Industry Standards

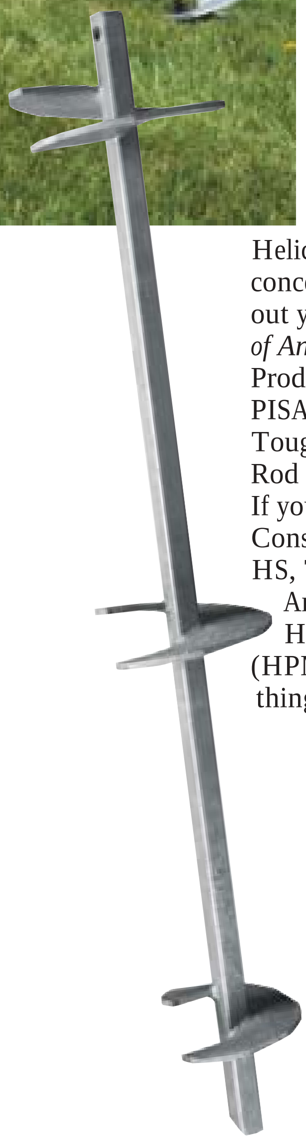
based on CHANCE® multi-helix anchor specs

State-of-the-Art:

R&D history of inter-helix spacing traces application of technical principles

The helical screw anchor is not a sophisticated product in the 21st century of cell phones, the Internet and High-Definition TV. A low-tech product in a high-tech world, it continues to serve ever-expanding roles for utilities and in civil construction. In fact, the screw anchor's elegant simplicity is its greatest asset: An uncomplicated product with multiple uses.

Historical Perspective: Low-tech to high-tech designs



Helical screw anchors may be simple in concept, but they come in many forms. Take out your copy of the CHANCE® *Encyclopedia of Anchoring* and look through the Anchor Product Section. It shows you these types: PISA® (Power Installed Screw Anchors), Tough One®, Square-Shaft (or SS), Round-Rod (or RR), and No-Wrench screw anchors. If you also have an A.B. Chance Co. Civil Construction SA Catalog, you can find Types HS, T/C, Street Light Foundations (SLF), Area Lighting Foundations (ALF), and HELICAL PULLDOWN™ Micropiles (HPM). These anchor types all have three things in common:

1. At least one helically shaped bearing plate,
2. A central steel shaft,
3. An appropriate structural connection at the top.

Yet each different anchor type serves different applications. And new uses seemingly come to light every day.

Answers to FAQs (Frequently Asked Questions):

This array of screw anchor types has led many to ask why so many? What requirements or design constraints have led to their current forms? Can the current design be improved? In the case of multi-helix screw anchors, particularly Type SS, how far apart should the helix plates be spaced along the shaft? Is there an optimum spacing that provides the best performance in terms of installation and load carrying capacity? Answering these questions requires looking back over some 40 years to just before A.B. Chance Company developed Type SS screw anchors.

Introduced in 1959, PISA anchors were well known and in widespread use by the early 1960's. They were available in single and twin-helix configurations (twin 8" and twin 10"). Their inter-helix spacing changed often over the years, but always has been in the 15- to 30-inch range. Their standard rod length was 7 ft. As the following quote from the 1966 edition of the *Encyclopedia of Anchoring* indicates, the chief advantage of multi-helix anchors was already known: *"Installed in place of larger single helix Type PISA. Higher holding powers can be obtained with the two helix anchors."*

Where two helices are better than one, logic indicates three or more helices would be better than two. This reasoning was put to good use in 1961, when the Chance Company developed extendable Type RR multi-helix anchors. The original application for multi-helix RR anchors was as tiedowns for underground pipelines in poor soil conditions along coastal regions of the Gulf of Mexico. Type

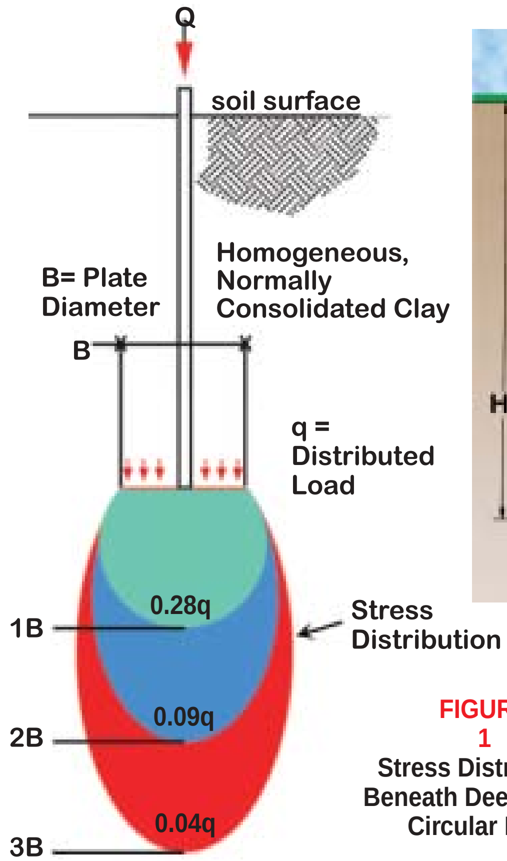


FIGURE 1
Stress Distribution Beneath Deep Buried Circular Plate

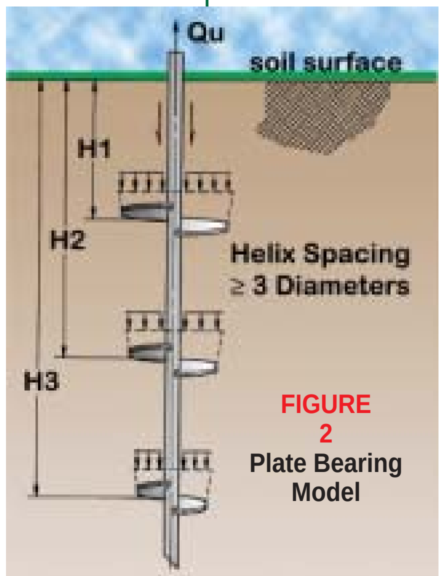


FIGURE 2
Plate Bearing Model

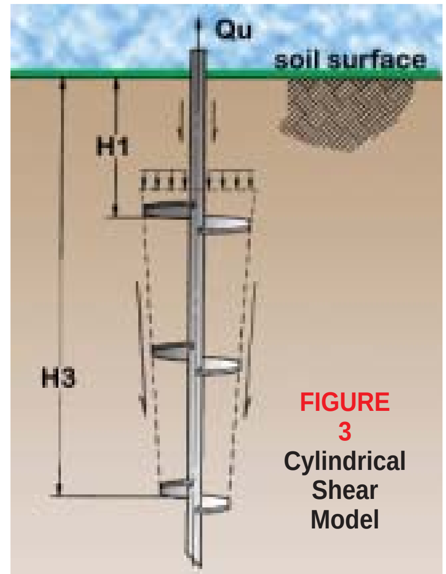


FIGURE 3
Cylindrical Shear Model

RR anchors worked well in weak surficial soils, but their 1¼" diameter shaft did not provide enough torque strength to penetrate very far into firm bearing soils.

Development of a high torque multi-helix anchor began in 1963, culminating in the Chance Company's introduction of Type SS 1½" square shaft multi-helix anchors in 1964-65.

Inter-helix spacing was 36" for both Types RR and SS anchors. Why 36 inches? Remember that the 7-ft. length of standard PISA rods was established as a length for a worker to reach when using the wrench-driven PISA system. Since Types RR and SS anchors also were driven by tooling attached to a torque motor, this same practical length applied to them as well.

Based on proportion, three helices equally spaced 36" apart fit well on a 7'-0" shaft. Using the same 36" spacing, two helices were placed on a 5'-0" shaft (for bed-mounted diggers) and four helices were placed on a 10'-0" shaft. The three helix configuration quickly became the most popular Type SS lead section and remains so today. Three-foot (36") spacing remained the norm for Types RR and SS, as well as for HS-8, HS-11, and HS-14 High-Strength guy anchors developed later in the 1960s.

Geotechnical science evolves changes

In the 1970s and early 1980s, a gradual change in the design philosophy at A.B. Chance Co. eventually led to changes in inter-helix spacing. Adopting generally accepted geotechnical engineering principles, it was recognized that a deep buried plate (i.e., screw anchor helix) transferred an applied load to the soil in end bearing (bearing capacity theory).

This transfer of load results in a "stress zone" within a defined soil volume immediately above or below the helix depending on the direction of the load (tension - above helix, compression - below helix). A necessary condition for this method to work is that the helices must be spaced far enough apart to avoid overlapping their stress zones.

The Boussinesq (circa 1885) Equation has described the stress distribution in soil resulting from a load applied via a buried plate/footing as shown in Figure 1. For a multi-helix anchor installed into uniform, homogeneous soil, spacing helix plates too close together can result in overlapping stress distributions, which may lead to unexpected failure.

Likewise, spacing helix plates too far apart prevents soil stress overlap, but results in a screw anchor that is unnecessarily long. As can be seen in Figure 1, the magnitude of stress one diameter away from the buried plate is 28% the magnitude of stress at the plate. Note the magnitude of stress three diameters away from the buried plate is only 4% the magnitude of stress at the plate. Greater distance from the plate results in stress magnitude reduction, but at a significantly reduced rate.

What inter-helix spacing is optimum?

The Boussinesq Equation suggests a spacing of three-helix diameters as a practical solution based on stress distribution. The design question posed by the above discussion also has been answered by two other accepted principles.

The bearing capacity theory (Figure 2, plate bearing model) suggests the capacity of a multi-helix screw anchor is equal to the sum of the capacities of the individual helix plates. Calculating the unit bearing capacity of the soil and multiplying by the individual helix areas determine the total end-bearing capacity.

The cylindrical shear theory (Figure 3, cylindrical shear model) suggests the capacity of a multi-helix screw anchor is equal to the bearing capacity of the top-most helix (tension load), plus the friction capacity resulting from the shear strength of the soil along a cylinder bounded by the top and bottom helix with a diameter defined by the average of all helix diameters on a multi-helix anchor.

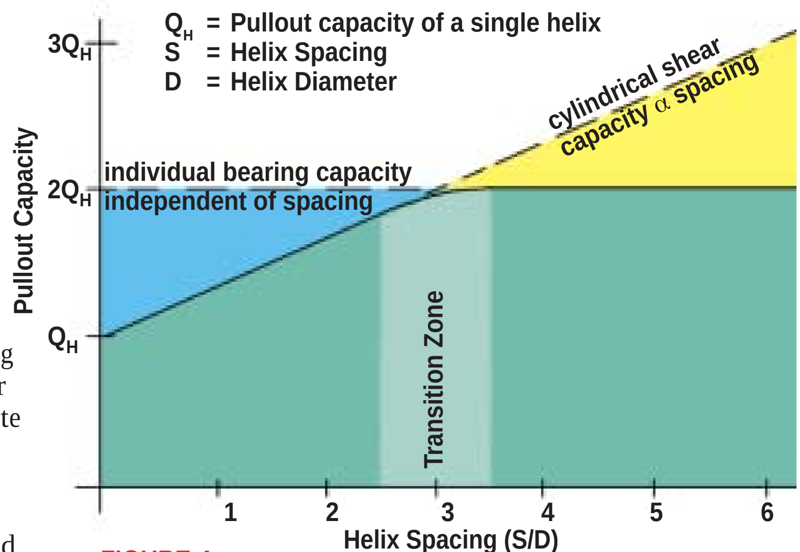


FIGURE 4
Pullout Capacity of 2-Helix Anchor vs Helix Spacing

Both cylindrical shear and individual bearing represent permissible failure mechanisms for any inter-helix spacing, therefore the ultimate capacity associated with them are upper bounds of the actual ultimate capacity at all spacings (see Figure 4). At "small" spacings, cylindrical shear is the least upper bound and controls capacity, per the Least Upper-Bound Theorem. At "large" spacings, individual bearing becomes the least upper bound and controls capacity.

To determine where the transition occurs from cylindrical shear to indivdual bearing, data from late 1970's field tests were analyzed. The interpreted results indicate that the transition spacing is about three diameters, as is indicated in Figure 4. This is consistent with the performance of multi-belled concrete piers (Bassett, 1977) and with the fact that the cylindrical shear and individual bearing methods usually give similar results for screw anchors with three-helix diameters spacing.

Industry Standard derived from CHANCE® three-diameters spacing

It is important to understand that soils generally are not homogeneous mixtures exhibiting uniform strength properties. Spacing helix plates unnecessarily far apart increases the possibility that one or more of them will not be located in the same soil layer as the others.

The key is to space the helix plates just far enough apart to maximize the bearing capacity of a given soil.

This works to reduce the overall length of the anchor and increases the likelihood for all helix plates to be located in the same soil layer. This leads to more predictable torque-to-capacity relationships and better creep (movement under load) characteristics.

Today, A.B. Chance Company manufactures helical screw anchors with three-helix-diameters spacing, the space between any two helices being three times the diameter of the lower helix. This is the optimum spacing that historically has been sufficient to prevent one helix from significantly influencing the performance of another, while at the same time preventing the previously mentioned disadvantages of spacing helices too far apart.

INDUSTRY STANDARD

A Definition: Three-helix-diameter spacing –

The optimum space between any two helical plates on a screw anchor is three times the diameter of the lower helix.

With the introduction of Chance Type SS150, SS175, SS200, and SS225 High Strength SS Anchors in the late 1970's and early 1980's, helix plates were located on the shaft using three-helix-diameters spacing. Type HS anchors were changed to this spacing in 1986. The standard-strength SS, known as the SS5 series, remained at 36 inch spacing until 1997, when it also was updated to the industry standard of three-diameters spacing, now common to other Chance shaft-driven multi-helix screw anchors.

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