Critical Depth for Helical Pile Design in Sands

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For new construction applications near and along coasts, helical piles compete well against the more traditional driven wood piles and driven precast concrete piles due to minimal vibrations and the ability to easily add extensions to reach deeper, competent soils. Installation equipment for helical piles can also be much smaller than the equipment needed to install driven piles, which allows helical pile contractors to bid on work with limited access and low headroom conditions.

Helical piles advanced to support pedestrian bridge; bearing within sand; limited working space

Helical piles share the same general design considerations as other end-bearing deep foundations; i.e., the soils must be capable of supporting the design working loads with an appropriate factor of safety and any observed or predicted settlements must be within the tolerable limits of the structure. That said, common sense should guide you away from designing a pile to bear within soft and/or organic soils, sensitive clays and silts, active soils, loose sands, saturated liquefiable sands….(the list goes on). In general, Standard Penetration Test (SPT) N-values of 15 to 30 blows per foot for clay soils and 10 to 30 blows per foot for sand are preferred for providing end-bearing resistance for helical piles and anchors. Higher or lower N-values may also be considered.

The design of helical piles in sands should also consider the concept of "critical depth". In both the Individual Bearing Method and the Cylindrical Shear Method used to determine helical pile capacity, we expect pile capacity in sandy soil to increase as the vertical effective overburden stress increases.

Individual Bearing Method:

$$Q_u = \sum A_h(cN_c + q'N_q)$$

Cylindrical Shear Method:

$$Q_u = 2\pi RL(c + K_o q' \tan Ø) + A_h(cN_c + q'N_q)$$

Where,

Q_u = Ultimate Pile Capacity (lb)

q' = Vertical Effective Overburden Stress at Helix Depth (lb/ft^2)

Since vertical effective overburden stress is a function of soil unit weight and depth, it would then follow that pile capacity should increase with pile depth. In a uniform soil, we know this does not happen below a certain depth….the critical depth. The critical depth is defined as the limiting depth within granular soil where a further increase in vertical effective overburden stress results in little to no increase in the end bearing capacity of the pile. Certainly, if the sandy soil becomes more or less dense below the critical depth and the internal friction angle varies, an increase or decrease in pile capacity will occur, but not because of an increase in overburden stress. This concept is well documented in many foundation design textbooks and design manuals.

Critical depth may range from 10D to 40D (where D is the largest helix plate diameter), depending upon the relative density and position of the water table. FSI recommends critical depths of 20D to 30D be considered for design purposes. For example, if the helix plate depth is greater than an assumed critical depth of 20D, limit the vertical effective overburden stress at the helix plate to that value corresponding to the critical depth of 20D.

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