Predicting Helical Pile Capacity

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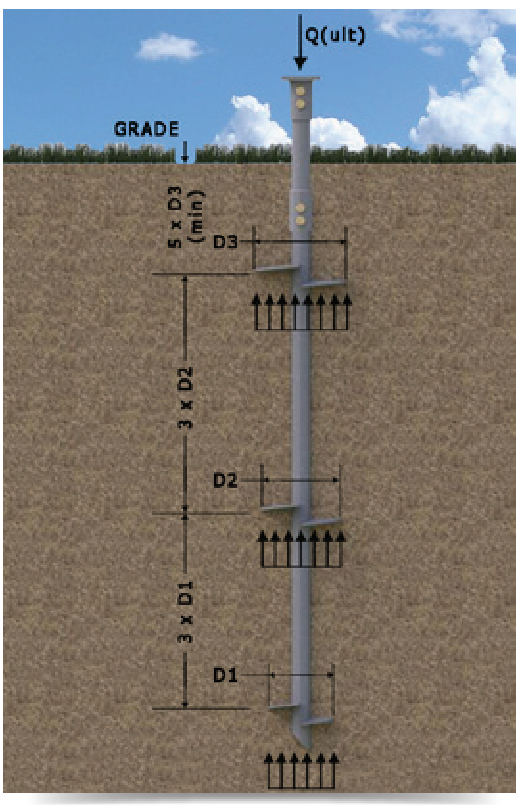
There are three common methods for predicting helical pile capacity; the individual bearing method, the cylindrical shear method and the torque correlation method. The first two methods are rooted in traditional geotechnical methodology, slightly modified with empirical data, and are generally used to calculate or estimate pile capacity during the design phase.

The torque correlation method is fully empirical and generally used to confirm or verify capacity during pile installation.

The individual bearing method states that the ultimate pile capacity is equal to the sum of the individual helix plate capacities. Figure 1 illustrates the load transfer mechanism for the individual bearing method in compression loading.

Figure 1: Individual Bearing Method



Helical pile capacity by the individual bearing method can be calculated from:

$$Q_u = \sum A_h(cN_c + q'N_q + 0.5\gamma DN_\gamma)$$

Where,

Q_u	=	Ultimate Pile Capacity (lb)
c	=	Cohesion at Helix Depth (lb/ft^2)
q′	=	Effective Vertical Overburden Stress at Helix Depth (lb/ft^2)
γ	=	Soil Unit Weight (lb/ft^3)
D	=	Diameter of Helix Plate (ft)
A_h	=	Area of the Helix Plate (ft^2)
N_c N_q N_γ	=	Dimensionless Bearing Capacity Factors

The last part of the equation is often ignored in the calculation of end-bearing capacity of deep foundations. The diameter or width of the pile is relatively small and therefore this portion of the equation contributes little to the overall pile capacity. With that portion of the equation conservatively ignored, the equation further simplifies to:

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

For purely cohesive soils with Ø = 0 and c = soil shear strength, $N_c \approx 9$ and $N_q = 1$. The equation can conservatively be rewritten as:

$$Q_u = \sum A_h(9c)$$

For purely granular (frictional) soils with c = 0, the equation can be rewritten as:

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

The cylindrical shear method assumes the development of a soil friction column (cylinder) between the upper and lower helix plates along with individual bearing of either the upper or lower helix, depending upon loading direction. Figure 2 illustrates the load transfer mechanism for the cylindrical shear method in compression loading.

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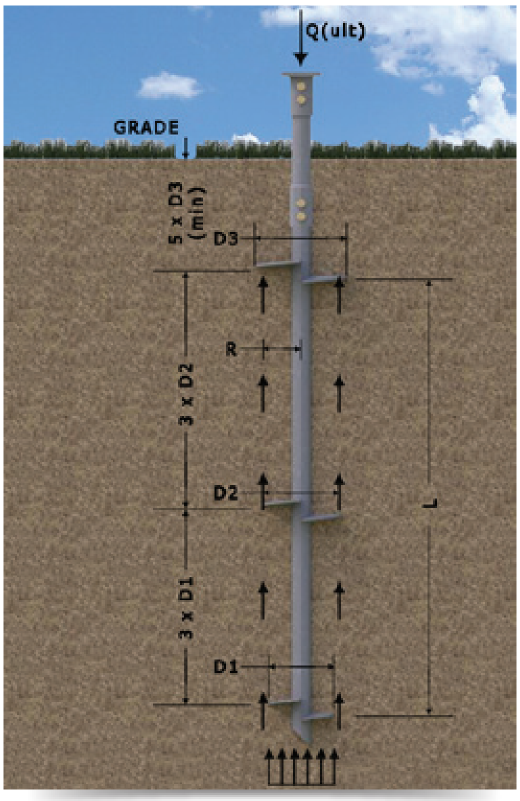
The helical pile capacity by the cylindrical shear method can be calculated as:

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

Where (in addition to the above definitions),
R = Average Helix Radius (ft)
L = Total Spacing Between All Helix Blades (ft)
K_o = Dimensionless At-Rest Earth Pressure Coefficient
Ø = Soil Friction Angle (degrees)

Figure 2: Cylindrical Shear Method



The individual bearing method and cylindrical shear method should provide similar results if reasonable, representative soil parameters are selected by the designer. That said, FSI promotes the use of the individual bearing method for determination of pile capacity due to its relative simplicity and since the original form from which this method is derived is widely accepted by the geotechnical engineering community.

The torque correlation method is a well-documented and accepted method for estimating helical pile capacity. In simple terms, the torsional resistance generated during helical pile installation is a measure of soil shear strength and can be related to the bearing capacity of the pile with the following equation:

$$Q_u = K_t \times T$$

Where,

K_t = Empirical Torque Correlation Factor (ft^{-1})
T = Final Installation Torque (ft-lb)

ICC-ES AC358 recognizes the following helical pile shaft sizes and default K_t factors for conforming systems, since the installation torque to capacity ratios have been established with documented research:

- 1.5 and 1.75-inch solid square shaft $K_t = 10\ ft^{-1}$
- 2.875-inch outside diameter round shaft $K_t = 9\ ft^{-1}$
- 3.0-inch outside diameter round shaft $K_t = 8\ ft^{-1}$
- 3.5-inch outside diameter round shaft $K_t = 7\ ft^{-1}$

Like other deep foundation alternatives, there are many factors to consider in designing a helical pile foundation. Foundation Supportworks® recommends that helical pile design be completed by an experienced geotechnical engineer or other qualified design professional. Please consult the FSI Technical Manual for additional information.

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Jeff is involved in product design, product verification testing, preliminary design applications, project consulting, conducting installation, sales and marketing training, as well as developing and presenting eduction-based material. Jeff routinely travels throughout the United States and Canada to consult with local installing contractors about general or project-specific needs, and to present technical information to engineers, architects and general contractors.