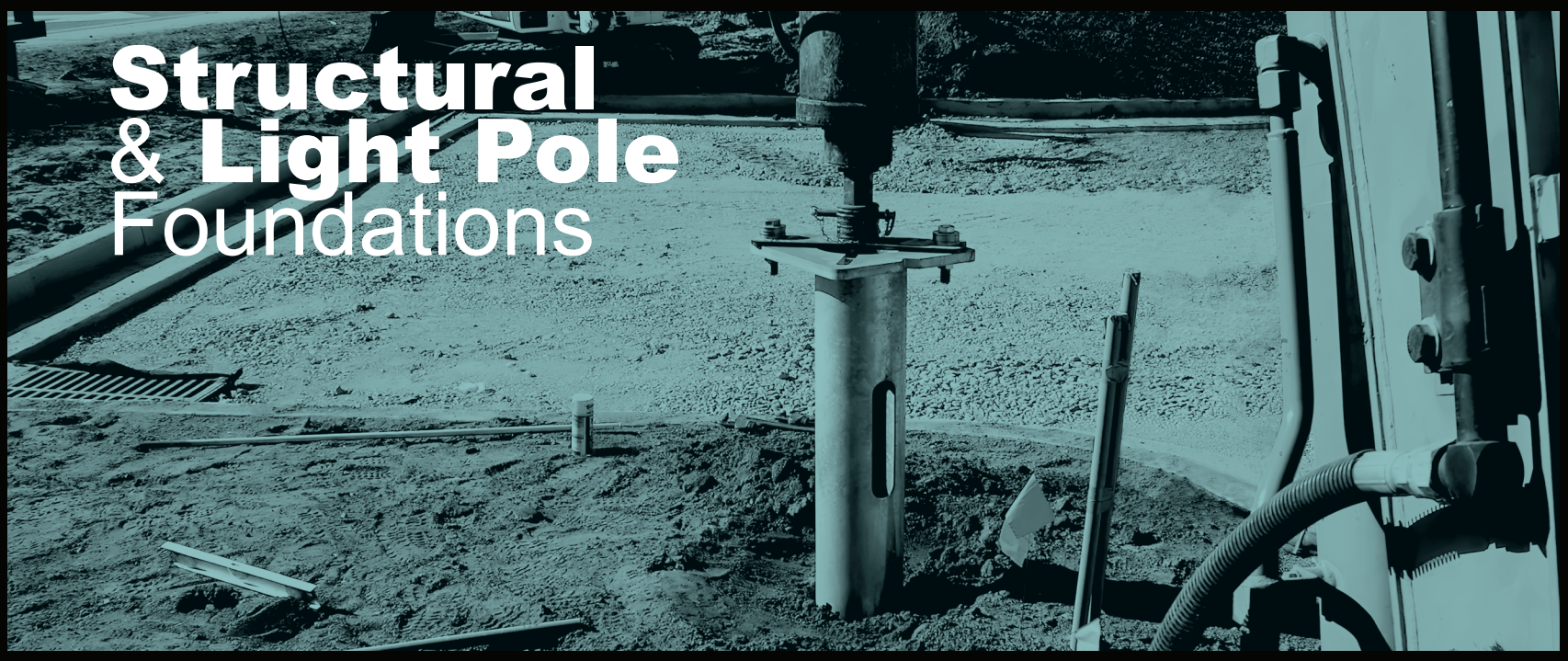
ECP and UTILITY ANCHORING HANDBOOK





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Utility Industry Field Handbook

Selection and Installation of **ECP Helical Torque Anchors™**

for

- **Guy Anchoring**
- **Compression Piles**

ECP UTILITY

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Preface

Earth Contract Products designs and manufactures quality foundation anchors and support products at competitive prices. The purpose of this handbook is to provide field technicians with quick installation guidance and product selection that will most economically fit a given application. In this Field Handbook we have attempted to take the highly technical engineering theories and distill them into a very user friendly format. The reader will find clear and simple explanations, data tables, graphs and examples.

When using this handbook the reader can arrive at a relatively accurate product design by following step by step instructions, tables and graphs.

This handbook is in no way intended to replace professional engineering input and judgment. We require that the user always incorporate a factor of safety suitable to the project for each design. We highly recommend consulting with a professional engineer on complicated or critical applications. We also consider it good practice to perform a field load test on any heavily loaded anchors or for compression pile placements in critical applications.

Thank you for your Trust and Confidence in ECP products.

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Introduction to ECP Helical Torque Anchors™

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Screw piles have been in use for more than 162 years. In 1838 a lighthouse was built upon screw piles designed by an Irish engineer, Alexander Mitchell. In 1863, Eugenius Birch designed the Brighton West Pier in Brighton, England. These piers are still in use 140 years later. The original screw piles were installed at 10 feet per hour using eight 20 foot long torque bars with the force of 32 to 40 men.

In the United States, the Thomas Point Shoal Lighthouse on Chesapeake Bay, Maryland is the only remaining lighthouse built upon helical screw piles that is situated at its original location near Annapolis, Maryland. The lighthouse has a hexagonal shape measuring 35 feet across, and it is still supported by seven original helical screw piles. The Thomas Point Shoal Lighthouse was first put into operation on November 20, 1875.



Thomas Point Shoal Lighthouse

The helical screw piles that support the structure consist of ten inch diameter wrought iron shafts with cast iron helical screw flanges at the end of the shafts. At Thomas Point, the screw piles were advanced into to sandy bottom of Chesapeake Bay a distance of 11-1/2 feet. The light is mounted 43 feet above the surface of the water.



Cast iron coupling at Thomas Point Lighthouse

Sporadic use of screw piles has been documented throughout the 19th and early 20th centuries mainly for supporting structures and bridges over weak or wet soil.

Hydraulic torque motors became available in the 1960's, which allowed for easy and fast installation of screw piles. Screw piles soon became the favored product for resisting tensile forces. Electric utility companies began to use screw piles for tie down anchors on transmission towers and for guy wires on utility poles. With the implementation of helical gear motors in the 1960's, easy and fast installation of helical screw piles by the electric utility companies became a leading consumer of helical anchors. Initially the helical screw piles were used for guy wire anchors for utility poles and subsequently as tie down anchors for transmission towers. The combination of the gear motor and the helical anchor provided excellent foundation support for utility infrastructure. Such applications are particularly beneficial in times of major storm damage where a rapid foundation support system is necessary to restore power to customers.

Helical screw piles are ideal for applications where there is a need to resist both tensile and axial compressive forces. Some examples of structures having such combination forces are metal building foundations, canopy supports and monopole telecommunication tower foundations. Current uses for helical screw pile foundations include foundations for commercial and residential structures, lighting standards, retaining walls tieback anchors, guy wire anchors, failed foundation restorations, pipeline and pumping equipment supports, elevated walkways, bridge abutments, and numerous other uses in the electric utility industry.

ECP Torque Anchors™

ECP Torque Anchors™ are a part of the complete product line of screw piles, steel piers and foundation support products manufactured by Earth Contact Products, LLC, a family owned company based in Olathe, Kansas. The company was built upon the ECP Steel Pier™, a fourth generation end bearing steel mini-pile designed and patented for ECP.

Our 100,000 square foot state of the art manufacturing facility produces all components and steel assemblies. The only processes not done in our facility are galvanization and hot forge upsetting of shaft couplings. We are able to

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custom design and configure products to your engineered specific applications. Earth Contact Products uses only certified welders and robotics for quality fabrication.

ICC-ES Evaluation Report ER-3559 covers most Torque Anchor™ products presented here.

ECP Torque Anchor™ Components

The ECP Torque Anchor™ consists of a shaft fabricated from either solid square steel bar or tubular steel. Welded to the shaft are one or more helix shaped circular plates. The helices can vary in diameter from 6 inches to 16 inches and have a thickness of 3/8 or 1/2 inch depending upon the soil and the load to be supported. Typically the plates attached to the shaft increase in diameter from the bottom of the shaft upward and are spaced at a distance of three times the diameter of the helice directly below unless specified otherwise by an engineer. The standard thickness for all helices is 3/8 inch, except for the 16 inch diameter plate which is manufactured only 1/2 inch thick steel. In high load applications or in obstruction laden soils, helices with thickness of 1/2 inch may be specified attached to the Guy Anchor or Compression Pile shaft. The pitch of all helical plates is three inches, which means that the anchor shaft advances into the soil a distance of three inches during one revolution.

The available lead lengths for shafts for most products range in standard lengths from three feet to 14-1/2 feet. Other lengths may be special ordered and fabricated for specialized applications. Because Torque Anchors™ are considered deep foundation elements; they are usually installed into the soil to a depth greater than just the length of the typical lead section. Extensions of various lengths are available and are supplied with couplings and hardware for attachment to the lead or another extension allowing the Torque Anchor™ assembly to reach any depth requirement. Extensions may in some instances have helices installed on the shaft when the length of the lead shaft is not sufficiently long to allow for the proper interval between all of the helices specified. The number of the helices per Torque Anchor™ is limited only by the capacity of the shaft to transmit the torque required to advance the Torque Anchor™ into the soil.

Torque Anchors™ may terminate with a cable eye for Guy Anchor applications; in other applications, such as tieback anchors, the connection is to a transition. A transition is a coupling that connects to the top of the anchor shaft that transition to a continuously threaded rod. Transitions are usually specified for connecting to a wall structure or to stabilize and support equipment. Various beams, plates, grillages, etc, can be attached to the threaded bar that extends from a transition. This can provide support for structural restoration, for structural stabilization, and/or for resistance to overturning forces.

For other applications such as equipment, structure foundation or equipment pad stabilization; Torque Anchor™ Compression Piles are available and are thoroughly discussion within this Handbook under the portion of the Handbook discussing design and application of Compression Helical Piles.

ECP also offers foundation brackets that attach Torque Anchor™ Compression Piles to existing structures to provide enhanced support or recovery of lost elevation. The foundation bracket transfers the load from the foundation element to the Compression Pile. Foundation bracket design and applications are discussed in the "ECP Technical Design and Service Manual, which is free upon request.

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Product Benefits

- **Quickly Installed**
- **Low Installed Cost**
- **Installs With Little Or No Vibration**
- **Installs In Areas With Limited Access**
- **Little Or No Disturbance To The Site**
- **Soil Removal From Site Unnecessary**
- **Installed Torque Usually Correlates To Capacity**
- **Easily Load Tested To Verify Capacity**
- **Can Be Loaded Immediately After Installation**
- **Installs Below The Unstable And Sinking Soil To Firm Bearing**
- **Small Shaft Size Limits "Down Drag" From Shallow Consolidating Soils**
- **All Weather Installation**
- **Warranted Against Defects in Materials and Workmanship**
- **Selected Products RUS Approved**

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Product Limitations

Helical anchors are not suitable in locations where subsurface material may damage the shaft or the helices during installation. Soils containing cobbles, large amounts of gravel, boulders, construction debris, and/or landfill materials are usually unsuitable for helical product installations.

Because these products have slender shafts, buckling may occur when helical pile shafts are loaded in compression and must pass through extremely soft soil, which cannot exert sufficient lateral force against the narrow shafts. When extremely soft soils are present, generally considered Class 8 and some Class 7 soils where measured Standard Penetration Test values of "N" $\leq$ 5 blows per foot, one must take into consideration the axial stiffness of the shaft in the compression load capacity design.

The slender shafts also render the typical helical anchors ineffective against large lateral loads or overturning moments when they are used as a compression foundation element.

Soil Types

The most commonly encountered soils that may be suitable for anchoring are clay soils and granular soil types. These soils are generally classified as cohesive or cohesionless by geotechnical engineers. Soils that have fine grained structures such as clay and silt are considered cohesive. Cohesionless soil is the other major soil type and refers to coarse grained soils. Sands and gravels are considered cohesionless soils.

Properties for cohesive soil are generally categorized by geotechnical engineers as soft, stiff, firm or hard soil. Cohesionless soils are usually categorized as loose, medium dense, dense, and very dense soil. These descriptors help to judge the strength of the soil.

In some instances, one encounters rather thick layers of soils, or strata, that are rather consistent *(homogeneous soil*); but this is often not the case as many soil strata are created from deposited soils, which have been transported from the area of formation to the present site. Residual soils

Table 1. SOIL CLASSIFICATION TABLE

Class	Soil Description	Geological Classification	Standard Penetration Test Range - "N" [1] (Blows/ft)
0 [2]	Solid Hard Rock (Unweathered)	Granite; Basalt; Massive Sedimentary	No penetration
1 [2]	Very dense/cemented sands; Coarse gravel and cobbles	Caliche	60 to 100+
2	Dense fine sands; Hard silts and/or clays	Basal till; Boulder clay; Caliche; Weathered laminated rock	45 to 60
3	Dense sands/gravel, Stiff/hard silt and clay	Glacial till; Weathered shale; Schist, Gneiss; Siltstone	35 to 50
4	Medium dense coarse sand/sandy gravels; Stiff/very stiff silt/clay	Glacial till; Hardpan; Marl	24 to 40
5	Medium dense coarse sand and sandy gravel; Stiff/very stiff silt and clay	Saprolites; Residual soil	14 to 25
6	Loose/medium dense fine/coarse sand; Stiff clay and silt	Dense hydraulic fill; Compacted fill; Residual soil	7 to 14
7 [3]	Loose fine sand; Medium/stiff clay; Fill	Flood plain soil; Lake clay; Adobe; Clay gumbo; Fill	4 to 8
8 [3 4]	Peat, Organic silts, Fly ash, Very loose sand; Very soft/soft clay	Unconsolidated fill; Swamp deposits; Marsh soil	WOH to 5 (WOH = Weight of Hammer)

Notes: 1. Standard Penetration Test (SPT) ranges are only broad estimates to assist with determining Soil Classes

2. Soils in class "0", class "1" and a portion of class "2" are generally not suitable for guy anchorage because the helices are unable to advance into the very dense/hard soil or rock sufficiently for anchorage.

3. When installing anchors into soils classified from "7" and "8", it is advisable to continue the installation deeper into more dense soil classified between "3" and "5" to prevent creep and enhanced anchor capacity.

4. Shaft buckling must be considered when designing compressive anchors that pass through Class 8 soils.

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are formed by physical or chemical forces that have broken down the rocks or the soil into a very fine structure. Residual soils may also be found in layers (strata) of varying soil categories. The process of residual formation of soil is referred to as “weathering”, and these soils are called “weathered soils”. Many of the cohesionless soils were formed from the sedimentation processes on lake and oceans bottoms millions of years earlier. Geological changes are responsible for the layering of these soils.

The transitioning through layer to layer (stratum to stratum) of the soil can create difficulties when anchoring into the soil, especially when a soft stratum is situated between two hard or dense strata. In cases when an anchor straddles weak strata, the soft soil could fail to provide the anticipated support to one or more helical plates embedded within this soft soil. The result could be creep of the anchor due to the soft soil migrating around the helical plate and overloading the other plates embedded into the denser strata.

Effects of Water Table Fluctuations and Freeze Thaw Cycle

When designing helical anchors, the amount of water present in the soil at the time of installation, and possible moisture changes in the future, must be considered. If the anchor is installed near the water table, the capacity of the anchor can dramatically change with the changing level of the water table.

Cohesionless soil is buoyed by the water when the soil becomes saturated due to a rise in the water table above the anchor. This buoyancy of the soil particles in the soil reduces the holding capacity of the anchor. A different situation exists if the anchor is just below the water table and dry conditions cause the water table to drop. As the water drains from between the soil particles, the soil around the helical plates could begin to consolidate. This soil consolidation may cause the anchor to creep and require later adjustment.

Anchors should always be installed below the lowest recorded frost depth to a distance of more than three diameters of the uppermost plate. In most cases this is usually three to four feet below the lowest expected frost depth. The reasoning here is that when the soil thaws and the ice changes to water, the soil can become saturated.

From the discussion above about installations made near the water table, a similar situation can exist here. Load capacity could reduce because the newly saturated soil cannot support as much load as damp to dry soil.

Clay soil is especially vulnerable and can become plastic when saturated. A saturated cohesive soil might simply flow around the helical plates and possibly cause an anchor failure. In addition, freezing water within the pores of the soil can lead to upward pressure, movement and loss of strength when helices are terminated within a freeze-thaw zone.

It is important to know the maximum frost depth and the range of depths for the water table at the specific job site to insure a solid and stable installation.

Monitoring the installation torsion on the shaft can predict the performance of the anchor at the time of installation, but changes in the soil moisture at a later time can affect the long term holding ability of the anchor.

Anchor Holding Capacity

The capacity of a helical anchor can be estimated by accurately measuring the installation shaft torsion. Several methods of measurement are commonly used. Transducers attached to hydraulic lines, strain gauge monitors, shear pins and pressure differential monitoring at the installation motor are all common ways to determine the installation torque being applied to the anchor shaft.

Helical piles and anchors should be installed to the specified shaft torsion, or greater, for a distance of at least three feet beyond the point at which the torque requirement is met.

Installation of the pile or anchor beyond where first reaching the specified torque insures that the helices are sufficiently embedded into the target soil. The chance of creep or pull out is remote when the helices are fully embedded.

Field Load Testing

If there is a question about the anchor or pile reaching suitable embedment, a field load test might be required to verify the actual capacity achieved. During a field test, the anchor is pulled in the direction of the intended load or guy

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installation angle. A compressive pile is loaded using a test frame. Field testing measures helical product deflections at increasing load increments up to the point when the product fails.

Guy Anchor Testing

Before performing a field load test, a small initial "seating" load of 1,500 to 2,000 pounds is usually applied to the anchor prior to the actual test load increments.

There will be a small deflection of the shaft when the helical pile or anchor is initially loaded, which is "seating" the plates into the soil. This movement is normally not considered in the total load-deflection measurements.

A load test consists of the pile or anchor being incrementally loaded. Once the increment is reached, the amount of shaft movement, if any, is measured and recorded. The deflection for a specific load increment is recorded after all movement ceases and the anchor becomes stable. If the movement persists, often referred to as "creep"; or the total measured creep exceeds the acceptable deflection for the specific project, the ultimate capacity of the product is said to have been exceeded. Acceptable guy anchor creep is generally in the range of up to 4 inches.

Keep in mind that the Ultimate Capacity is the load that produces unacceptable deflection of the product. Therefore it is absolutely necessary to apply a factor of safety to an Ultimate Load rating to arrive at a stable long term Service Load.

Soil type will affect the performance of the anchor during field testing. For example, anchors installed in clay will show minimal creep with increasing load and then suddenly and continuously start to move. Sandy and gravelly soils on the other hand usually will produce a more predictable load-to-creep curve.

When testing Tensile Guy Applications, the Ultimate Capacity or maximum allowable anchor holding load is the load that produces no more than four inches deflection.

Compression Pile Testing

When a field load test is required on a compression pile, it is slightly more complicated than tension testing. The full details are presented in the ECP Technical Service and Design Manual.

In order to load the test pile in compression, a testing frame is necessary. The frame is anchored to the soil with four tension anchors.

The testing procedure is performed in increments with the deflections measured at each increment until the pile reaches ultimate capacity. Compression applications are much more critical than guy anchoring, therefore a downward shaft deflection exceeding one inch is considered to have exceeded the compressive ultimate capacity and the pile has failed.

When testing Ultimate Capacity of a Structural Compressive Pile, the maximum allowable deflection shall be less than one inch. This will insure stable structural support.

Technical Design Assistance

Earth Contact Products, LLC. has a knowledgeable staff that stands ready to help you with understanding how to prepare preliminary designs, installation procedures, load testing, and documentation of each placement when using ECP Torque Anchors™. If you have questions or require engineering assistance in evaluating, designing, and/or specifying Earth Contact Products, please contact us at 913 393-0007, Fax at 913 393-0008.

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Field Handbook
Tension Applications - Guy Anchors
ECP Helical Torque Anchors™

- **PITA Helical Torque Anchors™**
- **HD Extreme PITA Torque Anchors™**
- **Solid Square Shaft Torque Anchors™**

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The following preliminary design information presented here is intended to assist with the selection of an appropriate ECP Torque Anchor™ configuration for a Tension Guy Anchor installation. **The Ultimate Guy Anchor Capacity is defined by a load on the anchor assembly that creates a deflection that does not exceed four inches.**

Deep Foundations

Helical Guy Anchor systems must be considered as deep foundation elements and as such must be, as a rule of thumb, installed to a **minimum depth from grade to at least six times the diameter of the largest helice on the shaft**.

The measurement shall be made vertically from the final surface elevation to the depth of the shallowest helice on the helical guy anchor shaft.

The capacity of a multi-helix deep foundation system assumes that the ultimate bearing capacity is the sum of the bearing support derived from each helice of the system. Testing has shown that when the helices are spaced at least three times the diameter of the immediately lower helice, each helice will have full efficiency and develop maximum load transfer capacity in the soil. Spacing the helices at less than three diameters apart is possible; however, each helice will not be able to develop full capacity due to interference between the soil stress bulbs from the adjacent helices. The designer will have to include a reduced helice efficiency factor in the analysis when conducting a design having helices closer than three diameters apart.

Guy Anchor Shaft Spacing

Maintain the center to center anchor or pile shaft spacing no closer than five times the diameter of the largest helical plate on the shaft, when measured at the target depth, to insure full load capacity of each anchor or pile. Product spacing as close as three diameters has been successfully installed, but this work requires special installation equipment that can maintain precise installation angle tolerances. The horizontal Guy Anchor shaft spacing recommended by ECP is five times the diameter of the largest plate on the shaft. The measurement is taken at the target depth. It is acceptable to cluster several anchor shafts adjacent to each other at the surface, if during installation each shaft has a suitable outward batter angle to achieve the recommended five diameter center to center shaft spacing of the largest helice at the final installed depth.

In all cases, we highly recommend a field test at the project site to verify the accuracy of the anchor design to verify actual load capacity, whether calculated from geotechnical data or from an assumed Soil Class in Table 1.

Table 1. SOIL CLASSIFICATION TABLE

Class	Soil Description	Geological Classification	Standard Penetration Test Range - "N" [1] (Blows/ft)
0 [2]	Solid Hard Rock (Unweathered)	Granite; Basalt; Massive Sedimentary	No penetration
1 [2]	Very dense/cemented sands; Coarse gravel and cobbles	Caliche	60 to 100+
2	Dense fine sands; Hard silts and/or clays	Basal till; Boulder clay; Caliche; Weathered laminated rock	45 to 60
3	Dense sands/gravel, Stiff/hard silt and clay	Glacial till; Weathered shale; Schist, Gneiss; Siltstone	35 to 50
4	Medium dense coarse sand/sandy gravels; Stiff/very stiff silt/clay	Glacial till; Hardpan; Marl	24 to 40
5	Med dense coarse sand and sandy gravel; Stiff/very stiff silt and clay	Saprolites; Residual soil	14 to 25
6	Loose/medium dense fine/coarse sand; Stiff clay and silt	Dense hydraulic fill; Compacted fill; Residual soil	7 to 14
7 [3]	Loose fine sand; Medium/stiff clay; Fill	Flood plain soil; Lake clay; Adobe; Clay gumbo; Fill	4 to 8
8 [3 4]	Peat, Organic silts, Fly ash, Very loose sand; Very soft/soft clay	Unconsolidated fill; Swamp deposits; Marsh soil	WOH (Weight of Hammer) to 5

Notes:

1. Standard Penetration Test (SPT) ranges are only broad estimates to assist in determining Soil Classes
2. Soils in class "0", class "1" and a portion of class "2" are generally not suitable for tieback anchorage because the helical plates are unable to advance into the very dense/hard soil or rock sufficiently for anchorage.
3. When installing anchors into soils classified from "7" and "8", it is advisable to continue the installation deeper into more dense soil classified between "3" and "5" to prevent creep and **enhanced anchor capacity.**
4. Shaft buckling must be considered when designing compressive anchors that pass through Class 8 soils.

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Soil Behavior

The following information is provided to introduce the reader to basic soil mechanics. Explained here are the terms and theories used to determine soil behavior and how this behavior relates to helical Torque Anchor™ performance. This is not meant as a substitute for actual geotechnical soil evaluations. A thorough study of this subject is beyond the scope of this manual. The *ECP Technical Design and Service Manuel* offers greater details and explanations. The values and soil descriptions presented here are typical of those found in geotechnical reports.

Cohesive Soil (Clays)

Cohesive soil is soil that is generally classified as a fine grained clay soil or silt. By comparison, granular soils like sands and gravels are referred to as non-cohesive or cohesionless soils.

Clays or cohesive soils are defined as soils where the internal friction between particles is approximately zero. This internal friction angle is usually referred to as "ϕ" or "phi" by engineers.

Cohesive soils have a rigid behavior when exposed to stress. Stiff clays act almost like rock. They remain solid and inelastic until they fail. Very soft clays act more like putty. The soft clay will bend and mold around the helice when under stress.

Cohesionless Soil (Sand and Gravel)

The particles of sand or gravel in cohesionless soil act independently of each other. This class of soils has fluid-like characteristics. When cohesionless soils are placed under stress they tend to reorganize into a more compact configuration. Cohesionless soils achieve their strength and capacity in several ways.

- The soil density,
- The overburden pressure (The density of the soil that exists above the helices on the anchor multiplied the height of soil above the helices.)
- The internal friction angle, "ϕ", of the soil particles.

Installation Torque

Shaft torsion during installation can provide a reasonably accurate estimate of the Ultimate Capacity of the helical screw anchor. The relationship between the shaft torsion during installation and the Ultimate Capacity of helical screw anchor is empirical and was developed from results from thousands of tests. When one applies rotational torsion to a anchor shaft at grade, some of the torque energy is lost before it reaches the helices at the bottom end of the shaft. This is due to the friction between the shaft and the soil.

In the sketch, next page, notice that not all of the torque applied to the shaft by the motor reaches the helical plates. The actual torque applied to the helices is $T_{Plates} = T_{Motor} - T_{Shaft}$. The friction generated between the surface of the shaft and the soil is directly related to the shaft size and helice configuration along with the properties of the soil. Because of this loss of efficiency in transmitting the motor torque to the helices, an empirical *Torque Efficiency Factor* ("k") is employed to arrive at a reasonable estimate of Ultimate Capacity for a given Guy Anchor.

Table 2. ECP Torque Anchor™ Product Designations

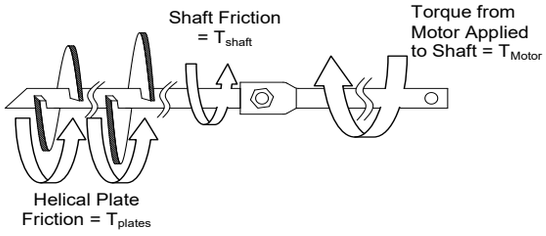
Product	Prefix	Product Description
Helical PITA Lead Sections	TAPL	1-3/8" Power Installed Torque Anchor (PITA)
	TAP	1-1/2 Power Installed Torque Anchor (PITA)
Extreme PITA Lead Sections	TAX	Extreme Power Installed Torque Anchor Lead (PITA) – 3/8" Helix
	HTAX	Extreme Power Installed Torque Anchor Lead (PITA) – 1/2" Helix
PITA Rods	TAR	Power Installed Rod for PITA Type Anchor
PITA Rod & Coupling	TARC	Power Installed Extension Rod & Coupler
PITA Coupling	TAC	Power Installed Rod Coupling
PITA Rod & Eye Nut	TARN	Power Installed Rod with Eye Nut
Torque Anchor™ Lead	TAF	Lead Section - Solid Square Shaft
	HTAF	Lead Section - Solid Square Shaft
Torque Anchor™ Extension	TAE	Extension Solid Square Shaft That May Have Additional Helical Plates
Guy Adapters	TAA	Termination from Square Shaft to Connection Eye(s)

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Torque Efficiency Factor

This relationship between installation torque and load capacity from a solid square shaft is used to estimate the Ultimate Capacity of screw piles. The value of the Torque Efficiency Factor ("k") is an estimation of friction loss during installation.

The amount of loss due to soil friction has a direct relationship to soil properties and the anchor design. The "k" value for square bar shafts is always higher than for tubular shafts. The Torque Efficiency Factor is based upon many years of testing different shafts installed into many different soils with the efficiencies calculated for each.



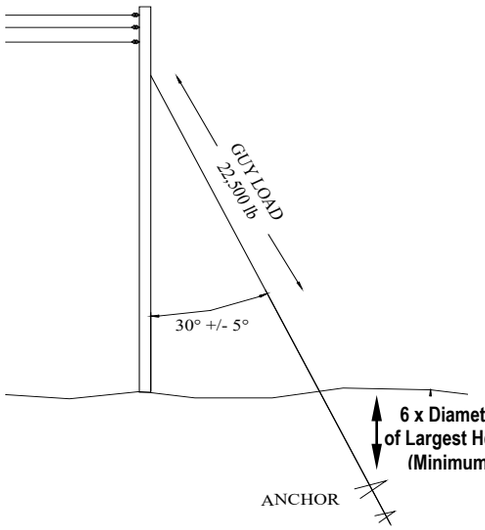
Unless a field load test is performed to provide an actual site specific value of Torque Efficiency Factor, ("k"), a value must be assigned when designing. While values for "k" have been reported from 2 to 20, most Guy Anchor projects using solid square shafts will produce a value of "k" in the 10 to 11 range. These values may be used unless a field load test provides a more accurate, site specific, value for "k".

It is also important to refer to Table 3, below, to determine the "*Useable Torsion Strength"* that can be applied to a specific anchor shaft. Being mindful of the maximum useable shaft torsional strength will help to avoid shaft fractures during installation. Failure to verify that the shaft configuration design has sufficient reserve torsional capacity could result in an unexpected shaft fracture during installation.

Minimum Embedment Depth

When a Guy Anchor must resist uplift or tension loads, the anchor must be adequately embedded into a firm bearing strata that offer adequate resistance to pull out.

In Guy Anchor applications there is a possibility of a shallow failure from inadequate soil overburden. The anchor fails when the soil suddenly erupts because of insufficient embedment of the Guy Anchor. To prevent such failures, all Guy Anchors must be installed to a depth that is sufficient to be considered a deep foundation.



As a general rule of thumb, most installers use six times the diameter of the largest helice as the minimum embedment depth for the Guy Anchor to be considered a deep foundation. It is important to understand that simply installing an anchor to a depth of six diameters of the largest helice is not the only consideration. In addition, to achieving a suitable overburden depth as discussed above, the anchor must be fully embedded into competent soil to resist the tensile load.

To insure that the anchor is fully embedded into competent soil, the torsion must be applied to the shaft continuously, torsion measurements averaged and recorded over a distance of no less than the final three feet of installation. This average shaft torsion must meet or exceed the torque requirement set forth in the required design load plus a factor of safety. If the Guy Anchor encounters an obstruction or stalls during the final three feet of installation, the final shaft torsion must be considered a false reading and must be discarded. One could use the average continuous shaft torque over three feet prior to encountering the obstruction as an estimate of anchor capacity.

Preventing "Pull Out" In Tension Applications

The torque installation record or a soil boring log, on occasion, may report a layer of very weak and soft soil overlaying a stratum of competent soil. When installing a Guy Anchor in this case, it is recommended that the installation torque requirement to achieve Ultimate Capacity be

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maintained for a minimum distance of three feet beyond the weak layer. The reason is to prevent "pull out" or "creep" of the Guy Anchor into the overlaying stratum of weak soil, and ultimately failing.

Shaft Strength

The data in Table 3 gives the strength ratings for various shaft configurations in axial tension and in torsion. The values are from mechanical testing and not from tests in the soil. Because helical Torque Anchor™ products are installed by rotating them into the soil; the installation torsion can limit the ultimate strength of the product. The "*Useable Torsional Strength*" columns in Table 3, below, indicates the maximum shaft torsion that should be intentionally applied to a Torque Anchor™ shaft during installation. The installation is assumed to be in homogeneous soil where the shaft torsion is relatively constant. The risk of product failure dramatically increases when one exceeds these torsional limits.

When choosing a product for a project, the designer should select a shaft that has an adequate margin of torsional strength above the shaft torque estimate for embedment. This margin will allow for increases in torque during the final embedment length after the initial torsional resistance criterion has been met. In addition, fractures from unexpected impact loading can and often occur during installation, especially in obstruction laden soils. It is recommended that a margin of at least 30% above the required installation torque in *homogeneous soil* be allowed to insure proper embedment and to prevent fractures from impacts.

Table 3. Capacities of ECP Helical Torque Anchors™

Product Designation	Useable Torsional Strength	Installation Torque Factor (k)	Connecting Rod Ultimate Tension Strength		
PITA Anchors			5/8" Dia	3/4" Dia	1" Dia
1-3/8" PITA	6,000 ft-lb	10 - 11	16,000 lb.	23,000	36,000
1-1/2" PITA	7,000 ft-lb	10 - 11	16,000 lb.	23,000	36,000
2-1/4" Extreme PITA	10,000 ft-lb	10 - 11	16,000 lb.	23,000	36,000
2-1/2" Extreme PITA	15,000 ft-lb	10 - 11	16,000 lb.	23,000	36,000

Square Shaft Torque Anchor™ Leads	Useable Torsional Strength	Installation Torque Factor (k)	Ultimate-Limit Tension Strength	Practical Load Limit
1-1/2" Square Bar	7,000 ft-lb	10 - 11	70,000 lb.	Load limited To the rated capacity of the attachments
1-3/4" Square Bar	10,000 ft-lb	10 - 11	100,000 lb.	
2" Square Bar	15,000 ft-lb	10 - 11	150,000 lb.	

The designer should select a product that provides adequate additional torsional capacity and attachments with adequate capacity for the specific project and soil conditions.

IMPORTANT NOTES:

The capacities listed for Tension and Torsion in Table 3 are mechanical ratings. One must understand that the actual installed load capacities for the product are dependent upon the actual soil conditions on a specific job site. The shaft "Useable Torsional Strengths" given here are the maximum values that should be applied to the product. Furthermore, these torsional ratings assume homogeneous soil conditions and proper alignment of the drive motor to the shaft. In homogeneous soils it might be possible to achieve up to 95% or more of the "Useable Torsional Strength" shown in Table 3. In obstruction-laden soils, torsion spikes experienced by the shaft may cause impact fractures of the couplings or other components. Where impact loading is expected, reduce shaft torsion by 30% or more from the value presented in "Useable Torsional Strength". The amount of useable torque reduction to reduce chance of fracture or damage depends upon site soil conditions.

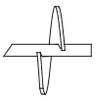
Attachment of guy wires shall be within five degrees of the anchor shaft installation angle to achieve maximum capacity.

Another advantage of selecting a torsional rating below the values shown in Table 3 is that one may be able to drive the helical anchor slightly deeper after the torsional requirement has been met, thus eliminating the need to cut the anchor shaft in the field.

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Guy Anchoring Product Catalog

Power Installed Torque Anchors™ (PITA)





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1-3/8" Square Shaft PITA Torque Anchors™ - 6,000 ft-lb*

Product Designation	Helix Diameter - inches		Rod Diameter inches	Bearing Area sq. ft.	Length inches
	First	Second			
TAPL-625-10 (08)	8	--	5/8	0.34	10
TAPL-625-10 (10)	10	--	5/8	0.53	10
TAPL-625-10 (12) (RUS APPROVED)	12	--	5/8	0.77	10
TAPL-100-10 (08)	8	--	3/4 or 1	0.34	10
TAPL-100-10 (10)	10	--	3/4 or 1	0.53	10
TAPL-100-10 (12)	12	--	3/4 or 1	0.77	10
TAPL-100-10 (14) (RUS APPROVED)	14	--	3/4 or 1	1.06	10
TAPL-100-26 (08-08)	8	8	3/4 or 1	0.67	26
TAPL-100-36 (10-10)	10	10	3/4 or 1	1.06	36

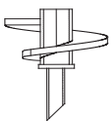
Power Installed Torque Anchors™ (PITA)

1-1/2" Square Shaft PITA Torque Anchors™ - 7,000 ft-lb*

Product Designation	Helix Diameter - inches		Rod Diameter inches	Bearing Area sq. ft.	Length inches
	First	Second			
TAP-625-10 (08)	8	--	5/8	0.33	10
TAP-625-10 (10)	10	--	5/8	0.53	10
TAP-625-10 (12) (RUS APPROVED)	12	--	5/8	0.77	10
TAP-100-10 (08)	8	--	3/4 or 1	0.33	10
TAP-100-10 (10)	10	---	3/4 or 1	0.53	10
TAP-100-10 (12)	12	--	3/4 or 1	0.77	10
TAP-100-10 (14) (RUS APPROVED)	14	--	3/4 or 1	1.05	10
TAP-100-26 (08-08)	8	8	3/4 or 1	0.67	26
TAP-100-36 (10-10)	10	10	3/4 or 1	1.06	36

Extreme Power Installed Torque Anchors™ (PITA)





2-1/4" Hub – 10,000 ft-lb*				
Product Designation		Helix Diameter - in	Rod Diameter inches	Bearing Area sq. ft.
Helix - 3/8 inch	Helix - 1/2 inch			
TAX-225-625 (08)	N/A	8	5/8	0.27
TAX-225-625 (10)		10	5/8	0.43
TAX-225-625 (12)		12	5/8	0.62
TAX-225-100 (08)	HTAX-225-100 (08)	8	3/4 or 1	0.27
TAX-225-100 (10)	HTAX-225-100 (10)	10	3/4 or 1	0.43
TAX-225-100 (12)	HTAX-225-100 (12)	12	3/4 or 1	0.62
TAX-225-100 (14)	HTAX-225-100 (14)	14	3/4 or 1	0.85

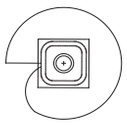
* Torque limits shown in the tables are maximum useable values and assume steady shaft torsion in homogeneous soil. Impact loads from encountering obstructions or stalling into very dense or hard soil could weaken the shaft or damage the helical flight. Always average the shaft torsion over the final three feet of installation when estimating the ultimate capacity of the guy anchor. Always apply a suitable factor of safety.

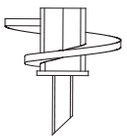
NOTES: The products listed in the product are standard items and are usually available from stock.
All product hot dip galvanized per ASTM a123 grade 100.

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Extreme Power Installed Torque Anchors™ (PITA)

Extreme Torque Anchor™ Lead Configurations

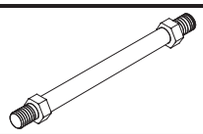




2-1/2" Hub – 15,000 ft-lb*				
Product Designation		Helix Diameter - in	Rod Diameter inches	Bearing Area sq. ft.
Helix - 3/8 inch	Helix – 1/2 inch			
TAX-250-625 (08)	N/A	8	5/8	0.27
TAX-250-625 (10)		10	5/8	0.43
TAX-250-625 (12)		12	5/8	0.62
TAX-250-100 (08)	HTAX-250-100 (08)	8	3/4 or 1	0.27
TAX-250-100 (10)	HTAX-250-100 (10)	10	3/4 or 1	0.43
TAX-250-100 (12)	HTAX-250-100 (12)	12	3/4 or 1	0.62
TAX-250-100 (14)	HTAX-250-100 (14)	14	3/4 or 1	0.85

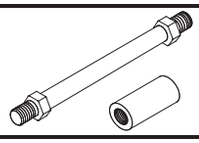
PITA Accessories

PITA Rods



Product Designation		
5/8" Rod	3/4" Rod (1" dia. threads.)	1" Rod
TAR-625-42	TAR-750-42	TAR-100-42
TAR-625-84 ◊	TAR-750-84 ◊	TAR-100-84

PITA Rod and Coupling Assemblies

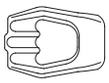


Product Designation			Rod Length (PITA Rods and PITA Rods with Couplings)
5/8" Rod	3/4" Rod (1" dia. threads)	1" Rod	
TARC-625-42	TARC-750-42	TARC-100-42	3'-6"
TARC-625-84	TARC-750-84	TARC-100-84	7'-0"



PITA Coupler

TAC-625	TAC-100	TAC-100	n/a

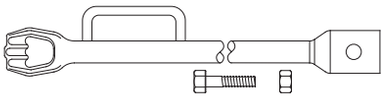


PITA Eye Nut

5/8" Rod	3/4" Rod (1" dia. threads)	1" Rod	NUMBER OF EYES
TAN-625-001	TAN-100-001	TAN-100-001	Single
TAN-625-002 ◊	TAN-100-002	TAN-100-002	Double
TAN-625-003	TAN-100-003 ◊	TAN-100-003 ◊	Triple

Cable Attachment Eyes

Round Corner Square Bar Adapters

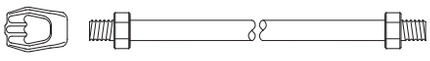


Product Designation		Eye Size	Length
1-1/2" Shaft	1-3/4" Shaft		
TAA-150-003	TAA-175-003	Triple	18"

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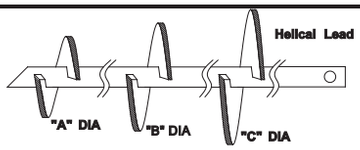
PITA Rod & Eye Assemblies



Product Designation			Eye Size	Rod Length
5/8" Rod	3/4" Rod (1" dia. threads)	1" Rod		
TARN-625-421	TARN-750-421	TARN-100-421	Single	3'-6"
TARN-625-422	TARN-750-422	TARN-100-422	Double	3'-6"
TARN-625-423	TARN-750-423	TARN-100-423	Triple	3'-6"
TARN-625-841	TARN-750-841	TARN-100-841	Single	7'-0"
TARN-625-842 ◊	TARN-750-842	TARN-100-842	Double	7'-0"
TARN-625-843	TARN-750-843 ◊	TARN-100-842	Triple	7'-0"

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Round Corner Square Bar ECP Torque Anchors™



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1-1/2" Shaft Standard Lead Configurations - 7,000 ft-lb*

Product Designation	3/8" Plate Diameter - inches				Bearing Area sq. ft.	Length
1-1/2" Solid Square Shaft	"A"	"B"	"C"	"D"		
TAF-150-36 (08-10) (RUS APPROVED)	8	10	--	--	0.86	3'-0"
TAF-150-42 (10-12)	10	12	--	--	1.30	3'-6"
TAF-150-66 (08-10-12) (RUS APPROVED)	8	10	12	--	1.63	5'-6"
TAF-150-84 (10-12-14)	10	12	14	--	2.35	7'-0"
TAF-150-126 (08-10-12-14)	8	10	12	14	2.69	10'-6"
TAF-150-126 (10-12-14-14)	10	12	14	14	3.39	10'-6"

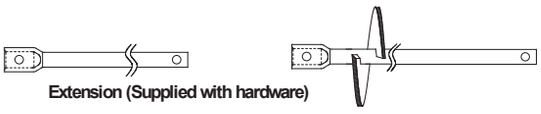
1-3/4" Shaft Standard Lead Configurations (10,000 ft-lb*)

Product Designation	3/8" Plate Diameter - inches				Bearing Area sq. ft.	Length
1-3/4" Solid Square Shaft	"A"	"B"	"C"	"D"		
TAF-175-36 (08-10)	8	10	--	--	0.86	3'-0"
TAF-175-42 (10-12)	10	12	--	--	1.29	3'-6"
TAF-175-66 (08-10-12)	8	10	12	--	1.62	5'-6"
TAF-175-84 (10-12-14)	10	12	14	--	2.34	7'-0"
TAF-175-126 (08-10-12-14)	8	10	12	14	2.67	10'-6"
TAF-175-126 (10-12-14-14)	10	12	14	14	3.39	10'-6"

2" Shaft Standard Lead Configurations (15,000 ft-lb*)

Product Designation	1/2" Plate Diameter – inches				Bearing Area sq. ft.	Length
1-3/4" Solid Square Shaft	"A"	"B"	"C"	"D"		
HTAF-200-60 (08-10)	8	10	--	--	0.86	5'-0"
HTAF-200-60 (10-12)	10	12	--	--	1.29	5'-0"
HTAF-200-60 (12-14)	12	14	--	--	1.80	5'-0"
HTAF-200-60 (14-16)	14	16	--	--	2.44	5'-0"
HTAF-200-84 (08-10-12)	8	10	12	--	1.62	7'-0"
HTAF-200-84 (10-12-14)	10	12	14	--	2.34	7'-0"
HTAF-200-84 (12-14-16)	12	14	16	--	3.20	7'-0"

1-1/2" 1-3/4" & 2" Shaft Standard Extension Configurations



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Product Designation			Plate Diameter inches	Area - ft²		Length
1-1/2" Shaft	1-3/4" Shaft	2" Shaft		1-1/2" BAR	1-3/4" BAR	
TAE-150-36	TAE-175-36		--	n/a	n/a	3'- 0"
TAE-150-42	TAE-175-42		--	n/a	n/a	3'- 6"
TAE-150-60	TAE-175-60	TAE-200-60	--	n/a	n/a	5'- 0"
TAE-150-84	TAE-175-84	TAE-200-84	--	n/a	n/a	7'- 0"
TAE-150-42 (14)	TAE-175-42 (14)		14	1.05	1.05	3'- 6"
TAE-150-60 (14)	TAE-175-60 (14)		14	1.05	1.05	5'- 0"

Note: The products listed above are standard items and are usually available from stock.
Other specialized configurations are available as special order – allow extra time for processing.
All helical plates are spaced at three times the diameter of the preceding plate
Effective length of extension is 3" less than overall dimension due to coupling overlap
All product hot dip galvanized per ASTM A123 grade 75

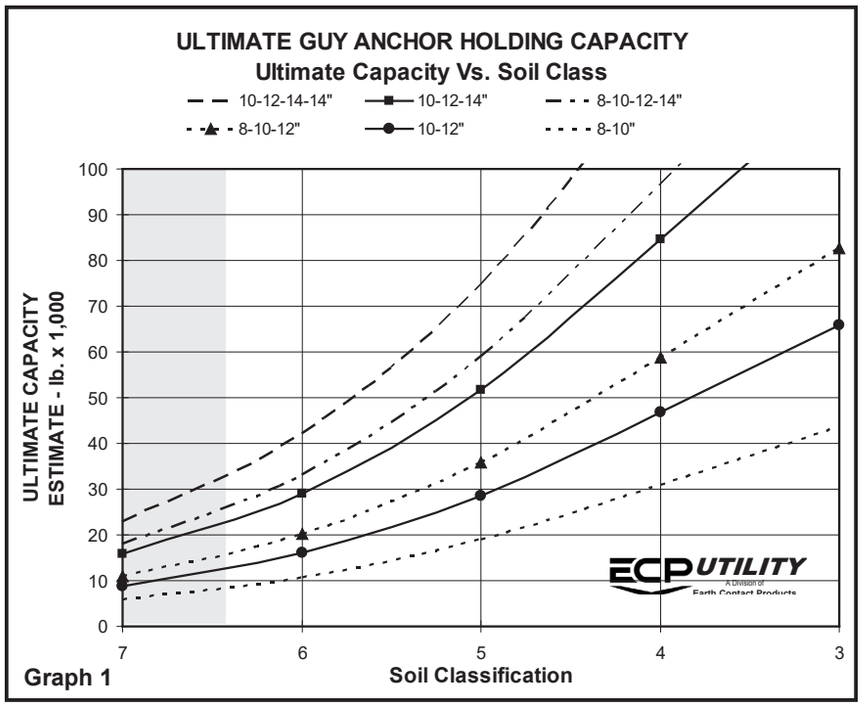
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Ultimate Torque Anchor™ Holding Capacity Estimates

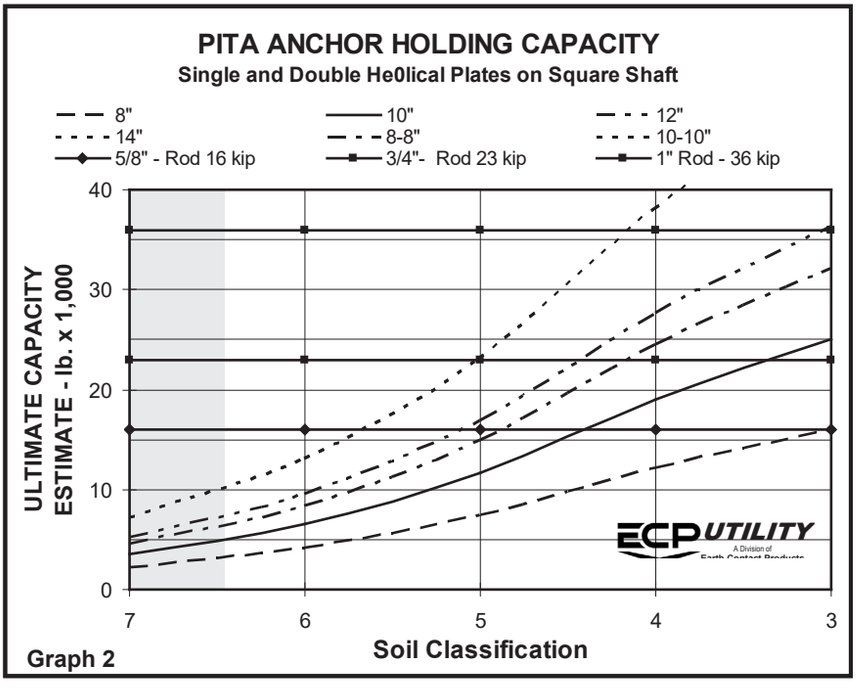
Graphs 1, 2 and 3 below were developed from testing and empirical calculations to give rapid estimations for a plate configuration selection that will provide sufficient Ultimate Capacity for a specific Guy Anchor project. The graphs represent the estimated Ultimate Tensile Capacities for various sizes and configurations of helices commonly used for Guy Anchor applications. The graphs represent general trends of capacity for Guy Anchors through different homogeneous Soil Classifications and average Standard Penetration Test ("N") values.

It must be clearly understood that these graphs are not intended to be a substitute for helical Guy Anchor engineering analysis that uses design requirements and soil data for a specific job.

One must always apply a suitable factor of safety to the Service Load or Design Load before using these graphs. This will insure reliability of a Guy Anchor system design.



Graph 1



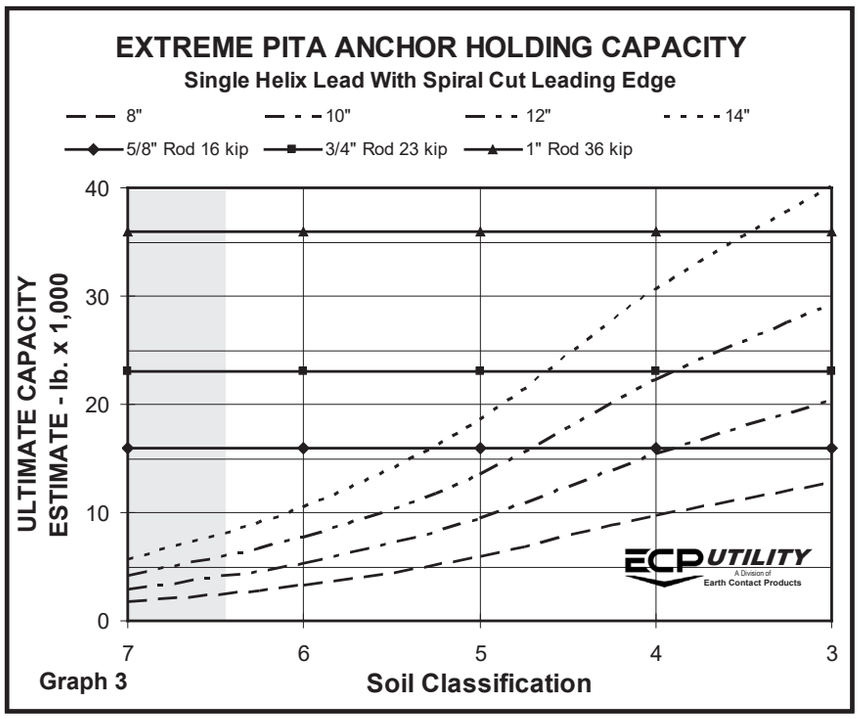
Graph 2

Notice that Soil Classes from Soil Class zero to 2 are not included. These soils are usually too dense for a Torque Anchor™ to advance without pre-drilling. When the rotation of the helical anchor shaft does not advance the product into the soil, the soil is too dense to allow the helices to embed. The capacity can be compromised and cannot be accurately estimated.

Likewise Soil Class 8 was not presented here because Class 8 soils usually contain significant amounts of organics, unconsolidated fill, swamp deposits and/or marsh soil. These components are unsuitable for anchorage. A shaded area is added for soils in Class 7 to alert the user that, in some cases, Class 7 Soil may not be robust enough for heavy loads or long term stability. The soil may not be fully consolidated and could contain various organics that could allow Guy Anchors to creep which could cause a serious long term installation problem.

When such weak soils are encountered, it is strongly recommended that the guy anchor be driven deeper so that the helices will advance

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Graph 3

completely through the weaker soil stratum and embed into an underlying, more suitable and stable, soil stratum. If the weak soil persists after installing the Guy Anchor deeper, then proof testing is strongly suggested and/use a larger design factor of safety.

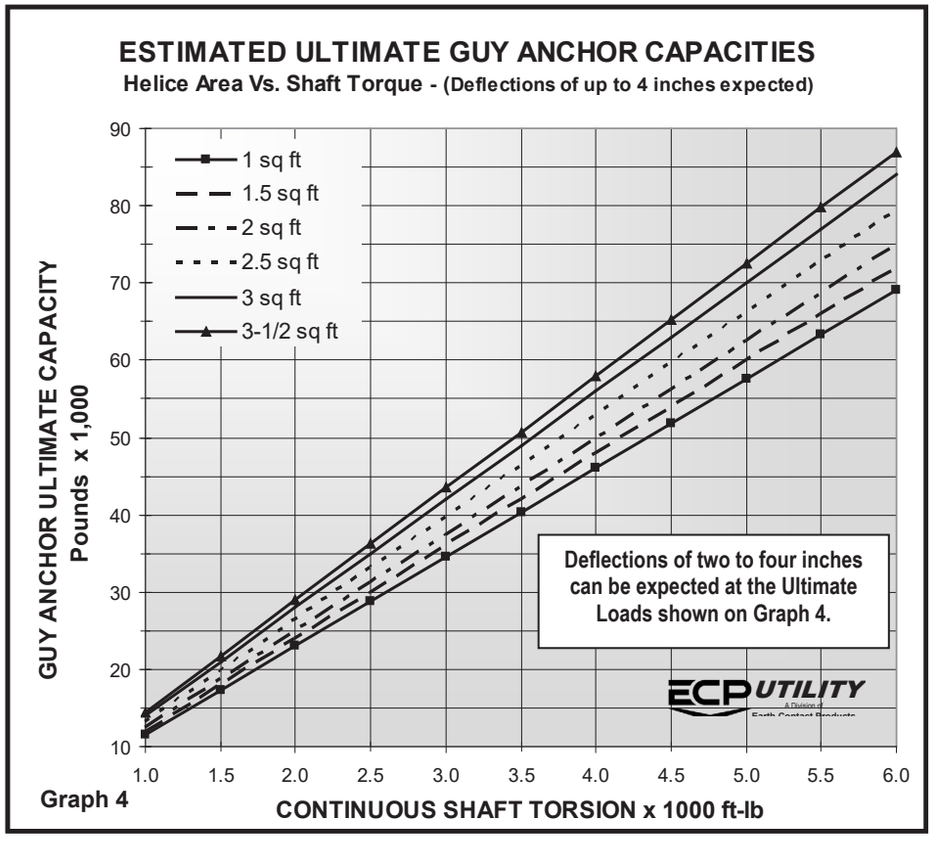
Caution: Graphs 2 and 3 can suggest holding capacities well above the Ultimate-Limit Tension Strength of some of the PITA anchor rods. The horizontal lines on Graphs 2 and 3 indicate the Ultimate Capacities of connecting rods. Always verify Ultimate or Useable Product Capacities in Table 3, or check the "*Guy Anchoring Product Catalog"*, to evaluate the tensile and torsion limits of various anchor bars, PITA sizes and Ultimate-Limit Tension Strength.

If a Torque Anchor™ is specified with special one-half inch thick helices instead of the standard three-eighths inch thickness, it might be possible to achieve higher Ultimate Mechanical Capacities of up to 50,000 pounds per helice. Please check with ECP or your engineer to determine if using thicker helical plates could satisfy a higher Ultimate Capacity requirement on a particular project.

Graphs 1, 2 & 3 are presented here to provide rapid selection of anchor design configurations that can provide sufficient Ultimate-Limit Tension Strength for a specific Guy Anchor project.

Use Graph 4 for Guy Anchor installations that allow for up to four inches deflection. Knowing the helice plate area allows for quickly estimating the installation torsion requirement.

Graph 4 is easy to use; simply locate the Ultimate Capacity required for the proposed Guy Anchor installation on the left side of Graph 4. Move



Graph 4

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horizontally across the graph until encountering the projected area of the helices of the Guy Anchor configuration selected. Referring to Table 3 or the *"Guy Anchoring Product Catalog"* near the beginning of this chapter is where the projected area for each different helical guy anchor configuration is listed. The estimated shaft torque required to achieve the desired Ultimate Capacity is located at the bottom of the graph.

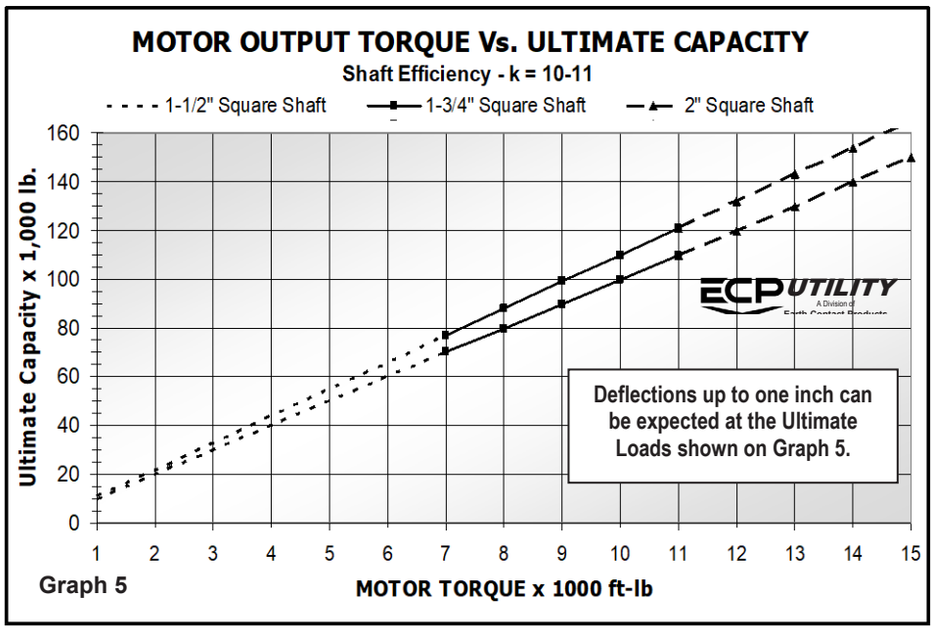
Installation Torsion

Shaft torsion should be monitored during the installation of helical guy anchors. The industry uses a rule of thumb of 10 to 11 times the average installation shaft torque to estimate the normally accepted value for Ultimate Capacity for an anchor that no more than one inch defection is permitted.

In Guy applications that permit up to 4 inches of deflection, the soil efficiency factor actually calculates to a higher value than the typically used anchor shaft efficiency factor of 10-11, this adjustment is reflected in Graph 4.

Obstruction Laden Soils

When estimating the anchor's capacity, do not consider any torque readings as valid when the shaft becomes stalled or encounters obstructions. If obstructions are encountered and the anchor stalls, use the readings from the three feet before the stall. Likewise, the shaft torsion readings on an anchor that spins upon encountering very dense soil cannot be used. When a tension or guy anchor spins on a dense stratum, it must be removed and repositioned. The torsion measurements at the new placement shall be averaged for three feet but the anchor shall not be installed to the spin depth.



Graph 5

It is also important to understand that Graph 5 has symbols to indicate the shaft torque limits for the various sizes of square shafts available with the same helical plate configuration. Always increase shaft size to match heavier loads.

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Design Example 1 – Guy Anchor in Cohesive (Clay) Soil

Design Details:

- Guy Tension Load = 22,500 lb.
- Installation angle is 30^0
- The soil was reported to be **inorganic clay stiff** – (CL), 100 pcf to a depth of 25 feet

Guy Anchor Design:

1. Determine which Soil Class to use based upon the available information provided. Refer to the Soil Classification Table 1 at the beginning of the chapter, or below, on page 20. Locate the soil description, *"Loose/medium dense fine/coarse sand; **Stiff clay and silt**"*. The closest match to the soil reported on the site as inorganic **clay stiff** is Soil Class 6.

Select **Soil Class 6**

2. Ultimate Tieback Capacity: Always keep in mind that the tables and graphs in this manual show the Ultimate Capacity. This project specified a Guy Anchor is required to resist a Design Tension Load of 22,500 pounds. A reasonable factor of safety of 1.5 is selected. The Ultimate Capacity for the Guy Anchor is:

T_{ult} = 22,500 lbs x 1.5 = **37,500 lbs**.

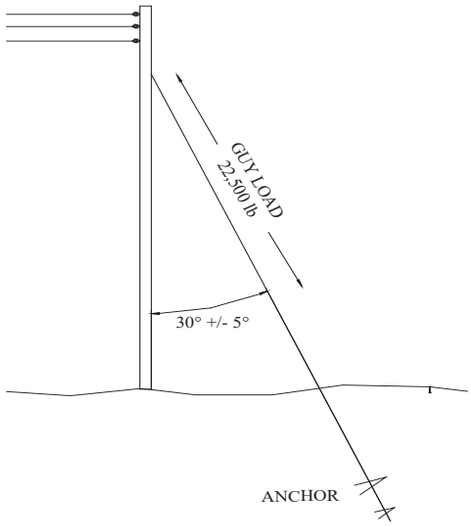
3. Select the proper tieback anchor from the estimated anchor holding capacity graph. Refer to Graph 1 at right. Begin with **Soil Class 6** at the bottom of the graph. Move vertically until reaching **T_{ult} = 37,500 lbs** at the left side of the graph. Notice that the capacity line for an anchor with a 10", 12", 14" and a 14" diameter plate configuration is slightly above 37,500 lb.

Use Anchor Configuration - **10-12-14-14" Dia.**

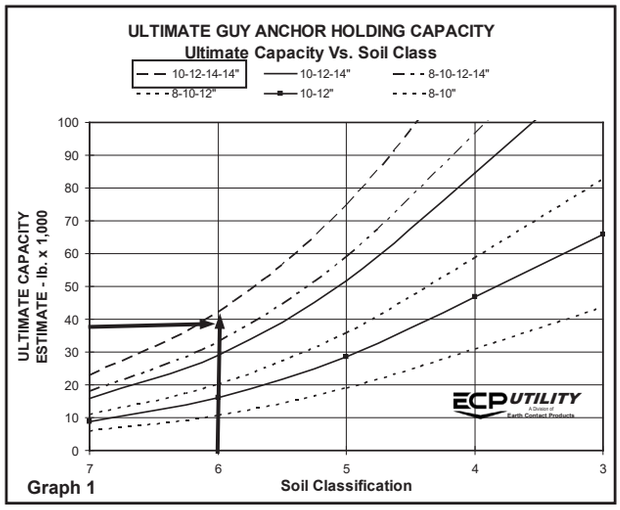
4. Check the shaft strength and the torsional strength to select a suitable shaft. The Ultimate Tensile Load for this job is 37,500 lb. By referring to Table 3 near the beginning of the chapter, notice that the 1-1/2 inch solid square shaft anchor shaft has an Ultimate-Limit Tensile Strength rating of 70,000 pounds and a Useable Torsional Capacity of 7,000 ft-lbs. This shaft configuration is suitable.

Use **- 1-1/2 inch square solid shaft**

5. Installation Torque: Refer to the *Guy Anchor Product Catalog* and locate the listing for 1-1/2 inch solid square shaft anchors. Select the **TAF-150-120 (10-12-14-14)** anchor with 10-12-14-14" helices attached to a 1-1/2 inch solid square shaft. The projected area of the helices on this Guy Anchor configuration is 3.39 ft^2.



Sketch for Design Example 1

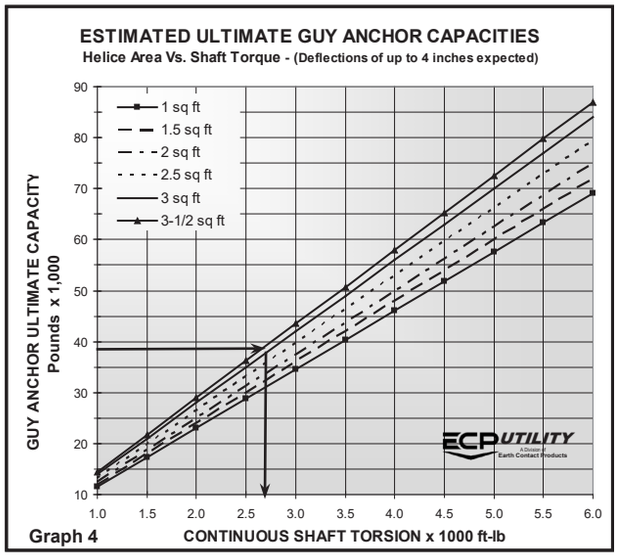


Graph 1

Installation shaft torsion must be developed for a sufficient distance to insure that all the helices are properly embedded. This will insure developing the required Ultimate Tensile Capacity of 37,500 lbs. Referring to Graph 4, below, the installation torsion for the selected anchor configuration can be estimated for 37,500 lb Ultimate Capacity.

Graph 4 allows up to 4 inches deflection and has been approved for this Guy Anchor application. To determine the minimum installation shaft torque, start on the left side of Graph 4 and locate 37,500 pounds. Read to the right until encountering a projected helices area of 3.39 ft^2. (Use the 3.5 ft^2 line) Reading downward to the Continuous Shaft Torsion, a shaft torque of 2,700 ft-lbs, minimum, is indicated.

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Graph 4

Keep in mind that the torque applied to the shaft must be applied continuously. To be properly embedded, the shaft torsion must continuously meet or exceed 2,700 ft-lbs over a distance of at least 3 feet. This is minimum torque required to develop the Ultimate Tensile Strength

Minimum Installation Torque - **2,700 ft-lbs**

6. Minimum Embedment Depth: There must be sufficient soil overburden on the helices to prevent the anchor from erupting out of the soil. It is generally accepted that the minimum depth from the surface to the uppermost helice should be at least six times the diameter. In this case it is the 14 inch diameter helice. **This distance is measured vertically.**

Minimum Vertical Embedment Depth:

$d = 6 \times d_{largest\ plate}$

d = 6 x (14" dia/12 in/ft) = 7 feet

Minimum Vertical Depth - **7 feet**

THIS IS NOT SHAFT LENGTH.

7. Total Shaft Length: First, determine the shaft length required to reach the Minimum Vertical Embedment Depth of 7 feet when installing the Guy Anchor shaft at a 30° angle, use a 1.7 multiplier for a 30° installation angle. $\mathbf{L_{shaft}}$ = 7 ft x 1.7 = 12 ft

Shaft Length to First Helice – **12 feet**

The shaft length to first helice for this installation must be at least 12 feet at 30^0 from the uppermost 14" helix to the surface. This is needed in order to achieve a **Minimum Vertical Embedment Depth of 7 feet**.

Second, the length of lead shaft beyond the upper 14 diameter helix down to the 10" diameter helice at the bottom of the anchor shaft must be determined and added to shaft length to first helice of 12 feet. This determines the **Minimum Total Shaft Length**.

(Note: All helices are spaced 3 times the diameter of the next lower helice.)

Calculate the minimum total shaft length to be installed on this project:

$\mathbf{L_{beyond\ 14"\ plate}}$ = 3 x (10" dia + 12" dia + 14" dia)/12"

$\mathbf{L_{beyond\ 14"\ plate}}$ = **9 feet**

$\mathbf{L_{total\ shaft}}$ = 12' + 9' = **21 Feet**

Minimum Total Shaft Length **– 21 feet**

8. Torque Anchor™ Specifications:

- **TAF-150-126 (10-12-14-14)** -- A 10", 12" and two 14" diameter helices attached to a 1-1/2" solid square shaft that is 10'-6" long.
- **TAE-150-84** extension – 7' extension bar & hardware, (6'-9" effective length).
- **TAE-150-60** extension – 5' extension bar & hardware, (4'-9" effective length).
- **TAA-150-003** – Triple Eye Adapter, 1'-6" long with hardware.

Installing these products at 30° angle will position the largest plate a vertical depth of slightly more than 7 feet below grade when the total of 22 feet of anchor shaft is installed at 30^0. The eye adaptor will extend up to 2-1/2 feet above grade.

It is suggested to order an additional 7' extension. This will allow extra shaft length should installation not achieve the minimum required shaft torsion of at least 2,700 ft-lb upon reaching the target depth.

End of Example 1

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Design Example 2 – Guy Anchor in Cohesionless (Granular) Soil

Design Details:

- Guy Tension = 20,000 lb
- Installation angle is 45^0
- The soil information from the site is reported **Medium to Coarse Gravelly Sand, medium Dense** - (SP)

Guy Anchor Design:

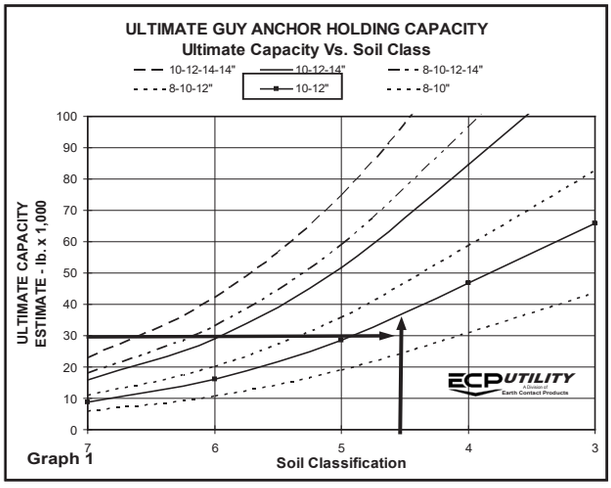
This Guy Anchor design is similar to the illustration in Example 1 but with 20,000 lb. tension and 45^0 installation angle.

1. Soil Class: The Soil Class is estimated based upon the available information provided. Refer to the Soil Classification Table 1, a copy is at right. Notice that both Class 4 and 5 have descriptions "***Medium dense coarse sand and sandy gravel***" Both are similar to the project soil description, **Medium to coarse gravelly sand, medium dense.**

Select **- Soil Class 4-5**

2. Ultimate Tieback Capacity: This project requires resisting a Guy Tension Load of 20,000 pounds. A reasonable factor of safety of 1.5 is chosen for this Guy Anchor application. Multiply the Design Tension Load x 1.5 Factor of Safety to calculate the required Ultimate Capacity for the Guy Anchor: $\mathbf{T_{ultimate}}$ = 20,000 lbs x 1.5 = **30,000 lbs**.

Ultimate Guy Anchor Capacity – **30,000 lbs**.



Graph 1

3. Select a suitable tieback anchor from the estimated anchor holding capacity graph: Refer to Graph 1 and select the 30,000 lb Ultimate Capacity line on the left. Select Soil Class 4-5 at the bottom of the graph. The suggested guy anchor configuration is located slightly above where the lines intersect.

Table 1. SOIL CLASSIFICATION TABLE		
Class	**Soil Description**	**Geological Classification**
0	Solid Hard Rock (Unweathered)	Granite; Basalt; Massive Sedimentary
1	Very dense/cemented sands; Coarse gravel and cobbles	Caliche
2	Dense fine sands; Hard silts and/or clays	Basal till; Boulder clay; Caliche; Weathered laminated rock
3	Dense sands/gravel, Stiff/hard silt and clay	Glacial till; Weathered shale; Schist, Gneiss; Siltstone
4	Medium dense coarse sand/sandy gravels; Stiff/very stiff silt/clay	Glacial till; Hardpan; Marl
5	Medium dense coarse sand and sandy gravel; Stiff/very stiff silt & clay	Saprolites; Residual soil
6	Loose/medium dense fine/coarse sand; Stiff clay and silt	Dense hydraulic fill; Compacted fill; Residual soil
7	Loose fine sand; Medium/stiff clay; Fill	Flood plain soil; Lake clay; Adobe; Clay gumbo; Fill
8	Peat, Organic silts, Fly ash, Very loose sand; Very soft/soft clay	Unconsolidated fill; Swamp deposits; Marsh soil

The bearing area for the selected Torque Anchor with 10"-12" helices and 1-1/2 inch solid square shaft can be found in the "*Guy Anchoring Product Catalog"* at the beginning of this chapter. The bearing area for this configuration is 1.30 ft^2.

Guy Anchor Configuration **- 10" & 12" helices**

4. Verify shaft strength and the torsional strength: Table 3 shows the "*Ultimate-Limit Tensile Strength"* for the 1-1/2" shaft is 70,000 lb and the *"Useable Torsional Strength"* is 7,000 ft-lbs. This shaft configuration is suitable.

5. Installation Torque: The installation torsion can be estimated from Graph 4. (Next page) Graph 4 is used because this project allows the Guy Anchor to have up to four inch deflection at full load.

From the left side of Graph 4 at 30,000 lbs Ultimate Capacity read right until encountering 1.30 ft^2 (Use 1.5 ft^2 line.) Read the solid arrow down to the Minimum Installation Torque, of 2,500 ft-lbs.

Minimum Installation Torque – **2,600 ft-lbs**

6. Minimum Vertical Embedment Depth: The uppermost helice must be installed to a vertical depth of at least six times the diameter of the shallowest helice. The depth requirement for the TAF-150-36 (10-12) Guy Anchor is calculated as follows:

Minimum Vertical Embedment: $\mathbf{d = 6 \times d_{largest\ plate}}$

d = 6 x (12" dia/12 in/ft) = **6 feet**

7. Total Product Length: Determine the total shaft length needed to obtain Minimum Vertical Embedment Depth at 45º for the TAF-150-36 (10-12) Guy Anchor configuration selected. (Use a 1.4 multiplier for 45º angle.)

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The TAF-150-36 (10-12) Torque Anchor lead has 10” & 12” helices on a solid 1-1/2” square shaft 3’-0” long.

$L_{\text{shaft to upper plate}}$ = 6’ x 1.4 (45° angle) = **8.4 ft**

Distance from the 12” helice to the 10” helice is:

$L_{\text{Total shaft}}$ = 8.4’ + (3 x 10”)/12 = 2.5’ **= 11 feet**

Products Required:

TAF-150-36 (10-12) with 10” and 12” helices on a 1-1/2 inch solid shaft 3’-0” long.

TAE-150 - 60 Extension is 5’-0” (4’-9” coupled length) with hardware. **2 Needed**

Total Product Length – 12-1/2 feet

TAA-150-003 Triple Eye Adapter, 1’-6” long with hardware to connect guy wire.

End of Design Example 2

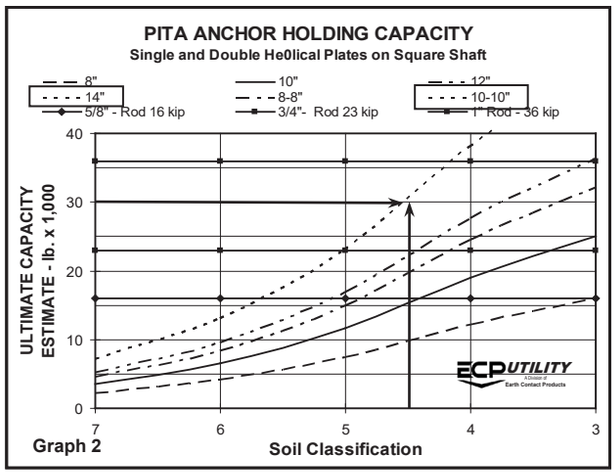
Alternate Guy Anchor Design:

There is usually more than one product that will provide suitable Guy Anchor support. Here are Alternate Product Selections for this design example. Since steps 1 & 2 are the same, we begin with Step 3, Alternate PITA Guy Anchors.

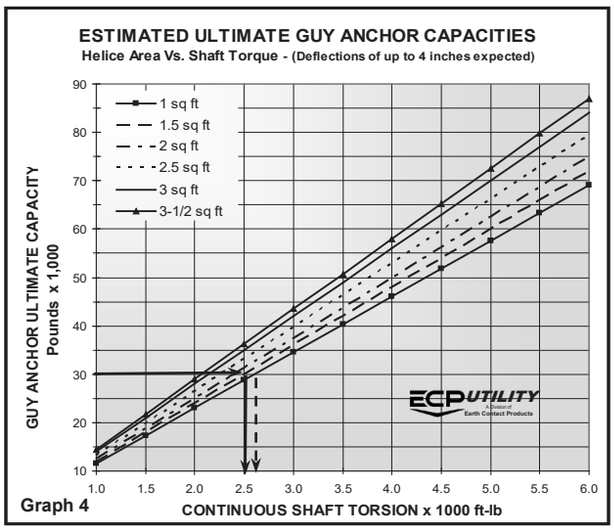
3A. Alternate: PITA Guy Anchors: Select PITA anchor products from Graph 2. Start at 30,000 lb Ultimate Capacity on the left side. Select Soil Class 4-5 at the bottom of the Graph 2. The graph line above where these two lines intersect suggests suitable PITA Guy Anchor configurations. Notice that both the 14” diameter and the 10”-10” diameter helices configurations are suitable.

The “*Guy Anchoring Product Catalog”* lists the projected areas at 1.06 ft^2 for these recommended PITA anchors. A higher installation torque is required due to smaller helice areas for these anchors, note the dashed line on Graph 4.

Minimum Installation Torque – **2,600 ft-lbs**



Graph 2



Graph 4

4A. Verify the PITA and connecting rod strength: Table 3 rates the PITA 1-3/8” square bar *“Useable Torsional Strength”* at 6,000 ft-lb. The 1” diameter connecting rod is rated at 36,000 lbs. *“Ultimate Tensile Strength”*.

These PITA Guy Anchor configurations have sufficient capacity when installed to slightly higher installation torque.

TAPL-100-36 (10-10) PITA Anchor or
TAPL-100-10 (14) PITA Anchor

6A. Minimum Vertical Embedment Depth: The uppermost helice must be installed at least six times the diameter of the shallowest helice measured vertically from the ground surface. The minimum vertical depths for the PITA Anchors are calculated:

Minimum Vertical Embedment: $\mathbf{d = 6 \times d_{largest\ plate}}$

TAPL-100-36 (10-10) = 6 x (10” dia/12”/ft) = **5 feet**
TAPL-100-10 (14) = 6 x (14” dia/12 in/ft) = **7 feet**

7A. Shaft Length Specifications: Determine the total shaft length needed for each PITA Guy Anchor configuration when installed at 45°.

TAPL-100-36 (10-10) PITA Lead: 1-3/8” sq. shaft, 36” long, with two 10” diameter helices that attach to a 1” diameter, 7’-0” connecting rod.

$L_{\text{shaft to upper plate}}$ = 5’ x 1.4 (45° angle) = **7 ft**

$L_{\text{total shaft}}$ = (3 x 10”)/12 = 2’- 6”(distance between plates)
= 7’ + 2’- 6” = 9-1/2 feet

Minimum Shaft Length - **9-1/2 feet**

TAPL-100-10 (14) PITA Lead: A 1-3/8” sq. shaft, 10” long, PITA with a 14” diameter helice connected to a 1” diameter connecting rod 7’-0” and one 3’-0” long.

$L_{\text{shaft to plate}}$ = 7’ x 1.4 (45° angle) = **9.8 ft**

Use Shaft Length **- 10 feet**

End of Alternate Design Example 2

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Steel Underground -- How Long Does It Last? Galvanized steel anchor products are subjected to a range of corrosive forces that are quite different from steel exposed to atmospheric conditions. The performance of underground steel and galvanized structural steel elements are not as well understood as is the life expectancy of steel products in above ground applications.

For corrosion to initiate, steel requires not only oxygen but also the presence of dissolved salts in water. If any one of these items is absent, corrosion will not occur.

Soil Resistivity: One of the simplest classifications for soil corrosivity is based upon the resistivity of the soil. To obtain the soil resistivity, one passes a current through the soil and measures the resistivity of the soil in ohm-centimeters. In general, sandy soils have high resistivity values and are considered the least corrosive. Clay soils and especially clay with saline water are sometimes highly corrosive to steel.

Table 4. Soil Resistivity and Relative Corrosivity Rating

Resistivity (ohm-cm)	Corrosivity Rating
> 10,000	Non-Corrosive
5,000 to 10,000	Mildly Corrosive
3,000 to 5,000	Moderately Corrosive
1,000 to 3,000	Corrosive
500 to 1,000	Highly Corrosive
< 500	Extremely Corrosive

Soil pH: The measure of acidity or alkalinity in a solution is given as pH. Values of pH < 7 are considered to be acidic and values from pH = 7 to pH = 14 are alkaline. Pure distilled water is neutral or has a pH = 7. As the water became more acidic (pH less than 4), steel corrodes more quickly than steel corrodes in a more alkaline environment (pH greater than 10). It is also interesting to note that zinc used for galvanization provides the best protection to steel in a somewhat similar environment.

Table 5. SOIL CORROSION CLASSIFICATION TABLE – SOIL RESISTIVITY RANGES

Class	Soil Description	Geological Classification	Resistivity Range[1] (ohm-cm)
0	Solid Hard Rock (Unweathered)	Granite; Basalt; Massive Sedimentary	200,000+
1	Very dense/cemented sands; Coarse gravel and cobbles	Caliche	40,000 to 200,000
2	Dense fine sands; Hard silts and/or clays	Basal till; Boulder clay; Caliche; Weathered laminated rock	10,000 to 100,000
3	Dense sands/gravel, Stiff/hard silt and clay	Glacial till; Weathered shale; Schist, Gneiss; Siltstone	5,000 to 50,000
4	Medium dense coarse sand/sandy gravels; Stiff/very stiff silt/clay	Glacial till; Hardpan; Marl	5,000 to 20,000
5	Medium dense coarse sand and sandy gravel; Stiff/very stiff silt and clay	Saprolites; Residual soil	2,000 to 10,000
6	Loose/medium dense fine/coarse sand; Stiff clay and silt	Dense hydraulic fill; Compacted fill; Residual soil	1,000 to 5,000
7*	Loose fine sand; Medium/stiff clay; Fill	Flood plain soil; Lake clay; Adobe; Clay gumbo; Fill	500 to 5,000
8*	Peat, Organic silts, Fly ash, Very loose sand; Very soft/soft clay	Unconsolidated fill; Swamp deposits; Marsh soil	50 to 2,000

*** IMPORTANT:** Use caution when using round PITA connecting rods in soil classes 7 & 8. Corrosion lives of these are usually low.

Notes:

1. Resistivity is highly variable from site to site and from place to place on the same site. These ranges are only guidelines and overlapping across soil classes is to be expected. Field test to verify resistivity.
2. High soil moisture content decreases the resistivity making the soil more corrosive.
3. Freezing the soil dramatically raises the resistivity, thus reducing the corrosivity
4. Corrosion life for guy anchors using solid square steel shafts larger than 1-1/2 inches in general have corrosion life exceeding 40 years, except in Class soils.

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Zinc Galvanizing for Corrosion Protection: Zinc galvanize provides the most effective protection through a range of pH = 5.5 to pH = 12.5.

Under favorable conditions, the zinc may corrode at less than 0.20 mils per year under mild conditions to more than 0.98 mils in unfavorable soil conditions.

The corrosion rate of steel in soil can range from less than 0.79 mils per year (0.0008 in/yr) under favorable conditions to more than 7.87 mils per year (0.0079 in/yr) in very aggressive soils. There are similarities in the corrosion rates of galvanized coatings.

Test results suggest that in the range of pH greater than pH = 4 up to pH = 10, the corrosion rate of iron is independent of the acidity or alkalinity measured as pH of the soil environment. In acidic conditions, when pH is less than 4, the corrosion rate dramatically increases. The scientists concluded that the acidic condition dissolves the iron oxide as it forms leaving the iron in direct contact with the water.

Hot Dip Galvanizing: The products manufactured by Earth Contact Products are offered with hot dip galvanizing. This coating of molten zinc contains not less than 98% pure zinc metal. The hot dip galvanization process meets, or exceeds ASTM A123 Grade 75 for steel plates, tubular or bar products.

ASTM A123 Grade 75 requires a minimum of 3.0 mils (0.004") or 1.7 oz/ft^2 of zinc. The coating thickness to ASTM A123 specifications is the minimum allowed. Most galvanized coatings will have a thickness in excess of these values which translates to longer than expected corrosion life.

Life of Galvanized Coating: The key to look for when there is concern about corrosion is to determine if the soil is highly acidic or highly alkaline.

- In most cases acidic soils will contain high amounts of organics.
- Fill soils, industrial waste areas, etc, are also areas for corrosion concern as are tidal areas.

The second component to look at is the resistivity or ability of the soil to conduct electricity.

- Well drained granular soils are less of a threat than wet silt or clay.

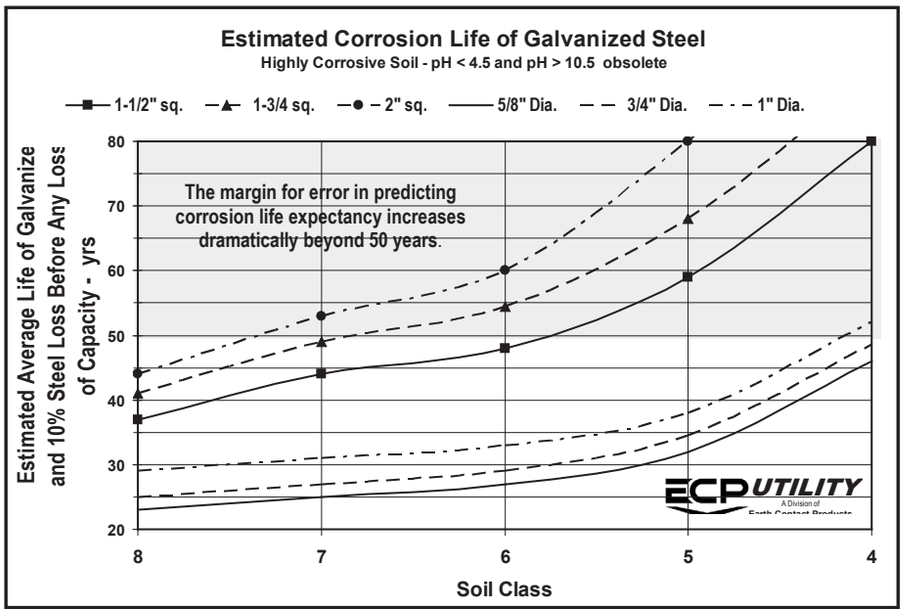
Estimating Corrosion Life of Solid Steel Shafts in Highly Corrosive Soils

Graph 6 suggests the life of solid square shaft Guy Anchors installed in highly corrosive soil. While corrosive conditions can also occur any soil or old waste dumps, Class 8 soils are usually the most highly corrosive.

A careful review the graph suggests that when installing galvanized solid square shaft anchors in most soil classes, other than Class 8 soil the 1-1/2 solid square bar has a corrosion life estimate in Class 7 soil of 44 years. A simple substitution to the larger 1-3/4 inch square shaft will add 5 years to a corrosion life of nearly 50 years.

It is clear from Graph 6 that long corrosion lives can be expected for square shafts in soil classes 6 and lower. Even in class 7, the life expectancy for all of these common solid square shafts exceeds 40 years.

Be cautious using the small diameter PITA connecting rods on projects requiring extended corrosion lives. These small diameter round shafts have much lower corrosion life expectancies, especially in soil classes 7 and 8. The lives for connecting rods are shown by the lowest graph lines



Graph 6. Estimated average corrosion life of galvanized steel in corrosive soil

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on Graph 6.

IMPORTANT NOTES:

1. The Estimated Corrosion Life of Galvanized Steel graph suggest life expectancy estimates for solid square galvanized Guy Anchor shafts and connecting rods that are installed in homogeneous soil with constant soil moisture in various soil classes. This graph is not intended to be used for corrosion design and is not to be considered a substitute for field measurements of pH and resistivity, and a site specific corrosion analysis.

2. The graph assumes steel with a Hot Dip Galvanize process to meet or exceed ASTM A123 – Grade 75.

Also, an allowance has been made for a 10% steel loss on the cross section of the solid square anchor shafts due to corrosion of the steel after the galvanizing is exhausted. The extra shaft material was required for torsional strength when initially installing the helical anchor and a 10% steel reduction should not affect the tension capacity. The guy anchor should retain the original design capacity with the full factor of safety intact even with this fractional amount of steel loss.

The graph also predicts corrosion life of PITA rods and adapter connectors. No reduction in rod area was considered on these products because the products are not subjected to torsion stress during installation.

3. Reaching the end of the stated corrosion life does not suggest that the product will immediately fail. At the end of the corrosion life estimate shown here, the product will still possess the full rated capacity along with a factor of safety. This means that the product does not automatically fail at the estimated corrosion life expectancy.

4. The life expectancies illustrated on the graph were calculated using recognized engineering principles and are for general information only. While believed to be accurate for general soil classes, the estimated corrosion life shown is acceptable in most cases.

This information should not be used or relied upon for any critical application without field testing and corrosion analysis by a registered professional engineer in order to determine suitability of the product on the site.

5. Variations in soil moisture content from season to season and year to year can adversely affect service life. Low field moisture content produces lower corrosion rates even in aggressive soils. Stray currents from pipe lines, power lines, etc may also affect corrosion life due to imposed currents. This is why in critical applications a corrosion analysis and testing is always recommended in suspected problem soils.

6. **CAUTION:** As the life expectancy predictions increase beyond 40 years, the margins for error increases dramatically. Predictions of corrosion life above 50 years are shaded on the graph and should not be considered accurate. They are presented to show a trend in the expected life. Corrosion life expectancy estimates are calculated from empirical equations derived from field testing and have been projected beyond the length of the actual corrosion testing.

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Field Handbook
Compressive Pile Applications
ECP Helical Torque Anchors™

- **Tubular Helical Torque Anchors™**
- **Solid Square Shaft Torque Anchors™**
- **Helical Torque Anchors™ for Light Poles**

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Compressive Helical Torque Anchor™ Design Considerations

The tables and graphs presented in this chapter are to be used when designing for helical piles that support compressive loads.

Helical Torque Anchors™ are found in many axial compression applications such as underpinning for structures, equipment frames, towers, etc. Similarities from the previous chapter for guy tension design and installations will be noted. The most important thing to keep in mind is that a compression pile is not permitted to deflect or creep like a guy anchor. Compression piles are considered to have failed if there is foundation support movement of more than one inch under the application of the Ultimate Load.

The tables and graphs in this chapter are to be used to design compressive structural load support.

CAUTION! Never use the design data for Guy Tension Loads from Chapter 2 here.

Table 6. Compression Product Designations of ECP Torque Anchor™

Product	Prefix	Product Description
Helical Lead Sections	TAH	Lead Section With One 3/8" Thick Helical Plate
	HTAH	Lead Section With One 1/2" Thick Helical Plate
	TAF	Lead Section with Multiple 3/8" Thick Helical Plates
	HTAF	Lead Section with Multiple 1/2" Thick Helical Plates
Shaft Extensions	TAE	Forged Extension Section with Coupling & Hardware
	TAEW	Welded Extension Section with Coupling & Hardware
Transitions	TAT	Helical Pile Shaft to Threaded Bar
New Construction Pile Caps	TAB–NC	New Construction Compression Pile Cap
	TAB-T	New Construction Tension Pile Cap
	TAB–TS	New Construction Pile Cap with Alignment Stud

Table 7. Capacities of ECP Helical Torque Anchors™

Shaft Size	Installation Torque Factor (k)	Axial Compression Load Limit	Ultimate-Limit Tension Strength	Useable Torsional Strength	Practical Load Limit Based Torsional Strength
1-1/2" Square Bar	10	70,000 lb.	70,000 lb.	7,000 ft-lb	Load limited to the rated capacity of the attachments and the lateral soil strength against the shaft
1-3/4" Square Bar	10	100,000 lb.	100,000 lb.	10,000 ft-lb	
2" Square Bar	10 - 11	150,000 lb*	150,000 lb.	15,000 ft-lb	
2-7/8" Tube – 0.276" Wall	9	100,000 lb.	100,000 lb.	9,500 ft-lb	85,000 lb
3-1/2" Tube – 0.300" Wall	8	115,000 lb.	120,000 lb.	13,000 ft-lb	104,000 lb
4-1/2" Tube – 0.337" Wall	7	160,000 lb.	160,000 lb.	22,000 ft-lb	154,000 lb

The designer should select a product that provides adequate additional torsional capacity for the specific project and soil conditions.

* The Axial Compression Load Limit for the 2" Square Bar, when installed in compression, is dependent upon lateral support derived from the soil surrounding the pile shaft. Weak soils (SPT, "N" < 5 bpf) may not provide sufficient lateral support to this very slender shaft, which can limit the Ultimate Capacity that can be achieved on a given installation, and not only the bar strength.

IMPORTANT NOTES: The capacities listed for "Axial Compression Load Limit", "Ultimate Limit Tension Strength" and "Useable Torsion Strength" in Table 7 are mechanical ratings. One must understand that the actual installed load capacities for the product are dependent upon the soil conditions at a specific job site. The "Useable Torsional Strengths" given here are the **maximum** values that one should apply to the product. Furthermore, these torsional ratings assume homogeneous soil conditions and proper alignment of the drive motor to the shaft. In homogeneous soils up to 95% or more of the "Useable Torsional Strength" shown in Table 7 can be applied. In obstruction-laden soils, torsion spikes may cause impact fractures of the shaft, couplings or other components. Where impact loading is expected, Actual Applied Shaft Torsion should be reduced by 30% or more from that shown in Table 7. When dealing with poor soil conditions on site, select a larger shaft to reduce chance of fracture or damage during installation.

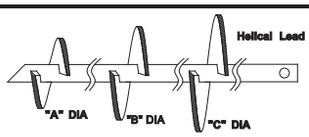
Another advantage of selecting a torsional rating below the values shown in Table 7 is that one may be able to drive the pile slightly deeper after the torsional requirements have been met, thus eliminating the need to cut the pile shaft in the field.

The load transfer attachment capacity must be verified for the design. Standard attachments and ratings are shown on the following pages.. Special configurations to fit your project can be fabricated to your specifications upon request.

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Compression Pile Product Catalog

Round Corner Square Bar ECP Torque Anchors™



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1-1/2" Shaft Standard Lead Configurations - 7,000 ft-lb*

Product Designation	3/8" Helice Diameter - inches				Area	Length
1-1/2" Solid Square Shaft	"A"	"B"	"C"	"D"	sq. ft.	
TAF-150-36 (08-10) (RUS APPROVED)	8	10	--	--	0.86	3'-0"
TA-150-42 (10-12)	10	12	--	--	1.30	3'-6"
TAF-150-66 (08-10-12) (RUS APPROVED)	8	10	12	--	1.63	5'-6"
TAF-150-84 (10-12-14)	10	12	14	--	2.35	7'-0"
TAF-150-126 (08-10-12-14)	8	10	12	14	2.69	10'-6"
TAF-150-126 (10-12-14-14)	10	12	14	14	3.39	10'-6"

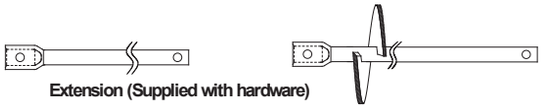
1-3/4" Shaft Standard Lead Configurations (10,000 ft-lb*)

Product Designation	3/8" Helice Diameter - inches				Area	Length
1-3/4" Solid Square Shaft	"A"	"B"	"C"	"D"	sq. ft.	
TAF-175-36 (08-10)	8	10	--	--	0.86	3'-0"
TAF-175-42 (10-12)	10	12	--	--	1.29	3'-6"
TAF-175-66 (08-10-12)	8	10	12	--	1.62	5'-6"
TAF-175-84 (10-12-14)	10	12	14	--	2.34	7'-0"
TAF-175-126 (08-10-12-14)	8	10	12	14	2.67	10'-6"
TAF-175-126 (10-12-14-14)	10	12	14	14	3.39	10'-6"

2" Shaft Standard Lead Configurations (15,000 ft-lb*)

Product Designation	1/2" Helice Diameter – inches				Area	Length
2" Solid Square Shaft	"A"	"B"	"C"	"D"	sq. ft.	
HTAF-200-60 (08-10)	8	10	--	--	0.84	5'-0"
HTAF-200-60 (10-12)	10	12	--	--	1.27	5'-0"
HTAF-200-60 (12-14)	12	14	--	--	1.80	5'-0"
HTAF-200-60 (14-16)	14	16	--	--	2.41	5'-0"
HTAF-200-84 (08-10-12)	8	10	12	--	1.60	7'-0"
HTAF-200-84 (10-12-14)	10	12	14	--	2.32	7'-0"
HTAF-200-84 (12-14-16)	12	14	16	--	3.17	7'-0"

1-1/2" 1-3/4" & 2" Shaft Standard Extension Configurations



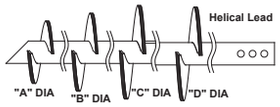
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Product Designation			Helice Diameter	Area - ft		Length
1-1/2" Shaft	1-3/4" Shaft	2" Shaft		1-1/2" BAR	1-3/4" BAR	
TAE-150-36	TAE-175-36		--	n/a	n/a	3'- 0"
TAE-150-42	TAE-175-42		--	n/a	n/a	3'- 6"
TAE-150-60	TAE-175-60	TAE-200-60	--	n/a	n/a	5'- 0"
TAE-150-84	TAE-175-84	TAE-200-84	--	n/a	n/a	7'- 0"
TAE-150-42 (14)	TAE-175-42 (14)		14"	1.05	1.05	3'- 6"
TAE-150-60 (14)	TAE-175-60 (14)		14"	1.05	1.05	5'- 0"

Note: The products listed above are standard items and are usually available from stock.
Other specialized configurations are available as special order – allow extra time for processing.
All helical plates are spaced at three times the diameter of the preceding plate
Effective length of extension is 3" less than overall dimension due to coupling overlap
All product hot dip galvanized per ASTM A123 grade 75

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Tubular Shaft Torque Anchor™ Lead Sections



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2-7/8" Dia. x 0.276" Wall Tubular Shaft Torque Anchor™ Configurations – 9,500 ft-lb

Product Designation	Helice Diameter - inches				Area sq. ft.	Length
	"A"	"B"	"C"	"D"		
TAF-288-60 (10-12)	10	12			1.24	5'-0"
TAF-288-60 (12-14)	12	14			1.76	5'-0"
TAF-288-84 (10-12-14)	10	12	14		2.26	7'-0"
TAF-288-120 (12-14-14)	12	14	14		2.79	7'-0"
TAF-288-126 (08-10-12-14)	8	10	12	14	2.57	10'-6"
TAF-288-126 (10-12-14-14)	10	12	14	14	3.29	10'-6"
TAF-288-174 (12-14-14-14)	12	14	14	14	3.81	14'-6'

3-1/2" Dia. x 0.300" Wall Tubular Shaft Torque Anchor™ Configurations – 13,000 ft-lb

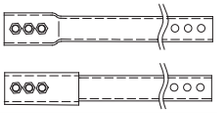
Product Designation	Helice Diameter - inches				Area sq. ft.	Length
	"A"	"B"	"C"	"D"		
TAF-350-60 (10-12)	10	12			1.20	5'-0"
TAF-350-60 (12-14)	12	14			1.72	5'-0"
TAF-350-84 (10-12-14)	10	12	14		2.20	7'-0"
TAF-350-120 (12-14-14)	12	14	14		2.72	7'-0"
TAF-350-126 (08-10-12-14)	8	10	12	14	2.48	10'-6"
TAF-350-126 (10-12-14-14)	10	12	14	14	3.20	10'-6"
TAF-350-180 (12-14-14-14)	12	14	14	14	3.73	15'-0"

4-1/2" Dia. x 0.337" Wall Tubular Shaft Torque Anchor™ Configurations – 22,000 ft-lb

Product Designation	Helice Diameter - inches				Area sq. ft.	Length
	"A"	"B"	"C"	"D"		
TAF-450-60 (10-14)	10	14			1.39	5'-0"
TAF-450-84 (08-10-14)	8	10	14		1.63	7'-0"
TAF-450-84 (10-12-14)	10	12	14		2.07	7'-0"
TAF-450-126 (08-10-12-14)	8	10	12	14	2.31	10'-6"
TAF-450-180 (10-12-14-14)	10	12	14	14	3.03	15'-0"

Tubular Shaft Standard Extension Configurations

TUBULAR EXTENSION
Supplied with hardware



TAE (FORGED)

TAEW (WELDED)

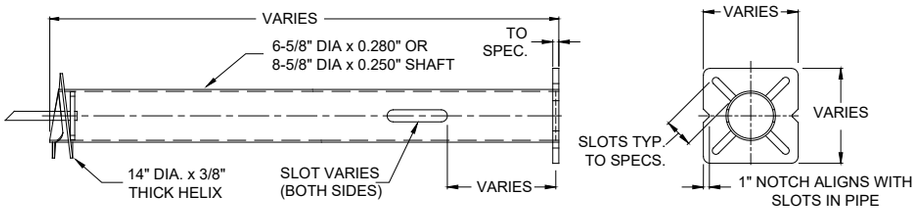
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Product Designation			Helice Diameter -		Helice Area - ft²	Length
2-7/8" Shaft	3-1/2" Shaft	4-1/2" Shaft	"A"	"B"	(2-7/8" / 3-1/2" / 4-1/2)	
TAE-288-36	TAE-350-36	TAE-450-36	--	--	n/a	3'-0"
TAE-288-60	TAE-350-60	TAE-450-60	--	--	n/a	5'-0"
TAE-288-84	TAE-350-84	TAE-450-84	--	--	n/a	7'-0"
TAE-288-120	TAE-350-120	TAE-450-120	--	--	n/a	10-0"
TAE-288-60 (14)	TAE-350-60 (14)	TAE-450-60 (14)	14	--	1.02 / 1.00 / 0.96	5'-0"
TAE-288-84 (14-14)	TAE-350-84 (14-14)	TAE-450-84 (14-14)	14	14	2.05 / 2.00 / 1.92	7'-0"

Note: The tubular products listed above are standard items and are usually available from stock.
Other specialized configurations are available as special order – allow extra time for processing.
All helical plates are spaced at three times the diameter of the preceding plate
Effective length of extension is 6" less than overall dimension due to coupling overlap
All product hot dip galvanized per ASTM A123 grade 100
Shaft Weight per Foot – 2-7/8" dia, shaft = 7.7 lb/ft; 3-1/2" dia. shaft = 10.2 lb//ft; 4-1/2" dia. shaft = 15.4 lb/ft

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Light Pole Anchor Configurations

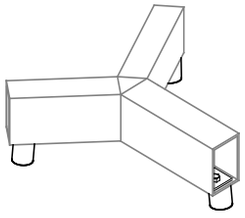


NOTE: 4" DIA FOUNDATION ANCHOR CONFIGURATION IS SIMILAR - NOT SHOWN

Product Designation		Shaft Size	Helice Diameter	Length	Ultimate-Limit Capacity at SPT ≥ 5 bpf	
Stinger End	Double Chamfer				Overturning Moment	Lateral Load
LPS-400-60 (12)	LPC-400-60 (12)	4”	12”	5’-0”	< 5,000 ft-lb	< 500 lb
LPS-663-60 (14)	LPC-663-60 (14)	6-5/8” x 0.280” Wall	14”	5’-0”	< 12,000 ft-lb	< 1,000 lb
LPS-663-84 (14)	LPC-663-84 (14)			7’-0”		
LPS-663-120 1(4)	LPC-663-120 (14)			10’-0”		
LPS-863-60 (14)	LPC-863-60 (14)	8-5/8” X 0.250” Wall	14”	5’-0”	< 17,500 ft-lb	< 1,200 lb
LPS-863-84 (14)	LPC-863-84 (14)			7’-0”		
LPS-863-120 (14)	LPC-863-120 (14)			10’-0”		

Notes: Standard Product Shown Includes:
Standard Integral Pile Cap - 1” thick x 15-3/4” Square pile cap welded to shaft
Standard 1-1/8” slots are designed for 1” diameter mounting bolts.
Cable Access Slot available on both sides of shaft – (2” x 10” Standard)
Supplied Hot Dip Galvanized Per ASTM A123 Grade 100.
Stinger End (LPS) has single chamfer on bottom of shaft with a “stinger” for alignment
Double Chamfer on bottom of LPC product shafts to ease installation - No “Stinger” on LPC (Not Shown)
Special Product Designs Are Available to your specifications - Please allow extra time for Special Product Designs.

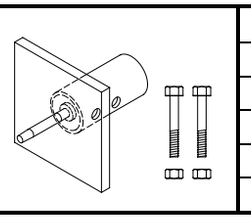
Foundation Grillages



Product Designation	Configuration	Ultimate Capacity	Max Service Load
2-7/8” Diameter Shafts			
ZTAG-288-336	Tripod – 36” Legs	250 kip	125 kip
ZTAG-288-436	Quad pod – 36” Legs	320 kip	160 kip
3-1/2” Diameter Shafts			
ZTAG-350-336	Tripod – 36” Legs	275 kip	135 kip
ZTAG-HD-350-336	Tripod – 36” Legs	300 kip	150 kip
ZTAG- 350-436	Quad pod – 36” Legs	390 kip	195 kip
4-1/2” Diameter Shafts			
ZTAG-450-336	Tripod – 36” Legs	360 kip	180 kip
ZTAG-HD-450-336	Tripod – 36” Legs	430 kip	215 kip
ZTAG-450-436	Quad pod – 36” Legs	575 kip	285 kip

Notes: Foundation grillages are custom fabricated to specification.
The appearance of the grillage will vary from the illustration depending upon the project load capacity requirement.
The recommended service load includes a factor of safety of 2.0.

Tubular Pile Cap



Part Number	TAB-288 TS	TAB-350 TS	TAB-450 TS
Pile Size	2-7/8” Dia. Tubular	3-1/2” Dia. Tubular	4-1/2” Dia. Tube
Bearing Plate	3/4” x 8” x 8”		1” x 10” x 10”
Alignment Pin	1 in. Dia x 4 in Long		
Pier Sleeve	3-1/2” Dia. x 7-3/4”	4” Dia. x 7-3/4”	5-9/16” Dia. x 9-3/4”
Ultimate-Limit Capacity	70,000 lb.	70,000 lb.	120,000 lb.

Notes: 1. Part numbers for “TS” Pile Caps include attachment holes and SAE J429 Grade 8 hardware and alignment pin as shown
2. Compressive capacity ratings of some pile caps are limited by compressive pile shaft capacity.
3. Pile caps are supplied hot dip galvanized per ASTM A123 Grade 100.
* Custom fabricated pile caps are available for all shaft sizes by special order – allow extra time for processing.

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The following preliminary design information is intended to assist with the selection of an appropriate ECP Torque Anchor™ configuration for a Compression Pile project.

The Ultimate Capacity for compressive support installations is defined by a pile deflection not exceeding one inch when an Ultimate Load is applied to the pile.

Deep Foundations

Helical anchor systems must be considered as deep foundation elements and as such must be installed to a depth of **at least six times the diameter of the largest helix on the shaft measured from grade**.

The measurement is made vertically from the final surface elevation to the depth of the shallowest helical plate on the helical compressive pile.

The capacity of a multi-helix deep foundation system assumes that the ultimate bearing capacity is the sum of the bearing support from each helice on the shaft. Testing has shown that when the helices are spaced at least three times the distance of lower helical plate diameter apart, each plate can develop full efficiency and develop maximum load transfer capacity in the soil. Spacing the helices at less than three diameters apart is possible; however, each helice will not be able to develop full rated capacity due to interference between the soil stress bulbs from adjacent helices. The designer will have to include a reduced plate efficiency factor in the analysis when preparing a design that specifies helices spaced closer than three diameters of the next lower helice apart.

Table 1. SOIL CLASSIFICATION TABLE

Class	Soil Description	Geological Classification	Standard Penetration Test Range - "N" [1] (Blows/ft)
0 [2]	Solid Hard Rock (Unweathered)	Granite; Basalt; Massive Sedimentary	No penetration
1 [2]	Very dense/cemented sands; Coarse gravel and cobbles	Caliche	60 to 100+
2	Dense fine sands; Hard silts and/or clays	Basal till; Boulder clay; Caliche; Weathered laminated rock	45 to 60
3	Dense sands/gravel, Stiff/hard silt and clay	Glacial till; Weathered shale; Schist, Gneiss; Siltstone	35 to 50
4	Medium dense coarse sand/sandy gravels; Stiff/very stiff silt/clay	Glacial till; Hardpan; Marl	24 to 40
5	Med dense coarse sand and sandy gravel; Stiff/very stiff silt and clay	Saprolites; Residual soil	14 to 25
6	Loose/medium dense fine/coarse sand; Stiff clay and silt	Dense hydraulic fill; Compacted fill; Residual soil	7 to 14
7 [3]	Loose fine sand; Medium/stiff clay; Fill	Flood plain soil; Lake clay; Adobe; Clay gumbo; Fill	4 to 8
8 [3 4]	Peat, Organic silts, Fly ash, Very loose sand; Very soft/soft clay	Unconsolidated fill; Swamp deposits; Marsh soil	WOH (Weight of Hammer) to 5

Notes:
1. Standard Penetration Test (SPT) ranges are only broad estimates to assist in determining Soil Classes
2. Soils in class "0", class "1" and a portion of class "2" are generally not suitable for tieback anchorage because the helical plates are unable to advance into the very dense/hard soil or rock sufficiently for anchorage.
3. When installing anchors into soils classified from "7" and "8", it is advisable to continue the installation deeper into more dense soil classified between "3" and "5" to prevent creep and **enhanced anchor capacity.**
4. Shaft buckling must be considered when designing compressive anchors that pass through Class 8 soils.

Preventing "Punch Through" in Compression Applications

A soil boring on occasion may report a layer of competent soil that is overlaying a soft, weaker stratum of soil. For an installed helical pile to achieve the designed axial compressive bearing in the competent soil that terminates above a weaker soil layer, where the lowest helice on the shaft is less than five diameters above the underlying weaker stratum, one must consider the possibility that the Torque Anchor™ could "punch through" to the weaker soil when fully loaded.

It is recommended when designing a helical pile in compressive loading that one is aware of the soil characteristics that exist below the bottom of the pile to a depth that is at least **five times the diameter of the lowest (smallest) helice**. If the soil below the lowest helice is as good as, or better, than the soil where the other helices reside to a depth of at least five diameters, the risk of a "punch through" (compressive pile failure) into the weaker soil stratum is very unlikely.

Generally a load test is recommended in installations where "Punch Through" is possible.

Minimum Embedment Depth

The Ultimate Capacity data for compression helical piles presented here is calculated from equations that require the pile qualifies as a deep foundation element. A deep helical foundation element is defined as a helical pile having a minimum depth from finished grade to the first helix on the shaft of at least six

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times the diameter of that helice.

CAUTION: When a helice is less than the minimum vertical depth requirement from the finished grade, the foundation acts as if it is a shallow footing. The bearing capacity equation used here for the load curves in the graphs and in the tables may not accurately predict Ultimate Compressive Capacity.

Torque Anchor™ Compressive Installation Limits

Shaft Strength

The data in Table 7 gives the mechanical strength ratings for various shaft configurations in axial tension, compression and in torsion. These values are from mechanical testing and not from tests in the soil. Because ECP Torque Anchor™ products are installed by rotating the shaft into the soil; the Torsional Strength of the shaft can limit the Ultimate Capacity of the product. In Table 7 the "*Useable Torsional Strength*" column indicates the maximum installation torque that should be intentionally applied to the shaft during installation. Table 7 assumes the soil is homogeneous. The risk of product failure dramatically increases when one exceeds these torsion limits, or if the helical pile encounters obstructions.

When choosing a helical foundation support product for a project, the designer should select a product that has an adequate margin of torsional strength above the torque required for embedment. This safety margin will provide for any increased torque experienced during installation of the final three feet of shaft length once the shaft torsion for the design is reached.

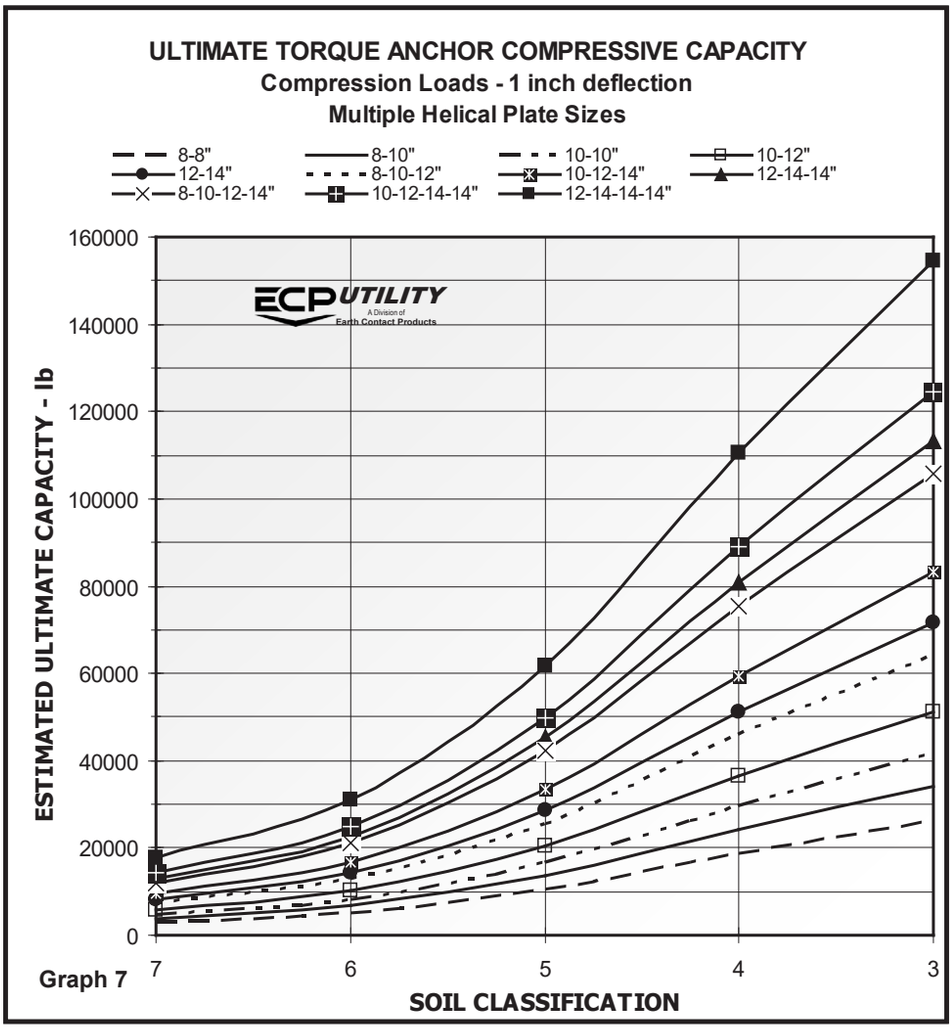
Keep in mind that shaft fractures from unexpected impact loading can, and often do, occur during high torque installation especially in obstruction laden soils.

It is recommended that a margin of at least 30% above the installation torque requirement be allowed when selecting a shaft size to insure proper embedment, and to prevent impact fractures when installing into non-homogeneous soils.

Ultimate Capacity

The "*Ultimate-Limit Compressive Capacity",* shown in Graph 7 is based upon conservative estimates obtained from field testing. The graph represents the Ultimate Capacity of the helices in the Soil Classes 3 through 7.

The Ultimate-Limit Load Capacity indicated on Graph 7 is the applied load that produces no more than one inch deflection.



Graph 7

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Always use a Factor of Safety. If designing only to Working Loads, the pile will likely experience unacceptable deflection.

Graph 7 represents general trends of capacity for helical piles in compression applications through different homogeneous soil classifications. The graph is based upon calculated Ultimate Capacity estimates using the bearing capacity equation for deep foundation and average Standard Penetration Test values for each Soil Class.

Notice that Graph 7 disregards soil classifications from Soil Class zero to 2. The reason for this is that these soils are usually too dense for a Torque Anchor™ to advance without pre-drilling. When the rotation of a helical anchor shaft does not advance all of the helices into the soil, the soil is considered too dense for proper Torque Anchor™ embedment.

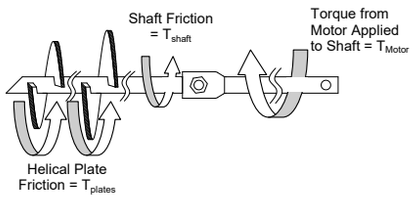
Likewise soil class 8 was not presented on Graph 7 because Soil Class 8 usually contains significant amounts of organics, unconsolidated fill, swamp deposits and/or marsh soil. These soils are usually unsuitable for stability and structural support.

In some cases, soils in Class 7 may not be robust enough for heavy compressive loads. The soil may not be fully consolidated and might contain traces of various organic components, which could allow for creep of a pile embedded within the stratum. This could cause serious long term settlement problems.

When such weak soils are encountered, it is strongly recommended that the helical pile be driven deeper, allowing the Torque Anchor™ to advance completely through this less desirable stratum and embed into an underlying, more robust and stable soil. If the weak soil persists after installing the pile deeper, then it is recommended that proof testing and/or increasing the factor of safety for the pile design.

Installation Torque

Shaft torsion applied during installation can provide a reasonably accurate estimate of the ultimate capacity of the helical screw anchor. The relationship between the shaft torsion during installation and the ultimate helical screw anchor capacity is empirical and was developed from results from thousands of tests. When one applies rotational torsion to a shaft at grade level, some of the torque energy is lost before it reaches the helices at the bottom end of the shaft. This is due to friction between the shaft and the soil and is shown as T_{shaft} on the sketch below.



As a result not all of the torque applied to the shaft by the motor arrives at the helices. The actual torque applied to the helices is the torque applied by the motor reduced by soil friction against the shaft. In the sketch this torque reduction due to soil friction is illustrated.

$$T_{Plates} = T_{Motor} - T_{Shaft}$$

The friction generated between the circumference of the shaft and the soil contact is directly related to the shaft configuration and size along with the soil properties. Because of this loss of efficiency in transmitting torque from the motor to the helices, the empirical *"Shaft Efficiency Factor"* ("k") was developed to suggest reasonable Ultimate Capacity estimates.

Shaft Efficiency Factor – "k"

It is important to also understand that the "*Shaft Efficiency Factor"*, "k", reduces the practical limit on Ultimate Capacity developed by the torque on a pile shaft in the soil. This is especially important when the design uses larger tubular products. Large tubular shafts pass through the soil with significantly less efficiency than smaller tubular shafts or solid square bars.

Table 8. Shaft Efficiency Factor "k"

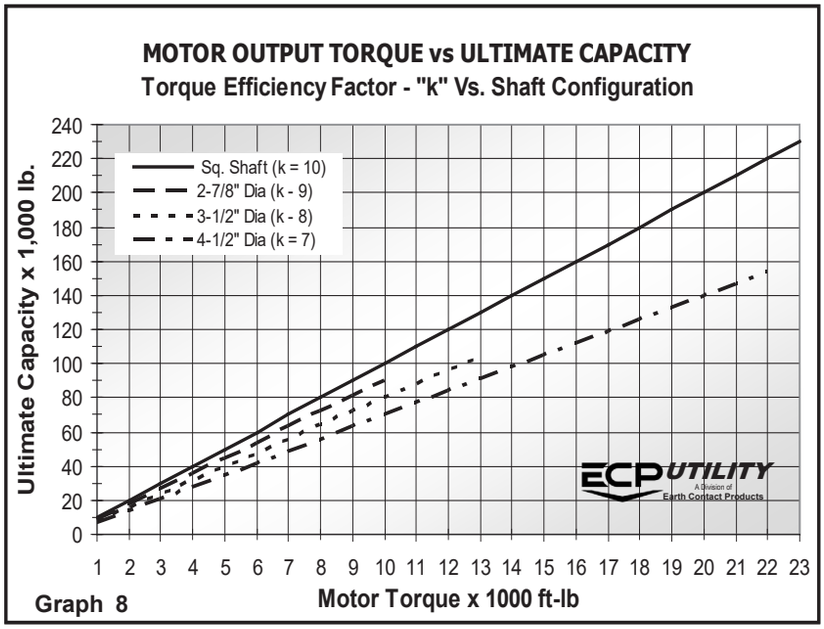
Torque Anchor™ Type	Average Efficiency	Suggested Average Value, "k"
All Square Shafts	90-100%	10
2-7/8" Diameter	90%	9
3-1/2" Diameter	80%	8
4-1/2" Diameter	70%	7

Keep in mind that the *"Shaft Efficiency Factor"* ("k") in Table 8 is an estimation of friction loss during installation. The amount of friction loss has a direct relationship to soil properties on the site and the anchor configuration. The "k" value for square bar shafts is higher than for tubular shafts.

The suggested values in Graph 8, *"Motor Output Torque vs. Ultimate Capacity"* (On the next page) are estimates that were developed from thousands of field tests. It is also important to refer to Table 7, "ECP Helical Torque Anchor™ Capacities" at

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the beginning of the chapter to check the maximum practical shaft torsion that can be applied to an anchor shaft. Being mindful that maintaining the shaft torsion during installation at below the rated *"Useable Torsional Strength"* in Table 7. This will help to avoid shaft fractures during installation. Failure to verify that the shaft configuration selected has sufficient reserve torsional capacity could result in an unexpected shaft fracture during installation.



Graph 8

Design Example 3 – Transmission Tower in Cohesive (Clay) Soil

Design Details:

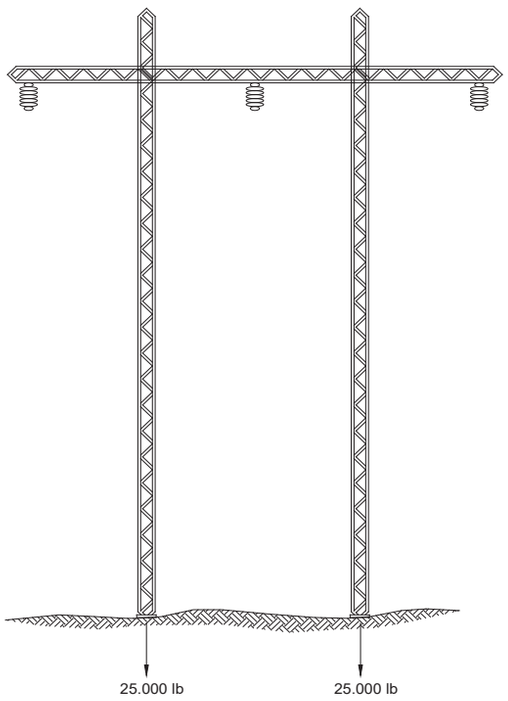
- Compressive Service Load = 25,000 lb at each leg.
- The soil information about the site indicated **very stiff inorganic clay** (CL), SPT, "N" = 8 to 12 Blows Per Foot to 25 feet deep.

ECP Torque Anchor™ Design

1. Determine the Soil Class: The description of the soil on the site is **very stiff inorganic clay**. Referring to Table 1, this most closely resemble Soil Class 4 - 5.

Select - **Soil Class 4-5**

Table 1. SOIL CLASSIFICATION TABLE		
Class	**Soil Description**	**Geological Classification**
0	Solid Hard Rock (Unweathered)	Granite; Basalt; Massive Sedimentary
1	Very dense/cemented sands; Coarse gravel and cobbles	Caliche
2	Dense fine sands; Hard silts and/or clays	Basal till; Boulder clay; Caliche; Weathered laminated rock
3	Dense sands/gravel, Stiff/hard silt and clay	Glacial till; Weathered shale; Schist, Gneiss; Siltstone
4	Medium dense coarse sand/sandy gravels; Stiff/**very stiff silt/clay**	Glacial till; Hardpan; Marl
5	Medium dense coarse sand and sandy gravel; Stiff/**very stiff silt & clay**	Saprolites; Residual soil
6	Loose/medium dense fine/coarse sand; Stiff clay and silt	Dense hydraulic fill; Compacted fill; Residual soil
7	Loose fine sand; Medium/stiff clay; Fill	Flood plain soil; Lake clay; Adobe; Clay gumbo; Fill
8	Peat, Organic silts, Fly ash, Very loose sand; Very soft/soft clay	Unconsolidated fill; Swamp deposits; Marsh soil



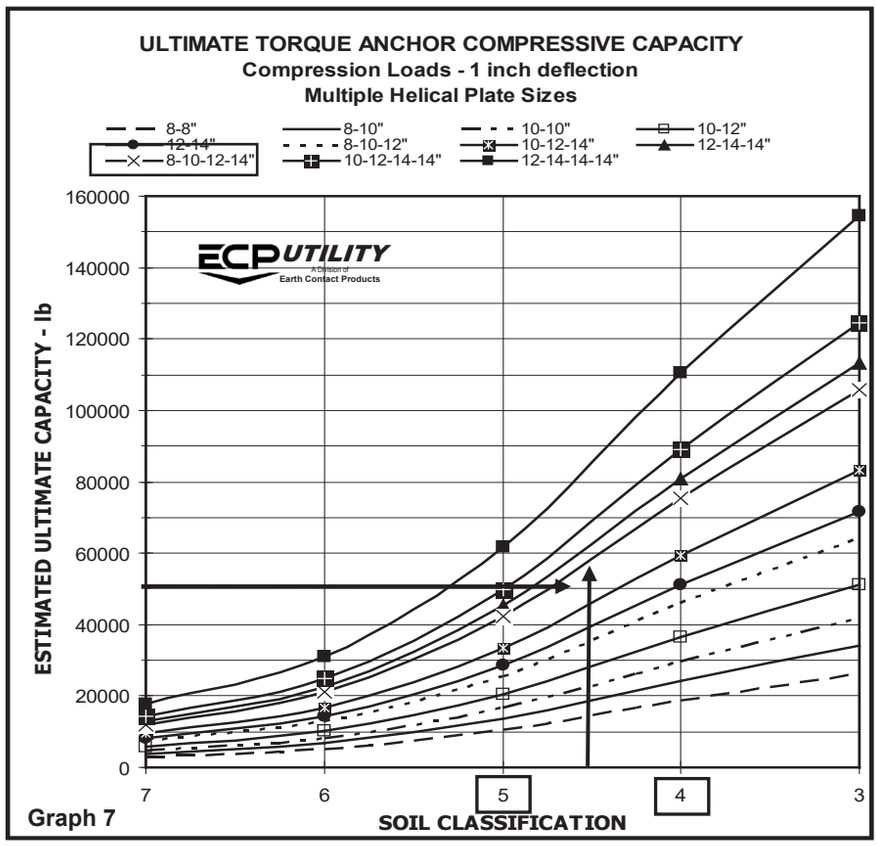
Sketch for Design Examples 4, 5 & 6

2. Ultimate Helical Pile Capacity. The tower manufacturer provided the Service Capacity (or Working Load) on this project to be 25,000 pounds at each leg. Because the pile must have the capability to support more than just the Service Load, a factor of safety must be added

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to obtain the Ultimate Capacity for the helical compressive pile design. In this case a typical factor of safety of 2.0 is used for compressive piles:

Ultimate Capacity = 25,000 lb x 2.0 = **50,000 lb**



Graph 7

3. Select a suitable compression pile: Referring to Graph 7 from earlier (reproduced right). Extend the 50,000 lb. capacity line to the right and where the line for Soil Class 4-5 meets, an anchor with an 8", 10", 12" and 14" configuration has a slightly higher capacity. The tower footings also require a pile cap. The pile caps are designed to fit tubular shafts.

Select: **TAF-288-126 (08-10-12-14)** Torque Anchor™ from the "*Compressive Pile Product Catalog"* at the beginning of this chapter. This pile has an 8", 10", 12" and 14" helices mounted to a 2-7/8" diameter tubular shaft that is 10'-6" inches long.

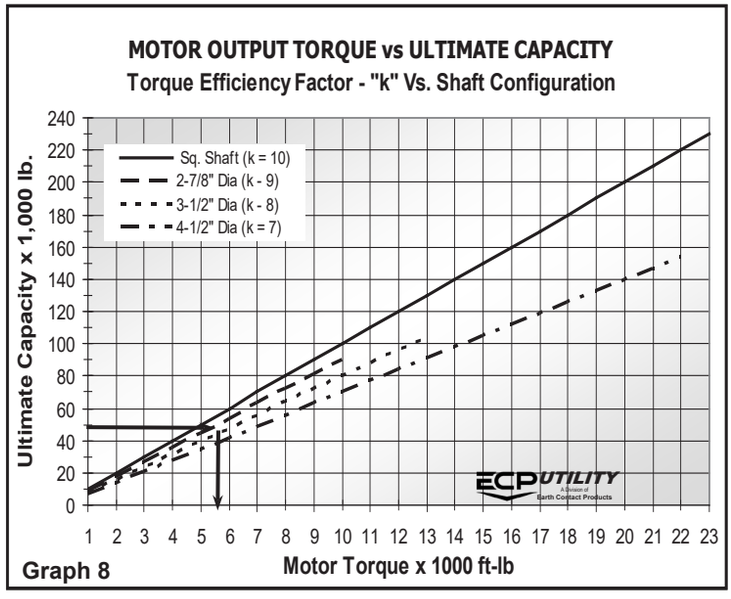
Select - **TAF-288-126 (08-10-12-14)**

4. Installation Torque: Graph 8, below, estimates the installation shaft torsion requirement for this pile. The 2-7/8" inch diameter shaft is designated by the long dash line (-- -- --) on the graph. The ultimate capacity requirement of 50,000 pounds can be seen on the left side of the graph. Move horizontally from 50,000 pounds to reach the line representing the 2-7/8 inch tubular shaft. Read downward until the required installation torque of 5,600 ft-lb is determined.

Installation Torque - **5,600 ft-lb**

5. Check the Shaft Strength and Torsional Strength: Refer to Table 7, *"Capacities of ECP Helical Torque Anchors*™, at the beginning of this chapter to confirm that the 2-7/8" diameter, 0.276" wall, tubular shaft is a suitable pile for this project. Table 7 indicates that a 2-7/8" diameter, 0.276" wall, tubular shaft has an Axial Compressive Load Limit of 100,000 pounds. This is double the Ultimate Capacity requirement.

Check the Torsional Strength: Referring to Table 7, the 2-7/8" tubular shaft has a Useable Torsional Limit of 9,500 ft-lbs which is sufficient to obtain 85,000 lb Ultimate Capacity.



Graph 8

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The TAF-288-126 (08-10-12-14) helical pile is verified to have:

- Suitable Projected Helices Area,
- Adequate Torsional Capacity
- Load Limit that exceeds the 50,000 lbs Ultimate Capacity

TAF-288-126 (08-10-12-14) design is verified.

6. Minimum Embedment Depth: From the discussion earlier about sufficient soil overburden depth, the minimum depth of six times the diameter of the shallowest helice is required. It is measured vertically from the surface to the shallowest helice is required. The Minimum Embedment Depth, "D" can be determined as follows:

$D = 6 \times d_{\text{largest plate.}}$

D = 6 x (14 in / 12 in) (ft)

D = 7 feet

Minimum Vertical Depth - **7 ft.**

7. Minimum Total Shaft Length:

Recall that helices are spaced at three times the diameter of the next lower helice on the shaft. The configuration selected has 8", 10" and 12" diameter helices mounted below the top 14" helice. The total shaft length from the 8 inch diameter helice at the bottom of the pile shaft up to the 14 inch plate must be determined.

This product shaft length needs to be added to the **Minimum Vertical Depth** requirement from grade that was determined in Step 6.

Adding these two shaft lengths together will determine the **Minimum Shaft Length** required for this installation.

Minimum Total Shaft Length:

$\mathbf{L = D_{14"} + L_{tip}}$ (Distance from 14" to 8" helice)

L = 7' + 3 x (8" dia + 10" dia + 12" dia)/12" =

L = 7' + 7.5' = 14.5 ft

Minimum Total Shaft Length - **14-1/2 feet.**

Specify an extension that has a coupled length of at least 5 feet to obtain the required minimum installed length of 14-1/2 feet. The 10.5 foot lead section plus a 7 foot extension (Which has a coupled length of 6'-6") provides a shaft length of 17', which is the most reasonable standard product lengths that can be ordered that exceeds the 14-1/2 foot Minimum Total Shaft Length.

8. Torque Anchor™ Specifications. The compression Torque Anchor™ assembly to support one leg of the tower will consist of:

- **TAF-288-126 (08-10-12-14)** – 2-7/8 inch diameter, 0.276 inch wall thickness tubular 10'–6" long pile shaft that has an 8", 10" 12" and a 14" diameter helice attached to the shaft.
- **TAE-288-84** extension – 7'- 0" tubular shaft extension & hardware, (6'-6" effective length).
- **TAB-288-TS New Construction Pile Cap**

It is suggested to have additional extension sections on hand if the Minimum Torsion Requirement of 5,600 ft-lb is not achieved when a total of 17 feet of shaft is fully installed into the soil. This can sometimes occur when the soil is actually weaker than expected.

End of Design Example 3

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Technical Design Assistance

Earth Contact Products, LLC. has a knowledgeable staff that stands ready to help you with understanding how to prepare preliminary designs, installation procedures, load testing, and documentation of each placement when using ECP Torque Anchors™. If you have questions or require engineering assistance in evaluating, designing, and/or specifying Earth Contact Products, please contact us at 913 393-0007, Fax at 913 393-0008.

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Shaft Buckling in Class 8 Soils

Class 8 soils usually have insufficient bearing strength to properly support a structural load long term. Proper design suggests that the helical screw pile must penetrate through the Class 8 soil to reach a stratum of soil with a suitable bearing capacity. A more robust soil located below the weak layer of soil can support the compressive load properly, but there is another problem that can occur when the slender compressive pile shaft passes through weak Class 8 soil. The problem is that the pile shaft may not receive adequate lateral support from the soil. As a result, the load carrying capacity of the pile needs to be evaluated due to the threat of the slender pile shaft buckling due to a lack of sufficient lateral support from weak Class 8 soil.

The purpose of this discussion is to estimate the maximum allowable axial load that can be applied to a slender pile shaft as it passes through Class 8 soil.

The Ultimate Capacities shown in Table 7 at the beginning of the chapter assume that there is sufficient lateral support against the pile shaft to prevent the shaft from buckling under full load.

It is possible for the pile shaft to buckle due to insufficient lateral support under the full load as shown in Table 7.

Therefore, when a Torque Anchor™ is installed through very soft soil such as Class 8 soil; the threat of shaft buckling must be evaluated to determine if a reduction in the pile's compressive capacity is needed to prevent shaft buckling as it passes through a layer of weak soil.

Remember, the *"Axial Compressive Load Limit"* given in Table 7 cannot be safely used in extremely soft or very loose soils.

The amount of reduction in the Ultimate Capacity expected due to shaft buckling as it passes through weak soil is dependent upon; the lateral strength of the weak soil that the shaft is exposed to and the stiffness (moment of inertia) of the pile shaft configuration.

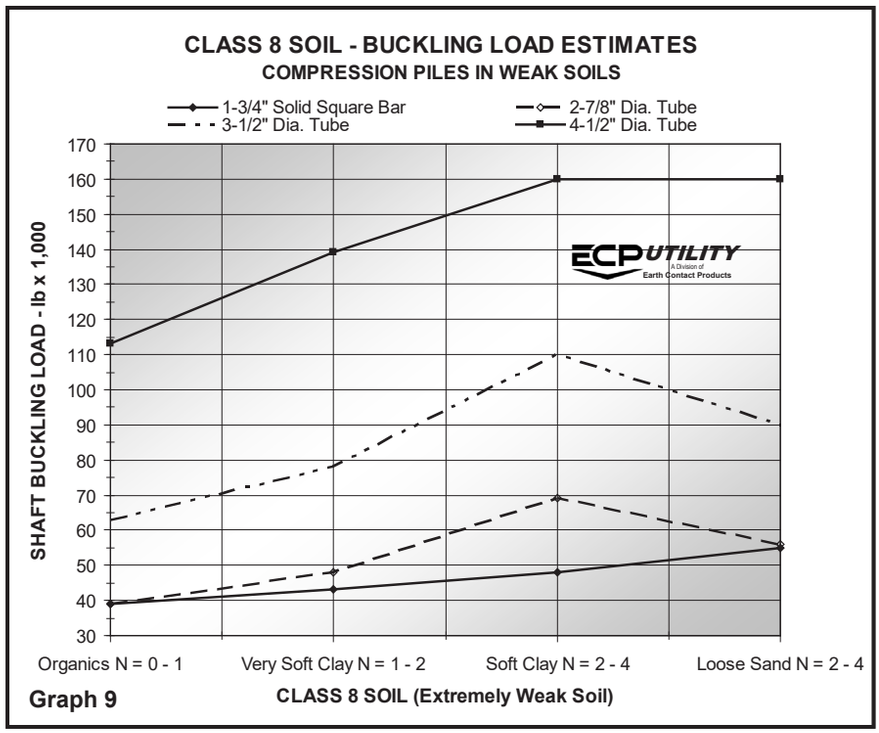
The data presented here are based upon calculations that assume the pile terminates within a fixed footing at the surface. The data presented in Graphs 9 and 10, below, assume both ends of the pile shaft are being constrained. In most cases the upper lateral restraint is usually not a problem because concrete footings are able to constrain lateral or rotational pier movements.

Seek professional engineering input when the pile shaft is not fixed at the surface. There are factors present that can cause shaft buckling at significantly lower loads. An engineering evaluation is required for such an application.

Do not use the data presented here where the upper pile shaft is not fully constrained by the structure.

When one encounters very weak soil in the field, general buckling information must be available to determine if the selected pile shaft configuration will have sufficient moment of inertia (stiffness) to resist shaft buckling when the intended load is applied. Graph 9 demonstrates reduction in pile capacity when there is insufficient lateral soil support against the shaft.

Graph 9 demonstrates the very low buckling loads for a solid square shaft. Solid shafts offer



Graph 9

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relatively low buckling strength when passing through weak soils that have low SPT values. Notice that larger diameter tubular pile shafts offer enhanced buckling strength, they are more resistant to buckling. When designing piles in axial compression that penetrate weak soils, it is good practice to select a tubular shaft.

Earth Contact Products does not recommend using solid square shafts in axial compression unless the installation takes place in soils rated Class 3 to Class 6. These soils generally have Standard Penetration Test values (SPT), "N", greater than 5 blows per foot. Likewise when tubular shafts are in soil with, SPT, "N" values greater than 4 blows per foot the shaft can achieve the full capacity indicated in Table 7. In these more robust soils the pile shaft receives sufficient lateral support against the shaft to prevent shaft buckling at the full rated loads.

Shaft Buckling in Air or Water (Unsupported Compression Piles)

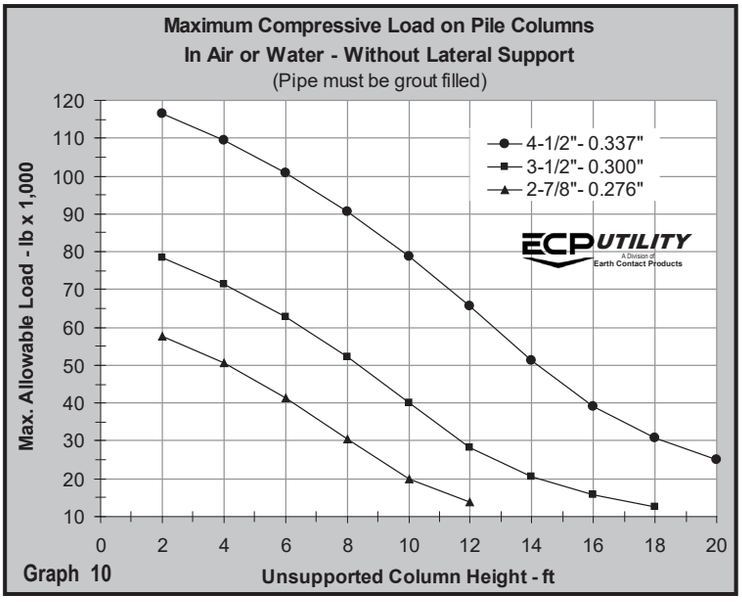
Graph 10 shows the reduction in *"Allowable Axial Compressive Load"* relative to the length of exposed pier shaft when the pile shaft is in air or water and fully exposed without any lateral support. A pile shaft in water or air with no lateral shaft support can easily buckle.

Graph 10 represent the Ultimate Compressive Capacity or *"Maximum Compressive Load"* that can be placed axially on a fully exposed pile shaft that is constrained within a structure and anchored into competent soil.

A suitable Factor of Safety must always be applied to the design load before using these tables that show *"Maximum Compressive Load"*. The Factor of Safety insures reliability of the compression pile system.

The most accurate way to determine the buckling load of a helical pile shaft in weak soil, or in air, or water is to perform a buckling analysis by finite differences. This is extremely complicated and requires engineering input.

Earth Contact Products recommends that a Registered Professional Engineer conduct the design of helical screw piles in situations where shaft buckling may occur when the shaft is fully exposed above grade level without any lateral support to the pile shaft.



Design Example 4 – Transmission Tower in Wetland Soil

Design Details:

- The transmission tower foundation project is from Design Example 3 above.
- Compressive Service Load = 25,000 lb. at each leg.
- The soil information about the site has been revised, a **five foot layer of Organic Soil** was found just below the layer of topsoil.
- The soil was determined to be an **organic swamp deposit**. Standard Penetration Test values, **"N" = 1 to 3 blows per foot**.
- Table 1 suggests that five feet of **organic swamp deposit** below the topsoil is Soil Class 8. Below the organics is a deep layer of very stiff inorganic clay (CL) as reported in the previous design example.

ECP Torque Anchor™ Design

1. Check the existing compression pile configuration for buckling: In Design Example 3, a TAF-288-126 (08-10-12-14) Torque Anchor™ product with four helices mounted to a 2-7/8 inch diameter, 0.276" wall tubular shaft was specified. This design was selected and verified in competent soil to adequately support the design load of 25,000 pounds along with a Factor of Safety of 2.0.

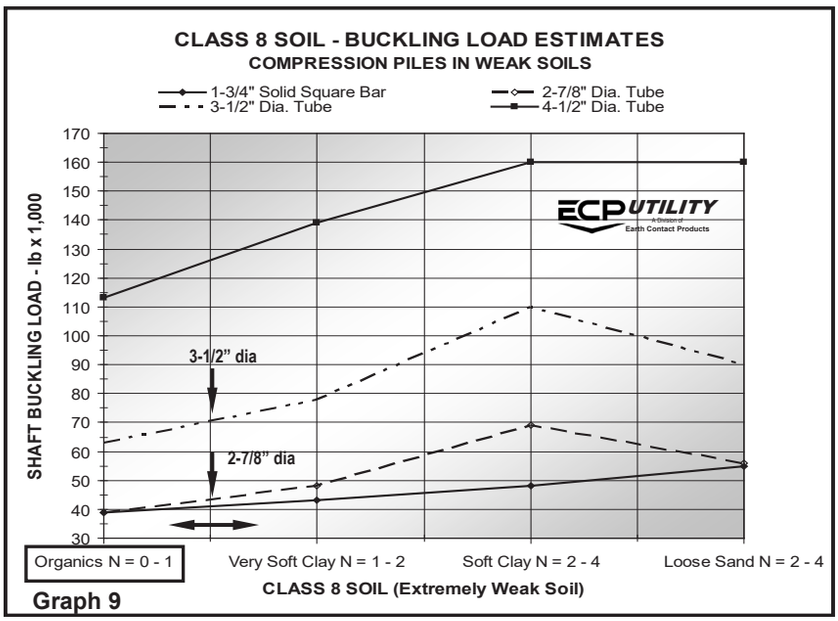
Recalling from Table 7, the 2-7/8 inch diameter tubular shaft has an *"Axial Compressive Load Limit"* of 100,000 pounds. Based upon an installation torsional limit of 9,500 ft-lbs, the 2-7/8

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inch diameter shaft has a *"Practical Load Limit"* of 85,000 pounds.

The selected pile in Example 3 has suitable helices area, torsional capacity and a load limit to exceed the required Ultimate Capacity of 50,000 pounds in Class 4-5 soil.

PROBLEM: Extremely weak (Class 8) soil was found near the surface at this site. The shaft must pass through very weak soil. The slender pile shaft may not receive sufficient lateral soil support to prevent shaft buckling at the rated Ultimate Capacity when the shaft is in Class 8 soil.



Graph 9

2. Verify the Buckling Strength of the 2-7/8" diameter tubular shaft: We must verify that the 2-7/8 inch diameter shaft has adequate buckling strength to support the Ultimate Design Load of 50,000 pounds as the shaft passes through five feet of weak Class 8 soil on this site. Refer to the "*Class 8 Soil – Shaft Buckling Estimates",* Graph 9, above.

The geotechnical report said the SPT values, "N" = 1 to 3 blows per foot within the **organic swamp deposit**. If it is assumed that the first vertical line on Graph 9 represents "N" = 1, a conservative buckling load can be estimated.

Notice the graph line for the 2-7/8" diameter tubular shaft installed through very weak organic soil. ("N" = 1 was selected as conservative.) The *"Shaft Buckling Load"* estimate for the 2-7/8 inch diameter pile shaft is 43,000+/- pounds, depending upon the actual SPT ("N") blow count of the organic soil at the specific installation site.

Graph 9 suggests the 2-7/8 inch diameter shaft has insufficient buckling capacity. The data suggests that the shaft could buckle and fail at 50,000 pounds Ultimate Capacity.

3. Select a larger Pile Shaft with Greater Buckling Strength: Graph 9 demonstrates that a larger diameter shaft will insure sufficient buckling strength of the pile shaft when passing through weak Soil Class 8, **organic swamp deposit**. Refer to Graph 9 and select the 3-1/2 inch diameter shaft. The estimated buckling load capacity is 71,000 +/- pounds.

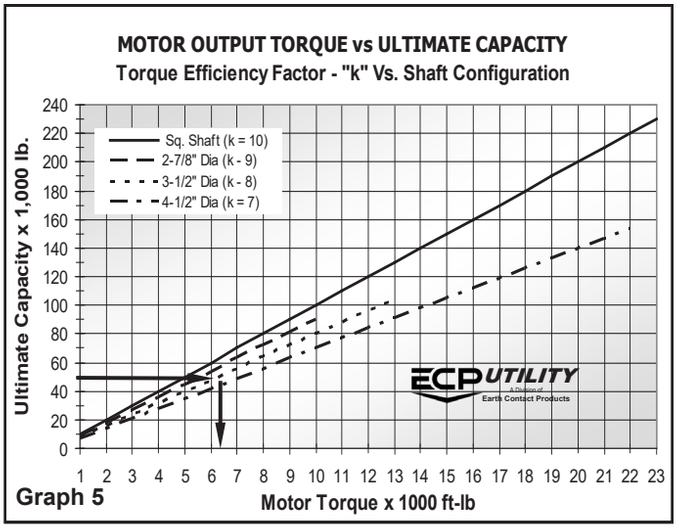
Specify - **3-1/2" Diameter Tubular Shaft**

Select Pile - **TAF-350-126 (08-10-12-14)**

3. Installation Torque: The larger diameter 3-1/2 inch tubular shaft has greater buckling strength, but unfortunately, the larger diameter tubular shaft passes through the soil with less efficiency during installation than the smaller 2-7/8" diameter shaft.

When the design requires a change in shaft diameter, the installation torque requirement MUST always be recalculated.

Graph 5 quickly estimates the installation torque requirement; the 3-1/2 inch diameter shaft. The Ultimate Capacity requirement of 50,000 pounds is read on the left side. Read to the right from



Graph 5

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50,000 lb to the graph line for the 3-1/2 inch shaft and then downward until the installation torque of 6,300 ft-lb is determined. The 3-1/2 inch diameter tubular shaft is designated by the (- - -) symbol on Graph 5.

Specify Installation Torque - **6,300 ft-lb**

3. Torque Anchor™ Specifications. The helice configuration of the Torque Anchor™ remains as originally determined in the previous Design Example 3 for compressive support plus a factor of safety. The 3-1/2 inch diameter, 0.300 inch wall pile has enhanced buckling strength and shall be installed to the same minimum depth, but with the higher 6,300 ft-lb shaft torsion. The new pile configuration consists of:

- **TAF-350-126 (08-10-12-14)** - 3-1/2" diameter tubular shaft with 0.300" wall thickness that has an 8", 10", 12" and 14" diameter helices on a 10-1/2 foot long shaft,
- **TAE-350-84** extension – 7' extension shaft & hardware, (6-1/2 foot effective length).
- **TAB-350-TS New Construction Pile Cap**

It is suggested to have additional extension sections on hand should additional weak soil be encountered causing the required shaft torsion not being achieved at 17 feet below grade.

End of Design Example 4

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Steel Underground - How Long Does It Last?

Galvanized steel anchor products are subjected to a range of corrosive forces that are quite different from steel exposed to atmospheric conditions. The performance of underground steel and galvanized structural steel elements are not as well understood as is the life expectancy of steel products in above ground applications.

For corrosion to initiate, steel requires not only oxygen but also the presence of dissolved salts in water. If any one of these items is absent, corrosion will not occur.

The soils that have the highest corrosive potential, are soils described or classified by geotechnical engineers as: silty, loamy, clay, organic (peats, cinders and ashes), and soils which are poorly aerated.

Granular soils (Sands and Gravels) which are highly aerated can drain water away rapidly. In well drained soil the electrolyte is not constantly in contact with the steel and the corrosion process is reduced.

Soil Resistivity

One of the simplest classifications for soil corrosivity is based upon the resistivity of the soil. To obtain the soil resistivity, one passes a current through the soil and measures the resistivity of the soil in ohm-centimeters. In general, sandy soils have high resistivity values and are considered the least corrosive. Clay soils and especially clay with saline water are sometimes highly corrosive to steel.

Table 4. Soil Resistivity and Relative Corrosivity Rating

Resistivity (ohm-cm)	Corrosivity Rating
> 10,000	Non-Corrosive
5,000 to 10,000	Mildly Corrosive
3,000 to 5,000	Moderately Corrosive
1,000 to 3,000	Corrosive
500 to 1,000	Highly Corrosive
< 500	Extremely Corrosive

Soil Acidity or Alkalinity – pH

The measure of acidity or alkalinity in water is measured as pH. A value of pH less than 7 is considered to be acidic and values of pH greater than 7 to pH = 14 are alkaline. Pure distilled water is neutral or has a pH = 7. How does this affect corrosion? As the water becomes increasingly acidic with pH = 4 and below, the steel corrodes

Table 5. SOIL CORROSION CLASSIFICATION TABLE – SOIL RESISTIVITY RANGES

Class	Soil Description	Geological Classification	Resistivity Range [2] (ohm-cm)
0	Solid Hard Rock (Unweathered)	Granite; Basalt; Massive Sedimentary	200,000+
1	Very dense/cemented sands; Coarse gravel and cobbles	Caliche	40,000 to 200,000
2	Dense fine sands; Hard silts and/or clays	Basal till; Boulder clay; Caliche; Weathered laminated rock	10,000 to 100,000
3	Dense sands/gravel, Stiff/hard silt and clay	Glacial till; Weathered shale; Schist, Gneiss; Siltstone	5,000 to 50,000
4	Medium dense coarse sand/sandy gravels; Stiff/very stiff silt/clay	Glacial till; Hardpan; Marl	5,000 to 20,000
5	Medium dense coarse sand and sandy gravel; Stiff/very stiff silt and clay	Saprolites; Residual soil	2,000 to 10,000
6	Loose/medium dense fine/coarse sand; Stiff clay and silt	Dense hydraulic fill; Compacted fill; Residual soil	1,000 to 5,000
7 [1]	Loose fine sand; Medium/stiff clay; Fill	Flood plain soil; Lake clay; Adobe; Clay gumbo; Fill	500 to 5,000
8 [1]	Peat, Organic silts, Fly ash, Very loose sand; Very soft/soft clay	Unconsolidated fill; Swamp deposits; Marsh soil	50 to 2,000

Notes:
1. Soils in Class 8 and part of Class 7 tend to be more highly corrosive than other soil classes
2. Resistivity is highly variable from site to site and from place to place on the same site. These ranges are only guidelines and overlapping across soil classes is to be expected. Field test to verify resistivity.
3. High soil moisture content decreases the resistivity making the soil more corrosive.
4. Freezing the soil dramatically raises the resistivity, thus reducing the corrosivity

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more rapidly than steel in a more alkaline environment when pH readings greater than pH = 7 and less than pH = 10.

It is also interesting to note that zinc used for galvanization provides the best protection to steel in a similar pH environment.

Zinc Galvanizing for Corrosion Protection

Zinc galvanize provides the most effective protection through a range of pH = 5.5 to pH = 12.5.

Under favorable conditions, the zinc may corrode at less than 0.20 mils per year (0.0002 in/yr) under mild conditions to more than 0.98 mils (0.001 in/yr) in unfavorable soil conditions.

The corrosion rate of steel in soil can range from less than 0.79 mils per year (0.0008 in/yr) under favorable conditions to more than 7.87 mils per year (0.0079 in/yr) in very aggressive soils. There are also similarities in the corrosion rates of galvanized coatings.

Test results suggest that pH greater than pH = 4 to pH = 10, the corrosion rate of iron is independent of the acidity or alkalinity measured as pH of the environment.

In acidic conditions when pH is less than 4, the corrosion rate dramatically increases. The scientists concluded that the acidic condition dissolves the iron oxide as it forms leaving the iron in direct contact with the water.

Hot Dip Galvanizing

The products manufactured by Earth Contact Products are hot dip galvanized, they are coated with molten zinc that contains not less than 98% pure zinc metal. The hot dip galvanization process meets or exceeds ASTM A123 Grade 75 for steel plate, tubular or bar products.

ASTM A123 Grade 75 requires a minimum of 3.0 mils (0.004") or 1.7 oz/ft^2 of zinc. The coating thickness to ASTM A123 specifications is the minimum allowed. Most galvanized coatings will have a thickness in excess of these values which means corrosion life may be slightly longer.

Life of Galvanized Coating

1. The key to look for when there is concern about corrosion is to see if the soil is highly acidic or highly alkaline.

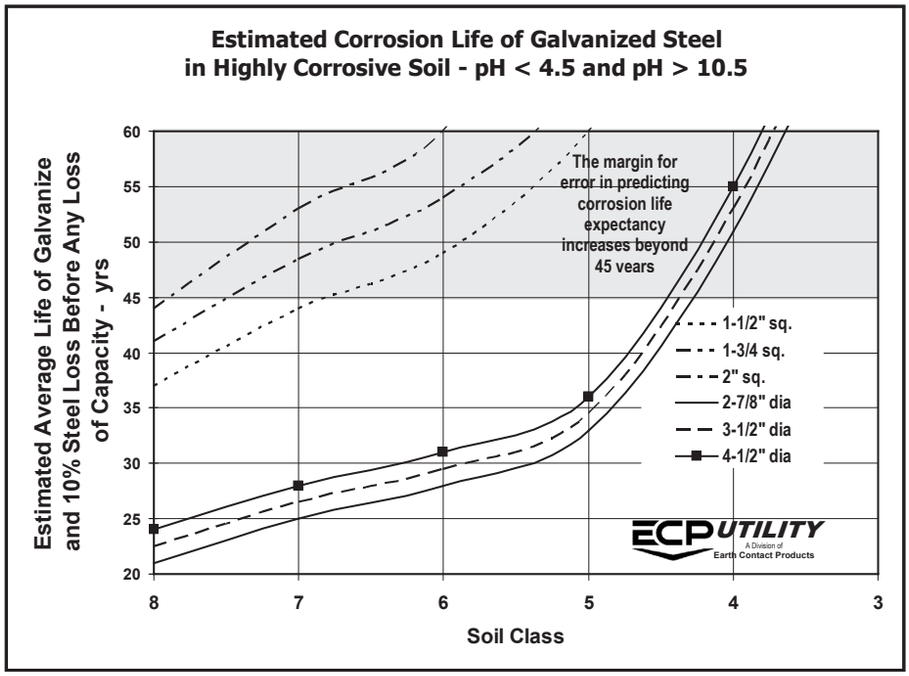
- In most cases acidic soils will contain high amounts of organics.
- Fill soils, industrial waste areas, etc, are also areas for corrosion concern
- Tidal areas have corrosion concerns due to flooding.

2. The second component to look for is soil resistivity, which is the ability of the soil to conduct electricity.

- Well drained granular soils are less of a threat than wet silt or clay.
- Tidal areas always have corrosion concerns due to flooding.

Estimating Corrosion Life of Steel Shafts in Highly Corrosive Soils

Graph 11 estimates the life of piles when installed in highly corrosive soil. While highly corrosive conditions can occur in filled soil and old waste dumps, Class 8 soils can often be highly corrosive. As the life expectancy predictions on Graph 11 increase beyond 40 years, the margins for error



Graph 11. Estimated average corrosion life of galvanized steel (ASTM-123 Gr. 75) in corrosive soil. (*See **Important Notes** below)

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increase dramatically. These long corrosion life expectancy estimates are calculated from empirical equations derived from field testing and are projected on the graph beyond the length of the actual corrosion testing. Predictions above 50 years should be evaluated cautiously and not considered accurate. The graph is shaded above 45 years for this reason.

In general, Graph 11 suggests that one should not be overly concerned when installing solid square shaft anchors in all classes of soil other than Class 8 soil.

Tubular pile shafts exhibit significantly shorter corrosion life expectancies. This shorter corrosion life expectancy is generally due to the larger surface area of the tubular shaft exposed to the corrosive soil environment.

Tubular shaft configurations, highlighted in Table 9, exhibit shorter than normally expected corrosion lives for compressive piles when installed in non-corrosive soil environments. The highlighting suggests a corrosion life analysis might be necessary.

One should consult a registered professional engineer for an evaluation of the site for potential corrosion problems. This is generally suggested when encountering low resistivity Class 7 and 8 soils on a Torque Anchor™ project.

TABLE 9. ECP Torque Anchor™ Corrosion Life Expectancy Estimates At Full Load*

Soil pH	Galvanized Steel Life Expectancy at Full Load					
	1-1/2" Square Bar	1-3/4" Square Bar	2" Square Bar	2-7/8" Dia x 0.276" Tube	3-1/2" Dia x 0.300" Tube	4-1/2" Dia x 0.337" Tube
Soil Resistivity – 500 ohm-cm (Soil Class 7 & 8)						
4.5	34 yrs	39 yrs	43 yrs	18 yrs	20 yrs	21 yrs
5	100+ yrs	100+ yrs	125+ yrs	56 yrs	66 yrs	71 yrs
8	54 yrs	61 yrs	68 yrs	24 yrs	26 yrs	28 yrs
10.5	34 yrs	39 yrs	43 yrs	18 yrs	20 yrs	21 yrs
Soil Resistivity – 1,000 ohm-cm (Soil Class 6, 7 & 8)						
4.5	40 yrs	45 yrs	49 yrs	21 yrs	23 yrs	24 yrs
5	100+ yrs	100+ yrs	150+ yrs	68 yrs	78 yrs	84 yrs
8	60 yrs	68 yrs	76 yrs	28 yrs	31 yrs	33 yrs
10.5	40 yrs	45 yrs	49 yrs	21 yrs	23 yrs	24 yrs
Soil Resistivity – 2,000 ohm-cm (Soil Class 5, 6 & 7)						
4.5	49 yrs	54 yrs	62 yrs	27 yrs	29 yrs	30 yrs
5	125+ yrs	125+ yrs	150+ yrs	100 yrs	100+ yrs	100+ yrs
8	62 yrs	72 yrs	82 yrs	34 yrs	37 yrs	39 yrs
10.5	49 yrs	54 yrs	62 yrs	27 yrs	29 yrs	30 yrs
Soil Resistivity – 5,000 ohm-cm (Soil Class 3, 4 & 5)						
4.5	70 yrs	77 yrs	90 yrs	41 yrs	43 yrs	45 yrs
5	150+ yrs	150+ yrs	175+ yrs	100+ yrs	100+ yrs	100+ yrs
8	105 yrs	115 yrs	100+ yrs	54 yrs	58 yrs	62 yrs
10.5	70 yrs	77 yrs	90 yrs	41 yrs	43 yrs	45 yrs

*** IMPORTANT NOTES:**

1. Graph 11 and Table 9 suggest life expectancy estimates for galvanized steel pier shafts **installed in homogeneous soil with constant soil moisture**. These are usually not the conditions found on job sites.

2. The graph and table are not intended to be used for formal corrosion designs. These are not to be considered a substitute for obtaining field measurements of soil pH and resistivity; and performing a site specific corrosion analysis.

3. The calculations have assumed Hot Dip Galvanize process to meet or exceed ASTM A123 – Grade 75. Also, an allowance for steel loss on the cross section of the shaft due to corrosion of the steel of 10% was assumed. The extra shaft material was required for torsional strength when initially installing the helical anchor and a 10% reduction should not affect the ultimate pile capacity. The helical screw pile should retain the original design capacity with the full factor of safety intact even with this fractional amount of metal loss.

4. It is important to understand that reaching the end of the stated corrosion life above does not suggest that the product will fail. At the end of the corrosion life estimate shown here, the product will still possess the full rated capacity along with a factor of safety.

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From this point on the product will experience a slow reduction of the factor of safety over time as the ultimate capacity of the product reduces down to the working load.

5. The life expectancies predicted in Graph 11 and Table 9 was calculated using recognized engineering principles and is for general information only. While believe the data to be accurate for the general soil classes and the suggested corrosion life, this information should not be used or relied upon for any critical application without field testing and corrosion analysis by a Registered Professional Engineer in order to determine suitability of the product to be used on the site.

6. Variations in soil moisture content from season to season and year to year can dramatically affect service life. Low field moisture content produces lower corrosion rates and longer life, even in aggressive soils. Stray currents from pipe lines, power lines, etc. may also affect life due to imposed currents. This is why in critical applications a corrosion analysis and soil testing is always recommended in areas of suspected problem soils.

6. **CAUTION: As the life expectancy predictions increase beyond 40 years, the margins for error increase dramatically because these life expectancy estimates are calculated from empirical equations derived from field testing and are projected beyond the actual length of the corrosion testing. Predictions above 45 - 50 years should be approached very cautiously and not considered to be accurate.**

Design Example 4 – Corrosion Life Transmission Tower in Wetland Soil

Design Details:

- The transmission tower foundation project requirements are from Design Example 3 above.
- The soil information about the site has been revised, however, due to discovering **five feet of Organic Soil** that is located just below the layer of topsoil.
- The soil is determined to be an **organic swamp deposit**. Standard Penetration Test values, "**N" = 1 to 3 blows per foot**.
- The Soil Class Table 1 suggests that five feet of organics below the topsoil is **Soil Class 8**.
- Further information from the Soil Testing reported that **pH = 4,** and the **soil resistivity ranged from 500 to 1,000 ohm-cm** at this site.

ECP Torque Anchor™ Corrosion Life Estimate

1. Determine the Soil Properties and Resistivity: Refer to table 5 – *"Soil Corrosion Classification Table – Soil Resistivity Ranges"* to determine that the Class 8 soil meets the description in the Design Details given above. Class 8 Soil is described as possibly containing **Organic Silt**, Unconsolidated Fill, and **Swamp or Marsh Soil.** Resistivity readings have wide variations. The resistivity can vary from 50 to 2,000 ohm-cm.

These details suggest that the soil could have very high to severe corrosion potential based upon the resistivity readings in the **organic swamp deposit** of **500 to 1,000 ohm-cm**.

2. Rough Estimate of Corrosion Life expectancy: The purpose in this section is to determine if the life expectancy of the steel shaft is sufficiently long to insure long term support, or if further analysis is needed to modify the design in order to extend the life of the selected helical pile for this site.

2A. Corrosion Life Estimate from Table 9: A quick roughly estimated corrosion life expectancy of the 3-1/2 inch diameter pile can be obtained from Table 9. Recalling the soil information reported above: **Class 8 Soil, pH = 4 and Resistivity ranged from 500 to 1,000 ohm-cm**.

The closest pH in Table 9 (Part of table shown below) is ph = 4.5, which is less corrosive than pH = 4, but the difference in corrosion life was judged to not be significant for the purpose of verifying if there is sufficient corrosion life for the Tower Support Piles. Notice at 500 ohm-cm the average life expectancy of the 3-1/2 inch diameter tubular pile shaft is **20 years**. As the resistivity increases to 1,000 ohm-cm, the estimated average life increased to **23 years**.

TABLE 9. ECP Torque Anchor™ Corrosion Life Expectancy Estimates At Full Load*

Soil pH	Galvanized Steel Life Expectancy at Full Load		
	2-7/8" Dia x 0.276" Tube	3-1/2" Dia x 0.300" Tube	4-1/2" Dia x 0.337" Tube
Soil Resistivity – 500 ohm-cm (Soil Class 7 & 8)			
4.5	18 yrs	**20 yrs**	21 yrs
5	56 yrs	66 yrs	71 yrs
8	24 yrs	26 yrs	28 yrs
10.5	18 yrs	20 yrs	21 yrs
Soil Resistivity – 1,000 ohm-cm (Soil Class 6, 7 & 8)			
4.5	21 yrs	**23 yrs**	24 yrs
5	68 yrs	78 yrs	84 yrs
8	28 yrs	31 yrs	33 yrs
10.5	21 yrs	23 yrs	24 yrs

2B. Corrosion Life Estimate from Graph 11: An alternate quick corrosion life expectancy can be obtained from Graph 11. This graph only requires

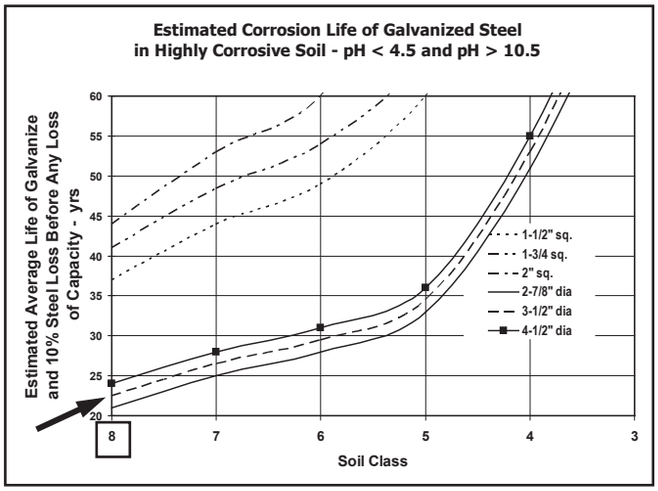
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that you know the Soil Classification and that the pH is less than 4.5 (or greater than 10.5) to roughly estimate the corrosion life expectancy of a pile shaft configuration.

Along the bottom of the graph are shown the Soil Classes. The 3-1/2 inch diameter pile shaft is indicated by dashed (----) line. Notice the 3-1/2 inch diameter pier shaft has estimated corrosion life of approximately 23 years at the left side of the graph.

The results of these preliminary corrosion life estimates suggest that a 3-1/2 inch diameter tubular pile will function satisfactorily with full Ultimate Capacity for 20 to 23 years with no loss of support due to corrosion. After the expiration of the corrosion life term there will begin a gradual loss of load capacity.

Estimated Corrosion Life - **20+ years**



Graph 11. Estimated average corrosion life of galvanized steel (ASTM-123 Gr. 75) in corrosive soil.

End of Design Example 5

Always remember you are part of The ECP Team when you are installing ECP Torque Anchor™ products. If you ever have a question about an installation or a problem on the job that cannot be answered by looking in this Utility Handbook, then please call The ECP Team at 913 393-0007 for assistance. We are standing by to give assistance, get answers and to help you succeed.

Quality ECP Torque Anchor™ products are made in Olathe, Kansas, USA by hard working people just like you. We want you to succeed and do the best work possible. Your success is OUR success!

The ECP Team is always with you with our full support. When you are installing an ECP foundation product, we want to assure high quality and product satisfaction for you, and your customer.

Thank you for trusting and using quality ECP Torque Anchor™ products.

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