Chapter 1

Helical Torque Anchors
Technical Design Manual

- Square Bar Helical Torque Anchors™
- Tubular Helical Torque Anchors™
- Torque Anchor™ Pile Caps, Utility Brackets and Shaft Terminations

EARTH CONTACT PRODUCTS
“Designed and Engineered to Perform”
Introduction

Screw piles have been in use for more than 160 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 150 years later. The original screw piles were installed at 10 feet per hour using eight 20 foot long torque bars and the force of 32 up to 40 men.

In the United States, the Thomas Point Shoal Lighthouse on Chesapeake Bay, Maryland, near Annapolis, Maryland; is the only remaining lighthouse built upon helical screw piles that is situated at its original location. This 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 constructed and first put into operation on November 20, 1875. 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 to a depth of 11-1/2 feet. The signal light is mounted 43 feet above the surface of the water.

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 then 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.

Screw piles are ideal for applications where there is a need to resist both axial tension and compression forces. Some examples of structures requiring resistance to both compressive and tensile forces are metal buildings, canopies and monopole telecommunication tower foundations. Current uses for screw pile foundations include foundations for commercial and residential structures, light poles, retaining walls tieback anchors, restorations of failed foundations, pipeline and pumping equipment supports, elevated walkways, bridge abutments, and numerous 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 custom design and configure products to your engineered specific applications. Earth Contact Products uses only certified welders and robotics for quality fabrication.

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 helical plates. The plates can vary in diameter from 6 inches to 16 inches and have a thickness of 3/8 or 1/2 inch depending upon the
application. Typically the plate diameters increase from the bottom of the shaft upward, and are spaced a distance of three times the diameter of the plate directly below unless specified otherwise by the engineer. The standard thickness for all helical plate diameters is 3/8 inch, except for the 16 inch diameter helical plate which is manufactured only in 1/2 inch thickness. In high capacity applications or in obstruction laden soils, a helical plate thickness of 1/2 inch may be special ordered for all sizes of plates. The standard pitch of all helical plates is three inches, which means that the anchor advances into the soil a distance of three inches during one revolution of the shaft. The standard lead shaft lengths of most products are 10 inches, 5 feet, 7 feet and 10 feet, however, other lengths may be specially fabricated for large quantity 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 other extensions allowing the Torque Anchor™ assembly to reach the desired depth. Helical plates may also be installed on the extensions where the length of the lead is not sufficiently long enough to allow for the proper interval between plates. The number of the plates per Torque Anchor™ is limited only by the shaft capacity to transmit the torque required to advance the Torque Anchor™ into the soil.

Torque Anchors™ may terminate with a pile cap that embeds into a new concrete foundation. In other applications such as tieback anchors, a transition is made from the anchor shaft to a continuously threaded rod for attachment to the wall. Various beams, wall plates, etc. can be attached to the threaded bar for wall support, for restorations, or to simply stabilize walls or other structure from overturning forces. When the application requires existing foundation restoration or stabilization, foundation brackets are available that attach between the Torque Anchor™ and the foundation beam, footing or slab. The purpose of the foundation beam is to transfer the load from the foundation element to the Torque Anchor™.

---

**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 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

**Product Limitations**

Torque Anchors™ are not suitable in locations where subsurface material may damage the shaft or the helices. Soils containing cobbles, large amounts of gravel, boulders, construction debris, and/or landfill materials are usually unsuitable for helical products.

Because the products have slender shafts, buckling may occur when passing through extremely weak soil because the soft soil may not exert sufficient lateral force on the narrow shaft to prevent buckling. When extremely soft soils are present, generally having a Standard Penetration Test – “N” < 5 blows per foot, one must take into consideration the axial stiffness of the anchor shaft in the design.

The slender shafts also render the typical Torque Anchor™ ineffective against large lateral loads or overturning moments.
### Table 1. ECP Torque Anchor™ Product Designations

<table>
<thead>
<tr>
<th>Product</th>
<th>Prefix</th>
<th>Product Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Helical Lead Sections</strong></td>
<td>TAH</td>
<td>Lead Section With One 3/8” Thick Helical Plate</td>
</tr>
<tr>
<td></td>
<td>HTAH</td>
<td>Lead Section With One 1/2” Thick Helical Plate</td>
</tr>
<tr>
<td></td>
<td>TAF</td>
<td>Lead Section With Multiple 3/8” Thick Helical Plates</td>
</tr>
<tr>
<td></td>
<td>HTAF</td>
<td>Lead Section With Multiple 1/2” Thick Helical Plates</td>
</tr>
<tr>
<td><strong>Shaft Extensions</strong></td>
<td>TAE</td>
<td>Extension Section with Coupling &amp; Hardware</td>
</tr>
<tr>
<td><strong>Transitions</strong></td>
<td>TAT</td>
<td>Transition Coupling – Helical Tieback Anchor Shaft to Threaded Bar</td>
</tr>
<tr>
<td><strong>New Construction Pile Caps</strong></td>
<td>TAB–NC</td>
<td>New Construction Compression Pile Cap</td>
</tr>
<tr>
<td></td>
<td>TAB–T</td>
<td>New Construction Tension Pile Cap (Compression and uplift support)</td>
</tr>
<tr>
<td><strong>Brackets for Foundation Repair</strong></td>
<td>TAB-150-SUB + TAB-150 TT</td>
<td>Foundation Bracket – Fits 1-1/2’ Sq. Shaft Helical Pile Shaft</td>
</tr>
<tr>
<td></td>
<td>TAB-150-LUB</td>
<td>Foundation Bracket – Fits 2-7/8’ x 0.203” Wall Tubular Helical Pile Shaft</td>
</tr>
<tr>
<td></td>
<td>TAB-175-TT</td>
<td>Large Foundation Bracket – Fits Under Footing and Connects to Pile Shaft:</td>
</tr>
<tr>
<td></td>
<td>TAB-288-TT</td>
<td>T-Tube for use with 1-3/4” Square Shaft</td>
</tr>
<tr>
<td></td>
<td>TAB-350-TT</td>
<td>T-Tube for use with 2-7/8” Diameter Tubular Shaft</td>
</tr>
<tr>
<td></td>
<td>TAB-288-LUB</td>
<td>T-Tube for use with 3-1/2” Diameter Tubular Shaft</td>
</tr>
<tr>
<td><strong>Brackets for Slab Repair</strong></td>
<td>TAB-150-LSB</td>
<td>Porch Bracket – Fits 1-1/2” Square or 2-7/8” Dia. Helical Pile Shaft</td>
</tr>
<tr>
<td></td>
<td>TAB-288-LP</td>
<td>Screw Lift Slab Bracket – Fits 1-1/2” Square Helical Pile Shaft</td>
</tr>
<tr>
<td></td>
<td>TAB-150-HSB</td>
<td>Hydraulic Lift Slab Bracket – Fits 1-1/2” Square Helical Pile Shaft</td>
</tr>
<tr>
<td></td>
<td>TAB-288-LHSB</td>
<td>Hydraulic Lift Slab Bracket – Fits 2-7/8” Diameter Tubular Shaft</td>
</tr>
<tr>
<td></td>
<td>TAB-288-HSB</td>
<td>Also Fits: 1-1/2” Square Shaft</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-3/4” Square Shaft</td>
</tr>
<tr>
<td><strong>Timber Bracket</strong></td>
<td>TAB-150-TB</td>
<td>Bracket to timber beams – Fits 1-1/2” Square Helical Pile Shaft</td>
</tr>
<tr>
<td><strong>Wall Plate</strong></td>
<td>PA</td>
<td>Stamped Wall Plate – Fastens Wall To Threaded Shaft From Tieback</td>
</tr>
</tbody>
</table>

### Table 2. Capacities of ECP Helical Torque Anchors™

<table>
<thead>
<tr>
<th>Shaft Size</th>
<th>Installation Torque Factor (k)</th>
<th>Axial Compression Load Limit</th>
<th>Ultimate-Limit Tension Strength</th>
<th>Useable Torsional Strength</th>
<th>Practical Load Limit Based on Torsional Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2” Square Bar</td>
<td>9 - 11</td>
<td>70,000 lb.</td>
<td>70,000 lb.</td>
<td>7,000 ft-lb</td>
<td>Load limited to the rated capacity of the attachments and the lateral soil strength against the shaft</td>
</tr>
<tr>
<td>1-3/4” Square Bar</td>
<td>9 - 11</td>
<td>100,000 lb.</td>
<td>10,000 lb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-1/4” Square Bar</td>
<td>10 - 12</td>
<td>200,000 lb.</td>
<td>200,000 lb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-7/8” Tubular – 0.203” Wall</td>
<td>8 - 9</td>
<td>60,000 lb.</td>
<td>60,000 lb.</td>
<td>5,500 ft-lb</td>
<td>44,000 lb</td>
</tr>
<tr>
<td>2-7/8” Tubular – 0.262” Wall</td>
<td>8 - 9</td>
<td>100,000 lb.</td>
<td>100,000 lb.</td>
<td>9,500 ft-lb</td>
<td>80,000 lb</td>
</tr>
<tr>
<td>3-1/2” Tubular – 0.300” Wall</td>
<td>7 - 8</td>
<td>115,000 lb.</td>
<td>120,000 lb.</td>
<td>13,000 ft-lb</td>
<td>97,000 lb</td>
</tr>
<tr>
<td>4-1/2” Tubular – 0.337” Wall</td>
<td>6 - 7</td>
<td>160,000 lb.</td>
<td>160,000 lb.</td>
<td>22,000 ft-lb</td>
<td>143,000 lb</td>
</tr>
</tbody>
</table>

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

**IMPORTANT NOTES:**

The capacities listed for “Axial Compression Load Limit”, “Ultimate Limit Tension Strength” and “Useable Torsional Strength” in Table 2 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 2. 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 “Useable Torsional Strength” depending upon site soil conditions to reduce chance of fracture or damage.

Another advantage of selecting a torsional rating below the values shown in Table 2 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.
1-1/2” Round Corner Square Bar Torque Anchors™

Standard ECP Torque Anchor™ Lead Configurations – 7,000 ft-lb*

<table>
<thead>
<tr>
<th>Product Designation</th>
<th>Plate Diameter - inches</th>
<th>Plate Area sq. ft.</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>“A”</td>
<td>“B”</td>
<td>“C”</td>
</tr>
<tr>
<td>TAH-150-10 08</td>
<td>8</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>TAH-150-10 12</td>
<td>12</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>TAH-150-60 08</td>
<td>8</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>TAH-150-60 12</td>
<td>12</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>TAF-150-60 06-08</td>
<td>6</td>
<td>8</td>
<td>--</td>
</tr>
<tr>
<td>TAF-150-60 08-10</td>
<td>8</td>
<td>10</td>
<td>--</td>
</tr>
<tr>
<td>TAF-150-60 10-12</td>
<td>10</td>
<td>12</td>
<td>--</td>
</tr>
<tr>
<td>TAH-150-84 12</td>
<td>12</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>TAF-150-84 08-10-12</td>
<td>8</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>TAF-150-84 10-12-14</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>TAF-150-120 8-10-12</td>
<td>8</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>TAF-150-120 10-12-14</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
</tbody>
</table>

Standard ECP Torque Anchor™ Extensions

<table>
<thead>
<tr>
<th>Part Number</th>
<th>36”</th>
<th>60”</th>
<th>84”</th>
<th>120”</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAE-150-36</td>
<td>TAE-150-60</td>
<td>TAE-150-84</td>
<td>TAE-150-120</td>
<td></td>
</tr>
</tbody>
</table>

Note: 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 100 Shaft Weight per Foot = 7.7 lb.

* Please see “IMPORTANT NOTES” on Table 2

If a Torque Anchor™ configuration is not shown above as a standard product; please see “How to Specify Special Order Torque Anchors™” on page 10.
1-3/4” Round Corner Square Bar Torque Anchors™

Standard ECP Torque Anchor™ Lead Configurations – 10,000 ft-lb*

<table>
<thead>
<tr>
<th>Product Designation</th>
<th>Plate Diameter - inches</th>
<th>Plate Area sq. ft.</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTAH-175-60 08</td>
<td>8</td>
<td>0.33</td>
<td>60”</td>
</tr>
<tr>
<td>TAF-175-60 10-12</td>
<td>10</td>
<td>1.29</td>
<td>60”</td>
</tr>
<tr>
<td>TAF-175-84 10-12-14</td>
<td>10</td>
<td>2.34</td>
<td>84”</td>
</tr>
</tbody>
</table>

Standard ECP Torque Anchor™ Extensions

<table>
<thead>
<tr>
<th>Part Number</th>
<th>36”</th>
<th>60”</th>
<th>84”</th>
<th>120”</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAE-175-36</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAE-175-60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAE-175-84</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAE-175-120</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Products Listed Above Are Standard Items And Are Usually Available From Stock
See page 11 – "How to Specify Special Order Torque Anchors” for Specialized Configurations – 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 100
Shaft Weight per Foot – 10.4 lb/ft.
“H” before part designation indicates helical plate thickness of 1/2 inch instead of standard 3/8”

2-1/4” Round Corner Square Bar Torque Anchors™

2-1/4” Square Bar Torque Anchor™ Leads – 23,000 ft-lb*

2-1/4” Square Bar Torque Anchor™ Extensions

<table>
<thead>
<tr>
<th>Shaft Length</th>
<th>36”</th>
<th>60”</th>
<th>84”</th>
<th>120”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Number</td>
<td>TAE-225-36</td>
<td>TAE-225-60</td>
<td>TAE-225-84</td>
<td>TAE-225-120</td>
</tr>
</tbody>
</table>

Note: All 2-1/4” square bar products available as special order – Inquire for pricing and delivery
See page 11 – “How to Specify Special Order Torque Anchors” for information
Helical plates are 1/2” thick and spaced at three times the diameter of the preceding plate.
Extensions supplied with coupling and SAE J429 grade 8 bolts and nuts.
Product hot dip galvanized per ASTM A123 grade 100.
Shaft weight per foot – 17.2 lb.

* Please see “IMPORTANT NOTES” on Table 2
2-7/8" Dia. x 0.262 Wall Tubular Shaft Torque Anchors™

![Diagram of torquing system]

**Standard ECP Torque Anchor™ Lead Configurations - 9,500 ft-lb**

<table>
<thead>
<tr>
<th>Product Designation</th>
<th>Plate Diameter - inches</th>
<th>Plate Area sq. ft.</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAH-288-60 08</td>
<td>8</td>
<td>0.30</td>
<td>60&quot;</td>
</tr>
<tr>
<td>TAH-288-60 10</td>
<td>10</td>
<td>0.50</td>
<td>60&quot;</td>
</tr>
<tr>
<td>TAH-288-60 12</td>
<td>12</td>
<td>0.74</td>
<td>60&quot;</td>
</tr>
<tr>
<td>TAF-288-60 8-10</td>
<td>8</td>
<td>0.80</td>
<td>60&quot;</td>
</tr>
<tr>
<td>TAF-288-60 10-12</td>
<td>10</td>
<td>1.24</td>
<td>60&quot;</td>
</tr>
<tr>
<td>TAF-288-84 08-10</td>
<td>8</td>
<td>0.80</td>
<td>84&quot;</td>
</tr>
<tr>
<td>HTAF-288-84 08-10</td>
<td>8</td>
<td>0.80</td>
<td>84&quot;</td>
</tr>
<tr>
<td>TAF-288-84 10-12</td>
<td>10</td>
<td>1.24</td>
<td>84&quot;</td>
</tr>
<tr>
<td>HTAF-288-84 10-12</td>
<td>10</td>
<td>1.24</td>
<td>84&quot;</td>
</tr>
<tr>
<td>TAF-288-84 8-10-12</td>
<td>8</td>
<td>1.54</td>
<td>84&quot;</td>
</tr>
<tr>
<td>TAF-288-84 10-12-14</td>
<td>10</td>
<td>2.26</td>
<td>84&quot;</td>
</tr>
<tr>
<td>TAF-288-120 8-10-12</td>
<td>8</td>
<td>1.54</td>
<td>120&quot;</td>
</tr>
<tr>
<td>TAF-288-120 10-12-14</td>
<td>10</td>
<td>2.26</td>
<td>120&quot;</td>
</tr>
<tr>
<td>TAF-288-120 14-14-14</td>
<td>14</td>
<td>3.07</td>
<td>120&quot;</td>
</tr>
</tbody>
</table>

**Standard ECP Torque Anchor™ Extensions**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>36&quot;</th>
<th>60&quot;</th>
<th>84&quot;</th>
<th>120&quot;</th>
</tr>
</thead>
</table>

**Note:** 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 – 7.7 lb. **H** before part designation indicates helical plate thickness of 1/2 inch instead of standard 3/8".

* Please see “IMPORTANT NOTES” on Table 2

If a Torque Anchor™ configuration is not shown above as a standard product; please see “How to Specify Special Order Torque Anchors™” on page 10.
3-1/2" Dia. x 0.300 Wall Tubular Shaft Torque Anchors™

Standard ECP Torque Anchor™ Lead Configurations – 13,000 ft-lb*

<table>
<thead>
<tr>
<th>Product Designation</th>
<th>Plate Diameter - inches</th>
<th>Plate Area sq. ft.</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>“A”</td>
<td>“B”</td>
<td>“C”</td>
</tr>
<tr>
<td>TAF-350-60 10-12</td>
<td>10</td>
<td>12</td>
<td>--</td>
</tr>
<tr>
<td>TAF-350-84 8-10-12</td>
<td>8</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>TAF-350-120 8-10-12</td>
<td>8</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>TAF-350-120 10-12-14</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
</tbody>
</table>

Standard ECP Torque Anchor™ Extensions

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAE-350-36</td>
<td>36”</td>
</tr>
<tr>
<td>TAE-350-60</td>
<td>60”</td>
</tr>
<tr>
<td>TAE-350-84</td>
<td>84”</td>
</tr>
<tr>
<td>TAE-350-120</td>
<td>120”</td>
</tr>
</tbody>
</table>

3-1/2" Dia. x 0.300 Wall Tubular Shaft Torque Anchors™ and 4-1/2" Dia. x 0.337 Wall Tubular Shaft Torque Anchors™

4-1/2" Dia. x 0.337 Wall Tubular Shaft Torque Anchors™

Standard ECP Torque Anchor™ Lead Configurations – 22,000 ft-lb*

<table>
<thead>
<tr>
<th>Product Designation</th>
<th>Plate Diameter - inches</th>
<th>Plate Area sq. ft.</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>“A”</td>
<td>“B”</td>
<td>“C”</td>
</tr>
<tr>
<td>TAF-450-84 10-12-14</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>HTAF-450-120 10-12-14</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
</tbody>
</table>

Standard ECP Torque Anchor™ Extensions

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAE-450-36</td>
<td>36”</td>
</tr>
<tr>
<td>TAE-450-60</td>
<td>60”</td>
</tr>
<tr>
<td>TAE-450-84</td>
<td>84”</td>
</tr>
<tr>
<td>TAE-450-120</td>
<td>120”</td>
</tr>
</tbody>
</table>

Note: 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 Extensions Are Supplied with an Internal Coupling and Hardware. All Product Hot Dip Galvanized Per ASTM A123 Grade 100. Shaft Weight per Foot – TAF-350 - 10.2 lb; TAF-450 – 15.4 lb “H” before part designation indicates helical plate thickness of 1/2 inch instead of standard 3/8”

* Please see “IMPORTANT NOTES” on Table 2

If a Torque Anchor™ configuration is not shown above as a standard product; please see “How to Specify Special Order Torque Anchors™” on page 10.
**2-7/8” x 0.203” Wall Tubular Shaft – Light Duty Torque Anchors™**

<table>
<thead>
<tr>
<th>Product Designation</th>
<th>Plate Diameter - inches</th>
<th>Plate Area sq. ft.</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAF-288L-60 08-10</td>
<td>&quot;A&quot; 8</td>
<td>&quot;B&quot; 10</td>
<td>&quot;C&quot; --</td>
</tr>
<tr>
<td>TAF-288L-60 10-12</td>
<td>&quot;A&quot; 10</td>
<td>&quot;B&quot; 12</td>
<td>&quot;C&quot; --</td>
</tr>
<tr>
<td>TAF-288L-84 08-10</td>
<td>&quot;A&quot; 8</td>
<td>&quot;B&quot; 10</td>
<td>&quot;C&quot; --</td>
</tr>
<tr>
<td>TAF-288L-84 10-12</td>
<td>&quot;A&quot; 10</td>
<td>&quot;B&quot; 12</td>
<td>&quot;C&quot; --</td>
</tr>
<tr>
<td>TAF-288L-60 12</td>
<td>&quot;A&quot; 12</td>
<td>&quot;B&quot; --</td>
<td>&quot;C&quot; --</td>
</tr>
</tbody>
</table>

**Available ECP Torque Anchor™ Lead Configurations – Not Stocked**

<table>
<thead>
<tr>
<th>Product Designation</th>
<th>Plate Diameter - inches</th>
<th>Plate Area sq. ft.</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAF-288L-84 8-10-12</td>
<td>&quot;A&quot; 8</td>
<td>&quot;B&quot; 10</td>
<td>&quot;C&quot; 12</td>
</tr>
<tr>
<td>TAF-288L-84 10-12-14</td>
<td>&quot;A&quot; 10</td>
<td>&quot;B&quot; 12</td>
<td>&quot;C&quot; 14</td>
</tr>
<tr>
<td>TAF-288L-84 12-14</td>
<td>&quot;A&quot; 12</td>
<td>&quot;B&quot; 14</td>
<td>&quot;C&quot; --</td>
</tr>
</tbody>
</table>

**Standard ECP Torque Anchor™ Extensions**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAE-288L-60</td>
<td>60&quot;</td>
</tr>
<tr>
<td>TAE-288L-84</td>
<td>84&quot;</td>
</tr>
<tr>
<td>TAE-288L-120</td>
<td>120&quot;</td>
</tr>
</tbody>
</table>

**Light Pole Support Torque Anchors™**

<table>
<thead>
<tr>
<th>Torque Anchor™ Configuration</th>
<th>Part Number</th>
<th>Ultimate-Limit Capacity at SPT &gt; 5 bpf</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-5/8&quot; Dia. x 0.280&quot; Wall &amp; 14&quot; Helix – 7’- 0’ Long**</td>
<td>HTAF-663-84 14</td>
<td>Overturning Moment: &lt; 12,000 ft-lb; Lateral Load: &lt; 1,000 lb</td>
</tr>
<tr>
<td>8-5/8&quot; Dia. x 0.250&quot; Wall &amp; 14&quot; Helix – 7’- 0’ Long**</td>
<td>HTAF-863-84 14</td>
<td>Overturning Moment: &lt; 17,500 ft-lb; Lateral Load: &lt; 1,200 lb</td>
</tr>
</tbody>
</table>

**Note:** Integral Pile Cap is 1" Thick x 15-3/4" Square Pile Cap Welded to Shaft With Slots for 1" Diameter Mounting Bolts
Double Cut Chamfer on Bottom of Shaft Aligns Pipe and Eases Installation
We Will Fabricate Custom Light Pole Supports to Your Design Specifications – Allow Extra Time For Processing.
Other Shaft Lengths are Available to Meet Your Engineering Specifications
Product Supplied Hot Dip Galvanized Per ASTM A123 Grade 100.

* Please see "IMPORTANT NOTES" on Table 2
** The products shown shaded are available but are not stocked – allow extra time for fabrication
HOW TO SPECIFY SPECIAL ORDER TORQUE ANCHORS™

**Typical Product Designation System:**

\[(H)TAF-(Shaft Dia.)-(Shaft Length)(D^*) (Plate Dia – “A(C)” -“B”-“C”)\]

*Notes: “H” at the beginning of the designation indicates that all helical plates will be 1/2” thick.
“F” following TA indicates a multi-helix configuration – “TAH” indicates a single flight pile.
“D^*” following the shaft length indicates a double taper cut at the tip of the shaft.
“C” following a plate diameter indicates that the plate will receive a special 90° spiral cut leading edge treatment.

**Special Order Product Designation Examples:**

- **HTAF-350-120 10-12-14**
  - 3/8” HELICAL PLATES
  - 3 HELICAL PLATES - 10”, 12” & 14” DIA
  - SHAFT DIAMETER - 3-1/2” x 0.300” WALL
  - SHAFT DIAMETER - 10’

- **TAF-288-84D 08C-10C-12**
  - 3/8” HELICAL PLATES
  - DOUBLE CUT TAPER AT TIP
  - 3 HELICAL PLATES - 8”, 10” & 12” DIA
  - WITH SPECIAL 90 DEG SPIRAL CUT ON THE 8” AND 10” DIA PLATES
  - SHAFT DIAMETER - 2-7/8” x 0.262” WALL

- **TAH-175-60 10C**
  - 3/8” HELICAL PLATE
  - SINGLE HELICAL PLATE
  - 10” DIA HELICAL PLATE - WITH SPECIAL SPIRAL CUT
  - SHAFT LENGTH - 5’

  - SHAFT SIZE - 1-3/4” SOLID SQUARE SHAFT

- **TAH-150-60 12**
  - 3/8” HELICAL PLATE
  - SINGLE HELICAL PLATE
  - 12” DIA HELICAL PLATE
  - SHAFT LENGTH - 5’

  - SHAFT SIZE - 1-1/2” SOLID SQUARE SHAFT

**Notes:**

- Allow Extra Time and Cost For Processing – Inquire for Pricing and Delivery
- All Helical Plates Are Spaced At Three Times The Diameter Of The Preceding Plate
- All Product Hot Dip Galvanized Per ASTM A123 Grade 100.
## Torque Anchor™ Utility Brackets

**TAB-150-SUB Standard Duty & TAB-288-MUB Light Weight Utility Bracket**

<table>
<thead>
<tr>
<th>Shaft Size:</th>
<th>1-1/2&quot; Sq.</th>
<th>2-7/8&quot; Dia.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bracket Designation:</td>
<td>TAB-150-SUB</td>
<td>TAB-288-MUB</td>
</tr>
<tr>
<td>Pier Cap:</td>
<td>TAB-150-TT T-Tube</td>
<td>TAB-288-TTM T-Tube</td>
</tr>
<tr>
<td>Ultimate-Limit Capacity:</td>
<td>40,000 lb.¹</td>
<td></td>
</tr>
<tr>
<td>Bearing Area:</td>
<td>68-1/4 sq. inches</td>
<td></td>
</tr>
<tr>
<td>Standard Lift Capacity:</td>
<td>4 inches²</td>
<td></td>
</tr>
</tbody>
</table>

**TAB-LUB Large Utility Bracket**

<table>
<thead>
<tr>
<th>Shaft Size:</th>
<th>1-3/4&quot; Sq.</th>
<th>2-7/8&quot; Dia</th>
<th>3-1/2&quot; Dia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bracket Designation:</td>
<td>TAB-LUB</td>
<td>TAB-LUB</td>
<td>TAB-LUB</td>
</tr>
<tr>
<td>Pier Cap:³</td>
<td>TAB-175-TT T-Tube</td>
<td>TAB-288-TT T-Tube</td>
<td>TAB-350-TT T-Tube</td>
</tr>
<tr>
<td>Ultimate-Limit Capacity:</td>
<td>98,000 lb.¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bearing Area:</td>
<td>75 square inches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Lift Capacity:</td>
<td>5-1/2 inches²</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**

1. These are mechanical capacity ratings. Foundation strength and soil capacity will dictate actual capacity.
2. Bracket Lift Height Can Easily Be Increased By Ordering Longer Continuously Threaded Bracket Rods.
3. The TAB-LUB Bracket is the same component for three different shaft sizes; the Pile Cap configuration varies to accommodate the appropriate shaft for the application.

### DETAILS FOR

**TAB-150-SUB & TAB-150-TT BRACKET ASSY**

**TAB-288-MUB & TAB-288-TTM BRACKET ASSY**

### DETAIL OF TAB-LUB & TAB-288-TT SUPPORT SYSTEM ASSEMBLY
# Torque Anchor™ Porch & Slab Brackets

<table>
<thead>
<tr>
<th>Tab Designation</th>
<th>Product Description</th>
<th>Fitting Torque Anchor</th>
<th>Ultimate Limit Capacity</th>
<th>Lift Capacity</th>
<th>Ultimate Limit Capacity</th>
<th>Lift Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAB-150-LP Porch Bracket</td>
<td>TAB-288-LP (not shown)</td>
<td>1-1/2&quot; Sq, 1-3/4&quot; Sq</td>
<td>9,000 lb, 16,000 lb</td>
<td>4-1/2&quot;</td>
<td>1-1/2&quot;, 1-3/4&quot; Sq &amp; 2-7/8&quot; Dia.</td>
<td>20,000 lb, 40,000 lb</td>
</tr>
<tr>
<td>TAB-150 SSB (8&quot; Dia. Hole)</td>
<td>TAB-288-HSB</td>
<td>1-1/2&quot; Sq</td>
<td>8,000 lb</td>
<td>4-1/2&quot;</td>
<td>1-1/2&quot;, 1-3/4&quot; Sq &amp; 2-7/8&quot; Dia.</td>
<td>40,000 lb</td>
</tr>
<tr>
<td>TAB-150 HSB (8&quot; Dia. Hole)</td>
<td>TAB-150 TB</td>
<td>1-1/2&quot; Sq</td>
<td>20,000 lb</td>
<td>4&quot;</td>
<td>1-1/2&quot; Sq</td>
<td>20,000 lb</td>
</tr>
</tbody>
</table>

* Load transfer and elevation recovery is accomplished using ECP Steel Pier™ Bracket Assembly (Purchased Separately) The TAB-150-HSB and TAB-288-LHSB Bracket requires an ECP Model 300 Lift Assembly and the TAB-288-HSB Bracket requires an ECP Model 350 Lift Assembly.

1. The capacities listed for foundation brackets are mechanical ratings, and the actual installed load capacities are dependent upon the strength and condition of the concrete, and the specific soil conditions on the job site. Concrete strength for the above ratings was assumed to be 3,000 psi.
2. Bracket lift height may be increased by ordering longer continuously threaded bracket rods.
3. Capacities based upon “soft” soil values 5" > 5 blows per foot
4. Special configurations to fit your project can be fabricated to your specifications upon request. Allow extra time for processing.
## Torque Anchor™ Pile Caps

| Compression (No Bolts) | Tension Illustration “A” (One Bolt) | Tension Illustration “B” (Two Bolts) |

### Square Bar Torque Anchor™ Pile Caps

<table>
<thead>
<tr>
<th>Part Number (Compression)</th>
<th>TAB-150 NC</th>
<th>TAB-175 NC</th>
<th>TAB-288L NC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Number (Tension)</td>
<td>TAB-150-T</td>
<td>TAB-175-T</td>
<td>TAB-288L-T NOTE 2</td>
</tr>
<tr>
<td>(Illustration “A”)</td>
<td>(Illustration “A”)</td>
<td>(Illustration “A”)</td>
<td></td>
</tr>
<tr>
<td>Pier Size</td>
<td>1-1/2” Sq. Bar</td>
<td>1-3/4” Sq. Bar</td>
<td>2-7/8” Dia. Tubular</td>
</tr>
<tr>
<td>Bearing Plate</td>
<td>1/2” x 6” x 6”</td>
<td>3/4” x 8” x 8”</td>
<td>1/2” x 6” x 6”</td>
</tr>
<tr>
<td>Pier Sleeve</td>
<td>2-3/8” Dia. x 5-3/4”</td>
<td>2-7/8” Dia. x 7-3/4”</td>
<td>3-1/2” Dia. x 5-3/4”</td>
</tr>
<tr>
<td>Ultimate-Limit</td>
<td>55,000 lb</td>
<td>70,000 lb</td>
<td>55,000 lb</td>
</tr>
<tr>
<td>Compressive Capacity</td>
<td>40,000 lb</td>
<td>70,000 lb.</td>
<td>40,000 lb.</td>
</tr>
</tbody>
</table>

### Tubular Torque Anchor™ Pile Caps

<table>
<thead>
<tr>
<th>Part Number (Compression)</th>
<th>TAB-288 NC</th>
<th>TAB-350 NC</th>
<th>TAB-450 NC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Number (Tension)</td>
<td>TAB-288-T NOTE 2</td>
<td>TAB-350-T</td>
<td>TAB-450-T</td>
</tr>
<tr>
<td>(Illustration “B”)</td>
<td>(Illustration “B”)</td>
<td>(Illustration “B”)</td>
<td></td>
</tr>
<tr>
<td>Pier Size</td>
<td>2-7/8” Dia. Tubular</td>
<td>3-1/2” Dia. Tubular</td>
<td>4-1/2” Dia. Tubular</td>
</tr>
<tr>
<td>Bearing Plate</td>
<td>3/4” x 8” x 8”</td>
<td>3/4” x 8” x 8”</td>
<td>1” x 10” x 10”</td>
</tr>
<tr>
<td>Pier Sleeve</td>
<td>3-1/2” Dia. x 7-3/4”</td>
<td>4” Dia. x 7-3/4”</td>
<td>5-9/16” Dia. x 9-3/4”</td>
</tr>
<tr>
<td>Ultimate-Limit</td>
<td>70,000 lb.</td>
<td>70,000 lb.</td>
<td>120,000 lb.</td>
</tr>
<tr>
<td>Compressive Capacity</td>
<td>70,000 lb.</td>
<td>70,000 lb.</td>
<td>120,000 lb.</td>
</tr>
</tbody>
</table>

### Pile Cap Notes:

1. Capacities based upon 3,000 psi concrete. Reduce loading or increase plate area appropriately for lower strength concrete.
2. Pile caps shown are standard items and are usually available from stock. Note: TAB-288L-T and TAB-288-T are not interchangeable because bolt hole spacing varies.
3. Part numbers for tension include attachment holes and SAE J429 Grade 8 hardware as shown; compression pile caps do not include hardware or mounting holes.
4. Compressive capacity ratings of some pile caps are limited by compressive pile shaft capacity.
5. Pile caps are supplied plain steel -- hot dip galvanized per ASTM A123 Grade 100 is available.
6. Configuration for the TAB-225 NC Pile Cap is slightly different than illustrations

Custom fabricated pile caps are available for all shaft sizes by special order – allow extra time for processing.

---

ECP Helical Torque Anchors™ Technical Service Manual
2013-09
Page 13

© 2013 Earth Contact Products, L.L.C.
All rights reserved
# Torque Anchor™ Transitions & Wall Plates

<table>
<thead>
<tr>
<th>Transition Assemblies</th>
<th>Stamped Wall Plates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TAT-150</strong></td>
<td><strong>PA-SWP</strong></td>
</tr>
<tr>
<td>Output Thd. Major Dia. 1&quot; (B-12 Coil Rod)</td>
<td>11&quot; x 16&quot;</td>
</tr>
<tr>
<td>Plate Washer 3/8&quot; x 5&quot; x 5&quot;</td>
<td>1.2 ft² Bearing</td>
</tr>
<tr>
<td>Ultimate Limit Capacity 38,000 lb.</td>
<td><strong>PA-LWP</strong></td>
</tr>
<tr>
<td><strong>TAT-150-HD</strong></td>
<td>Wall Plates include:</td>
</tr>
<tr>
<td>Output Thd. Major Dia. 1-1/8&quot; (WF-8)</td>
<td>Flat Washer 3/16&quot; x 4&quot; Sq.</td>
</tr>
<tr>
<td>Plate Washer 3/8&quot; x 5&quot; x 5&quot;</td>
<td>Hot Dip Galv.</td>
</tr>
<tr>
<td>Ultimate Limit Capacity 70,000 lb.</td>
<td>Clamping Capacity: 8,250 lb.</td>
</tr>
<tr>
<td><strong>TAT-175-HD</strong></td>
<td></td>
</tr>
<tr>
<td>Output Thd. Major Dia. 1-3/8&quot; (WF-10)</td>
<td></td>
</tr>
<tr>
<td>Plate Washer 3/8&quot; x 6&quot; x 6&quot;</td>
<td></td>
</tr>
<tr>
<td>Ultimate Limit Capacity 99,000 lb.</td>
<td></td>
</tr>
<tr>
<td><strong>TAT-225</strong></td>
<td></td>
</tr>
<tr>
<td>Output Thd. Major Dia. 1-7/8&quot; (WF-14)</td>
<td></td>
</tr>
<tr>
<td>Plate Washer Not Supplied</td>
<td></td>
</tr>
<tr>
<td>Ultimate Limit Capacity 225,000 lb.</td>
<td></td>
</tr>
</tbody>
</table>

**Transition Notes:**
1. Transitions listed are standard items; usually available from stock.
2. Hot dip galvanized per ASTM A123 Grade 100
3. The capacities listed are mechanical ratings.
4. All Transitions are supplied with 22” All Thread Rod, Nut and Mounting Hardware. Square shaft transitions also have a flat washer included with the exception of the TAT-225 Transition. (See Sketch Below)

## ECP Plate Anchor Kit

ECP Earth Plate Anchors are supplied as illustrated below. Available wall plate area is 1.3 or 2.3 ft² and available soil bearing area is 1.3, 1.6, 2.3 or 3.0 ft². The ultimate-limit tension capacity is 10,000 lb. The plate spacing is adjustable from 9 ft to 17-1/2 ft. (Please request Typical Specifications for installation and load details.)

The sketch above shows the components that are shipped with solid bar transition assemblies. The transition and the hardware required to attach the transition to the tieback will vary depending upon the product ordered. Please refer to the table above for additional details. Tubular transitions and TAT-225 do not include a flat wall plate. As the angle of installation usually varies generally from 15° to 30°, bevel washers should be ordered separately.
Design Criteria

The Bearing Capacity of a Torque Anchor™ (P_u) can be defined as the load which can be sustained by the Torque Anchor™ without producing objectionable settlement, either initially or progressively, which results in damage to the structure or interferes with the use of the structure.

Bearing Capacity is dependant upon many factors:

- Kind Of Soil,
- Soil Properties,
- Surface and/or Ground Water Conditions,
- Torque Anchor™ Configuration (Shaft Size & Type, Helix Diameter(s), and Number Of Helices),
- Depth to Bearing,
- Installation Angle,
- Torque Anchor™ Spacing,
- Installation Torque,
- Type of Loading - Tension, Compression, Alternating Loads, etc.

The design of Helical Torque Anchors™ uses classical geotechnical theory and analysis along with empirical relationships that have been developed from field load testing. In order to prepare an engineering design, geotechnical information is required from the site along with structural load requirements including a factor of safety - “FS”.

The most accurate design requires knowledge from soil testing using the Standard Penetration Test (SPT) standardized to ASTM D1586 plus laboratory evaluations of the soil shear strength, which is usually given as soil cohesion – “c”, soil density – “γ”, and granular friction angle – “ϕ”

Soils will vary from site to site and may vary from point to point on some sites. Each analysis must use data relevant to the project at hand as each project has different parameters.

Each design requires specific information involving the structure and soil characteristics at the site. Each design should involve geotechnical and engineering input.
Preliminary Design Guideline Using Site Specific Soil Data

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

**Deep Foundations**

Torque Anchor™ systems must be considered as deep foundation elements.

As a rule of thumb, helical products must be installed to a Critical Depth of at least six times the diameter of the largest helix. The depth is measured from the intended final surface elevation to the uppermost helical plate of the Torque Anchor™.

The capacity of a multi-helix deep foundation system assumes that the ultimate bearing capacity is the sum of the bearing support from each plate of the system. Testing has shown that when the helical plates are spaced at three times the diameter away from the adjacent lower helical plate, each plate will develop full efficiency in the soil. Spacing the helical plates at less than three diameters is possible, however, each plate will not be able to develop full capacity and the designer will have to include a plate efficiency factor in the analysis when conducting the design.

Pile or anchor spacing should be no closer than five times the diameter of the largest plate at the bearing depth. Pile spacing as close as three diameters has been successfully installed, but this work requires special installation equipment that can maintain accurate installation angles. The spacing requirement of five times the diameter of the largest plate is measured at the target depth. It is acceptable to install several shafts at the same surface location with suitable outward batter to accomplish the required shaft to shaft spacing at the final installed depth.

Using guidelines described above, the ultimate capacity of an ECP Torque Anchor™ system can be calculated from the following equation:

**Equation 1: Ultimate Theoretical Capacity:**

\[ P_o \text{ or } T_o = \sum A_{H} \left( c N_c + q N_q \right) \]

Where:
- \( P_o \) or \( T_o \) = Ult. Capacity of Torque Anchor™ (lb)
- \( \sum A_{H} \) = Sum of Projected Helical Plate Areas (ft²)
- \( c \) = Cohesion of Soil (lb/ft²)
- \( N_c \) = Bearing Capacity Factor for Cohesion
- \( q \) = Soil Overburden Pressure to \( h_{int} \) depth (lb/ft²)
- \( N_q \) = Bearing Capacity Factor for Granular Soil.

The ultimate capacity is defined as the load that results in a deformation of one inch. In general ultimate capacity is the working or service load with a factor of safety of 2.0 applied.

If one has access to a soil report in which “c”, “γ”, and “\( \phi \)” are given, then Equation 1 can be solved directly. Unfortunately, often many soil reports do not contain these values and the designer must decide which soil type is more likely to control the ultimate capacity.

When one is unsure of the soil type or the soil behavior cannot be determined, we recommend that one calculate loads using cohesive soil behavior because the result will be conservative.

**In all cases, we highly recommend field testing to verify the accuracy of the preliminary design load capacities.**

**Soil Behavior**

The following information is provided to introduce the reader to the field of soil mechanics. Explained are the terms and theories used to determine soil behavior and how this behavior relates to Torque Anchor™ performance. This is not meant to substitute for actual geotechnical soil evaluations. A thorough study of this subject is beyond the scope of this manual. The values presented here are typical of those found in geotechnical reports.
Cohesive Soil (Clays & Silts)

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

Cohesive soils have a rigid behavior when exposed to stress. Stiff clays act almost like rock. They remain solid and inelastic until they fail. Soft clays act more like putty. The soft clay bends and molds around the anchor when under stress.

Undrained Shear Strength – “c”: The undrained shear strength of a soil is the maximum amount of shear stress that may be placed on the soil before the soil yields or fails. This value of “c” only occurs in cohesive soils where the internal friction “ϕ” of the fine grain particles is zero or nearly zero. The value of “c” generally increases with soil density; therefore, one can expect that stiff clays have greater undrained shear strength than soft clay soil. It is easy to understand that when dealing with cohesive soils; that the greater the shear strength “c” of the soil, the greater the bearing capacity. It also follows that the capacity of the soil tends to increase with depth.

### Table 4. Cohesive Soil Classification

<table>
<thead>
<tr>
<th>Soil Description</th>
<th>USCS Symbol</th>
<th>Density Description</th>
<th>Density “y” lb/ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inorganic silt, rock flour, silty or clayey fine sand or silt with low plasticity</td>
<td>ML</td>
<td>Soft</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stiff</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hard</td>
<td>130</td>
</tr>
<tr>
<td>Inorganic clay of low to medium plasticity, sandy clay, gravelly clay, lean clay</td>
<td>CL</td>
<td>Soft</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stiff</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hard</td>
<td>130</td>
</tr>
<tr>
<td>Organic silts and organic silty clays, low plasticity</td>
<td>OL</td>
<td>Soft</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stiff</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hard</td>
<td>105</td>
</tr>
<tr>
<td>Inorganic silt, fine sandy or silty soils, elastic silts - high plasticity</td>
<td>MH</td>
<td>Soft</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stiff</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hard</td>
<td>105</td>
</tr>
<tr>
<td>Inorganic clays of high plasticity, fat clay, silty clay</td>
<td>CH</td>
<td>Soft</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stiff</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hard</td>
<td>115</td>
</tr>
<tr>
<td>Organic silts and organic clays of medium to high plasticity</td>
<td>OH</td>
<td>Soft</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stiff</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hard</td>
<td>110</td>
</tr>
<tr>
<td>Peat and other highly organic soils</td>
<td>PT</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

### Table 5. Properties of Cohesive Soil

<table>
<thead>
<tr>
<th>Soil Density Description</th>
<th>SPT Blow Count - &quot;N&quot;</th>
<th>Undrained Shear Strength (lb/ft²)</th>
<th>Unconfined Compressive Strength (lb/ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Soft</td>
<td>0 – 2</td>
<td>&lt; 250</td>
<td>&lt; 500</td>
</tr>
<tr>
<td>Soft</td>
<td>2 – 4</td>
<td>250–500</td>
<td>500–1,000</td>
</tr>
<tr>
<td>Firm</td>
<td>4 – 8</td>
<td>500–1,000</td>
<td>1,000–2,000</td>
</tr>
<tr>
<td>Stiff</td>
<td>8 – 15</td>
<td>1,000–2,000</td>
<td>2,000–4,000</td>
</tr>
<tr>
<td>Very Stiff</td>
<td>15 – 32</td>
<td>2,000–4,000</td>
<td>4,000–8,000</td>
</tr>
<tr>
<td>Hard</td>
<td>32 – 48</td>
<td>4,000–6,000</td>
<td>8,000–12,000</td>
</tr>
<tr>
<td>Very Hard</td>
<td>&gt; 48</td>
<td>&gt; 6,000</td>
<td>&gt; 12,000</td>
</tr>
</tbody>
</table>

Cohesive Bearing Capacity Factor - “Nc”: The bearing capacity factor for cohesion is an empirical value proposed by Meyerhof in the Journal of the Geotechnical Engineering Division, Proceedings of ASCE, 1976. For small shaft helical piles or tieback anchors with plate diameters under 18 inches, the value of the Cohesive Bearing Capacity Factor, “Nc,” was found to be approximately nine, therefore “Nc” = 9 is generally accepted as a reasonable value to use when determining capacities of these helical piles and anchors embedded in cohesive soils.

When determining the ultimate capacity for a Torque Anchor™ situated in cohesive soil, Equation 1 may be simplified because the internal friction, “ϕ”, of the soil particles can be assumed to be zero and the cohesive bearing factor, “Nc,” is assumed to be 9. Equation 1 can be modified when dealing with cohesive soil as shown below:
**Equation 1a**

**Ultimate Capacity - Cohesive Soil**

\[ P_u \text{ or } T_u = \Sigma A_H \times (9c) \text{ or } \Sigma A_H = P_u \text{ or } T_u / (9c) \]

Where:
- \( P_u \) or \( T_u \) = Ultimate Cap. of Torque Anchor™ - (lb)
- \( \Sigma A_H \) = Sum of Projected Helical Plate Areas (ft²)
- \( c \) = Cohesion of Soil - (lb/ft²)

**Graph 1**

*REQUIRED HELICAL PLATE AREA vs. SPT, "N"*

Cohesive Soils

Graph 1 above may be used to quickly get a rough estimate the plate area requirements in cohesive (clay & silty) soils based upon Standard Penetration Test, “N”, values at the termination depth of the pile or anchor. One may also use Graph 1 to compare results obtained from Equation 1a.

---

**Cohesionless Soil (Sands & Gravels)**

In cohesionless soil, particles of sand act independently of each other. This type of soil has fluid-like characteristics. When cohesionless soils are placed under stress they tend to reorganize into a more compact configuration as the load increases.

Cohesionless soils achieve their strength and capacity in several ways.

- The soil density,
- The overburden pressure (The unit weight of the soil above the Torque Anchor™),
- The internal friction angle “\( \phi \)”,

**Soil Overburden Pressure – “q”**: The soil overburden pressure at a given depth is the summation of density “\( \gamma \)” (lb/ft³) of each soil layer multiplied by its thickness, “\( h \)”. The moist density of the soil is used when calculating the value of “\( q \)” for soils above the water table. Below the water table the buoyancy effect of the water must be taken into consideration. The submerged density of the soil where all voids in the soil have been filled with water is

---

**Table 6. Cohesionless Soil Classification**

<table>
<thead>
<tr>
<th>Soil Description</th>
<th>USCS Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well Graded Gravel Or Gravel-Sand</td>
<td>GW</td>
</tr>
<tr>
<td>Poorly Graded Gravel Or Gravel-Sand</td>
<td>GP</td>
</tr>
<tr>
<td>Silty Gravel Or Gravel-Silt Mixtures</td>
<td>GM</td>
</tr>
<tr>
<td>Clayey Gravel Or Gravel-Sand-Clay Mixtures</td>
<td>GC</td>
</tr>
<tr>
<td>Well Graded Sand Or Gravelly-Sands</td>
<td>SW</td>
</tr>
<tr>
<td>Poorly Graded Sand Or Gravelly-Sands</td>
<td>SP</td>
</tr>
<tr>
<td>Silty Sand Or Sand Silt Mixtures</td>
<td>SM</td>
</tr>
<tr>
<td>Clayey Sands Or Sand-Clay Mixtures</td>
<td>SC</td>
</tr>
</tbody>
</table>
determined by subtracting the buoyant force of the water (62.4 lb/ft³) from the moist density of the soil.

To arrive at value for soil overburden pressure on a single helical plate of a Torque Anchor™, the value of “q_plate” for each stratum of soil must be determined from the intended final surface elevation to the helical plate elevation, “h_plate”. By using Equation 2b, the ultimate bearing capacity of the helical plate is determined. The ultimate capacity of a multi-plate helical pile may be determined by summing the capacities of all helical plates. A simpler method often used to estimate the ultimate capacity of a multi-plate pile configuration is to determine the soil overburden, “q”, at a depth midway between the upper helical plate and the lowest helical plate, “h_mid”. This value of “q” is used to estimate the ultimate capacity of the pile configuration.

**Cohesionless Bearing Capacity Factor - “N_q”:**
Zhang proposed the ultimate compression capacity of the helical screw pile in a thesis for the University of Alberta in 1999. From this work the dimensionless empirical value “N_q” was introduced. “N_q” is related to the friction angle of the soil - “φ”, as estimated in Table 7.

When determining the ultimate capacity for a Torque Anchor™ in cohesionless soils, Equation 1 may be simplified because granular soils have no soil cohesion. Therefore “c” may be assumed to be zero. Equation 1 when used for cohesionless soils can be modified as follows:

**Equation 1b:**
Ultimate Capacity - Cohesionless Soil
\[ P_u \text{ or } T_u = \Sigma A_H (q N_q) \]
\[ \Sigma A_H = P_u \text{ or } T_u / (q N_q) \]

Where:
- \( P_u \text{ or } T_u = \text{Ult. Capacity of Torque Anchor™} - \text{ (lb)} \)
- \( \Sigma A_H = \text{Projected Helical Plate Area(s) (ft}^2\text{)} \)
- \( q = \text{Soil Overburden Pressure from the surface to plate depth “h” – (lb/ft}^3\text{)} \)
- \( N_q = \text{Bearing Capacity Factor for Granular Soil} \)

**Effect of Water Table on Pile Capacity:**
It cannot be emphasized enough that the buoyant force of water on the soil overburden can dramatically change the load capacity of the helical pile or anchor. Calculating soil overburden for a specific site usually entails determining the density of each stratum of soil between the surface and the termination depth of the helical support product.

To illustrate the effect of the water table on the pile capacity the following example assumes that site contains 25 feet of cohesionless soil that is homogeneous, has a constant density of 100 lb/ft³ and a constant SPT - “N” = 10 bpf that extends beyond 25 feet. Such uniform soil as this is seldom found. In the second example all assumptions remain except the water table is assumed to be located ten feet below grade.

Using Equation 1b and Table 7 the ultimate capacity of a TAF-288 (8-10-12) pile (1.54 ft²) is calculated when no ground water is present:

\[ P_u = \Sigma A_H (q N_q) = 1.54 [(100 \times 25 \text{ ft}) \times 16] \]

\[ P_u = 61,600 \text{ lb} \] (Damp soil - no water Present)

When the water table is present at 10 feet below grade, notice the reduction in pile capacity that is caused by the buoyant force of the water.
\[
P_u = \Sigma A_H \ (q \ N_q) \\
P_u = 1.54 \ [(100 \times 10 \ ft) + (60 \times 15)] \times 16 \\
P_u = 46,816 \ lb \ (\text{Water Table at 10 feet})
\]

The reduction in capacity of the same pile configuration in the same soil when water is present at 10 feet below grade is approximately 76%. This demonstrates that knowing the level of the water table is necessary for safe design.

Using Equation 1b must be used again to determine a new helical plate area requirement and a new pile configuration that will have sufficient plate area to support 61,600 pounds in the soil with the higher water table.

\[
\Sigma A_H = P_u/(q \ N_q) \\
\Sigma A_H = 61,600/[(100 \times 10 \ ft) + (60 \times 15)] \times 16 \\
\Sigma A_H = 2.03 \ ft^2
\]

The closest standard product that will provide this helical plate area is a TAF-288 (10-12-14), which offers 2.26 ft² of plate area.

This example clearly illustrates that if subsurface water is not considered during the designing process, it is highly likely that the pile or anchor will be under designed and could fail.

---

**Mixed Soils – Cohesive and Cohesionless Soils**

When reviewing soil boring logs one often sees descriptions that combine the two soil types. One often sees such terms as “clayey sand” or “sandy clay” in the soil descriptions on the soil boring log.

The soils engineers use terms to describe soils that contain both cohesive soil and granular soil in the samples. When one encounters such descriptions in the soil report, the design analysis requires that both soil types be considered. Equation 1 must be used to determine the ultimate capacity or projected helical area requirement. The designer must assign a percentage of each type of soil present when placing data into Equation 1.

Table 8 provides guidance for relative percentages of each type of soil. Experience has shown that there is no national standard for these soil descriptions. Because of this, Table 8 provides the most typical percentages. It is always a good idea to check with the soil engineer to verify his or her soil type percentages on a specific soil boring log when working on a critical project.

When preparing a load capacity design when mixed soils are present, adjust for the percentages of cohesive and cohesionless soils present in Equation 1. For example, assume that the soils engineer described the soil on the site as being “clayey sand”. Referring to Table 8 there is a range from 20% to 49% for the cohesive clay component in the sample. For this illustration it is assumed that no additional data is available from the soil engineer regarding the percentages present. A value for the cohesive clay component of the soil is estimated at 30% and the remaining 70% of the soil is assumed to be sand:

<table>
<thead>
<tr>
<th>Table 8</th>
<th>Mixed Soil Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Description</td>
<td>Estimated Percentage Present</td>
</tr>
<tr>
<td>&quot;trace&quot;</td>
<td>1% to 5%</td>
</tr>
<tr>
<td>&quot;slightly&quot;</td>
<td>6% to 15%</td>
</tr>
<tr>
<td>&quot;little&quot;</td>
<td>10% to 20%</td>
</tr>
<tr>
<td>&quot;with&quot;</td>
<td>15% to 25%</td>
</tr>
<tr>
<td>&quot;silty&quot; or clayey&quot;</td>
<td>20% to 49%</td>
</tr>
<tr>
<td>&quot;some&quot;</td>
<td>20% to 34%</td>
</tr>
<tr>
<td>&quot;very&quot;</td>
<td>35% to 49%</td>
</tr>
</tbody>
</table>

**Note:** There is no national standard for soil description percentages reported by soil engineers. Listed above are the descriptors and most commonly encountered percentages. For increased accuracy, or when working on a critical project, verify the descriptive percentages with the project soil engineer.

Equation 1 is modified as shown to adjust to the reported soil composition:

\[
P_u = \text{Helical Plate Area} \times (30\% \ \text{strength of clay} + 70\% \ \text{strength of sand}) \\
P_u = \Sigma A_H \ (0.30 \ c \ N_c + 0.70 \ q \ N_q)
\]

The result of the analysis will be a helical pile capacity that is lower than if it was embedded in only sand, but greater than if embedded only in clay.

Keep in mind that when dealing with incomplete data, it is wise to add a sufficient factor of safety to the result or to choose the percentage for the cohesionless soil component at the lower end of the range provided in Table 8.
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 around the helical pile or anchor becomes saturated. This buoyancy of the soil particles in the soil reduces the load 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 adjustment.

It is also important to know the maximum frost depth along with the range of depth for the water table at the job site to insure a solid and stable installation. Anchors should always be installed below the lowest recorded frost depth to a depth of more than three diameters of the uppermost plate. In most cases this is usually means installing the helical plates 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 exists with thawing frost. Load capacity could reduce because 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 could cause creep or failure. In addition, freezing water within the pores of the soil can lead to upward pressure on the helical plates resulting in movement and/or loss of strength when the plates are terminated within the freeze-thaw zone.

Monitoring the installation torsion on the shaft (Discussed below and in Chapter 2) can predict the performance of the anchor at the time of installation, but changes in the soil moisture can affect the product’s long term holding ability.

Budgetary Capacity Estimates by “Quick and Rough” Design Method

Many installers and engineers are familiar with the Soil Classification Table that other manufacturers use for budgetary helical anchor designs. This table “classifies” soil into eight soil groups ranging from solid rock down to very soft clays, organics and peats. These Soil Classifications are used for reference to estimate expected pile capacities indicated by graphs or tables.

Table 9 below is the Soil Classification Table that relates the classification levels offered by other manufacturers along with anticipated values for Standard Penetration Tests, “N”, likely to be found within each classification. The Holding Capacity Graphs 2 through 5 that follow were developed to provide rough estimates of holding capacities for various sizes and combinations of helical plates attached to Torque Anchor™ shafts and installed into these soil classifications.

It must be clearly understood that Graphs 2 through 5 are provided to help offer a general estimated load capacity for a pile or anchor configuration installed into a soil that fits within a certain soil classification. The graphs are not intended to be a substitute for engineering judgement and design calculations detailed earlier that rely upon specific soil data relative to the project. Table 10 and Graphs 2 through 5 represent general trends of capacity through different homogeneous soil classifications. The graphs are based upon conservative estimates.

Graphs 2 - 5 represent the ultimate capacity of the helical plate configuration in the soil, and one must always apply a suitable factor of safety to the service load before using these tables to insure reliability of any tieback or pile installation.

In very dense soil or rock stratum when rotation of the helical anchor shaft does not advance the product into the soil, the helical plates are not able to fully embed and cannot achieve the capacity level predicted by Terzaghi’s bearing capacity formula (Equation 1). The graphs disregard soil classifications zero through class 2 because these soils are usually too dense for the
Torque Anchors™ to advance without pre-drilling.

Likewise, soil class 8 was not represented in the graphs because class 8 soils usually contain significant amounts of organics or fill materials. The organics may continue to decay and/or soil with organics and/or fill may not be properly consolidated and are therefore not considered suitable for long term support.

Graphs 2 through 5 presented here also show a shaded area for Class 7 soils and part of Class 6 soils. This is to alert the user that, in some cases, soils that fall within these shaded areas of the graphs may not be robust enough to support heavy loads. If the soil in the shaded areas contain fill; the fill could contain rocks, cobbles, trash, and/or construction debris. In addition, these soils may not be fully consolidated and/or could contain organic components. Any of these could allow for creep of a foundation element embedded within the stratum. This could cause a serious problem for permanent or critical installations. When such weak soils are encountered, it is strongly recommended that the anchor or pile be driven deeper so that the Torque Anchor™ will penetrate beyond all weak and possibly unstable soil into a more robust and stable soil stratum underlying these undesirable strata.

It is also important to understand that the Graphs 2 through 5 below do not take into consideration the size of the shaft or type of shaft being used in conjunction with the helical plate configurations. As a result, these graphs could suggest holding capacities well above the “Useable Torsional Capacity” of the helical shafts shown in Table 2.

Where the graph line is truncated at the top of the graph for a particular helical plate configuration, one should not try to extrapolate a higher capacity than indicated by the top line because these plate configurations have reached the ultimate mechanical capacity for that particular configuration being represented. It might be possible to achieve higher capacities with a given configuration presented in the graphs if one orders the Torque Anchor™ with one-half inch thick helical plates instead of the standard three-eighths inch thickness. Please check with ECP or your engineer to determine if using thicker helical plates could achieve a higher ultimate capacity requirement on a particular project.

<table>
<thead>
<tr>
<th>Table 9</th>
<th>SOIL CLASSIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class</td>
</tr>
<tr>
<td>0</td>
<td>Solid Hard Rock (Unweathered)</td>
</tr>
<tr>
<td>1</td>
<td>Very dense/cemented sands; Coarse gravel and cobbles</td>
</tr>
<tr>
<td>2</td>
<td>Dense fine sands; very hard silts and/or clays</td>
</tr>
<tr>
<td>3</td>
<td>Dense sands/gravel, hard silt and clay</td>
</tr>
<tr>
<td>4</td>
<td>Medium dense sand/sandy gravels; very stiff /hard silt/clay</td>
</tr>
<tr>
<td>5</td>
<td>Medium dense coarse sand and sandy gravel; Stiff/very stiff silt and clay</td>
</tr>
<tr>
<td>6</td>
<td>Loose/medium dense fine/coarse sand; Stiff clay and silt</td>
</tr>
<tr>
<td>7</td>
<td>Loose fine sand; soft/medium clay; Fill</td>
</tr>
<tr>
<td>8</td>
<td>Peat, Organic silts, Fly ash, Very loose sand; Very soft/soft clay</td>
</tr>
</tbody>
</table>

Notes:
1. 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.
2. 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.
3. Shaft buckling must be considered when designing compressive anchors that pass through Class 8 soils.
Note: It is advisable not to install Torque Anchors™ into Soil Classes in the shaded area for better stability and performance. In situations where this is not possible, we recommend increasing the factor of safety for a safer design. Installing the Torque Anchors™ to an underlying stratum that has a higher bearing capacity and a more stable soil classification is recommended.
Note: It is advisable not to install Torque Anchors™ into Soil Classes in the shaded area for better stability and performance. In situations where this is not possible, we recommend increasing the factor of safety for a safer design. Installing the Torque Anchors™ to an underlying stratum that has a higher bearing capacity and a more stable soil classification is recommended.
The capacity of a helical product can be estimated by accurately measuring the installation shaft torsion. Several methods are commonly used. Transducers attached to the hydraulic lines, strain gauge monitors, shear pins and monitoring pressure differential across the installation motor are all common ways to determine installation torque being applied to the anchor shaft. The average recorded shaft torsion must be at or above the torque requirement during the final three feet of installation to confirm meeting the installation torque requirement. By continued installation of the helical product beyond first reaching the shaft torsion requirement insures that all anchor plates are sufficiently embedded into the target soil and this reduces the chance of creep, settlement or pullout in the future.

Field load testing is required to verify the actual load capacity. During a field test, the helical product is loaded in the direction of the intended compressive or tensile load and at the intended installation angle. ASTM D1143 and ASTM 3689 field load tests measure the ultimate capacity of the helical product when fully loaded. There is normally a small shaft movement when a helical product is initially loaded due to “seating” the plates into the soil. This movement is normally not considered in the test measurement. Before beginning the field load test, a small initial “seating” load of 1,500 to 2,000 pounds is usually applied to the pile or anchor prior to commencing test procedures. During testing, the load on the helical shaft is incrementally increased and after applying each load increment the movement at the top of the shaft is measured against a fixed point. If creep occurs only during the application of the incremental load, the test can continue immediately after measuring the initial creep increment. As the load increases and nears ultimate capacity, the pile or anchor may continue to slowly move for a period of time after the incremental load was applied. During this time the incremental load on the helical product must be maintained as the shaft continues to creep. The total deflection shall not be determined until the movement ceases and the pile or anchor becomes stable. If after 15 to 20 minutes, the movement is continuing or the total measured creep exceeds the established limit for acceptance, the useful capacity of the pile or anchor has been exceeded. The load increment prior to this final load increment shall be recorded as the ultimate capacity of the product. Load capacity is discussed in greater detail in Chapter 2.

Soil type will affect the performance of the helical product during field testing. For example, piles or anchors installed in clay will show minimal creep with increasing load and then suddenly and continuously start moving. Cohesionless soils, on the other hand, usually will produce a more predictable load to creep curve.

Installation Torque

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

Figure 2, below, illustrates that not all of the torque applied to the shaft by the motor reaches the helical plates. The actual torque applied to the helical plates is $T_{plate} = T_{Motor} - T_{Shaft}$. The friction generated between the circumference of the shaft and the soil is directly related to the shaft configuration and size along with the properties of the soil. Because of this loss of efficiency in transmitting the motor torque down to the plates, an empirical Soil Efficiency Factor (“k”) must be employed to arrive at a reasonable estimate of pile or anchor ultimate capacity.

Shaft torsion should always be monitored during
the installation of helical screw piles and anchors. Generally, the ultimate holding capacity of the typical solid square shaft helical product within a given soil stratum is ten times the average shaft torsion measured over the final three feet of installation.

When estimating the anchor’s capacity, one must not consider any torque readings on an anchor when it is stalled or encountering obstructions; instead average the readings 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 anchor spins, it must be removed and repositioned. The torsion measurements on the new placement shall be averaged over three feet, but the anchor shall not be installed to the spin depth.

Due to larger friction between the soil and tubular shaft configurations, one cannot use the ten to one relationship mentioned above to estimate ultimate capacity of tubular shafts.

A more detailed discussion of the relationship between torque on the shaft and anchor capacity is presented in the next section.

---

**Helical Torque Anchor™ Design Considerations**

**Projected Areas of Helical Plates:**
When determining the capacity of a screw pile in a given soil, knowledge of the projected total area of the helical plates is required. This projected area is the summation of the areas of the helical plates in contact with the soil less the cross sectional area of the shaft. Table 10 provides projected areas in square feet of bearing area for various plate diameters on different shaft configurations.

**Allowable Helical Plate Capacity:**
When conducting a preliminary design, one must also be aware of the mechanical capacity of the helical plate and the shaft weld strength. Average capacities of plates are given in Table 11. Actual capacities are generally higher than shown for smaller diameter helical plates. Capacities are also slightly higher when the helices are mounted to larger diameter tubular shafts.

**Table 10. Projected Areas* of Helical Torque Anchor™ Plates**

<table>
<thead>
<tr>
<th>Shaft</th>
<th>6” Dia.</th>
<th>8” Dia.</th>
<th>10” Dia.</th>
<th>12” Dia.</th>
<th>14” Dia.</th>
<th>16” Dia.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2” Sq.</td>
<td>0.181</td>
<td>0.333</td>
<td>0.530</td>
<td>0.770</td>
<td>1.053</td>
<td>1.381</td>
</tr>
<tr>
<td>1-3/4” Sq.</td>
<td>0.175</td>
<td>0.328</td>
<td>0.524</td>
<td>0.764</td>
<td>1.048</td>
<td>1.375</td>
</tr>
<tr>
<td>2-1/4” Sq.</td>
<td>0.161</td>
<td>0.314</td>
<td>0.510</td>
<td>0.750</td>
<td>1.034</td>
<td>1.361</td>
</tr>
<tr>
<td>2-7/8” Dia</td>
<td>0.151</td>
<td>0.304</td>
<td>0.500</td>
<td>0.740</td>
<td>1.024</td>
<td>1.351</td>
</tr>
<tr>
<td>3-1/2” Dia</td>
<td>0.130</td>
<td>0.282</td>
<td>0.478</td>
<td>0.719</td>
<td>1.002</td>
<td>1.329</td>
</tr>
<tr>
<td>4-1/2” Dia</td>
<td>0.086</td>
<td>0.239</td>
<td>0.435</td>
<td>0.675</td>
<td>0.959</td>
<td>1.286</td>
</tr>
</tbody>
</table>

* Projected area is the face area of the helical plate less the cross sectional area of the shaft.

Important: When a 90° spiral cut leading edge is specified, the projected areas listed in Table 10 will be reduced by approximately 20%.

Designs using 12” to 14” diameter plates on square bar shafts will have ultimate mechanical capacities that are slightly lower than shown in Table 11. This variance is usually not a concern except when a small shaft is highly loaded with only a single or double helix configuration.

**Relationships between Installation Torque and Torque Anchor™ Capacity:** Estimating the capacity of a given screw pile based upon the installation torque has been used for many years.

Unless a load test is performed on site to determine a specific value for the relationship between installation shaft torsion and ultimate product capacity, commonly referred to as Soil Efficiency Factor, “k”, a conservative value should be selected when designing. While
values for “k” have been reported from 2 to 20, most projects will produce a value of “k” in the 6 to 14 range. Earth Contact Products suggests using the values for “k” as shown in Table 12 when estimating Torque Anchor™ ultimate capacities.

It is important to understand that the value of “k” is a measure of friction during installation as illustrated in Figure 2 on page 25 above. This friction has a direct relationship between the soil properties and anchor design. For example, “k” for clay soil would usually be greater than for dry sand. The “k” for a square bar is generally higher than for a tubular pile. Keep in mind that the suggested values in Table 12 are only guidelines. Graph 6 illustrates how the Soil Efficiency Factor, “k” affects the ultimate capacity of a pile or anchor. It can be seen that the ultimate capacity varies significantly when the same torque is applied to each different shaft configuration.

It is also important to refer to Table 2 for the Useable Torque Strength values to avoid shaft fractures during installation.

### Table 12. Soil Efficiency Factor “k”

<table>
<thead>
<tr>
<th>Torque Anchor™ Type</th>
<th>Typically Encountered Range “k”</th>
<th>Suggested Average Value, “k”</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2” Sq. Bar</td>
<td>9 - 11</td>
<td>10</td>
</tr>
<tr>
<td>1-3/4” Sq. Bar</td>
<td>9 - 11</td>
<td>10</td>
</tr>
<tr>
<td>2-1/4” Sq. Bar</td>
<td>10 - 12</td>
<td>11</td>
</tr>
<tr>
<td>2-7/8” Diameter</td>
<td>8 - 9</td>
<td>8-1/2</td>
</tr>
<tr>
<td>3-1/2” Diameter</td>
<td>7 - 8</td>
<td>7-1/2</td>
</tr>
<tr>
<td>4-1/2” Diameter</td>
<td>6 - 7</td>
<td>6-1/2</td>
</tr>
</tbody>
</table>

An appropriate factor of safety of 2.0, minimum, must always be applied when using design or working loads with Equation 3.

To determine Soil Efficiency Factor, “k” from field load testing, Equation 2 can be rewritten as:

### Equation 2a: Soil Efficiency Factor

\[
k = \frac{P_u}{T} = \frac{P_a}{T_a} = k \times T
\]

Where,

- \( T \) = Final Installation Torque - (ft-lb)
- \( P_u \) or \( T_a \) = Ult. Capacity of Torque Anchor™ - (lb)
- \( k \) = Empirical Torque Factor - (ft\(^{-1}\))

Graph 6 - Motor Output Torque vs Ultimate Capacity

**Torque Efficiency Factor - "k" to Shaft Configuration**

- Sq. Shaft (k = 10)
- 2-7/8” Dia (k = 8.5)
- 3-1/2” Dia (k = 7.5)
- 4-1/2” Dia (k = 6.5)
Always verify capacity by performing a field load test on any critical project.

**Torque Anchor™ Spacing – “X”**: Equation 3 is used to determine the center-to-center spacing of Torque Anchors™.

**Equation 3: Torque Anchor™ Spacing**

\[ X = \frac{P_a}{w \times (FS)} \quad \text{or} \quad P_a = (X) \times (w) \times (FS) \]

Where,

+ \(X\) = Product Spacing - (ft)
+ \(P_a\) = Ultimate Capacity - (lb)
+ \(w\) = Distributed Load on Foundation or Wall (lb/ft)
+ \(FS\) = Factor of Safety (Typically 2.0 – Foundations or Permanent Walls and 1.5 for Temporary Walls)

**Plate Embedment in Tension Applications**: When a pile must resist uplift or tension loads, the pile must be adequately embedded into the bearing stratum to offer resistance to pull out.

The pile must first qualify as a deep foundation, defined as being installed to a depth from intended surface elevation of no less than six times the diameter of the largest and shallowest helical plate (6 x \(d_{\text{largest}}\)). In addition, to insure that the pile is fully embedded, the required terminal torsion applied to the shaft must have been an average of the torsion developed over a distance of no less than three times the diameter of the uppermost (largest) plate (3 x \(d_{\text{largest}}\)).

**Preventing “Punch Through”**: A soil boring on occasion may report a layer of competent soil overlaying a weak and softer stratum of soil. One must consider the possibility that the Torque Anchor™ could “punch through” to the weaker soil when fully loaded in situations when designing the Torque Anchor™ to achieve axial compressive bearing in any competent soil situated directly above a weaker soil stratum.

When designing a pile in such situations, it is recommended that a distance greater than five times the diameter of the lowest (smallest) helical plate (5 x \(d_{\text{lowest}}\)) exist below the lowest Torque Anchor™ to prevent “punching through” to the stratum of weaker soil and possibly failing.

---

### Tieback Design Considerations

One of the most common applications for helical tieback anchors is for supplemental basement wall support. Many basement walls show signs of inwardly bulging, have horizontal tension fractures and/or have rotated inwardly.

---

![Figure 3. Elements of Tieback Design](image-url)
Consolidation of the fill soil, inoperative drain tiles, plumbing leaks, ponding water on the surface near the basement wall, or other environmental factors are largely the cause of the distress seen in many basement wall failures. When ECP Helical Torque Anchors™ are installed and anchored into the soil; two repair options are available:

1. The tieback is designed and loaded to support or supplement the wall structure. Soil is not removed from behind the wall; therefore, the wall can be only supported and not restored.

2. The soil behind the wall is removed and the tieback anchor is used to restore the wall to near its original position. Proper granular material must be used as backfill against the wall after restoration along with a proper ground water drainage system for stability.

The wall will always be exposed to active pressure from the soil and possible hydraulic force from water. For the Torque Anchor™ to properly develop resistance against this active pressure, the anchor must be installed beyond this active soil area. Once beyond this area, the tieback can develop passive earth pressure against the helical plate(s). Figure 3, above, shows the general layout for a tieback project and design elements for the embedment of the helical plates for proper support.

It is most important that any basement wall repair include an investigation, and any remedial work required to prevent any future conditions where the soil behind the wall can become saturated. If the drainage work is not accomplished immediately following tieback installation, the design must assume that there will be hydraulic pressure against the wall. An engineer can determine if the wall has sufficient structural integrity to support these combined loads if drainage corrections are not implemented.

Design of retaining walls is very complicated and requires engineering input. This manual has greatly simplified the equations so that the reader can quickly and relatively easily obtain an estimate of the reaction force required to stabilize and support a failing retaining wall. This material should be used with caution for new construction retaining walls or basement wall designs.

**Placement of Tiebacks:** The vertical placement of the tieback is dictated by the height of the soil against the wall. It is recommended that the tieback be installed close to the point of maximum bulging of the wall and/or close to the most severe horizontal crack in the wall. When the wall is constructed of blocks, or where a concrete wall is severely distressed, vertical steel supports and/or horizontal water beams must be used to provide even distribution of the reaction force of the anchor across the face of the wall.

The typical vertical mounting location for tieback anchors is 20% to 50% of the distance down from the elevation where the soil touches down to the wall to the bottom of the wall. Seek engineering assistance for walls taller than 12 feet and/or more complicated projects.

**Hydrostatic Pressure:** If water is present or suspected behind a basement or retaining wall, the additional force of the hydrostatic pressure must be added to the load requirements of the tieback anchor.

When soil and/or subsurface conditions are unknown, it MUST be assumed in the design that water pressure is present.

**Basement Tieback Applications:** If a basement wall fails because of insufficient structural integrity, improper fill against the wall and/or improper compaction of the fill, then Equation 4 may be used for approximating the load per lineal foot against the basement wall. This equation assumes that no hydrostatic pressure is present. Please refer to Figures 3 & 4.
Equation 4: Basement Wall Load
\[ P_H = 18 \times (H^2) \]  (No Water Pressure)

When water pressure is present behind the basement wall or if it is not known if hydrostatic pressure exists, Equation 5 should always be used to estimate the load.

Equation 5: Basement Wall Load
\[ P_H = 45 \times (H^2) \]  (Water is Present)

Where:
- \( P_H \) = Soil Load on Wall - (lb/lineal foot)
- \( H \) = Height of Backfill - (ft)

Simple Retaining Wall Tieback Applications:
Similarly, if a retaining wall fails because of insufficient structural capacity, improper fill against the wall and/or consolidation of the fill, then Equation 6 may be used to approximate the load per lineal foot of retaining wall. If the soil at the top of the wall is level as shown in Figure 5, then the value of “S” in Equations 6 & 7 becomes zero. This equation assumes no hydrostatic pressure present. (Refer to Figures 3 and 5.)

Simple Retaining Wall Tieback Applications with Soil Surcharge: A load on a retaining wall with a simple soil surcharge load such as shown in Figure 6 may also be approximated using Equations 6 & 7. One must first estimate the surcharge height, “S” as shown.

Equation 6: Simple Retaining Wall Load
\[ P_H = 24 \times (H + S)^2 \]  (No Water Pressure)

Equation 7: Simple Retaining Wall Load
\[ P_H = 50 \times (H + S)^2 \]  (Water is Present)

Where:
- \( P_H \) = Soil Load on Wall - (lb/lineal foot)
- \( H \) = Height of Backfill - (ft)
- \( S \) = Height of Soil Surcharge - (ft)

When water pressure is present behind the retaining wall of it is unknown if hydrostatic pressure exists, Equation 7 must be used to estimate the load on the retaining wall.

Ultimate Tieback Capacity Selection: To determine the ultimate tieback capacity requirement, multiply the soil force against the wall by the selected center to center tieback spacing appropriate for the existing or planned wall construction and loading.

Equation 8: Ultimate Tieback Capacity
\[ T_U = (P_H) \times ("X") \times FS \]

Where:
- \( T_U \) = Ultimate Tieback Capacity Tension – (lb)
- \( P_H \) = Foundation Load or Force on Wall – (lb/lin.ft)
- FS = Factor of Safety (Typically 2.0 - Permanent Walls and 1.5 for Temporary Walls)
- “X” = Center to Center Spacing of Tiebacks – (ft)

It is highly recommended to consult a registered professional engineer when more complex surcharge loads such as a structure, parking lot, road, etc. is located on the surface near the top of the retaining wall.

Horizontal Embedment Length – “L_0”: The
Helical Torque Anchor™ must be installed into soil a sufficient distance away from the wall so that the helical plate(s) can fully develop anchoring capacity beyond any failure planes. (See Figure 3.)

**Equation 9: Horizontal Embedment**

\[ L_0 = H + 10d_{\text{largest}} \]

Where:

- \( L_0 \) = Minimum Horizontal Embedment Length from Wall to the Shallowest Plate - (ft)
- \( H \) = Height of Soil Against Wall - (ft)
- \( d_{\text{largest}} \) = Diameter Of Largest Plate - (ft)

**Installation Angle – “a”:** Typically in tieback applications, Torque Anchors™ are installed at downward angles of 5° to 30° measured from horizontal. Most often the designer calls for installed angles between 10° and 20°. The smaller the angle, the less shaft material is required to reach a suitable horizontal embedment length; however, a large enough installation angle is required to reach critical depth, “D”, which insures that a shallow embedment failure cannot occur. (See Figure 3.)

Table 13 provides equations to obtain minimum horizontal embedment length when the anchor is installed at various downward angles.

---

**Torque Anchor™ Installation Limits**

**Shaft Strength:** The data in Table 2 gives the strength ratings for various shaft configurations in axial tension, compression and shaft torsion. The values are from mechanical testing and not from tests in the soil. Because 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 column in Table 2 indicates the maximum installation torque that should be intentionally applied to the Torque Anchor™ shaft during installation in homogeneous soil. The risk of product failure dramatically increases when one exceeds these limits.

When choosing a 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 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 be allowed to insure proper embedment and to prevent shaft impact fractures.

It is important to also understand that the empirical torsional factor “k” reduces the practical limit on the ultimate capacity that can be developed in the soil. This is especially important when designing with larger tubular products because large tubular shafts pass through the soil less efficiently than smaller tubular shafts and solid square bars.

**Shaft Stiffness:** When the tubular Torque Anchor™ is installed through soft soils that display a Standard Penetration Test value “N” ≤ 4 blows per foot (“N” ≤ 5 for square shafts), the possibility of shaft buckling must be considered.

---

**Table 13. Angular Embedment Length**

<table>
<thead>
<tr>
<th>Installation Angle “a” (Downward From Horizontal)</th>
<th>Length “L” of installed product required to reach the proper embedment length</th>
</tr>
</thead>
<tbody>
<tr>
<td>10°</td>
<td>( L_{10} = (H + (10d_{\text{largest}})) \times 1.015 )</td>
</tr>
<tr>
<td>15°</td>
<td>( L_{15} = (H + (10d_{\text{largest}})) \times 1.035 )</td>
</tr>
<tr>
<td>20°</td>
<td>( L_{20} = (H + (10d_{\text{largest}})) \times 1.064 )</td>
</tr>
<tr>
<td>25°</td>
<td>( L_{25} = (H + (10d_{\text{largest}})) \times 1.103 )</td>
</tr>
<tr>
<td>30°</td>
<td>( L_{35} = (H + (10d_{\text{largest}})) \times 1.155 )</td>
</tr>
</tbody>
</table>

Where:

- \( H \) = Height of Backfill (ft)
- \( d_{\text{largest}} \) = Largest Plate Dia. (ft)
in assessing the axial compressive capacity of the pile.

It is important to remember that tubular shafts provide superior resistance to buckling than solid square bars when used in axial compression applications. This is because tubular shafts have greater flexural stiffness. (They have a larger moment of inertia.) In general tubular pile configurations the larger shaft diameter will provide greater resistance to lateral deflection or buckling within the soil.

Table 14 illustrates how tubular piles have superior shaft stiffness when compared to solid square bars. It is interesting to note that the 2-7/8” diameter Torque Anchor™ with a wall thickness of 0.262 inches costs approximately the same as a Torque Anchor™ fabricated from 1-3/4” solid square bar stock. Please notice in Table 14 that the 1-3/4” solid square bar is only 40% as stiff as the 2-7/8” diameter tubular product. It is clear that the 2-7/8” tubular product is the better choice when designing foundation piles that are to be loaded in axial compression.

Another situation where shaft buckling should be considered is where there are both axial compression and lateral forces acting upon the pile. Normally when the pile terminates within a footing, this is not a problem. When the pile is not fixed at the surface, there may be factors present that affect buckling. These factors include shaft diameter, length, soil density and strength, and pile cap attachment.

**Buckling Loads In Weak Soil:** Whenever a slender shaft does not have adequate lateral soil support, the load carrying capacity of the shaft is reduced as shaft buckling becomes an issue. In the case of tubular Torque Anchors™, the full ultimate capacity is available provided the soil through which the pile penetrates maintains a value for “N” ≥ 4 blows per foot or greater as reported on a Standard Penetration Test for the entire length of the pile embedment. The pile must also be secured to a suitable footing at grade level to prevent lateral forces transmitting to the top of the pile.

Whenever one encounters weak soils such as peat or other organic soils, improperly consolidated soil, or where the pile may become fully exposed from the soil due to erosion; the pile will not be able to support the full rated capacity listed in Table 2.

In addition to the amount of lateral soil support on the shaft, both the length of the pile pipe that is exposed to insufficient lateral support and the stiffness of the slender shaft will affect the reduction in allowable capacity.

<table>
<thead>
<tr>
<th>Torque Anchor™ Shaft Configuration</th>
<th>Cross Section Area - in²</th>
<th>Moment of Inertia - in⁴ (Stiffness)</th>
<th>Pier Stiffness Relative to TA-288</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA-150 (1-1/2” Square)</td>
<td>2.21</td>
<td>0.40</td>
<td>22%</td>
</tr>
<tr>
<td>TA-175 (1-3/4” Square)</td>
<td>3.00</td>
<td>0.74</td>
<td>40%</td>
</tr>
<tr>
<td>TA-225 (2-1/4” Square)</td>
<td>5.00</td>
<td>2.04</td>
<td>110%</td>
</tr>
<tr>
<td>TA-288L (2-7/8” Dia x 0.203”)</td>
<td>1.70</td>
<td>1.53</td>
<td>82%</td>
</tr>
<tr>
<td>TA-288 (2-7/8” Dia x 0.262”)</td>
<td>2.08</td>
<td>1.85</td>
<td>100%</td>
</tr>
<tr>
<td>TA-350 (3-1/2” Dia x 0.300”)</td>
<td>3.02</td>
<td>3.89</td>
<td>206%</td>
</tr>
<tr>
<td>TA-450 (4-1/2” Dia x 0.337”)</td>
<td>4.41</td>
<td>9.61</td>
<td>519%</td>
</tr>
</tbody>
</table>

It should be noted that solid square shafts are only recommended to be installed through soils having SPT, “N” values greater or equal to five blows per foot.

The reason for this is the shaft offers very little strength against buckling when subjected soils with SPT blow less than five. When designing piles in axial compression that must penetrate weak soils, it is good practice to consider tubular products for the application.

The most accurate way to determine the buckling load of a helical pile shaft in weak soil is by performing a buckling analysis by finite differences. There are several specialized computer programs that can perform this analysis and allow the introduction of shaft properties and soil conditions that can vary with depth. Another, less accurate method of estimating critical buckling is by Davisson Method, “Estimating Buckling Loads for Piles” (1963). In this method, Davisson assumes various combinations of pile head and tip
boundary conditions with a constant modulus of sub-grade reaction, “kkl” with depth. Load transfer to the soil due to skin friction is assumed to not occur and the pile is straight. Davison’s formula is shown as Equation 10 below.

**Equation 10: Critical Buckling**

\[ P_{cr} = U_{cr} E_p I_p / R^2 \]

Where:
- \( P_{cr} \) = Critical Buckling Load – lb
- \( U_{cr} \) = Dimensionless ratio (Assume = 1)
- \( E_p \) = Shaft Mod. of Elasticity = 30 x 10^6 psi
- \( I_p \) = Shaft Moment of Inertia = in^4
- \( R = \sqrt[4]{E_p I_p / k_{hl}} \)
- \( d \) = Shaft Diameter – in

Computer analysis of shaft buckling is the recommended method to achieve the most accurate results. Many times, however, one must have general information to prepare a preliminary design or budget proposal. Table 15 below provides conservative working load estimates for various shaft sizes penetrating through different types of weak homogeneous soils. Graph 7 presents a visual representation of critical buckling loads that will quickly identify shaft configurations with Insufficient Buckling Strength when passing through soft soils that do not adequately support the shaft.

**Allowable Compressive Loads - Pile in Air:** Graph 8 shows the reduction in allowable axial compressive loading relative to the length of the pier shaft that is **without** lateral support. Table 14 illustrates that the 4-1/2” diameter tubular Torque Anchor™ provides an axial stiffness of more than five times that of a 2-7/8” diameter shaft. In addition, Graph 8 demonstrates that the 4-1/2” diameter pile has an ultimate capacity of more than four times that of the 2-7/8” diameter shaft when each shaft has ten feet of exposed column height without any lateral support. When one compares the buckling capacity of the 4-1/2” and diameter shaft to the 1-3/4” solid square shaft, the 4-1/2” diameter tubular shaft has more than three times the capacity. The same comparison between the 3-1/2” diameter shaft and the 1-3/4” solid square shaft, the 3-1/2” has 1.6 times greater buckling capacity.

<table>
<thead>
<tr>
<th>Table 15</th>
<th>Working Loads Under Buckling Conditions For Budgetary Estimating (Factor of Safety = 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shaft Size</strong></td>
<td><strong>Uniform Soil Condition</strong></td>
</tr>
<tr>
<td>1-1/2” Sq</td>
<td></td>
</tr>
<tr>
<td>1-3/4” Sq.</td>
<td></td>
</tr>
<tr>
<td>2-1/4” Sq.</td>
<td></td>
</tr>
<tr>
<td>2-7/8” Dia x 0.203”</td>
<td></td>
</tr>
<tr>
<td>2-7/8” Dia x 0.262”</td>
<td></td>
</tr>
<tr>
<td>3-1/2” Dia x 0.300”</td>
<td></td>
</tr>
<tr>
<td>4-1/2” Dia x 0.337”</td>
<td></td>
</tr>
</tbody>
</table>
Each design where shaft buckling is possible requires specific information involving the structure and soil characteristics at the site. We strongly recommend that the final structural design be prepared or reviewed and approved by a geotechnical and structural engineer.

**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 call us at 913 393-0007, Fax at 913 393-0008.