1.8 Helical Tiebacks

Helical anchors/tiebacks are commonly used in tension applications to provide either temporary or permanent lateral or tie-down support for applications including:

- Earth retention systems such as concrete retaining walls, soldier pile and timber lagging, and sheet piling (*Figure 1.42* and *Figure 1.43*)
- Seismic loading restraint for foundation uplift and lateral support systems
- Guy anchor support for power line and communication towers
- Seawalls and marine bulkhead support (*Figure 1.44*)

Helical tiebacks are manufactured with similar helix plate sizes and helix spacing as helical piles installed vertically to support foundation loads. Tiebacks differ from helical piles in that they are typically installed in a horizontal to 45-degree downward from horizontal orientation to laterally support the tops of earth retaining structures. Helix plates are typically limited to the lead section or the lead and first extension of the tieback. The helix plate design depends on the soil strength parameters and the required capacity. Multi-helix leads generally consist of increasing plate sizes from the tip. Helical tiebacks may consist of either hollow round shaft or solid square shaft, although square is more common due to its socket-and-pin style coupling (quicker and easier to connect) and the ability to penetrate further into the soil with a similar installation torque than a comparably-sized round shaft. The end of the shaft is typically coupled to an adaptor that transitions the shaft to threaded rod (refer back to *Figure 1.29*).

Figure 1.42 Rendering of helical tieback installation for soldier pile and timber lagging wall

Figure 1.43 Multi-tier helical tieback installation to support sheet pile wall

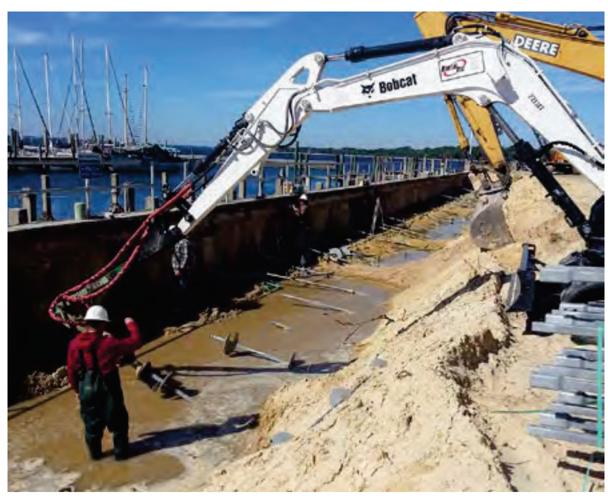

Figure 1.44 Helical tiebacks stabilize marina seawall

Both the Individual Bearing Method and the Cylindrical Shear Method are appropriate for determining helical tieback capacity. The Torque Correlation Method is commonly used to verify capacity during tieback installation. These methods are discussed in *Section 1.7*.

Helical tiebacks are often used to stabilize existing earth retaining structures that have experienced excessive movement, e.g., walls that are cracked, leaning and/or bowing (*Figure 1.45* and *Figure 1.46*). The wall distress may be a result of changes in soil moisture conditions, rise in groundwater levels, plugging of the wall drainage system over time, plumbing leaks, expansive clay soils, frost jacking, or surcharge loads above the wall.

Figure 1.45 Helical tiebacks stabilize sheet pile wall below historic home

Figure 1.46 Helical tiebacks and tube steel walers stabilize concrete retaining wall

1.8.1 Design Considerations

The helix plates along the tieback shaft must be located beyond the active wedge or failure plane to provide proper anchorage. The last helix plate from the tip (plate closest to the wall) shall be at least five (5) times its diameter beyond the estimated failure plane (*Figure 1.47*). The effective tieback length, i.e., the axial embedment of the last helix plate from the tip, should also be a minimum distance of twelve (12) times its diameter from the wall face, following the general guidelines in AC358 for K_t verification for tension piles. Again, the design professional may determine effective tieback lengths more or less than this value based upon site-specific soil and project conditions. The helix plates should also be located at least five (5) diameters below the ground surface of the retained soils to model deep foundation behavior. Multiple tiebacks shall have a center-to-center spacing at the helices of at least three (3) times the diameter of the largest helix plate to avoid significant stress overlap within the bearing soils.

Helical tiebacks are often installed at a downward angle from horizontal, typically on the order of 5 to 15 degrees. This downward angle is often considered in order achieve the 5D depth criteria below the surface of the retained soils, to increase the vertical effective overburden stress at the helix depths (in granular soils), or to extend the helix plates to a deeper, more competent soil layer. A slight downward angle may also be considered to simply minimize the potential for groundwater to follow the shaft and seep through the wall penetration.

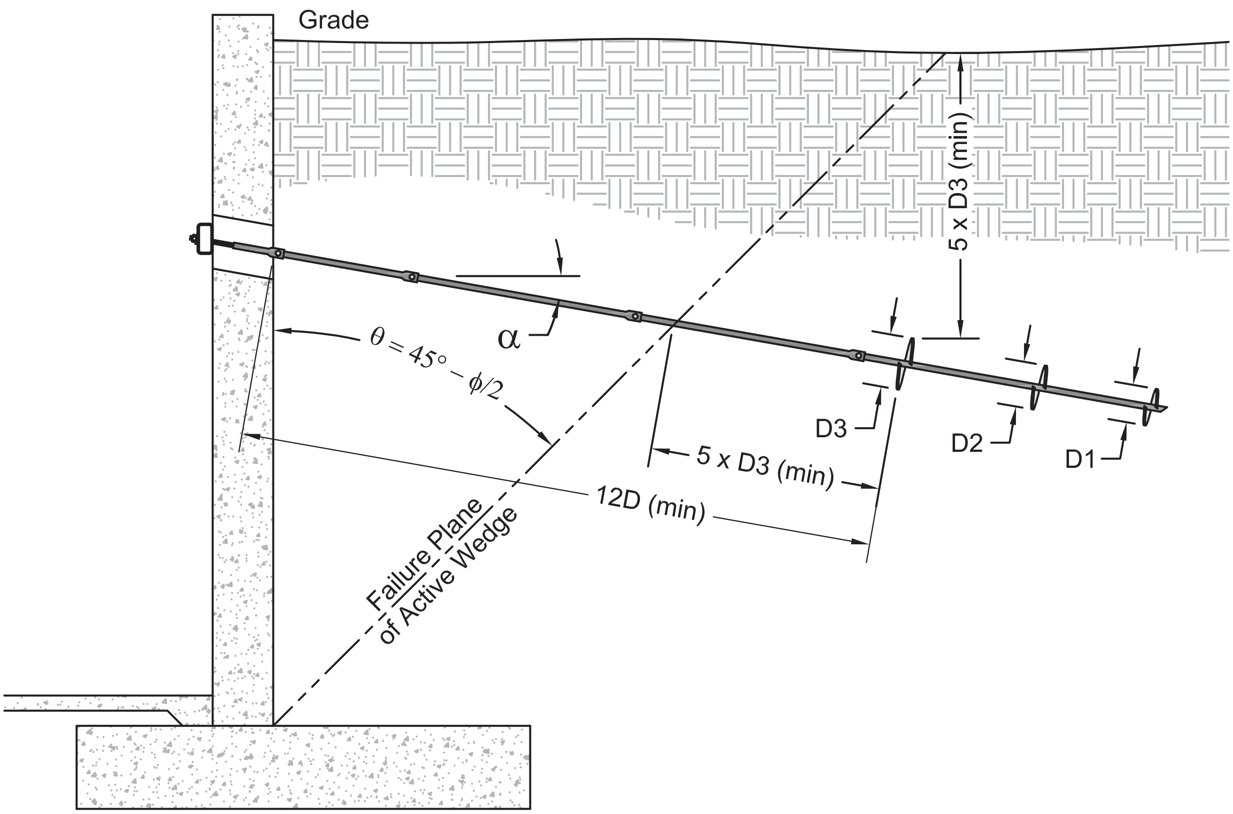

Figure 1.47 Helical tieback design considerations
(Failure plane origin varies based on project-specific parameters)

Tiebacks designed with a downward installation angle (α) should be installed to a torque-correlated capacity equal to or greater than the required axial tieback capacity (T_R) (*Figure 1.48*). The required axial tieback capacity increases with an increase in tieback installation angle, provided the calculated horizontal tieback capacity (T_{CH}) is held constant. The calculated horizontal tieback capacity (T_{CH}) is determined from analysis considering the various loads on the wall. ***Remember that the torque-correlated ultimate capacity should exceed the service load by an appropriate factor of safety.*** The equation for determining the required axial capacity of a downward battered tieback is:

$$T_R = T_{CH} / \cos(\alpha)$$

The vertical component of the tieback force should also be considered so as not to overstress the wall or the wall bearing soils. The vertical component of the tieback force (T_{CV}) will increase with an increase in installation angle, provided the calculated horizontal tieback capacity (T_{CH}) is held constant. The vertical force on the wall generated by the tieback may be calculated by:

$$T_{CV} = T_{CH} \tan(\alpha)$$

or

$$T_{CV} = T_R \sin(\alpha)$$

Where,

T_R	=	Installed capacity of tieback at angle α
α	=	Angle of tieback installation measured downward from horizontal
T_{CH}	=	Calculated horizontal tieback capacity determined from wall analysis
T_{CV}	=	Calculated vertical load on the wall due to tieback installation

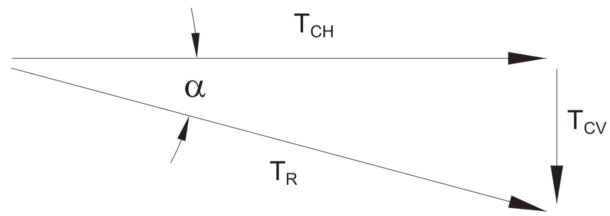

Figure 1.48 Vector mechanics of tieback forces

Angled or beveled washers are recommended at the tieback/bearing plate interface to more uniformly transfer the tension loads (refer back to *Figure 1.29*). Beveled washers are especially critical when the tiebacks are pretensioned with a torque wrench. Uniform bearing of the nut to the beveled washer to the bearing plate provides a more accurate reading of resistance and torque, which in turn is a more accurate determination of axial force on the tieback.

The design of the tieback system should consider the structural details of the wall, the wall reinforcing, present wall condition, and the effect of any penetrations necessary to install the tiebacks. Cantilevered concrete retaining walls, for example, are generally designed with significant reinforcing steel on the backfilled side of the wall where tension and bending are greatest. Reinforcing steel within the compression side of the wall is generally the minimum required by code. Tieback installation induces a negative bending in the cantilevered wall for which the wall was not originally designed. Walls to be stabilized with tiebacks, or walls that will be designed with tieback support, should be reviewed by a design professional.

The assumed failure plane behind an earth retaining wall is dependent upon soil conditions and wall type. As a general rule of thumb, a failure plane can be projected from the bottom back face of the wall or wall footing upward at an angle of 45-Φ/2 (degrees) from vertical for both active and at-rest conditions. For basement walls, this failure plane is usually assumed to begin at the bottom of the wall. For cantilevered retaining walls, it may be appropriate to model the failure plane beginning at the bottom of the wall or the bottom back edge of the footing heel. For sheet-pile walls, the failure plane is usually assumed to begin at or slightly below the mud line.

Failure modes for restrained walls should be evaluated for internal stability, external stability, bearing capacity and global stability. It is the responsibility of the design professional of record to perform these evaluations. Helical tiebacks used in conjunction with earth retention systems should have a minimum factor of safety of two.

Foundation Supportworks engineers recommend that all helical anchors and tiebacks (excluding soil nails) be pretensioned or proof tested following installation (**Figure 1.49**). Pretensioning to 1.0 to 1.33 times the service load minimizes deflection of the tiebacks and structure as the tiebacks are put into service and the soil strength around the helix plates is mobilized. Tiebacks installed to support existing walls are typically locked off at 0.75 to 1.1 times the service load after proof testing. Helical anchors and tiebacks to be cast into new concrete retaining walls may be completely unloaded, locked off with a modest seating load, or locked off near service load after proof testing. The design professional should determine pretensioning and lock-off procedures based upon project conditions, anticipated tieback deflections and the estimated tolerable movement of the supported structure. Tiebacks can be pull tested or load tested to typically two (2) times the service load or more to identify the ultimate system capacity, better assess soil conditions and soil/anchor interaction, and validate design assumptions and parameters. Tiebacks that undergo load testing to greater than 1.5 times the service load, or failure, are generally considered sacrificial and should not be used as production tiebacks.

Figure 1.49 Pretensioning helical tieback