Chapter 4

Torque Anchors
Introduction to Helical Soil Nails
Introduction

Before one can begin a discussion of soil nailing, a clear understanding of the difference between soil nails and tieback anchors is required. Many times one hears the term "Soil Nail" and "Tiebacks" used interchangeably and this demonstrates a lack of understanding of the products.

Suppose that a construction project requires an excavation where the side of a soil cut cannot be provided with a stable slope. Figure 1 illustrates the soil cut and excavation for this project.

Figure 1

One can easily understand that without some kind of containment of the soil at the face of the cut, a collapse of the soil along a failure plane is likely to occur. This failure can happen very quickly and without warning. The failure might look something like Figure 2. The unstable soil moves to the bottom of the excavation leaving a natural and stable slope for the remaining soil. This interface between the stable and unstable soil is called a slip plane.

Figure 2

The most common way to prevent this kind of soil failure is to provide lateral support to the unstable soil situated in front of the slip plane.

One common way to do this is with a retaining wall and tieback anchors. The tiebacks work together with the structural retaining wall to provide sufficient lateral support to retain the unstable soil mass. The retaining wall must be designed and constructed to provide rigid support for the soil mass over the distance between the tieback anchor placements. One often sees tieback anchors spaced eight to twelve feet apart along the length of the retaining wall. The spacing and number of anchors depends upon the wall height, surcharge loads and properties of the retained soil. Tieback anchors must be driven into the soil to a depth that is sufficient to provide tension resistance in the anchor shaft that is equal to the soil forces pushing against the retaining wall. A typical soil cut with a retaining wall is illustrated in Figure 3.

Figure 3

In many construction projects soil nails are used to retain the unstable soil mass.

To accomplish this, soil nails are installed in an evenly spaced close geometric pattern without the massive retaining wall structure. When constructing a soil nail stabilization project, the soil nail placement spacing and the incremental excavation depth must be accomplished with incremental excavations that typically measure 4 to 6 feet until the final depth of cut is accomplished.

Usually only one depth increment can be completed per day. Immediately following the incremental excavation of the soil and the installation of the soil nails, the vertical face of the soil cut is covered with steel mesh reinforcement and a coating of shotcrete.
Soil nails are passive structural elements and are not tensioned after installation. The soil nail achieves pullout resistance from within the sliding soil mass in front of the slip plane and the stable soil mass located behind the slip plane. The geometric system of soil nail placements creates an internally reinforced soil mass that is stable. Figure 4 shows a sketch of a typical soil nail installation.

Notice that each soil nail shaft has a great number of helical plates with each plate the same diameter. These helical plates are evenly spaced along the entire length of the shaft. By comparison, a tieback anchor has one or more helical plates situated at the tip of the tieback.

![Image of soil nail installation](Image)

**Figure 4**

Soil nails work very efficiently in medium dense to dense sand with Standard Penetration Test values, "N" > 7 blows per foot. They also are suited for low plasticity cohesive soil (clays) with SPT values, “N” ≥ 8 blows per foot, which also have soil cohesion values exceeding 1,000 psf through the entire depth of soil to be stabilized.

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### ECP Soil Nail Components

ECP Soil Nail products consist of a shaft fabricated from either 1-1/2 inch or 1-3/4 inch solid square steel bar. Welded along the entire length of the soil nail shaft are identically sized helical plates measuring six or eight inches diameter with a plate thickness of 3/8 inch. The available lead shaft lengths for ECP Soil Nails are nominally five or seven feet long; however, other lengths may be specially fabricated. Soil nail extensions are also available in nominal lengths of five and seven feet. The extensions shall also contain evenly spaced helical plates of the same diameter as the lead section. Soil nail extensions are supplied with integral couplings and hardware for attachment to already installed lead or other extensions allowing the soil nail assembly to reach the designed embedment length requirement.

Soil nails may be terminated with a large flat wall plate or an assembly of reinforcing bars welded to a small wall plate. The wall plates will eventually be embedded into the reinforced shotcrete wall covering.

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### Product Benefits

- Quickly Installed Using Rotary Hydraulic Torque Motor
- Installs With Little Or No Vibration
- Installs In Areas With Limited Access
- No Post-Tensioning – Immediate Support
- No Need for “H” Piles, Sheet Piling, or Walers
- In Temporary Applications, Soil Nail Removal and Reuse is Possible
# ECP Square Shaft Soil Nails

![Diagram of ECP Square Shaft Soil Nails](image)

## ECP Soil Nail Product Configurations

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Shaft Size</th>
<th>Torque Limit*</th>
<th>Plate Size</th>
<th>Number Plates</th>
<th>Shaft Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAS-150-60 06-06 Lead</td>
<td>1-1/2&quot; Square</td>
<td>7,000 ft-lb</td>
<td>6&quot; Diameter</td>
<td>2</td>
<td>5'-0&quot;</td>
</tr>
<tr>
<td>TAS-175-60 06-06 Lead</td>
<td>1-1/2&quot; Square</td>
<td>10,000 ft-lb</td>
<td>8&quot; Diameter</td>
<td>2</td>
<td>5'-0&quot;</td>
</tr>
<tr>
<td>TAS-150-60 08-08 Lead</td>
<td>1-3/4&quot; Square</td>
<td>7,000 ft-lb</td>
<td>6&quot; Diameter</td>
<td>2</td>
<td>5'-0&quot;</td>
</tr>
<tr>
<td>TAS-175-60 08-08 Lead</td>
<td>1-3/4&quot; Square</td>
<td>10,000 ft-lb</td>
<td>8&quot; Diameter</td>
<td>2</td>
<td>5'-0&quot;</td>
</tr>
<tr>
<td>TASE-150-60 06-06 Extension</td>
<td>1-1/2&quot; Square</td>
<td>7,000 ft-lb</td>
<td>6&quot; Diameter</td>
<td>2</td>
<td>5'-0&quot;</td>
</tr>
<tr>
<td>TASE-175-60 06-06 Extension</td>
<td>1-1/2&quot; Square</td>
<td>10,000 ft-lb</td>
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<td>2</td>
<td>5'-0&quot;</td>
</tr>
</tbody>
</table>

### Note:
- Custom fabrication of soil nail products to your specifications is available – Inquire for pricing and delivery.
- All helical plates are 3/8” thick and spaced as shown above.
- Extensions supplied with integral coupling and SAE J429 grade 8 bolts and nuts.
- Product is hot dip galvanized per ASTM A123 grade 100.
- Soil Nail products available as special order – Allow extra time for processing.

*Please see “IMPORTANT NOTE” on Table 17, Page 83*
Product Limitations

Soil nails are designed to attain pullout resistance from within the sliding soil mass along with the resistance from the stable soil behind the movement plane. As a result of this tensioning, one must anticipate movements horizontally and vertically at the top of the excavation on the order of 1/8 inch movement for each five feet of excavation. These movements are normally not of concern unless a building is situated close to the proposed soil cut. Creep of the soil mass after the initial soil movement is usually not a problem; however when the soil liquidity index is > 0.2, a soil nail matrix is not recommended.

Soil nails may not be suitable in situations where the soil report indicates the presence of weathered rock anywhere within the area to be stabilized. Soil nails are also not recommended in loose sand with SPT value of “N” < 7 blows per foot. The use of soil nails must be approached with caution where highly plastic clays and silts are present within the soil mass. Soil nails are not recommended for low plasticity clay soil having SPT value of “N” ≤ 6 blows per foot.

The practical limit for excavations using the soil nail stabilization technique is approximately 20 feet; although under ideal soil conditions, excavations as deep as 25 feet deep have been reported.

When designing soil stabilization with surcharge loads near the top of the excavation such as buildings, roads, soil overburden, etc, the surcharge loads must be included with the weight of the soil mass being retained. With an expected slump of 1/8 inch for each five feet of excavation, one should consider stabilizing the perimeter footing of nearby structures whenever the excavation exceeds 10 to 12 feet because lateral and vertical movements on the order of 1/4 to 3/8 inch could cause structural damage to existing structures nearby.

### Table 17. CAPACITIES OF ECP SOIL NAILS

<table>
<thead>
<tr>
<th>Shaft Size</th>
<th>Shaft Configuration</th>
<th>Ultimate-Limit Tension Strength</th>
<th>Useable Torsion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2” Square</td>
<td>Solid Bar</td>
<td>70,000 lb.</td>
<td>7,000 ft-lb</td>
</tr>
<tr>
<td>1-3/4” Square</td>
<td>Solid Bar</td>
<td>100,000 lb.</td>
<td>10,000 ft-lb</td>
</tr>
</tbody>
</table>

**IMPORTANT NOTE:**
The capacities listed are mechanical ratings. One must understand that the actual installed load capacities are dependent upon the actual soil conditions on a specific job site and the strength of the termination connection. The Useable Shaft 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. In homogeneous soils it might be possible to achieve 90% to 95% of the ultimate torsional strength shown in the table.

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

Each soil nail design requires very specific and detailed information involving the soil characteristics at the site and surcharge loads, if any. Each design is complicated and highly technical. The design and specifications should only be prepared by a Registered Professional Engineer trained in soil nail design and familiar with the specific job site.
Soil nails not only look different from Torque Anchor™ tiebacks they are designed differently. It is important to understand the dramatic differences in these products before working with soil nails.

For soil nails to be effective, they must have equal diameter helical plates spaced evenly along the entire length of shaft.

Remember that soil nails are not tensioned to gain strength; they gain pullout resistance from within the sliding soil mass that is located in front of the slip plane. The concept is rather simple to understand. As the soil mass begins to slip downward and outward, the sliding soil creates a force against the back side of the helical plates embedded within this sliding soil mass. The force generated by the sliding soil against these helical plates is resisted equally, and in the opposite direction, on the front side of the remaining helical plates that are embedded within the stable soil behind the slip plane. Figure 5 illustrates the way that the forces are developed along the Soil Nail shaft.

The forces developed within the soil nail system remove the structural requirement for an exterior retaining wall. In most cases the soil nails wall plates are embedded directly into the shotcrete coating. There is no need for sheet piles, “H” piles or wales. The soil mass is stabilized by the matrix of soil nails, therefore only the thin shotcrete wall is necessary.

Soil nails are installed in a geometrical matrix to distribute the load evenly; and as such, soil nails are more lightly loaded than tieback anchors.

Some engineers might specify a small “seating” load to be applied to the soil nail after installation to remove slack in the couplings; but in general practice, soil nails are usually not tensioned after installation because tensioning can change the balance of stresses on the helices.

Soil nailing is a passive restraint system, meaning that the soil nails are not post-tensioned, the unstable soil mass has to slump slightly before the soil nail system can develop internal forces to resist the soil movements.

Soil nailed walls can be expected to deflect both downward and outward during the slumping of the soil mass.

Expected movements of approximately 1/8” of vertical and horizontal movement of the top of the wall for each five feet of excavation are common.

These movements are normally not a concern except when an existing structure is situated near the
top of the excavation. The soil overburden load from a nearby structure can be reduced by providing supplemental foundation support to the perimeter beam and/or column footings of the existing structure. ECP Steel Piers™ are recommended to transfer the structural load of the existing build-ing foundation to the deep support provided by ECP Steel Piers™. The ECP Steel Piers™ not only reduce the surcharge on the soil mass, they prevent vertical settlement of the existing footing as the slight movement of the soil mass occurs during the tensioning of the soil nail matrix. If there are concerns with regard to lateral movements of the building’s footings, the designer has the ability to prevent lateral footing movements of the existing structure by using Torque Anchor™ tieback anchors along with ECP Steel Piers™ to provide both lateral and vertical stability to the building’s footing.

Figure 6 shows details of a typical soil nail installation. Usually four to five feet of soil is excavated and immediately followed by the installation of the first row of soil nails. Notice that the first row has the longest shaft length because the distance to the slip plane is the greatest. The soil nail is not installed to a specified torsion requirement like tieback anchors; rather the length of embedment, the installation angle and center to center spacing are the important elements in soil nail installations.

Once all of the soil nails situated within the first excavation increment are installed, one-half of the required thickness of shotcrete is placed on the wall followed immediately by the installation of the wall plates and reinforcing steel mesh. The reinforcing mesh is cut long enough to provide suitable splice overlap at the next increment of soil excavation. A surface coating of shotcrete is installed over the steel reinforcement to provide the final thickness of concrete specified by the engineer. All work is then left to cure prior to the next depth increment excavation.

Prior to the beginning the next excavation increment (usually the next day), the amount of slump at the top of the excavation must be measured to insure that the recently installed soil nails are performing as intended. When approved, the next depth increment can be excavated followed by the installation of the next
row of soil nails followed by the immediate installation of the first layer of shotcrete. The only difference between the initial and subsequent incremental excavations is that the new layers of shotcrete and steel must be interlocked to the previous work to provide continuity to the wall.

--- Shotcrete ---
Shotcrete is a process where Portland cement concrete, or mortar, is propelled under air pressure onto a surface. ECP recommends the wet process where the dry ingredients are mixed with water and then sent to the spray nozzle as opposed to “Gunite” where the materials are mixed as they leave the nozzle. Shotcrete deposits more concrete with less rebound upon impact than “Gunite”.

--- Engineering Design and Supervision ---
Design should involve professional geotechnical and engineering input. Each soil nail design requires very specific and detailed information involving the soil characteristics at the site and surcharge loads, if any. Each design is complicated and highly technical. The final design and specifications should only be prepared by a Registered Professional Engineer trained in soil nail design and familiar with the specific job and job site.

The photographs show ECP Soil Nail installation and Shotcrete application.

--- Field Documentation ---
It is very important for the installer to be aware that soil nailing projects involve risk; and as such, close communications with the engineer and attention to detail is extremely important. The data collected on site will assist the engineer to determine if the project is progressing according to plan. Field data should be recorded on each soil nail product installed. Usually, the field superintendent is the person responsible for recording field data. This raw field data is normally compiled at the end of the day into a Daily Installation Report. This report should be assembled in a form that is easy to read and understand. At the start of each day the Daily Installation Report from the previous day should be provided to the engineer prior to his field measurements and before beginning the next excavation increment. ECP suggests reporting
the following data on each installed soil nail to the engineer each day:

1. A diagram with the numbered locations of the installed ECP Soil Nail for reference
2. ECP Soil Nail product part numbers of the items that were installed
3. The elevation from the surface to the soil nail entry point
4. The soil nail installation angle
5. The installed length of the soil nail
6. The installation torque required to advance the soil nail into the soil recorded at one foot intervals
7. Notes should be made on the torsion log for each soil nail placement to report the presence of non-uniform soil or if the soil nail encounters an obstruction during installation

Two skid steer machines are shown above installing a wall. second row of ECP Soil Nails. A view of a finished ECP Soil Nail retaining

NOTE: Technical Design Assistance Is Not Offered For Soil Nail Projects
Soil Nail design should only be performed after a thorough soil investigation by a registered professional engineer because soil nail projects carry the risk of severe failure. All field installation procedures should be performed under the direct supervision of the design engineer of record on site. As these types of projects require extremely detailed soil reports, extensive engineering calculations, and intimate knowledge of the job site, ECP is unable offer complementary preliminary designs for soil nail projects.