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BEHAVIOR OF A SCREW PILES GROUP FOR SOFT CLAY OVERLAYING SAND

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

By

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بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

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Dedication

To …

My Father, who taught me the right path and cause of my success,

My mother, the light of my eyes

My husband, who supported me in critical time.

My sister, brothers whose love flow in my veins.

My close friends and everyone, who wishes me success in my life,

Our honorable teachers who taught and rewarded us their knowledge.

I dedicate this humble work.

Abeer

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Abeer Saad Jamill

ABSTRACT

Behavior of A Screw Piles Group for Soft Clay Overlaying Sand

By

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Supervisor

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

The Screw piles are one of the best solution used in various engineering applications, which have relatively low capacity foundations offering stability against compression, overturning moment, uplift tension, and horizontal loads.

This study presents a series of(42) practical model tests of practical to evaluate the behavior of the single screw pile and a group of screw piles that were placed in two shapes: square and triangle implanted in soft clay soil underneath a layer of sand under the influence of the compressive load.

The effect of a number of factors was taken, including, the length of the screw pile (250, 320 and 390mm), the number of helix plates (single and double), in addition to that three different pile spacing were taken (1.5Dh, 3.5Dh and 4.5Dh) where Dh represents the diameter of helix plate. These factors used to both square and triangle shapes.

The results of this study showed that the increase in bearing capacity for a group of screw piles under compressive load reached (34-49.6) times for the square pattern and (36-76) times for the triangular pattern when increasing L/D ratio from (25 to 39), the number of helix that give the most ductility withstand pressure forces. Also, the results showed that the spacing between piles embedded in soft clay soil only, (L/D=25 by1.5Dh) was more efficient to resist the forces of compressive loads of the square and triangular pattern, while pile spacing extended to the sandy soil

(L/D=32 and 39 by 3Dh) was more efficient for square pattern, 1.5Dh pile spacing was more efficient for the triangle pattern. In addition, the settlement of screw piles group decreases by (25% -71%) with increasing of pile spacing to minimum value at 3Dh for the square pattern and decreases by (12% -30.7%) with the decrease of pile spacing, to minimum value at (1.5Dh) pile spacing for the triangular pattern. In general, the screw piles group are considered one of a best solution to carry compressive loads of different structures constructed on multi layers of weak soil and dense sand.

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LIST OF ABBREVIATIONS

Abbreviation	Total Name
ASTM	American Standard of Testing Measurements
B.S	British Standards Institution
CFA	Continuous Flight Auger
CFEM	Canadian Foundations Engineering Manual
C	Cohesion
Cc	Compression Index
CRP	Constant Rate of Pentration
C_u	Undrained Shear Strength
Cv	Coefficient of Consolidation
D	Pile Shaft Diameter
D_h	Helix Plate Diameter
D.H	Double Helix Plate
e_o	Initial Void Ratio
FHWA	Federal Highway Administration
H	Thickness of Soft Clay Layer
ISSMFE	International Society for Soil Mechanics and Foundation Engineering
Ic	Consistency Index
L	Pile Length
Ls	Thickness of Sandy Layer
P	Helix Pitch
Q_c	The Ultimate Compressive Capacity
S	Inter Spacing between Helix
Sp	Spacing between piles
S.H	Single Helix Plate
UCS	Unconfined Compressive Strength

Wc	Water Content
W_L	Liquid Limit
W_p	Plastic Limit
Φ	Internal Friction Angle

CHAPTER ONE
INTRODUCTION

1.1 General

The soft clay soil is found in common areas in Iraq, especially in the central and southern Governorates. Soft clays are latest grainy sedimentary deposits molded above the older 10,000 years by seas, lakes, rivers. these clays in nature are fine grained plastic soils with clay, among its characteristics high compressibility and low shear strength. In general, these soils are hard in its dry state and then loses this property when saturated with water. Floods, leakage of sewer lines, rains and lack of evaporation due to buildings are the popular causes of cumulative moisture content in clay soils (Firoozi et al, 2017). This kind of soil causes many problems related to geotechnical engineering with settlements, low bearing capacity, and constancy buildings problems. Actually, the term "soft soil" does not have a clear definition usually it can be known through high, water content, (40-60) % (Broms ,1990),these soil having an undrained shear strength Cu < 10 kPa, as said by Terzaghi, 1936 (as cited by Brand and Brenner, 1981), suggested (Brand and Brenner, 1981) that soil can be known by Cu< 40 kPa and British Standards (B.S. C.P 8004.1986), definite the soil is soft when Cu ranged 20kap to 40 kPa, while Kamon and Bergado, (1991) are known the soil is very soft through Cu less than 20 kPa (cited by Bergado et al. 1996) definite that can be evaluated the smoothness of the crushed for the clayey soils by its Cu, or by its unconfined compression strength (UCS), where the soft soils are measured very soft, when UCS <25 kPa and soft when Cu between (25 and 50) kPa ، (Terzaighi and Peck, 1967).

Actually, the soft clay soils cover middle and southern parts in country of Iraq. Random surveys from different location showed valid

values, for Cu in Governorate of AL-Basra Cu< 30 kPa and Governorates of AL-Nasriya and Missan Cu<40 kPa, and moreover stated clay fraction range (50-70)% and great compression indices about 0.3 (Buringh, 1960). So, the rise level of groundwater in the basins of the governorates of Southern Iraq showed that the clay deposits were weak (Abbawi,2010).

The Pile is the Structure's part that transfer the structure load to the bearing ground at a definite depth under the ground surface. The piles are slender and long parts that transmit the load through weak compressible layers or water into deeper soil or rock of high bearing capacity and less compressibility to avoid shallow soil of low bearing capacity, (Abeb and Smith, 2005). Pile foundations in more conventional civil engineering applications that have a wide range of types and sizes and materials used in practice.

1.2 Screw Pile

Screw piles are named helical anchors or helical piles, and are structural and deep foundation members used to offer constancy to tension, compressive, and lateral loadings (Abbase, 2017). Screw piles contain of a steel tube, either a solid circular shaft or a square tube with single or more helix committed to it (Albusoda and Abbase, 2017). The screw piles, design involves the select of the shaft length(L) and its diameter (D) and their number and diameter(Dh) of helix plate, the spacing between helix diameter. All parameters can effect on the ultimate bearing capacity of screw pile (Wang et al, 2017). The popularity of screw piles has increased harshly in modern periods because of the simple installation method compared to the other deep foundations (e.g. bored and drilling piles) and a high receipt in the geotechnical, industry. Screw piles vary from traditional piles in that they are made of high, strength steel containing helices stable to the shaft at spread out rests and having a sharp tip to

permit for well installation in the earth (Geotechnics, 2005). In a screw piles, there are different in dimensions that are exact to definite conditions, which that shaft and helix pitches, helical plate diameters, spacing between helical plates and embedded depth are variance opinions. The screw piles in gravely or stiff soil are not suitable for the use because the plates of helix can be damaged in process of installation.

1.3 Screw Piles Group

Piles group are widely used as a deep foundation to improve stability of the residential building, transmission tower, drilling platform, and several other types of infrastructure(Chen et all, 2019).

The group behavior of screw piles may differ from that of conventional piles owing to the unique geometry of this pile type. For screw piles, the helix diameter is always larger than the shaft diameter, while straight shaft concrete piles and driven piles often have cylindrical shafts with an equal-diameter toe and shaft. Group pile spacing is often described by the ratio of the pile center-to-center spacing to pile toe diameter (D) for conventional pile groups, or to the helix diameter (Dh) for screw pile groups. The pile spacing within screw piles group will be greater than in conventional piles group.

Figure 1.1 shows a conceptual schematic of the stress fields around a conventional piles group and a screw pile group. Both groups have equal pile spacing; however, the shaft diameter (D) of the conventional pile group is greater than that of the screw pile group (d), thus, resulting in less shaft interaction in the screw pile group (Lanyi and Deng, 2019).

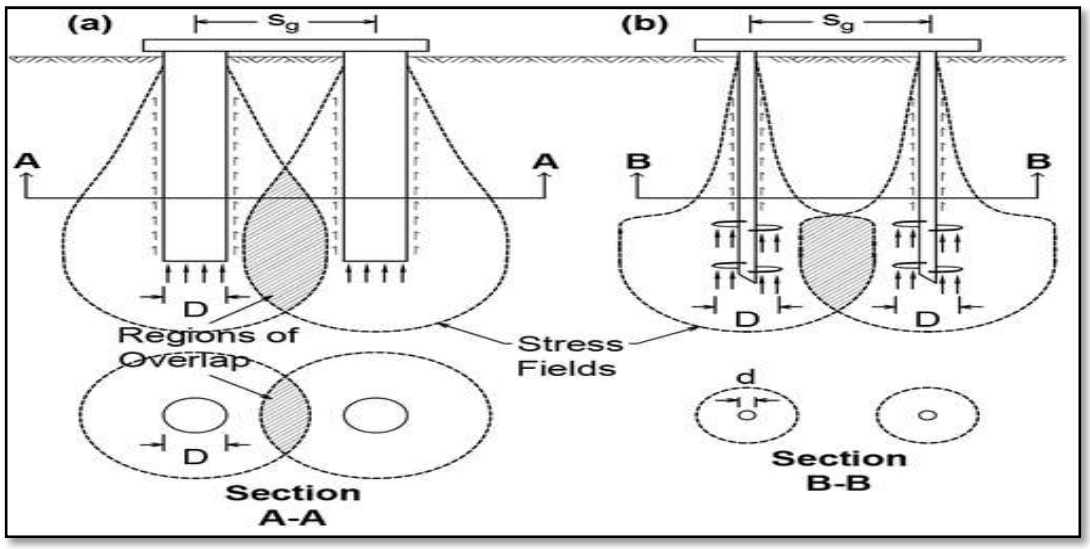

Figure 1.1 Theoretical diagram of stress fields round pile groups:(a) conventional pile group (adapted from Bowles 1997 and Hannigan et al ,2016) (b) Screw pile group.

1.4 Importance of the Study

Over the last few decades, there have been unrelenting efforts to understand and solve engineering problems in soft soils. Various methods can be used to minimize the effects of soft soil damage. These include soil replacements, physical and chemical treatment and use of speciall techniques. The application of these methods remains for a long time. However, many of them have certain limitations and can be very expensive. To address these shortcomings, an attempt to develop a simple, effective, easy-to-install and low cost alternative foundation system, this study presents a simple foundation method in the name of screw piles as a reliable solution for suppressing problems caused by soft soils.

In this study, the behavior of screw piles group in soft clay soils has focused predominantly on the behavior of screw piles group loaded in axial compression with varying embedment depth, number of helix plate, pile length L, spacing between piles Sp and group pattern. Figure (1.2) shows the geometry of a screw pile.

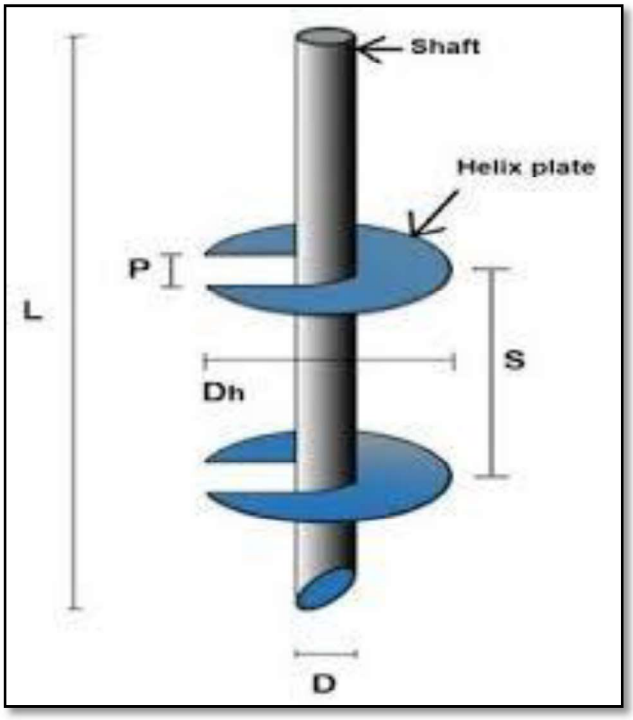

Figure 1.2 Geometry of the Screw Pile

1.5 Statement of the Study Problem

Soft clay soil covers vast areas of the central and southern governorates of Iraq. In most soils of these areas, the shear strength parameters (i.e. cohesion (c) and internal friction angle (ϕ)) vary with depth, as shown in Figure (1.3). Low cohesion values appear for soil samples with depth. That can be attributed to the particle size of the soil at which the clay with water content approaches to the liquid limit than the plastic limit. However, values are increasing with internal friction with depth. This is mainly due to the increase in coarse grains (Sand content) (Al-Taie, 2015).

Due to the large lack of information concerning the use of screw pile in such a profile and the difficulty of implementation and high costs of other treatment methods, in addition to the need for the country to fast and efficient and inexpensive solutions to address damage to buildings due to

earthquakes and explosions, which may be provided by the use of this type of piles characterized by Fast and easy installation, Versatility, low cost and high efficiency, it was necessary to simulate the development of this field through scientific research programs.

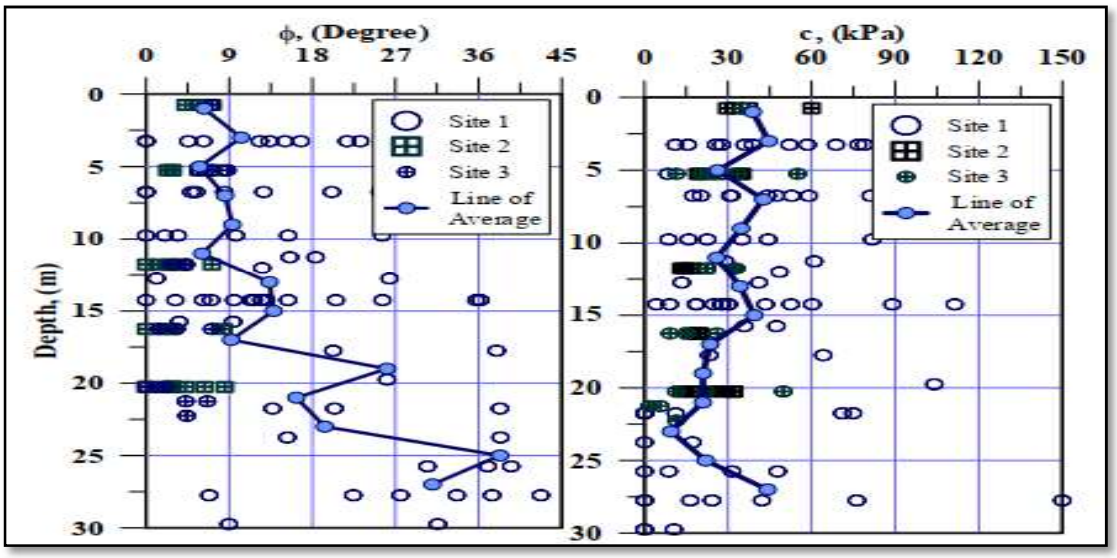

Figure 1.3 Difference of values of the direct shear test for the Basra soil (Al-Taie, 2015)

1.6 Research Objectives

Due to limited information now offered in the works around using screw piles group in soft clay, the current study is to understand and show the behavior of screw piles group in soft clay soil. In this research, the following parts are covered :

- The performance of screw piles group embedded in soft clay soil overlying sand soil under compressive load.
- The influence of embedded depth(L/D) ratio, number of helix plate, number of piles and piles spacing ratio (Sp/Dh) on the ultimate capacity of group.
- The influence of piles spacing on group efficiency.
- The influence of pile spacing on group settlement.

- The influence of extended length in sand layer on ultimate capacity of group .

  In addition, all these parts are performed on two shapes, (square and triangular pattern).

1.7 Thesis Layout

The current thesis consists of five chapters as the following:

Chapter One: Discusses an introduction of soft clay soil, screw piles, screw piles group behavior, important and aims of study.

Chapter Two: Discusses past studies on the soft clay soil, screw piles, and group of screw piles.

Chapter Three: Discusses a detailed experimental work that contains on materials used, piles model, preparation of soil, installation of the screw piles group and compressive loading test.

Chapter Four: presents the results of the compressive tests for all models used in the study with discussions.

Chapter Five: Includes conclusions of the important points and recommendations for future works.