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Behavior of Helical Piles in Cohesionless Soils Under Combined Loads

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Presented by

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Abstract

Helical piles have earned considerable attention as an effective deep foundation alternative due to their rapid installation process and their dual purpose in compression and tension. These piles find common uses as foundations for structures like solar panels, wind turbines, offshore platforms, and retaining walls. These structures usually transfer different combinations of loads to foundations in forms like axial and lateral loads. Helical piles are mainly used as axially tensioned and laterally loaded deep foundations. When they are required to resist bearing combined loads (BCLs), such as axial compression and lateral thrust, different behavior is expected, necessitating further investigation. Extensive research has been conducted to investigate and understand the behavior of these piles under the influence of axial or lateral loads. However, the impacts of loading patterns that may act on the helical piles as combinations of axial compression and lateral loads still require more research work. The main objective of the present study is to clarify the behavior of helical piles, single and groups, in cohesionless soil under the action of BCLs. The behavior is studied by investigating the effect of key factors like; shaft rigidity, helix location, pile geometry, pattern of load combination as simultaneous or successive and direction of lateral load for 2-pile groups.

Shaft rigidity is investigated in three cases: flexible, intermediate, and rigid. Helix location (H) varies along the shaft length (L) as the ratio (H/L = 0.20 to 0.90). The pile geometry is varied by changing the shaft diameter (d), pile length (L), and helix to shaft diameter ratio (D/d). The action forms of BCL components, horizontal (Q) and axial vertical compression (V), are varying (Q) during constant (V). Three cases of V are considered, zero, V1 and V2, in two loading patterns with (Q), simultaneous and successive. A simple analytical model is

first developed based on fundamentals and assumptions compatible with the well-established theories of the distribution of bearing stresses and soil pressures. The study is extended experimentally by conducting laboratory loading tests on a set of helical pile models and numerically by a Finite Element model using the software (PLAXIS-3D).

The results indicate highly interactive effects of the studied parameters, but the confirmed is the improvement of lateral capacities with the increase of shaft rigidity and the action of BCLs in successive patterns. The helix's locations along the pile's shafts significantly affect the lateral capacities of helical-pile groups, where the optimal performance is achieved at (H/L = 0.40). Furthermore, groups of rectangular plan distribution exhibit greater lateral capacity if subjected to lateral horizontal load in the direction of its long axis.

Additionally, the research emphasizes that the presence of vertical compression loading may decrease the lateral capacity, contrary to previously believed. This depends upon the value of the vertical compression load, lateral load direction, helix location, and shaft rigidity, which highlights the complex interaction effect of these factors. Finally, the study provides insightful information for the design of helical piles in structures loaded by complex sequences of forces, wind turbines, and industrial shafts.

Keywords: Helical pile, Lateral Loads. Combined Loads, Cohesionless Soil, Analytical Model, Experimental Work, Numerical Analysis.