FOUNDATION NATION™
FSI NEWSLETTER FOR DESIGN PROFESSIONALS

An Introduction to Helical Soil Nails

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Soil nailing is a method of earth retention that relies on a grid of individual reinforcing strands or members installed within a soil mass to create an internally stable gravity wall/retaining system. Soil nail wall technology began in Europe with use of the New Austrian Tunneling Method in rock formations in 1961. The technology then carried over to applications involving unconsolidated soil retention, primarily in France and Germany. Soil nail walls were first used in North America for temporary excavation support in the late 1960's and continued to gain recognition and acceptance during the 1970's and 1980's for higher profile projects including highway applications. Much of the soil nail wall research performed in North America was funded by the Federal Highway Administration (FHWA) and other state highway agencies during the 1990's. Although helical piles have been used as tiebacks since the early 1950's, helical soil nails are a relatively new alternative to their grouted counterparts.

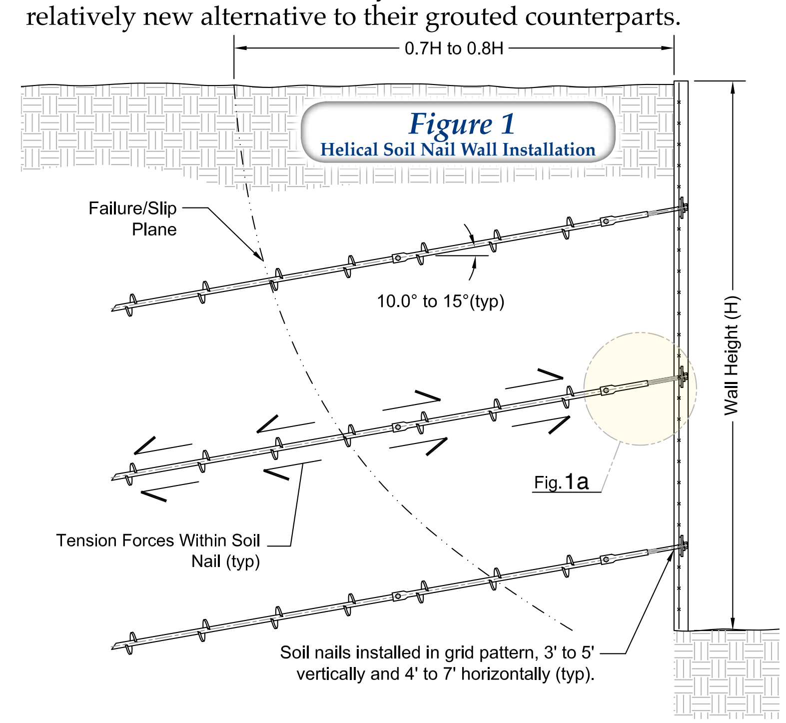

Figure 1
Helical Soil Nail Wall Installation

A helical soil nail typically consists of square shaft lead and extension sections with small diameter (6 to 8 inches) helix plates spaced evenly along the entire shaft length (See Figure 1). Helical soil nails are typically installed in a grid pattern, spaced 3 to 5 feet vertically and 4 to 7 feet horizontally, and are advanced by application of torque.

Excavation, soil nail installation and application of wall facing is completed in steps from the top of the wall downward. The construction sequence for a typical helical soil nail wall includes:

- Initial vertical excavation of about 3 to 5 feet deep depending upon design parameters and soil conditions
- Installation of the first row of helical soil nails to the required inclination angle, torque and embedment length
- Placement of drainage medium (if required)
- Placement of wall reinforcement and bearing plates
- Placement of shotcrete to the required design wall thickness
- After shotcrete has cured, repeat sequence for successive rows of soil nails. Continue process to the final design depth (wall height).

Helical soil nails are passive bearing elements which rely on movement of the soil mass to mobilize the soil shear strength along the nail. As a result, soil nail walls typically experience more lateral movement than tieback walls of similar height. As a general guide, the soil mass located between the failure plane and the wall facing may slump approximately 1/8-inch laterally and 1/8-vertically for each 5-foot depth of excavation. Any structure, utility, roadway, etc. that would be impacted by the wall movement and/or failure plane should be considered in the design phase. By allowing this movement, the highest stress in the soil nail is near the failure plane, centered between the opposing tensile forces. Conversely, the highest stress in a tieback is at the wall face. Therefore, soil nails have less nail head force than tiebacks for a similar size wall, which results in potential cost savings by using soil nails due to reduced wall thickness requirements.

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- Helical Tiebacks
- Hydraulically Driven "Push" Piers
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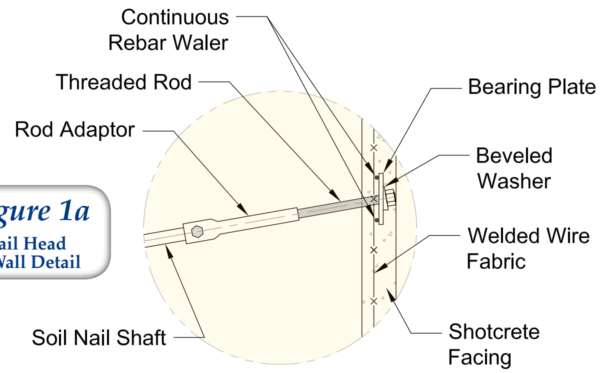


Figure 1a
Nail Head to Wall Detail

The design procedure for helical soil nails is similar to that for grouted nails. For a helical soil nail, the bond stress with the soil is assumed to act along a cylindrical surface area defined by the outside edge of the helix plates. Bearing capacity of the soil nail is determined using the Individual Bearing Method and is correlated to bond stress by:

$$q_u = \frac{Q_u}{L \pi D_h FS}$$

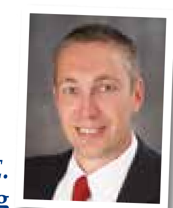
Where,

q_u	=	Bond Stress (psi)
Q_u	=	Bearing Capacity of the Helical Soil Nail by Individual Bearing Method (lb)
L	=	Soil Nail Length (in)
D_h	=	Helix Diameter (in)
FS	=	Factor of Safety for Uncertainties in Soil Conditions (Typically 1.5 to 2.0 Based on Quality of Soil Information)

Helical soil nail walls are used most often in temporary shoring applications, with reinforced shotcrete the most common temporary wall facing material. Shotcrete is concrete conveyed through a hose and projected through a nozzle at high velocity onto a working surface. The shotcrete is applied/sprayed in thin lifts until the design thickness requirement is met for the wall. For temporary wall applications, the shotcrete is typically applied to a thickness of 3 to 4 inches. Internal reinforcement of the shotcrete may consist of welded wire fabric (WWF), steel reinforcing bars (rebar), or fiber reinforcement. WWF with rebar walers at the nail heads is typically favored due to ease of installation (See Figure 1a).

Permanent helical soil nail walls may either have an additional thickness of shotcrete applied or another facing attached to the temporary shotcrete layer. For permanent soil nail walls with shotcrete facing, the typical wall thickness varies from 6 to 12 inches, not including the thickness of the temporary facing. Cast in place and precast concrete facings can also be used in conjunction with the temporary shotcrete wall facing. Facings can be attached to the shotcrete wall to form decorative facades.

Helical soil nails may be the most economical and/or feasible solution for your next earth retention project. The information presented herein is simply an overview. Please contact FSI if you have any questions regarding helical soil design or installation.



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FOUNDATION SUPPORTWORKS

FOUNDATION NATION™
FSI NEWSLETTER FOR DESIGN PROFESSIONALS
Quarterly Newsletter • Issue 7
Spring 2011

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CASE STUDIES

Helical Soil Nails

Commercial

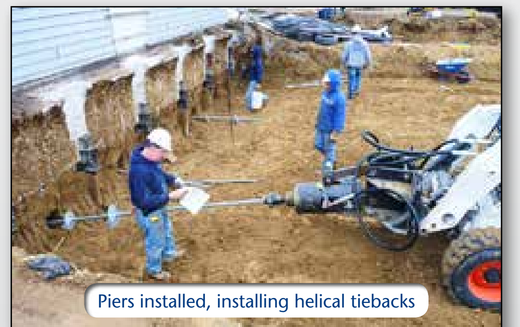
Project: St. Michael's Church Addition
Location: Omaha, NE
Foundation Supportworks™ Dealer/Installer: Foundation Supportworks by Thrasher

Challenge: An addition was planned east of the St. Michael Lutheran Church sanctuary. The addition had plan dimensions of 40 feet by 90 feet and the design included a full basement 14 feet below the slab-on-grade floor elevation of the existing building. The west basement wall of the addition was proposed six feet from the east wall of the sanctuary, which would therefore require; (1) support of the existing foundation along the 40-foot east wall of the sanctuary, and (2) some method of soil retention to prevent foundation soils below the existing structure from caving into the excavation. A driven sheet pile wall was considered for temporary support, but the piling could not effectively be removed after basement wall construction without risk of damage to the structures. Leaving the sheet piling in place would be too expensive. The nearest test boring identified three feet of lean clay fill soils over stiff to very stiff lean clay (Peoria loess) to the bottom of the boring at 20 feet.

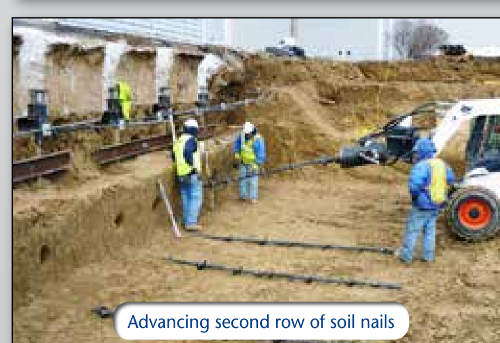
Solution: A helical soil nail wall was selected to provide the temporary soil retainage while the new basement walls were constructed and backfilled. With the helical soil nail option, the proposed west basement wall could also be moved three feet closer to the existing structure, providing an additional 120 square feet of basement area. The east foundation of the sanctuary was exposed and stabilized with Model 288 (2.875-inch OD) push piers. The piers penetrated the upper strata of lean clay soils and were installed to depths ranging from 64 to 79 feet. The ultimate pier capacities were at least twice the design working load. Four Model 150 (1.5-inch square) helical tiebacks were then installed with waler beams to provide lateral support to the piers. The tiebacks consisted of 8"-10"-12" triple helix lead sections and were installed to torque-rated ultimate capacities of at least 1.5 times the design working load (FOS≥1.5). The tiebacks were pre-tensioned to the design load after the walers were set. Twenty-four Model 150 helical soil nails were installed in a grid pattern, three rows of eight with a vertical spacing of four feet and a horizontal spacing of five feet. The soil nails had six-inch helix plates spaced evenly along the lead section and extensions. The soil nails were installed to lengths of at least 15, 12 and 10 feet, for the top, middle and bottom rows, respectively. Torque-rated ultimate capacities were at least 1.5 times the design working load.

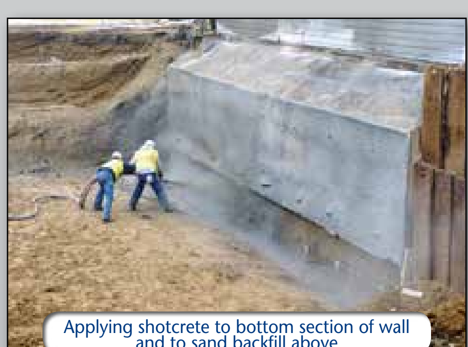
The installation of the push piers and walers required an excavation bench be made adjacent to the existing building. With the project under construction during the winter months, frost protection had to be provided for the east sanctuary foundation. A wood-framed wall was constructed above the bench, connected to the top row of soil nails, sprayed with shotcrete, and then backfilled with loose-dumped sand. This sand backfill was also then sprayed with shotcrete to protect it from moisture infiltration. The shotcrete wall was at least 4 inches thick and reinforced with woven wire fabric and horizontal rebar walers at the nail heads.

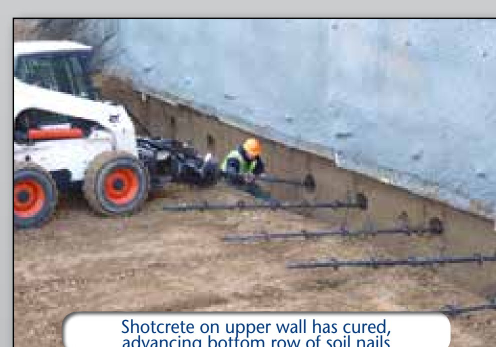

Addition proposed east of sanctuary


Piers installed, installing helical tiebacks

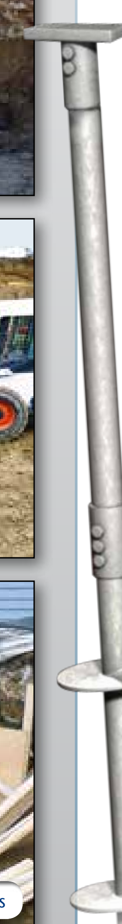

Tieback and waler installation complete


Advancing second row of soil nails


Applying shotcrete to bottom section of wall and to sand backfill above


Shotcrete on upper wall has cured, advancing bottom row of soil nails


Placing formwork and connecting to top row of soil nails



New Construction Helical Piles

Commercial


Site for proposed wash bay addition


Tops of helical piles cast into pile caps

Project: Light Rail Maintenance Facility
Location: Englewood, CO
Foundation Supportworks™ Dealer/Installer: Complete Structural Systems

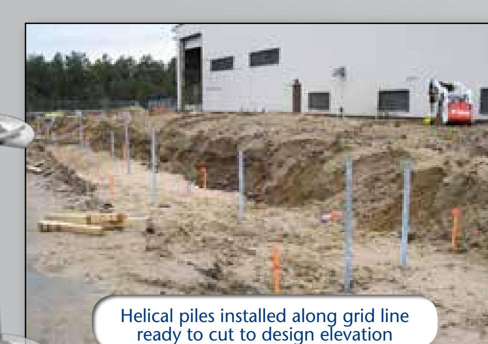
Challenge: The RTD Elati Light Rail Maintenance Facility project included the construction of a new rail car wash bay. The 120-foot by 40-foot addition was planned immediately adjacent to the west wall line of the existing building. Two test borings identified sandy clay to clayey sand fill to depths up to 8 feet, stiff lean clay with sand from 8 to 16 feet, medium dense to very dense sand with gravel from 16 to 24 feet, and sandstone bedrock to the bottoms of the test borings at 28 feet. Although the SPT blow count values within the fill indicated relatively stiff/dense conditions, the degree of fill compaction could not be verified. There was also some risk that areas or pockets of loose fill may exist within the footprint of the addition. Even so, the lightly loaded continuous wall footings could be reasonably sized for a relatively low allowable bearing pressure for support within the fill. The proposed 200 to 400 kip column loads, on the other hand, could not practically be supported with a spread footing sized for a similar bearing pressure.

Solution: Helical piles were selected to support the proposed column loads so the dimensions of the footings (pile caps) could be minimized. Helical piles could also be installed with smaller equipment, which was an advantage for this site given the limited access. The foundation design for the columns included 80 Model 350 (3.5-inch OD by 0.313-inch wall) round shaft helical piles with 10"-12"-14" triple-helix lead sections to support a design working load of 50 kips per pile. The 10-inch diameter helix plate also included a "V-style" cut to allow for easier penetration into dense soils. The helical piles installed adjacent to the existing building included a batter of 5 degrees to further minimize the size of the pile cap. The batter allowed the tops of the piles to be closer together, while also creating the design spacing at the helix plate depth. The piles were advanced to depths ranging from 18 feet to 25 feet for bearing within the medium dense to very dense sand or the sandstone bedrock. Installation torque values of at least 14,300 ft-lbs correlated to ultimate pile capacities of at least 100 kips (FOS=2).

New Construction Helical Piles

Commercial


Helical piles advanced next to the existing building


Helical piles installed along grid line ready to cut to design elevation

Project: Brookhaven Recycling Facility
Location: Yaphank, NY
Foundation Supportworks™ Dealer/Installer: Foundation Supportworks Northeast

Challenge: The Brookhaven Recycling Facility in Yaphank, New York planned an expansion project to increase the size of the existing facility by 12,000 square feet. The 200-foot by 60-foot addition would be a prefabricated metal building supported on cast-in-place concrete footings and foundation walls. The metal building and the foundations would be designed to resist compression loads as well as tension/uplift loads due to wind. For such metal building designs, it is often most economical to simply oversize the footings to increase the dead load of the structure and offset the uplift force. However, deep foundations may also be considered to reduce the dimensions of the footings (pile caps).

A geotechnical investigation at the property included nine soil borings completed to depths of 16 to 22 feet below grade. The general subsurface profile within the area of the addition consisted of approximately five feet of fill soils, loose sand, silt and gravel, underlain by medium dense sand and gravel. The existing fill was determined as unsuitable to support the foundations.

Solution: Helical piles were selected as the ideal foundation support option for this project. The helical piles would penetrate the loose fill for bearing within the underlying medium dense sand and gravel, effectively supporting the design compression and uplift loads and reducing pile cap dimensions. The foundation design included 75 Model 287 (2.875-inch OD by 0.203-inch wall) round shaft helical piles with 8"-10"-12" triple-helix lead sections to support the design compression and tension working loads of 25 kips. The piles were installed to the maximum recommended torque of 5,600 ft-lbs for the Model 287 shaft, correlating to ultimate pile capacities of at least 50 kips (FOS=2). Pile depths ranged from 10 to 25 feet below the bottom of pile cap elevation. Helical pile installation continued through several sustained rain events and even downpour conditions. Although work was slowed by the weather, Foundation Supportworks Northeast was still able to install all 75 piles in six days, keeping the project on schedule.