FOUNDATION NATION
FSI NEWSLETTER FOR DESIGN PROFESSIONALS

Design Considerations For Retrofit Helical Piers

Kyle Olson, P.E. • *Senior Structural Engineer*

Issue 8 (Summer 2011) of this newsletter presented three ways to predict helical pier capacity with respect to the soil; i.e., individual bearing, cylindrical shear and torque correlation methods. These methods are appropriate for both new construction and retrofit applications. Although soil capacity typically governs the design for new construction helical piers, the allowable mechanical capacity of the retrofit pier "system," which includes the pier, bracket and the concrete foundation, may govern in higher-strength soil conditions. The spanning capability of the footing and foundation wall between proposed retrofit pier locations should also be checked as this often limits pier spacing beneath unreinforced or lightly-reinforced foundations.

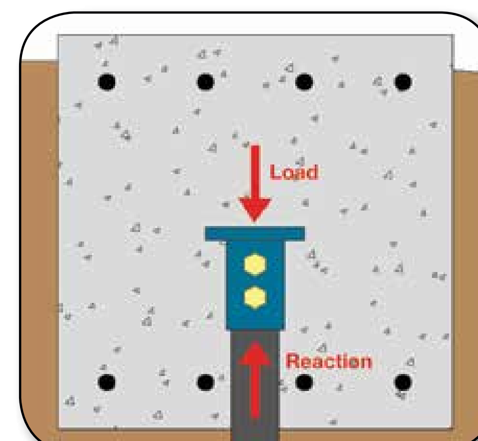


Figure 1: New Construction Piers are concentrically loaded.

New construction helical piers are generally designed to be concentrically loaded without inducing bending (Figure 1). New construction piers that are concentrically loaded will behave purely as columns and will be capable of supporting loads up to the maximum allowable mechanical capacity per AISC design methods. The maximum allowable mechanical capacity should consider the bracket capacity, the shaft and coupling capacity, and the helix plate capacity. The connection to the structure must also be designed appropriately with proper pier head embedment in the concrete, concrete strength, reinforcing steel, etc. Consideration of the maximum allowable mechanical capacity assumes that the soil is fully capable of supporting the load and that the shaft is laterally supported or braced along its entire length. In practice, the maximum allowable mechanical capacity of the pier is seldom achieved as the capacity is typically limited by soil strength.

Helical piers used in retrofit applications utilize side-load brackets directly adjacent to the structure (Figure 2). The pier shaft is not located directly under the footing or structural load. Therefore, retrofit piering systems are exposed to bending moments created by this eccentrically loaded condition and must be designed accordingly.

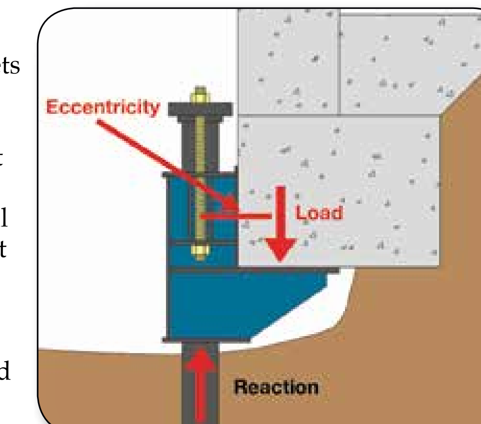


Figure 2: Retrofit Piers are eccentrically loaded.

Most helical piers installed in retrofit applications have outer dimensions of 3.5 inches or less. These sections are therefore very sensitive to bending, thereby reducing the capacity of the pier to carry axial load. The retrofit pier does not act as a pure column as in a new construction application, but rather as a beam-column that must resist both axial load and bending. Herein lies the problem. The pier shaft has quantifiable axial and bending capacities, and independent of the other, may be significant. However, when both of these forces interact on the same element, both the allowable compressive capacity and allowable bending capacity are reduced. In fact, according to AISC design methods, the allowable compressive capacity may be reduced by more than two-thirds for many typical pile sections when applying a bending moment generated by an eccentricity of only two inches.

Foundation Supportworks addresses the issue of retrofit helical pier eccentricities in one of two ways. The first is to increase the stiffness of the pier system itself, allowing it to resist more of the eccentricity. This is accomplished by incorporating an external sleeve to resist the bending forces. The external sleeve extends through and below the foundation

Continued on back . . .

Distribution Checklist

- ☐ ____________
- ☐ ____________
- ☐ ____________
- ☐ ____________
- ☐ ____________

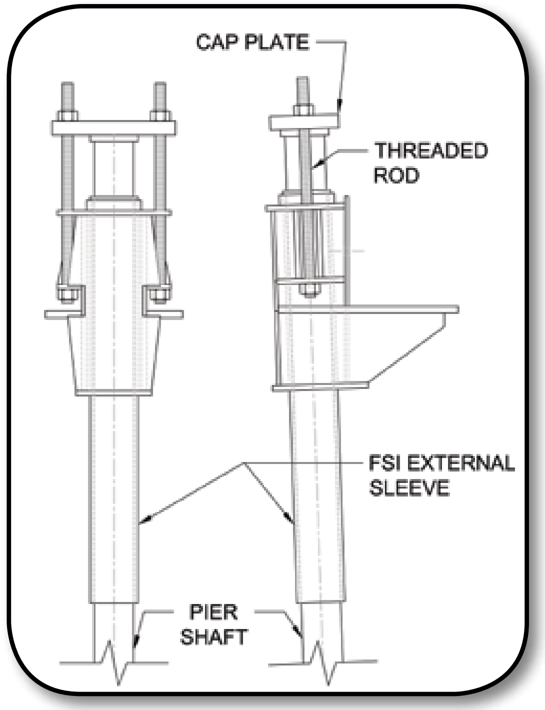


Figure 3: Retrofit Bracket Detail

bracket to essentially create a bracket that is 30 inches tall (Figure 3). Since the external sleeve and the pier shaft are confined by the earth, the bending moment dissipates quickly into the surrounding soils and generally within the first few feet (Figure 4). The depth at which the bending moment dissipates is a function of the soil strength and is greater in soft soils and less in stiff soils. With the external sleeve present to resist only bending forces, the column capacity of the pier is preserved to resist the axial compressive forces.

The second way to address retrofit helical pier eccentricities is to increase rigidity of the bracket connection to the foundation, allowing it to function more like a cantilever from the structure.

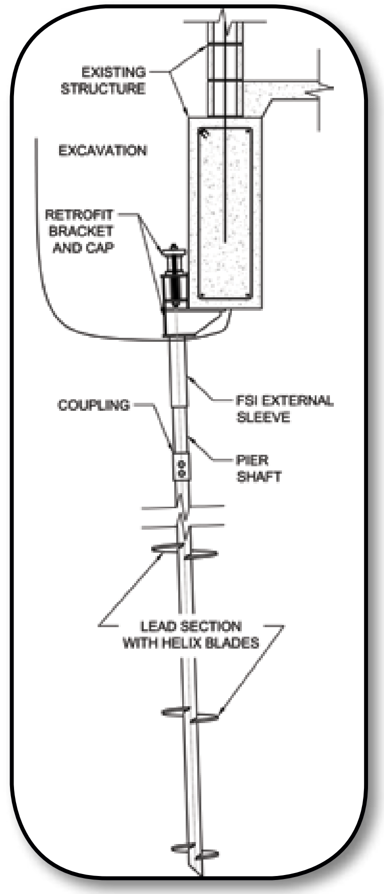
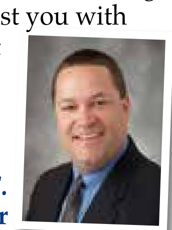


Figure 4: Retrofit Helical Pier Installation

With an adequately designed rigid connection, much of the eccentricity is therefore transferred back to the foundation. This connection detail typically consists of several strategically-located, deeply embedded adhesive anchors. For example, the FSI HP350B helical bracket is attached to a foundation with six (6) 5/8-inch adhesive anchors embedded seven (7) inches.

The four case studies in this newsletter highlight retrofit helical pier installations. A motel is stabilized to prevent further movement; apartments and an office/warehouse are stabilized and lifted back toward level; and columns at a school are temporarily supported during construction of new additions. Contact FSI or an FSI installing contractor to assist you with your next retrofit piering project.



Kyle Olson, P.E.
Senior Structural Engineer

FOUNDATION NATION
FSI NEWSLETTER FOR DESIGN PROFESSIONALS
Quarterly Newsletter • Issue 12
Summer 2012

Contact Information:
For more information about Foundation Supportworks® or to locate a Foundation Supportworks® dealer in your area, please visit our website at www.foundationsupportworks.com or call 800.281.8545.

Your local dealer:

CASE STUDIES

Helical Piers and Driven Slab Piers

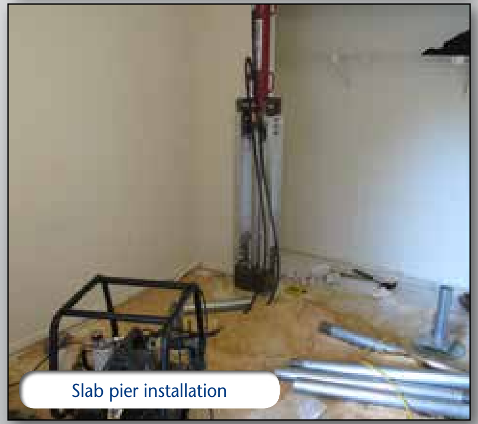
Commercial

Project: Oxford Manor Apartment Complex ● **Location:** Gainesville, FL
Foundation Supportworks® Dealer/Installer: Alpha Foundation Specialists, Inc.

Challenge: Eleven single-story, slab-on-grade buildings within the Oxford Manor Apartment Complex were experiencing settlement, evident by cracked and sloping floors, cracks in the drywall, and cracks within the brick and mortar veneer. Differential settlements within the buildings ranged from ¼-inch to eight inches. Cosmetic repairs were continuously being completed in order to make the units "presentable" for rent. Test borings encountered sand fill and medium dense clayey sand from the surface to depths of about five to eight feet. Plastic clays were sampled between the near-surface sands and the medium dense to very dense weathered limestone at 21 to 25 feet. Recent settlement of the buildings was likely prompted by drought-like conditions and drying and shrinking of the clay soils beneath the foundations and slabs. Large trees and bushes surrounding the buildings contributed to the movement by drawing moisture from the foundation soils.

Solution: The project geotechnical engineer recommended that the exterior foundations be supported with retrofit helical piers and the interior floor slabs be supported with hydraulically-driven "push" piers. The piers were to penetrate the upper clay soils for bearing within weathered limestone. Four hundred eight (408) Model 288 (2.875-inch OD by 0.276-inch wall) round shaft helical piers were installed along the foundations of the eleven buildings. The 8"-10" double-helix lead section was selected to support the design working load of 18 kips. The helical piers were installed to an average depth of 30 feet and to torque values of at least 4,000 ft-lbs, correlating to ultimate pier capacities of at least 36 kips (FOS ≥ 2). Two hundred eighty (280) Model 288 (2.875-inch OD by 0.165-inch wall) slab piers were installed to an average depth of 25 feet and an average ultimate capacity of 12 kips. Design working loads for the slab piers were generally less than five kips. The slab piers were generally installed in a grid pattern with a spacing of five feet. Following lifting operations of the floor slabs, void space was filled with cement grout injected at low pressure. Due to previous cosmetic repairs that were completed, the foundations were generally lifted less than one inch. The foundations for one building were lifted as much as four inches to recover some of the measured eight inches of differential settlement.


Helical pier installation


Slab pier installation

Model 288 Helical Piers

Commercial


Advancing helical piers adjacent to existing column footings


Hydraulic cylinders to apply load to the piers

Project: Abraham Lincoln High School Addition ● **Location:** Council Bluffs, IA
Foundation Supportworks® Dealer/Installer: Foundation Supportworks® by Thrasher

Challenge: The Abraham Lincoln High School was built in 1960 with construction consisting of poured concrete foundations, steel framing and masonry block walls. A renovation and three additions were planned. With the planned additions, excavations would be made around and below four existing exterior column footings for utility installation and placement of new wall footings. These columns would therefore require temporary support during construction to prevent settlement/movement of the columns and damage to the existing structure.

Test borings completed for the project extended to depths of 15 to 25 feet and encountered lean clay fill to depths of 4 to 19 feet over native lean clay and silt (Peoria loess). The consistency of the native soils was described as firm to hard. Groundwater was not encountered in the test borings.

Solution: Helical piers were selected to provide temporary support for the four columns. The design included 16 piers, four on each column, and each pier to support a design working load of 20 kips. The helical pier configuration consisted of 2.875-inch OD by 0.276-inch wall hollow round shaft with 10"-12"-14" triple-helix lead sections. With their past experience installing helical piers within and through the silty Peoria loess, Foundation Supportworks® by Thrasher anticipated pier depths greater than the depths of the soil borings. The piers were advanced to average depths of 33 feet in order to generate installation torques correlating to ultimate pier capacities of at least 40 kips (FOS ≥ 2). Retrofit brackets were set and the design loads were applied to the piers with hydraulic cylinders.

Model 350 Helical Piers

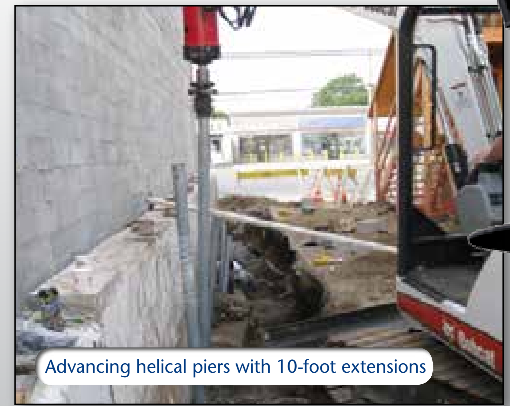
Commercial

Project: Surfside Motel ● **Location:** Howard Beach, NY
Foundation Supportworks® Dealer/Installer: Foundation Supportworks® Northeast

Challenge: The Surfside Motel was originally constructed in the mid-1950's on a foundation supported on timber piles. The building is located adjacent to an ocean inland waterway. New construction on a neighboring property included a sheet pile wall installation adjacent to the Surfside Motel's end wall. This end wall is a support wall spanning an opening in the motel to allow vehicle access to a back parking lot. After the sheet pile wall was installed, the neighboring property was dewatered to allow for excavations to proceed. Reportedly, the dewatering process effectively lowered the groundwater table and caused the end wall of the Surfside Motel to settle. Deflection of the sheet pile wall may have also contributed to the end wall movement. Square bar retrofit helical piers were quickly installed in the hopes of stabilizing the wall from further movement. Upon completion of this repair, creep movement continued until work on the adjacent site was completed.

In the fall of 2010, the owner of the Surfside Motel began a renovation project, which included the construction of an additional third floor level. The original foundation design of the building theoretically allowed for the additional floor to be added. However, the design consultants and owners were concerned whether the end wall could handle additional loads considering the past history of movement. With the building on the neighboring property just a few feet from this end wall, load tests or other evaluations of the existing foundation did not appear feasible. They instead decided to install additional retrofit helical piers along the wall to ultimate design capacities of 60 kips per pile.

Solution: The retrofit pier design included 11 Model 350 (3.5-inch OD by 0.313-inch wall) helical piers. The new helical pier configuration consisted of 10"-12"-14"-14" quad-helix blade, ten-foot long lead sections. Meticulous site layout was required as the new helical piers would be installed between the existing square bar helical piers and the original timber piles. The leads were installed at a slight angle to allow for the uppermost 14-inch helix blade to extend past the bottom edge of the footing. Once the lead was installed, extensions were added to advance the piers to an average depth of 24.5 feet. The piers were installed to torque-rated ultimate capacities ranging from 60 to 64 kips. Foundation Supportworks® Northeast installed the 11 retrofit helical piers in two days.


Advancing helical piers with 10-foot extensions


Completed pier installation - west end

New Construction & Retrofit Helical Piers

Commercial


Helical pile installation in low overhead conditions

Retrofit pile systems used to re-level structure


BEFORE AFTER

Project: BH Construction ● **Location:** Charles City, VA
Foundation Supportworks® Dealer/Installer: JES Construction, Inc.

Challenge: BH Construction began construction of a new 5,400 sq. ft. office and warehouse to serve as the company's new headquarters. The new building is a wood-framed, metal-sided structure supported by wood columns. Signs of settlement were observed soon after construction started, evident by racked windows, buckled siding and distress in the roof. Settlement up to four inches was measured. The general subsurface profile, determined from three test borings to depths of 40 feet, consisted of sandy and clayey fill soils to depths of 13.5 to 17.5 feet over native sand with isolated clay layers. A drainage swale was reportedly filled in to develop the property. The fill soils were variable in strength with standard penetration test blow count values (N-values) ranging from 4 to 16 blows per foot. The native sands were generally medium dense (N = 10 to 19 bl/ft) above 30 feet and medium dense to dense (N = 16 to 40 bl/ft) below 30 feet. The clay layers were described as stiff to very stiff in consistency.

Solution: The structural settlement was caused by consolidation of the loosely placed fill. One hundred fifty-two (152) helical piers with retrofit brackets were installed to re-support the existing building by extending through the fill to bear within the native medium dense to dense sands or stiff to very stiff clay. The retrofit pier system consisted of the Model 287 (2.875-inch OD by 0.203-inch wall) hollow round shaft with 8"-10"-12" triple-helix lead sections to support a design working load of 15 kips. The retrofit piers were installed to torque-correlated ultimate capacities of at least 30 kips to provide factors of safety (FOS) ≥ 2.0. Hydraulic cylinders were used to lift the foundations to near the original, pre-settlement elevations. Since the concrete floor had not yet been poured, a new structural slab was proposed. The structural slab was supported on 82 new construction helical piers spaced at eight feet center to center in a grid pattern. The helical piers supporting the structural slab consisted of the Model 287 hollow round shaft with 10"-12" double-helix lead sections to support a design working load of 10 kips. The piers were installed to torque-correlated ultimate capacities of at least 20 kips to again provide FOS ≥ 2.0. The retrofit and new construction piers were installed to depths (below bracket bearing elevation) ranging from 22 to 40 feet.