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BEHAVIOR OF RETAINING WALL ENHANCED WITH SCREW PILES SUBJECTED TO CYCLIC LOADS

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

BY

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CHAPTER ONE

INTRODUCTION

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1.1 General

Since life is moving forward quickly overall, an inevitable development in engineering constructions must also occur. This development is reflected in the growth in the number of structures, their heights, and their sizes, which creates significant problems and necessitates raising the safety factor in the buildings or if the structure is placed in a sloping environment or to resist and combat side gravity. Here's where the civil engineer steps in using retaining walls are structures designed to restrain soil to a slope that it would not naturally keep to (typically a steep, near-vertical or vertical slope). They are used to bound soils between two different elevations often in areas of terrain possessing undesirable slopes or in areas where the landscape needs to be shaped severely and engineered for more specific purposes like hillside farming or roadway overpasses as shown in figure (1.1), (Wiba and Vineetha, 2014).

As for the areas of slopes and areas near the offshore exposed to periodic loads resulting from the influence of loads caused by nearby facilities, the impact of vehicles with heavy loads, or any other reason. retaining wall systems are affected by lateral pressure. A lateral earth pressure develops at or near the ground surface as a result of seasonal moisture variation. In the active zone of soil at the top near the ground surface, both the seasonal rainfall ratio and the hot summer moisture evaporation alter. Even the amount of underground water can change with the seasons. The soil-retaining wall structure is stressed and deformed as a result of the soil expansion in the active zone. In addition to stress and pressure, high lateral pressure also results in bending moments and shear forces in the retaining wall (Sahin, 2012). So piles are fixing in the retaining walls to act as a steady supporting soil laterally. Piles transfer the loads from structures to hard strata, rocks, or soil with high bearing capacity. The piles support the structure by remaining solidly placed in the soil.

Figure (1.1): Retaining wall insulation by helical piles (Link1).

1.2 Retaining wall

A retaining wall is any constructed wall that restrains soil or other material at locations having an abrupt change in elevation (Brooks and Nielsen, 2010). Retaining walls are constructions designed to provide earth or other materials stability along their natural slopes. earth retaining structures keep the earth in place and preserve the ground surface height difference, other externally exerted loads are safely transmitted to a foundation by retaining structures designed to withstand the soils or backfill (Diwalkar, 2020). Additionally, retaining walls are frequently utilized when it's important to keep embankments or dirt in a roughly vertical position during the construction of highways, bridges, or structures with basements. In situations where water may erode or undercut the foundation soil, such as in water front constructions, retaining walls are frequently supported by soil (or rock) beneath the base slab or supported on piles. These situations include bridge abutments. Surcharge, Front face, and Back face are the primary components of a retaining wall., Stem, Weep hole, Toe, Base, Heel, Angle of repose.

1.3 Helical piles

Helical piles derived their origin as anchors for structures such as power poles or transmission lines. They began to be used fairly frequently for foundation systems in the early 1936 by Irish engineer Alexander Mitchell. The original helical pile system had little resistance to lateral loads, (Nelson et al. 2015).

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 (Tappenden, 2007).

1.4 Problem of the Study

Previously, several techniques have appeared to support soil in areas exposed to cyclic loads, some of which include adding polymeric or physical materials to the soil, including using sheet pile, using a retaining wall only, or supported by inclined or vertical piles at the base, and a few of them are supported by piles installed horizontally in the wall, so this study will be comprehensive and complementary to what previously, a retaining wall was used supported by screw piles embedded in sandy soil with different distances, lengths and helix subjected to different cyclic loads.

1.5 Aims of the Study

In view of the great and modern development of construction of the retaining walls and the different design and implementation methods and for many and wide areas in different ways and places, in addition to the great development of the manufacturing of helical piles and large areas for their use and the lack of knowledge of their behavior while they are embedded in the soil and connected to the retaining wall. Therefore, this study aims to understand the behavior of the retaining wall subjected to cyclic loads. The screw piles are extended horizontally in sandy soil under the influence of cyclic lateral loads, this study is intended to understand the following:

1. Studying the effect of changing the lateral periodic load on the lateral resistance of the retaining wall.

2. Investigate the effect of the spacing between the screw piles on the lateral resistance of the retaining wall under lateral cyclic load.

3. The effect of changing the number of helix plate (single helix, double helix) for the same length under lateral cyclic load and comparing it with other used lengths.

4. The influence of changing the relative density ratio (D_r) of the sandy soil used on the lateral strength of the retaining wall with or without anchored piles under cyclic lateral load.

5. Investigate the effect of the length of screw piles embedded in the sandy soil which are connected to the retaining wall on the lateral resistance of the retaining wall under the same periodic lateral load.

1.6 Outline of the Thesis

The main content of this study consists of five chapters:

Chapter One: explains and gives a clear idea of the retaining wall and their uses, and advantages, and the helical piles that installation in soil and connected with retaining wall and the main aim of this study.

Chapter Two: shows a review of past theoretical and laboratory studies, with some field studies regarding retaining wall and the helical pile that is installed in it, and the review of cyclic loading.

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

Chapter Four: displays the result for retaining wall with or without helical piles under the effect of the lateral cyclic load and discuss it in this study.

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

Behavior of Retaining Wall Enhanced with Screw Piles Subjected to Cyclic Load

ABSTRACT

A retaining wall is a structure designed to resistance the lateral pressure of soil. The importance of retaining walls was evident in their widespread use in land and sea facilities and areas of changing levels in mountainous areas, but there are few studies on their lateral behavior when subjected to periodic load.

The purpose of this study is to understand and evaluate the response behavior of the retaining wall under the influence of different cyclic loads for 100 cycles in sandy soil, it is characterized by poorly graded sandy soil brought naturally from Karbala Governorate in Iraq, its specific gravity is 2.67. Fixed by three anchored piles horizontally and embedded in the soil with different spacing under the influence of symmetric bi-directional periodic load at 0.11 Hz environmental frequency. Various parameters were investigated such as the effect of the cyclic load, the embedded length, the spacing between the piles, the effect of the number of helices, and the relative density of the sandy soil. The results showed that the increase in the cyclic load affects the lateral resistance of the wall in the direction of decline and its lateral displacement for cyclic No.100 increased 167% and 388% for the single helix anchored model piles, 217% and 489% for the double helix anchored model piles when cyclic load ratio CLR (the ratio between each of the periodic lateral load value and the maximum static lateral load on retaining wall) is 10% and changed to 20% and 30% respectively. The anchored piles showed a significant improvement in the lateral wall resistance by 87% compared to when they were not used

at a cycle No. 100. The reduction in lateral displacement of the wall is 31% and 3% as compared single helix to double helix for spacing between anchored piles in dense sand S=3Dh and S=5Dh respectively and 16% and 2% in loose sand in cyclic number 100, where S represents spacing between anchored piles and Dh is helix diameter.

The relative density of the soil showed an effect on increasing the resistance of the wall and reducing its displacement by 37% and 27% if the dense soil was used instead of the loose for single and double helix anchored piles respectively. At cycle number 100 and as compared spacing S=3Dh to S=4Dh, S=5Dh and S=6Dh, the reduction of lateral displacement of the wall is 16.4%, 37%, and 38.5% for single helix anchored piles and 5.3%, 26.5%, and 28.4% for double helix anchored piles in loose sand.

Finally, the screw piles in dense soil showed better efficiency than if they were in loose soil connected to the retaining wall under cyclic load. Also, the length of the pile gave better resistance than the distance between the piles, which in turn also gave better resistance than the helix number.