FOUNDATION
SUPPORTWORKS™

MODEL 150 HELICAL ANCHOR SYSTEM

STABILITY. SECURITY. INTEGRITY.

150 Helical Anchor System

About FOUNDATION SUPPORTWORKS

▶ **Foundation Supportworks™** is a network of the most experienced and knowledgeable foundation repair and new construction piering and anchoring contractors in North America. With dealers from coast to coast, Foundation Supportworks™ is focused on training, gathering, and sharing the best practices in the industry. Your authorized dealer is therefore operating with the resources of literally hundreds of years of combined experience. Each dealer is trained, authorized, and certified by Foundation Supportworks™.

Foundation Supportworks™ has major dealer support facilities in Omaha, Nebraska and Seymour, Connecticut.

Omaha, Nebraska

Seymour, Connecticut

ENGINEERING

▶ Foundation Supportworks™ has both geotechnical and structural engineers on staff for product design, quality assurance of products, and dealer support. Our in-house engineers are available to assist with preliminary designs and provide technical support to engineers, architects, building departments, and general contractors local to the projects.

HELICAL ANCHORS

▶ Helical anchors are a factory-manufactured steel foundation system consisting of a central shaft with one or more helix-shaped bearing plates, commonly referred to as blades, welded to the lead section. Extension shafts, with or without additional helix plates, are used to extend the anchor into competent load-bearing soils. Helical anchors are advanced ("screwed") into the ground with the application of torque.

The terms helical piles, screw piles, helical piers, helical anchors, helix piers, and helix anchors are often used interchangeably by specifiers. However, the term "pier" more often refers to a helical foundation system loaded in axial compression, while the term "anchor" more often refers to a helical foundation system loaded in axial tension.

DID YOU KNOW?

The use of helical foundation systems in construction dates back nearly 200 years. In the 1830's, the earliest versions of today's helicals were used in England for moorings and for the foundations of lighthouse structures. Today, helical foundation options are gaining worldwide acceptance throughout the construction industry and engineering community due to the versatility of both the product and the installation equipment. In 2007, the International Code Council Evaluation Service, Inc. (ICC-ES) approved AC358, Acceptance Criteria for Helical Foundation Systems and Devices. Helical foundation systems are also now included in the 2009 International Building Code.

▶ DESIGN CONSIDERATIONS

Helical anchors are designed such that most of the axial capacity of the anchor is generated through bearing of the helix blades against the soil. The helix blades are typically spaced three diameters apart along the anchor shaft to prevent one blade from contributing significant stress to the bearing soil of the adjacent blade. Significant stress influence is limited to a 'bulb' of soil within about two helix diameters from the bearing surface in the axial direction and one helix diameter from the center of the anchor shaft in the lateral direction. Each helix blade therefore acts independently in bearing along the anchor shaft.

Multiple anchors shall have a center to center spacing at the helix depth of at least four (4) times the diameter of the largest helix blade (ICC-ES AC358). The tops of the anchors may be closer at the ground surface but installed at a batter or angle away from each other in order to meet the spacing criteria at the helix depth. Helix blades shall have an embedment depth of at least twelve (12) diameters in the direction of loading (ICC-ES AC358).


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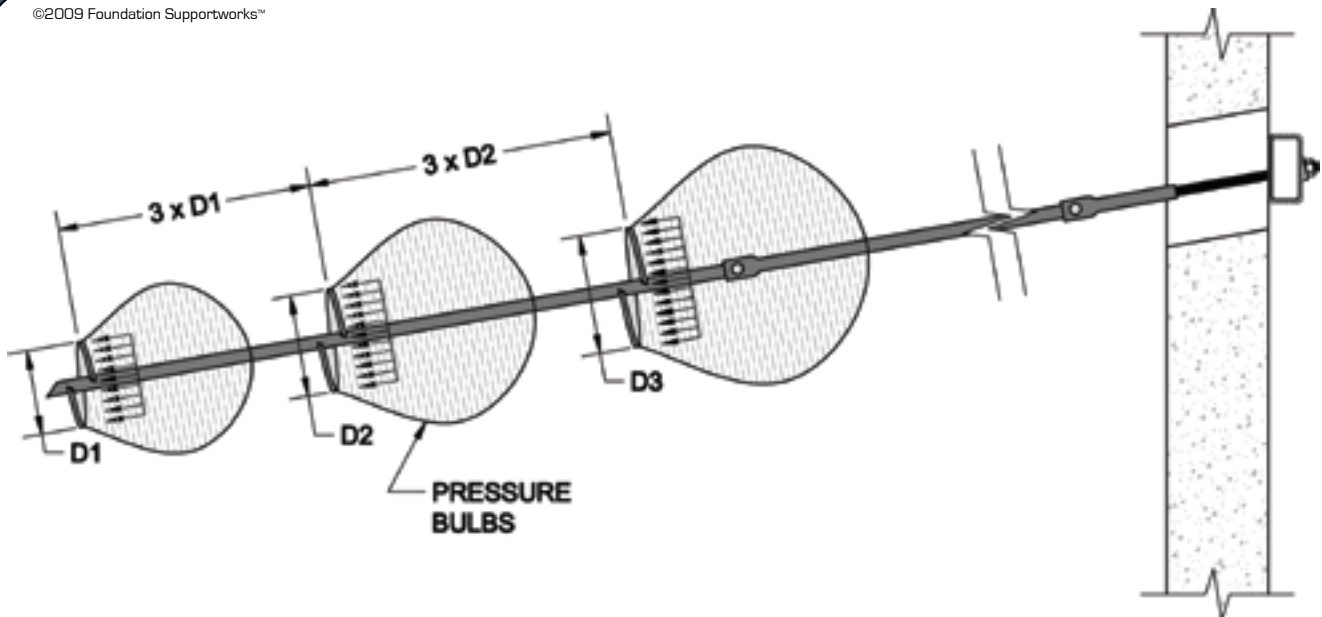
▶ HELIX BLADE GEOMETRY

Foundation Supportworks' helical anchors feature blades manufactured with a true helix shape conforming to the geometry criteria of ICC-ES AC358. The leading and trailing edges of true helix blades are within one-quarter inch of parallel to each other and any radial measurement across the blade is perpendicular to the anchor shaft. A true helix shape along with proper alignment and spacing of the blades is critical to minimize soil disturbance during installation.

Conversely, blades that are not a true helix shape are often formed to a 'duckbill' appearance. These plates create a great deal of soil disturbance and do not conform to the helix geometry requirements of ICC-ES AC358 since their torque to capacity relationships are not well documented.
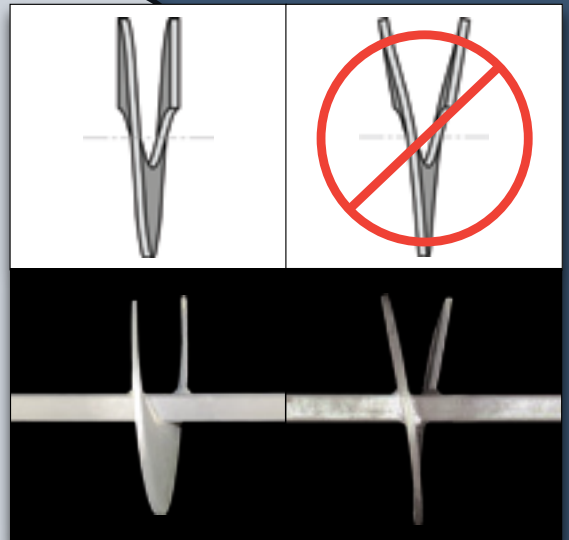
▶ DETERMINATION OF CAPACITY

The ultimate capacity of a helical anchor may be calculated using the traditional bearing capacity equation:

$$Q_u = \sum [A_h (cN_c + qN_q)]$$

Where
- Q_u = Ultimate Anchor Capacity (lb)
- A_h = Area of Individual Helix Plate (ft²)
- c = Effective Soil Cohesion (lb/ft²)
- N_c = Dimensionless Bearing Capacity Factor = 9
- q = Effective Vertical Overburden Pressure (lb/ft²)
- N_q = Dimensionless Bearing Capacity Factor

Total stress parameters should be used for short-term and transient load applications and effective stress parameters should be used for long-term, permanent load applications. A factor of safety of 2 is typically used to determine the allowable soil bearing capacity, especially if torque is monitored during the helical anchor installation.

*Like other deep foundation alternatives, there are many factors to be considered in designing a helical anchor foundation. Foundation Supportworks™ recommends that helical anchor design be completed by an experienced geotechnical engineer or other qualified professional.

Another well-documented and accepted method for estimating helical anchor capacity is by correlation to installation torque. In simple terms, the torsional resistance generated during helical anchor installation is a measure of soil shear strength and can be related to the bearing capacity of the anchor.

$$Q_u = KT$$

Where
- Q_u = Ultimate Anchor Capacity (lb)
- K = Capacity to Torque Ratio (ft⁻¹)
- T = Installation Torque (ft-lb)

The capacity to torque ratio is not a constant and varies with soil conditions and the size of the anchor shaft. Load testing using the proposed helical anchor and helix blade configuration is the best way to determine project-specific K-values. However, ICC-ES AC358 provides default K-values for varying anchor shaft sizes, which may be used conservatively for most soil conditions. The default value for the Model 150 Helical Anchor System (1.50" square shaft) is K = 10 ft⁻¹.

▶ AREA OF HELIX BLADES

Helix Diameter (inches)	Helix Area (ft²)
6	0.18
8	0.33
10	0.53
12	0.77
14	1.05

▶ ANCHOR CAPACITY

The cross section of a square shaft is very compact which can allow the anchor to penetrate more easily through the soil. This compact shape also reduces the stiffness of the cross section and introduces more potential for buckling. These two factors make square shaft helical anchors better suited for tension loads. Foundation Supportworks™, Inc. therefore recommends their use mainly for these types of applications. Square shaft helical anchors (piles) used in compression should be evaluated on a case by case basis by the project engineer.

Mechanical Axial Capacity (see note):
    Allowable Tension = 26.5 kips*

*The mechanical tensile capacity of the Model 150 Helical Anchor System is limited by the allowable stress levels dictated by AISC for a high strength bolt in double shear. The allowable tensile capacity of the shaft is actually much higher than this Allowable Tension value.

Torque Limited Axial Design Capacities based on Ultimate Torsional Resistance of Anchor Shaft = 6,340 ft-lbs**:
    Ultimate Soil Capacity = 63.4 kips** (with K = 10 ft^{-1}, see note)
    Allowable Soil Capacity = 31.7 kips (FOS = 2, Allowable System Capacity therefore governed by mechanical capacity = 26.5 kips*)

**This Ultimate Torsional Resistance and its corresponding Torque Limited Capacities are based on laboratory test results from an IAS accredited facility and may only be approached in idealized conditions. Plastic torsional deformations can begin in the anchor shaft near 4,600 ft-lbs. This value may be reached and exceeded in the field by maintaining alignment between the anchor and the drive head, limiting impact forces and torque reversal, and reducing the tendency to "crowd" (push down on) the anchor. Installation through soils with obstructions or high variability may result in impact loading on the anchor. In these cases, achieving high torque values becomes more difficult and a further reduction in the Design Torque Limit may be appropriate.
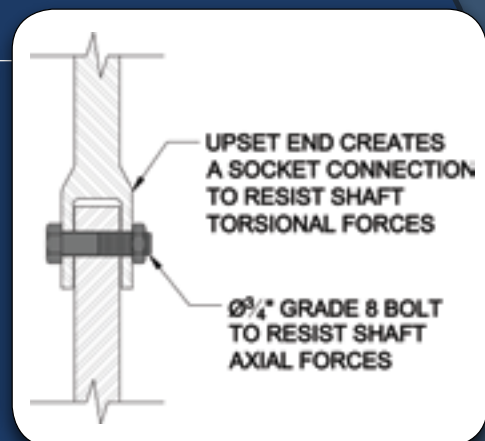
▶ NOTE

K = 10 ft^{-1} is a default value as published in ICC-ES AC358 which can, in many cases, be considered conservative. Higher capacities can often be achieved with site-specific load testing. Allowable capacities based on site testing shall not exceed the Mechanical Axial Capacity.
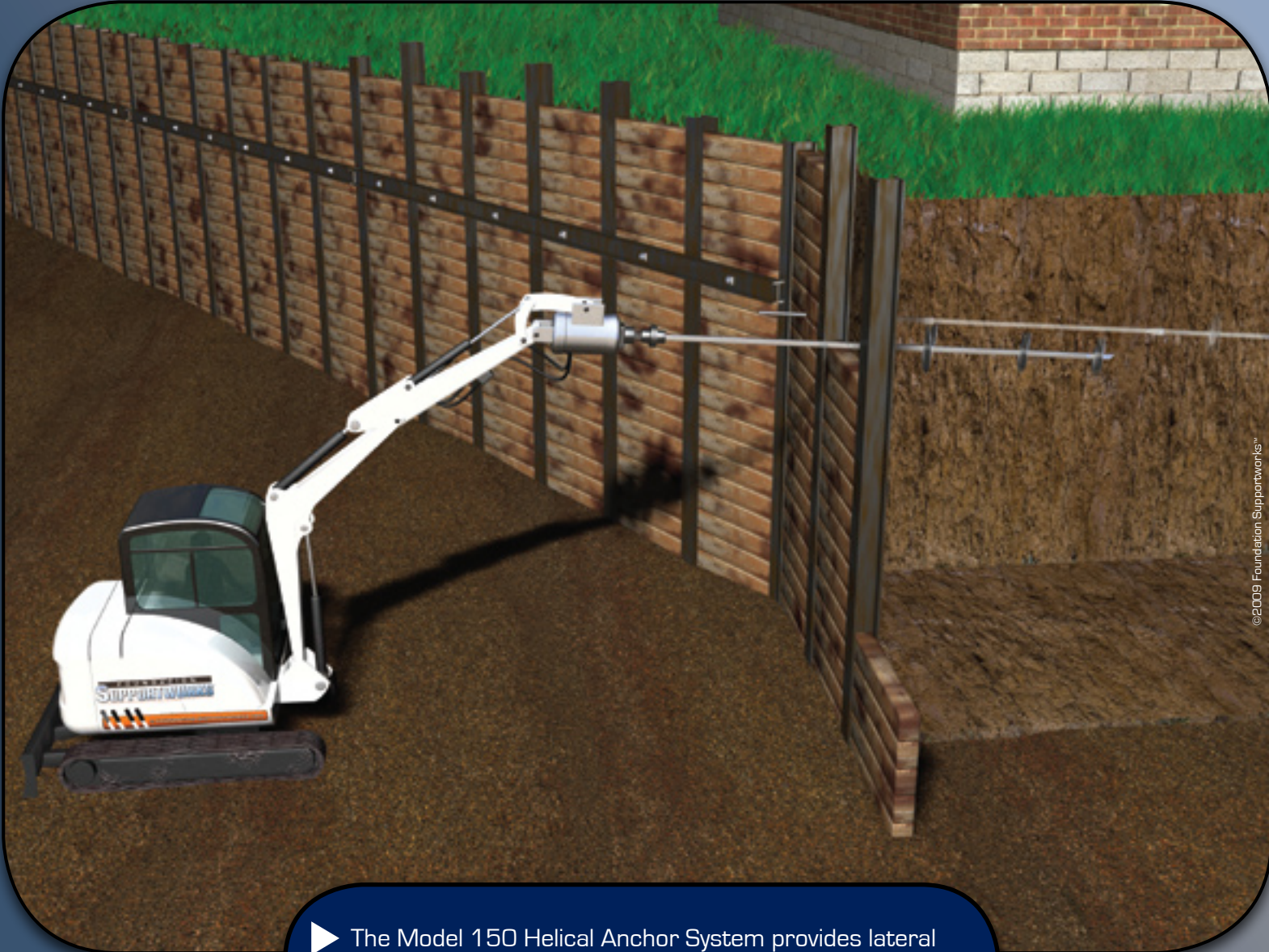
▶ TECHNICAL SPECIFICATIONS

- Outer Dimensions = 1.50" x 1.50"
- Anchor Shaft Yield Strength = 90 ksi (min.)
- Coupling Hardware: Ø¾" Grade 8 Bolt with Nut
- Available Helix Blade Diameters = 6", 8", 10", 12" and 14"
- Helix Blade Thickness = 0.375"
- Termination Hardware: Ø1" Threaded Rod, Tensile Strength = 120 ksi (min.)

▶ COUPLING DETAIL

The extensions for the Model 150 Helical Anchor System are manufactured with forged, upset ends that are drilled to create a socket and bolt coupling. Direct, sufficient contact of the anchor shaft is much more difficult to achieve within upset couplings than couplings for shafts with machine cut ends. The coupling bolt then acts in double shear for both tension and compression applications. Since FSI recommends that square shaft anchors be used mainly to resist tension loads, this level of precision is not justified.

UPSET END CREATES A SOCKET CONNECTION TO RESIST SHAFT TORSIONAL FORCES

Ø¾" GRADE 8 BOLT TO RESIST SHAFT AXIAL FORCES
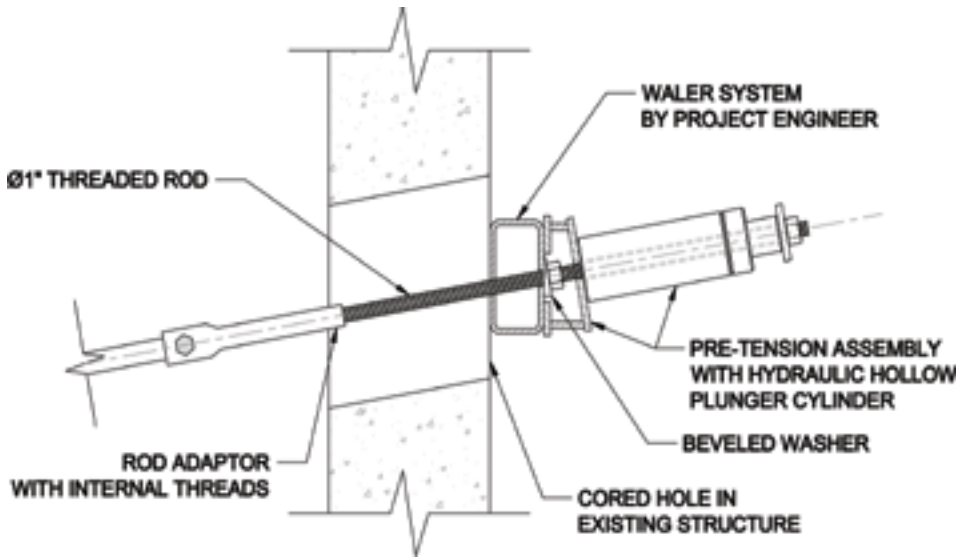
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▶ The Model 150 Helical Anchor System provides lateral stability to foundation walls and retaining walls with unbalanced earth pressures. Helical anchors can be installed with hand-held equipment, mini-excavators, skid steers, backhoes, trackhoes, or crane-supported rigs so the installation equipment can be sized for the project.

Model 150 Helical Anchor System
ADVANTAGES ✓

- Predictable capacity

- Helix blade configuration selected to achieve design embedment and capacity

- All-weather installation

- Can be installed in areas of limited or tight access

- Installation does not generate spoils

- Clean installation with no messy grout

- Load tests can be performed immediately following installation

- Available with optional hot-dip galvanizing for added corrosion protection

Ø1" THREADED ROD

ROD ADAPTOR
WITH INTERNAL THREADS

WALER SYSTEM
BY PROJECT ENGINEER

PRE-TENSION ASSEMBLY
WITH HYDRAULIC HOLLOW
PLUNGER CYLINDER

BEVELED WASHER

CORED HOLE IN
EXISTING STRUCTURE

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▶ Foundation Supportworks™ recommends that all helical anchors be pre-tensioned following installation. Pre-tensioning to the design load minimizes deflection of the anchors and structure as the anchors are put into service. Anchors can also be "pull tested" or load tested to typically two (2) times the design load or more to identify the ultimate system capacity, better assess soil conditions and soil/anchor interaction, and validate design procedures.
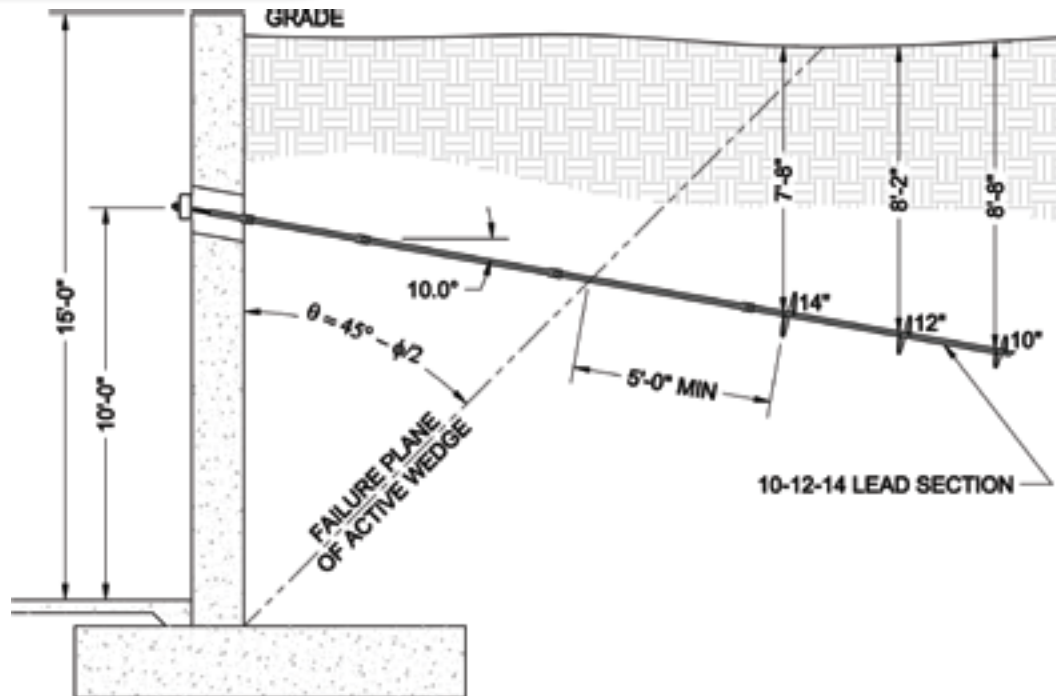
EXAMPLE 1

▶ Soil Type: Lean Clay (CL)
Unit Weight (γ) = 115 lb/ft^3
Cohesion (c) = 1,000 lb/ft^2
Friction Angle (ϕ) = 0 degrees

$$Q_u = \Sigma \left[A_h (cN_c + qN_q) \right]$$

when ϕ = 0, conservatively neglect (qN_q) term

$$Q_u = \Sigma \left[A_h (cN_c) \right]$$

$$
\begin{aligned}
Q_u = \quad & 0.53 * 1,000 * 9 \\
+ \ & 0.77 * 1,000 * 9 \\
+ \ & 1.05 * 1,000 * 9 \\[6pt]
= \ & 4,770 + 6,930 + 9,450 \\
= \ & 21,150 \text{ lbs.} = 21 \text{ kips}
\end{aligned}
$$

$Q_{allowable}$ = 21 / 2 (FOS) = <u>10.5 kips</u>

EXAMPLE 2

▶ Soil Type = Silty Sand (SM)
Unit Weight (γ) = 120 lb/ft^3
Cohesion (c) = 0 lb/ft^2
Friction Angle (ϕ) = 30 degrees

$$Q_u = \Sigma \left[A_h (cN_c + qN_q) \right]$$

when c = 0,

$$Q_u = \Sigma \left[A_h (qN_q) \right]$$

$$q = \gamma d$$

where d = depth to helix plate

$$N_{q, 30 \text{ degrees}} = 18.4$$

$$
\begin{aligned}
Q_u = \quad & 0.53 * 120 * 8.67 * 18.4 \\
+ \ & 0.77 * 120 * 8.17 * 18.4 \\
+ \ & 1.05 * 120 * 7.67 * 18.4 \\[6pt]
= \ & 10,146 + 13,890 + 17,782 \\
= \ & 41,818 \text{ lbs.} = 41 \text{ kips}
\end{aligned}
$$

$Q_{allowable}$ = 41 / 2 (FOS) = <u>20.5 kips</u>