3, and 4.5) having a diameter (10 mm) and different embedded length to shaft diameter ratio (L/d = 40, 33, and 26) by using single and double helix is carried out. In addition, ordinary pile group (2x2) with the same three spacing's between the screw piles and have the same shaft diameter of screw piles and with embedded length (L/d= 40) is also investigated.

The entire pile group embedded in experimental model content soft clay in the top with thickness equal to 200 mm and extends to stiff clay with thickness 450 mm and tests under the influence of pure two way symmetrical lateral cyclic load with environmental frequency of (0.2 Hz).

In this work, different parameters has been studied such as the effect of configuration and spacing between piles group, the effect of number of helix in screw pile and compare with ordinary pile, and the effect of embedded length for screw pile under the influence of different level in cyclic load ratio (CLR) and by use number of cyclic equal to 100.

The results showed that increasing the distance between the piles had a great effect on increasing the lateral resistance. For the same embedded length the increase of screw pile spacing in the all groups model from (1.5 Dh) to (3 and 4.5 Dh) increases the lateral resistance about (25-39)% and (49-64)% respectively at cyclic load ratio of 80%. Also, the arrangement of the same piles number in the group affects the lateral resistance; the group (2×1) gave a lateral resistance more than the group (1×2) about 11% for single helix and about 6% for a double helix.

From the results also found that the screw piles performance is better than ordinary piles under lateral cyclic load impact, as the ordinary piles gave lateral displacement more than the screw piles with a ratio of (20-88) % at different cyclic load ratio, and for the same spacing and configuration the screw pile with double helix gives an increase in lateral resistance about (4-19) % from the single helix.

As well, the results showed that, reducing the embedded length of the screw piles has a significant effect on increasing the lateral displacement, as reducing the embedded length by 17.5% leads to an increase in lateral displacement by a rate ranging between (14-50) % at low cyclic load ratios (CLR= 20 and 40) %, while it increases by rates ranging between (50-150) % at a high cyclic load ratio (CLR= 50, 60, and 80) %.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

Symbol	Term
C	Cohesion
Cc	Compression Index
Cs	Swelling index
Cu	Undrained Shear Strength
Cv	Coefficient of Consolidation
d	Pile Shaft Diameter
Dh	Helix Plate Diameter
H	Thickness of Clay Layer
Ic	Consistency Index
L	Embedded length of pile
P	Helix Pitch
S	Spacing between piles
Wc	Water Content
L.L	Liquid Limit
P.L	Plastic Limit
I.P	Plasticity Index
Gs	Specific Gravity
O.M.C	Optimum Moisture Content
y	Pile deflection
f	Frequency
HZ	Hertz

LIST OF ABBREVIATION

Abbreviation	Term
USCS	Unified Soil Classification System
ASTM	American Society For Testing and Materials
CLR	Ratio of magnitude of cyclic lateral load to static ultimate lateral capacity of the pile
LVDT	Linear Variation Displacement Transducer
PLC	Programmable Logic Controller
B.S	British Standards Institution

CHAPTER ONE

INTRODUCTION

CHAPTER ONE

INTRODUCTION

1.1 General

Soft clay is considered one of the most difficulties and problems facing the geotechnical engineer during the design and implementation of construction projects because it has low resilience to deformation and compression index and low shear strength. Due to these properties of soft soil, many damages may occur during construction or the design life of the structure (Kempfert and Gebreselassie, 2006).

As a result of the spread of soft clay in many region of Iraq and with building design obstacles and the growing need for the continuous pursuit of economically viable solutions. The use of screw piles can be considered as a suitable solution for this soil because it is characterized by low cost and speed of installation and can be re-used, as well as for the great development in the last decades of this technology (Abbas and Ali, 2021).

1.2 Screw Pile

Screw piles or helical piles were first used as a foundation for homes in 1936 by Irish engineer Alexander Mitchell. Screw piles or helical piles are deep foundation elements used to resist forces exerted by tension, axial compression, and lateral loading and available in many diameters and lengths. Screw piles consist of one or more circular helical plates (or flanges) welded onto a steel shaft or made with the shaft as one piece and it may be coated with zinc or galvanized to protect it from corrosion as shown in Figure 1.1 .Screw piles are installing into the soil by applying a torque at the head of the shaft of the pile, which produce penetrate the helix or helices to the ground in a circular motion (Kristen, 2007).

Figure (1.1) Components of Screw Piles (Hussein and Karkush, 2021)

During the past few years, great progress has been made in installing and increasing the axial capabilities of helical piles. Currently in use, helical piles with axial capacities in excess of 3MN. The availability of high torque rotary heads has made it easier to install screw piles of large diameter in competent soils such as very stiff clay and very dense sand. Helical piles of diameters more than 508 mm have been successfully installed into very stiff clay and very dense sand (Sakr, 2010).

Recently helical piles are used in many applications in civil engineering such as bridges, commercial and residential buildings, foundations for damaged and historical buildings, foundations of wind turbines, machine foundations, transmission towers, marine anchors, and pier supports (Türedi, and Örnek, 2020). In many applications, such as the high rise and medium commercial buildings and wind turbines, helical piles are used as a group to give a high bearing capacity, for example, three screw piles give a bearing capacity ranging from 75 to 600 tons and when using helical piles as a group, the effect of the distances between the piles must be taken into account to avoid the effect of the group on the bearing capacity because close distances between the piles reduce the efficiency of the group, so the distance between the piles is a critical element when designing (Perko, 2009).

1.3 Statement of the Problem

The soft soil extends over most of the central and southern regions of Iraq, and this soil is characterized by its high tendency to deform and compression, in addition to its weak resistance to shear and friction. For example, in Basra soil, for the highest 25 m of it, the value of shear strength ranges between (15- 45) kPa and the angle of internal friction between (5-36) degrees as shown in Figure 1.2 (Abbas J. Al-Taie, 2015). Therefore, most of the large construction projects are implemented on this soil using deep foundations.

The deep foundations, in addition to the vertical load, are exposed to a large cyclic side load, especially in tall buildings and offshore platforms, as a result of wind and wave impact. These cyclic loads lead to deformations in the soil surrounding the piles and the occurrence of a large side cumulative displacement that leads to the failure and inversion of the structures supported by the piles (Li Z. et al., 2010).

The ratio of side load to vertical load is estimated from 10-20% in onshore facilities, while in offshore facilities this percentage increases to

30% (Rao et al., 1998). Therefore, when designing, it is necessary to take into account the effect of lateral loads for the safety of the structures.

Therefore, this study focuses on the lateral behavior of helical piles , as they are considered to be commonly used in such soils, as well as being an economical and less expensive solution in addition to the wide scope of their applications (Perko, 2009).

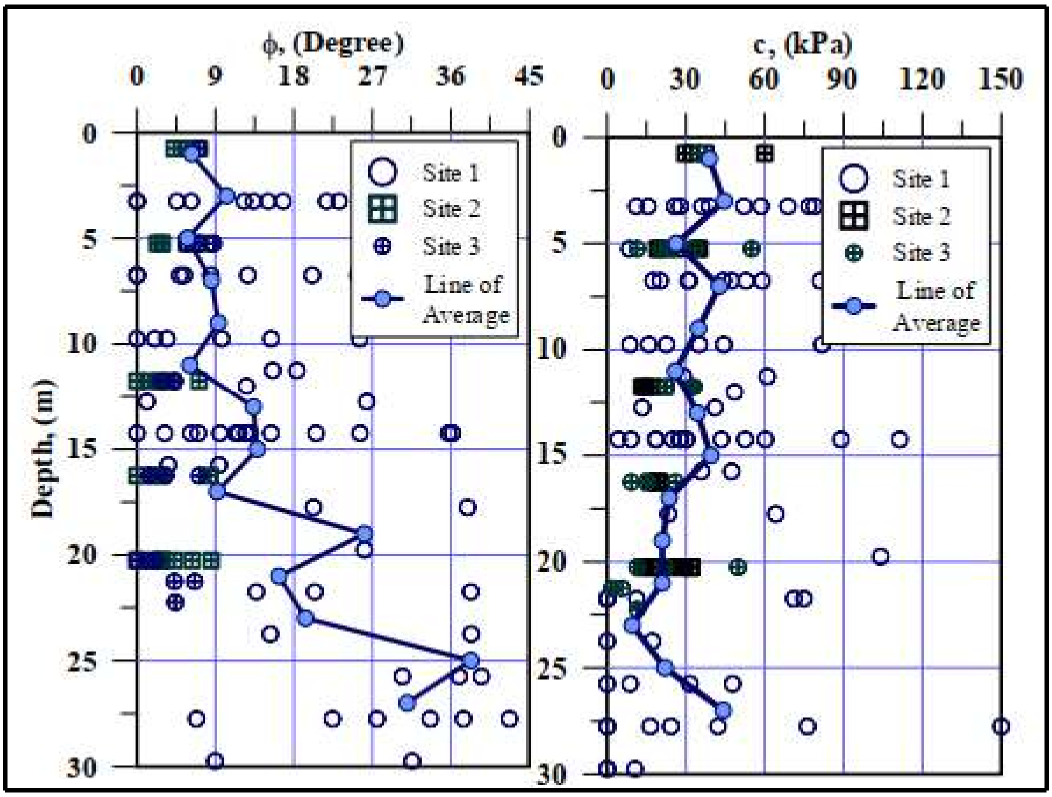

Figure (1.2) Values of Strength with Depth for Basra Soil (Abbas J. Al-Taie, 2015)

1.4 Importance of the Study

There are many studies on understanding the behavior of helical piles in Iraqi soft clay under the influence of static and cyclic vertical loads such as (Abbas and Ali, 2020 ; Jamill and Abbas 2020; Hussein and Karkush, 2021). However, very little information on their lateral behavior is available. Screw piles are characterized by fast installation, low cost, can be reused, available in many lengths and diameter, and used in many applications under tension and axial loads. In addition to its ability to withstand lateral loads, helical piles are also a successful and more feasible alternative when compared to methods using to treat chemically and physically weak soils or replace weak soils, as these methods are time-consuming and are also more expensive. Therefore, the current study is an extension of the previous studies for the purpose of understanding the behavior of the helical piles under the influence of the two-way cyclic lateral load in soft clay.

1.5 Objectives of the Study

This study is devoted to understand the following :

1. Investigate the influence of two way lateral cyclic load on the screw pile group.
2. To study the effect of number of parameter such as group configuration, spacing between screw piles and embedded length.
3. Identify the effect of the number of the helix for screw pile on the lateral resistance under lateral cyclic load and compared it with an ordinary pile for the same conditions.
4. Investigate the effect of cyclic load ratio and number of cyclic on the lateral response for screw piles group.

1.6 Thesis Outline

The main content of this study consists of five chapters:

Chapter One: explains and gives a clear idea of the screw piles and their uses, the magnitude and effect of the lateral cyclic load on the piles' group, the problems of soft clay in Iraq, and the main objective of this study.

Chapter Two: presents a review of previous studies, including theoretical and laboratory studies, in addition to some field studies on the lateral behavior of helical piles.

Chapter Three: includes the details of the laboratory work including the soil used, the model of piles and pile cap, soil container, the method of installing the piles and the device test used for the cyclic lateral load.

Chapter Four: displays the result for different configurations of screw piles groups under the effect of the pure lateral cyclic load and discuss it in this study.

Chapter Five: presents the conclusions derived from this study, as well as the main important recommendations for future studies.