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When to Evaluate Helical Pile Buckling Capacity

Consider this, you receive two widely different helical pile quotes from two contractors, for the same project and the same compression loading. So, why would one contractor quote a 2 7/8-inch pile and the other a 5 ½-inch pile? It could be that one of the bidders has identified a pile buckling concern and the other has not. Design professionals often overlook the need to evaluate pile buckling potential. It could be that they lack the knowledge to identify when buckling may occur, or assume that it's not a concern if it's not mentioned in the geotechnical report. The fact is, helical piles are slender deep foundation elements and evaluating buckling potential should be part of the design process for every helical pile project that involves compression loading. In most cases, you will be quick to check that box.

There are several methods available to calculate the allowable pile buckling capacity. This article, however, is instead focused on first identifying the more common project or site conditions where the potential for pile buckling may exist.

Fluid Soils: The International Building Code (IBC) requires a buckling analysis when fluid soils are identified within the soil profile penetrated by a deep foundation. Specifically, the IBC states, ***"Any soil other than fluid soil shall be deemed to afford sufficient lateral support to prevent buckling of deep foundation elements and to permit the design of the elements in accordance with accepted engineering practice and the applicable provisions of this code. Where deep foundation elements stand unbraced in air, water or fluid soils, it shall be permitted to consider them laterally supported at a point 5 feet into stiff soil or 10 feet into soft soil unless otherwise approved by the building official on the basis of a geotechnical investigation by a registered design professional."*** So, if you have a project designed in accordance with the IBC, you need to evaluate buckling if fluid soils are present within the depths that could affect the lateral stability of the pile. This section of the code also mentions elements unbraced in air or water, which brings us to the next common condition to evaluate buckling, exposed pile lengths.

Exposed Pile Lengths: Some projects require helical pile shafts to extend above grade to support elevated structures. Common examples may include above-grade pipeline supports, elevated boardwalks, pole foundations and steel grillage supports for towers. There may also be projects that require an existing or retrofit helical pile foundation to be exposed temporarily due to adjacent construction activities.

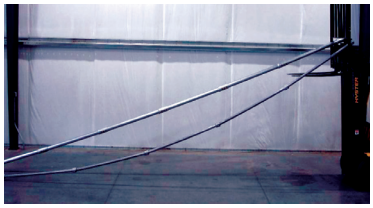
Liquefaction Potential: Seismic regions generally require a geotechnical boring deep enough to identify liquefaction potential during a seismic event. Soil conditions that may be most prone to liquefaction are saturated cohesionless deposits, due to the quick buildup of pore water pressure and subsequent loss of soil shear strength. Therefore, a pile may lose lateral support if it is located within potentially liquefiable soil layers. The loss of soil strength along a deep foundation element due to liquefaction can be a complicated analysis, with different layers of the soil profile providing varying shaft support.

Shaft Coupling Rigidity: Although the IBC recognizes that, "Any soil other than fluid soil shall be deemed to afford sufficient lateral support to prevent buckling of deep foundation elements," this may not be the case for helical piles with upset couplings. Upset couplings allow significant rotational movement within the coupling; therefore, solid square shaft or hollow round shaft helical piles that have forged, upset couplings would be more prone to creating a buckling situation than similar shafts with welded or external/internal sleeve-type couplings. This loss of coupling rigidity for upset couplings is one reason that Supportworks does not recommend square shaft helical piles for compression loading unless they are installed in higher strength soil, such as soil with a standard penetration test N-value of 10 blows per foot, or more. To that end, helical piles with upset couplings used for compression loading in weak soil conditions may warrant a buckling analysis. The third photo from the top shows the lack of coupling rigidity for an upset square shaft coupler versus an external, welded round shaft coupler.

DON DEARDORFF, P.E.

Helical piles installed for elevated boardwalk

Exposed helical pile shafts for adjacent excavation



Difference in coupling rigidity between forged (square shaft) and welded couplers (round shaft)

Knowing when to evaluate a deep foundation system for buckling capacity is an important part of the project design process. This article hopefully provides you with more insight regarding when a buckling analysis should be performed based on the project type, site soil conditions and product coupling details. For more information see Appendix 1D of the Supportworks Technical Manual and GroundED Issue 35. View both online at www.OnStableGround.com.