

NATIONWIDE TRAINING OPPORTUNITIES FOR DESIGN PROFESSIONALS

Helical piles have been used in construction for nearly 200 years. Provisions for helical piles were also included within the 2009 International Building Code. Even so, we tend to find that, generally speaking, there seems to be a lack of knowledge amongst design professionals on the applications and technical aspects of these systems. As such, Foundation Supportworks (FSI) has created a variety of training opportunities to provide education to those who would like to enhance their understanding of helical foundation systems. At FSI, we take training seriously. We know there are many people and companies who claim to offer great learning opportunities, but we find that it is the collaboration of both subject matter experts and curriculum design experts that yields the best results in terms of attendees meeting learning objectives. To take it a step further, our curriculum and education methods have been evaluated by national institutions such as the American Council of Engineering Companies' (ACEC) Registered Continuing Education Program (RCEP) as well as the American Institute of Architects (AIA), and FSI has been named an approved provider

of continuing education through both of these organizations. Our curriculum has also been evaluated and approved directly by the Florida State Board of Engineers as Florida was the one state where RCEP approval was not recognized. We offer both distant and live learning opportunities. On the first and third Wednesday of every month at both 11:30am and 1:30pm central time, FSI conducts a one hour webinar called "An Introduction to Helical Foundation Systems." If you are interested in logging in to one of these webinar times, please contact your local FSI installing contractor. For more in-depth information about helical foundation systems, FSI facilitates a full five-hour presentation several times throughout the year in various locations around the country. To see if there is an upcoming presentation near you, please visit our commercial website at www.fsicommercial.com and click on the "Events Calendar" in the "About Us" section. All of our learning opportunities are free of charge, and best of all, can be submitted as hours to fulfill your CE requirements. We hope to see you at an event soon!



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FOUNDATION NATION

COMMUNICATION PIPELINE FOR ENGINEERS
FSI NEWSLETTER FOR DESIGN PROFESSIONALS



"Critical Depth" for Helical Pile Design in Sands

The projects represented by all four case studies in this issue of Foundation Nation were completed within the state of Florida where helical piles have become a popular deep foundation alternative for both retrofit and new construction applications. For new construction applications near and along the coasts, helical piles compete well against the more traditional driven wood piles and driven precast concrete piles due to minimal vibrations and the ability to easily add extensions to reach deeper, competent soils. Installation equipment for helical piles can also be much smaller than the equipment needed to install driven piles, which allows helical pile contractors to bid on work with limited access and low headroom conditions. Difficult working conditions are clearly shown in the photos for the included Joe's Crab Shack Repair case study. Helical piles were installed beneath the structure, with hand-held equipment, and within waist-deep water.



Helical piles share the same general design considerations as other end-bearing deep foundations; i.e., the soils must be capable of supporting the design working loads with an appropriate factor of safety and any observed or predicted settlements must be within the tolerable limits of the structure. That said, common sense should guide you away from designing a pile to bear within soft and/or organic soils, sensitive clays and silts, active soils, loose sands, saturated liquefiable sands... (the list goes on). In general, Standard Penetration Test (SPT) N-values of 15 to 30 blows per foot for clay soils and 10 to 30 blows per foot for sand are preferred for providing end-bearing resistance for helical piles and anchors.

Higher or lower N-values may also be considered.

The design of helical piles in sands should also consider the concept of "critical depth". The lead article for Issue 8 of Foundation Nation presented methods for determining helical pile capacity. In both the Individual Bearing Method and the Cylindrical Shear Method, we expect pile capacity in sandy soil to increase as the vertical effective overburden stress increases.

Individual Bearing Method:

$$Q_u = \sum A_h (cN_c + q'N_q)$$

Cylindrical Shear Method:

$$Q_u = 2\pi RL(c + K_o q' \tan \phi) + A_h (cN_c + q'N_q)$$

Where,

Q_u = Ultimate Pile Capacity (lb)

q' = Vertical Effective Overburden Stress at Helix Depth (lb/ft²)

Since vertical effective overburden stress is a function of soil unit weight and depth, it would then follow that pile capacity should increase with pile depth. In a uniform soil, we know this does not happen below a certain depth...the critical depth. The critical depth is defined as the limiting depth within granular soil where a further increase in vertical effective overburden stress results in little to no increase in the end bearing capacity of the pile. Certainly, if the sandy soil becomes more or less dense below the critical depth and the internal friction angle varies, an increase or decrease in pile capacity will occur, but not because of an increase in overburden stress. This concept is well documented in many foundation design textbooks and design manuals.

Critical depth may range from 10D to 40D (where D is the largest helix plate diameter), depending upon the relative density and position of the water table. FSI recommends critical depths of 20D to 30D be considered for design purposes. For example, if the helix plate depth is greater than an assumed critical depth of 20D, limit the vertical effective overburden stress at the helix plate to that value corresponding to the critical depth of 20D.

Please refer to the latest version of the FSI Technical Manual for additional information.



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CASE STUDIES

Model 150 Helical Anchors

Project: FSU Circus Tent ● **Location:** Tallahassee, FL
Foundation Supportworks® Dealer/Installer: Alpha Foundation Specialists

Challenge: Florida State University (FSU) claims to have the only tented collegiate circus in the world, having operated for over 60 years. The FSU Flying High Circus planned to replace their old tent with an 18,000 square-foot double cupola "Big Top" tent. The eight main columns near the center would be supported with shallow spread footings. The tops of the main columns would be interconnected with cables and then braced with guy wires and a tie-down system. The perimeter of the tent would be supported with small diameter steel pipe columns with the bottoms of the columns pinned to the concrete slab and the tops of the columns pulled/braced with ratchet straps to a tie-down system. The tent would remain constructed year-round. Six test borings identified sandy clay and fine sand fill soils within the top five to ten feet of the soil profile. Standard penetration test (SPT) blow count values within the fill varied widely from three to 34 blows per foot, with an average value of ten blows per foot. The fill was underlain by native sandy clay and clayey sand to the bottoms of the borings at 20 feet. SPT values within the native alluvial soils ranged from five to 20 blows per foot.

Solution: Helical anchors were selected to provide the tie-down support for the tent. Helical anchor capacity can be estimated by correlation to the installation torque and a relative soil strength profile can be generated by monitoring installation torque continuously. Both are considered benefits of helical anchors, especially for a site with variable fill soils. The tie-down system design included two helical anchor configurations to support design working loads of 2.7 to 6.6 kips (tension). Forty-five (45) Model 150 (1.5-inch round corner square bar) anchors with 10"-12" double-helix lead sections were installed to lengths of 14 feet to support the main columns. These anchors were installed vertically and at 45-degree angles, fitted with new construction brackets and cast into concrete pile caps. One hundred nine (109) Model 150 anchors with 12" single-helix lead sections were installed around the perimeter of the tent with lengths of seven feet. The lower-capacity perimeter anchors were installed at an angle of 45 degrees, matching the design angle of the ratchet tie-down straps. Ultimate anchor capacities determined by correlation to installation torque were generally greater than twice the design working loads. Tension load tests were completed on two non-production seven-foot long helical anchors. Ultimate capacities and deflections were acceptable for both of the anchors tested. The 154 helical anchors and two load tests were completed in only three days.

Commercial



New FSU Flying High Circus tent tied down with helical anchors



Connection detail for ratchet strap to helical anchor

Commercial



Vertical & battered helical piles installed



Limited working space

Model 288 Helical Piles

Project: Gaines Street Corridor Reconstruction ● **Location:** Tallahassee, FL
Foundation Supportworks® Dealer/Installer: Alpha Foundation Specialists

Challenge: The Gaines Street reconstruction project included widening of the road to handle increased traffic volumes. However, the presence of a large oak tree northwest of the intersection of Gaines Street and Bronough Street complicated the proposed construction. The City planned to save the existing tree which was located only ten feet from the edge of the planned widening. Due to the proximity of the tree and its large root ball to the planned work, a typical cantilevered retaining wall design was not feasible. A sloped excavation or an excavation to install a segmental block retaining wall with geogrid reinforcement would also cut too far into the roots of the tree. Other design and construction considerations for the work area included overhead electric and cable lines and underground gas and water.

Solution: The project structural engineers decided upon a poured concrete retaining wall design with helical piles providing vertical support as well as sliding and overturning resistance. Helical piles appeared to be an ideal solution given the limited working space and low overhead conditions. Due to lack of soil information for the project, Alpha Foundation Specialists installed test piles prior to final design of the foundation to determine the appropriate helical pile configuration and depth for the design loads. The retaining wall design included 46 Model 288 (2.875-inch OD by 0.276-inch wall) hollow round shaft helical piles with 10"-12" double-helix lead sections. All piles were specified to support design working loads of 25 kips in both tension and compression. Three pile load tests were completed on nonproduction helical piles. The first was a compression test (ASTM D1143) completed 20 feet from the proposed retaining wall. A pile head deflection of only 0.098 inch was measured at the design working load. Following the compression test, a tension test (ASTM D3689) was then completed on the same pile. Even with load reversal, the measured pile head deflection at the design working load was only 0.099 inch. The third load test was a compression test completed about five feet from the end of the proposed wall. Pile head deflection of 0.043 inch was measured at the design working load. Twenty-three (23) piles were installed vertically and 23 piles were installed at a 45 degree batter. The piles were advanced to provide an embedment depth of at least 14 feet to the uppermost helix plate. With installation torque values of at least 6,000 ft-lbs, torque-correlated ultimate capacities were at least 54 kips (FOS > 2). The 46 production piles were installed in two days.

Model 350 Helical Piles

Project: Joe's Crab Shack Repair ● **Location:** Fort Myers, FL
Foundation Supportworks® Dealer/Installer: N Square, Inc.

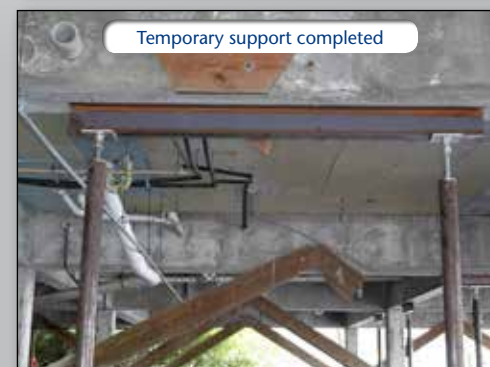
Challenge: Joe's Crab Shack, built in 1983, is a single story structure with approximate plan dimensions of 80 feet by 120 feet. The building extends from the shoreline over inlet waters on a combined foundation system. The area of the building over land is generally supported on round wood piers, wood beams and wood floor joists. The area of the building over water was constructed with precast concrete floor panels, concrete beams and twenty-two (22) 14-inch square precast concrete piles. Eleven (11) of these concrete piles were severely deteriorated with spalling concrete and corrosion of the reinforcing steel. The existing structure needed to be temporarily supported while these concrete piles were repaired. A single test boring was completed from the shoreline to a depth of 50 feet. A generalized subsurface profile consists of very loose to medium dense silty and clayey sand to 36 feet over stiff to very stiff sandy clay to the bottom of the boring.

Solution: The support solution had to be installed beneath the structure in limited access and low headroom conditions, and could not significantly affect or disturb the marine habitat and the operation of the restaurant. Helical piles appeared to be a practical solution given the difficult installation conditions. Helical piles could be installed with handheld equipment with little disruption to the surrounding area. The piles could also be removed following the repair work. Forge Engineering, Inc. consulted with the engineering staff at Foundation Supportworks® to develop an adjustable top detail for the piles so the vertical load from the structure could be easily applied and then removed. Components of FSU's SmartJack™ system, a supplemental crawlspace support system, were modified for the proposed pile shaft. The support system design included 29 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 10 kips per pile. Buckling of the piles had to be considered due to the exposed lengths and anticipated soft soil conditions at mud line. The helical piles were installed with handheld equipment to torque-correlated ultimate capacities of at least 20 kips (FOS ≥ 2). Pile lengths varied from 25 to 50 feet across the building footprint. The piles were installed and the support system completed in nine working days despite the difficult working conditions, high tides and occasional late summer storms.

Commercial



Joe's Crab Shack



Temporary support completed

Commercial



Advancing helical piers next to footing



Uniform seating load applied to the piers

Model 287 Helical Piers

Project: Westminster Bradenton Manor ● **Location:** Bradenton, FL
Foundation Supportworks® Dealer/Installer: LRE Ground Services, Inc.

Challenge: The Westminster Bradenton Manor was built in 1961. Planned renovation to the five-story, 250-foot long south wall of the building included a new stucco exterior with Mediterranean detailing, hurricane resistant windows and a new mansard roof feature. The entire façade would be removed and replaced to be compliant with current building codes. The renovation would generate additional loading to the existing wall footing. The design team was concerned that the new structural load, when transferred through the existing footing, would overstress the bearing soils and result in building settlement. The foundation design would include widening the existing spread footing to support a new reinforced concrete foundation wall and exterior wall framing. The new footing and foundation wall would be doveled into the existing footing and slab-on-grade. The existing footing would first be stabilized with a deep foundation to prevent settlement. Four borings completed for the geotechnical exploration encountered loose to medium dense sand from the surface to a depth of 13 feet. Standard penetration test N-values within the sand ranged from 4 to 19 blows per foot. Underlying the sand was a five to ten-foot thick layer of weathered limestone with N-values ranging from 26 to 100 blows per foot. Groundwater was encountered at depths of 6 to 8 feet below grade.

Solution: Helical piers were selected as the ideal deep foundation system for this project. Benefits of helical piers specific to this project include: helical piers can be installed with smaller equipment to minimize disturbance to the property, they are installed without vibrations induced to the structure, they can be installed through groundwater without the need for casing or pumping pre-drilled holes, and they can be installed relatively quickly with attachment to the footings with pre-manufactured retrofit foundation brackets. The foundation design included 54 Model 287 (2.875-inch OD by 0.203-inch wall) hollow round shaft helical piers with 8"-10" double-helix lead sections to support the design working load of 20 kips per pier. The piers were spaced at 4.5 feet center to center. The piers were installed to an average depth of 14 feet for bearing on or within the weathered limestone. With the retrofit brackets installed, hydraulic cylinders were connected to each pier and used to apply a uniform seating load. When complete, the retrofit brackets and the tops of the helical piers were encapsulated by the concrete of the new footing and foundation wall.