FOUNDATION NATION
FSI NEWSLETTER FOR DESIGN PROFESSIONALS

An Introduction to Retrofit Push Piers

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

Design professionals are becoming confident with utilizing helical piers on their retrofit foundation stabilization or repair projects. There is, however, another solution that can often achieve similar results. For certain projects, "push piers" (occasionally referred to as "resistance piers"), may offer a more practical solution for areas of even tighter access. Push piers can also commonly be more economical in many soil profiles.

What is a Push Pier?

As the name suggests, push piers have a blunt end and are simply "pushed" into the ground until a suitable bearing stratum is reached (Figure 1). They are not to be confused with driven piles that utilize the impact of a falling hammer. Push piers are assembled from three foot pier segments that couple together and utilize hydraulics to advance them into the ground at a steady rate, usually between three to five feet per minute. Push piers are strictly intended for retrofit applications since in order for the hydraulics to push down against the pier, the system needs to push up against an object substantial enough to provide a sufficient reaction. The existing structure is what provides this reaction.

At the top of the pier, the difference between a push pier and a retrofit helical pier will be difficult to distinguish. Both types of systems utilize side load brackets that are placed directly adjacent to the structure and are eccentrically loaded. Issue 12 (Summer 2012) of this newsletter presented some design considerations for retrofit helical piers and some of the unique ways that Foundation Supportworks® addresses these challenges. That article promoted the use of a reinforcement mechanism that Foundation Supportworks® refers to as an external sleeve. These same considerations also apply to push pier systems and they, therefore, also utilize an external sleeve, although a push pier sleeve is typically 48 inches long as opposed to the 30-inch variety most often used with retrofit helical piers.

One significant advantage that push piers have is their ability to penetrate various layers and strengths of soil to achieve great depths. An important feature that makes this possible is called a friction reducing collar which is simply a ring that is welded to the first pier segment (Figure 1). This slightly enlarged end creates a small annular space around the pier shaft that can dramatically reduce skin friction as the pier is advanced through the soil. This results in a pier that generates most of its capacity in end bearing. Over time, the soils surrounding the pier will relax and heal back against the pier shaft and provide an additional skin frictional component to the pier's capacity. This can begin to happen in a matter of hours or days. This frictional resistance in some cases can be significant, but since it is impossible to quantify and is highly variable between jobsites, it is conservatively neglected in the determination of the pier's factor of safety against pier settlement.

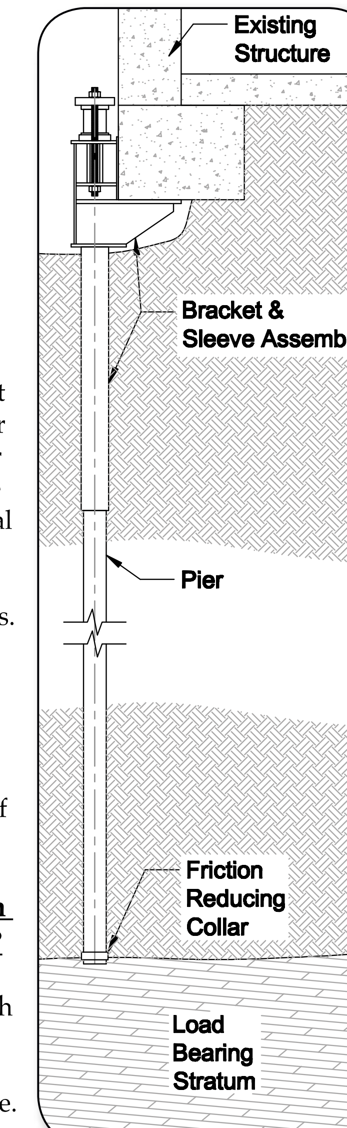

Figure 1

When should I consider push piers over retrofit helical piers?

Helical piers are installed through the application of torque and their capacity is directly related to the level of torque that they can achieve. We often say that a helical pier needs more steel to get itself into the ground than it needs to resist the axial loads it will experience once

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Distribution Checklist

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the pier is in service. Push piers do not have to resist torque and therefore utilize thinner-walled pipe than their helical counterparts of similar diameters. This is also one reason that a push pier benefits from having a longer external sleeve. At similar pier depths, the thin-walled push pier will have lower material costs. It's important to understand, however, that a push pier will tend to achieve greater depth than a helical pier but most often the push pier remains more economical. An evaluation should be done for each site to determine if the difference in depth can be significant enough to eliminate the push pier's economical advantage.

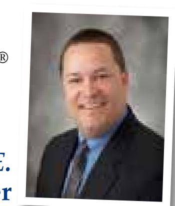
One particular circumstance where push piers have a distinct advantage is when a highly compressible soil layer has been identified below a layer of material that has much higher strength and density such as an engineered fill. A helical pier will tend to develop its torque in the denser material. A push pier will have much more success in penetrating through the dense layer and beyond the compressible material to develop its resistance from below the problem soils.

Factor of Safety

Push piers develop a factor of safety against pier settlement by utilizing a larger force to drive the piers into the ground than is used to lift the structure. A common concern for individuals first becoming familiar with push piers has to do the feasibility of developing the larger drive forces since a structure cannot provide a reaction beyond its own weight. Although this is true, these concerns are soon dismissed once more is learned about the sequence of the installation. Push piers are advanced one at a time and are therefore gathering their reaction from a larger tributary area of the structure during installation. After all of the individual installations, the piers are connected hydraulically in series to be re-loaded to stabilize or lift the structure. The combined resistance of all of the piers working together allows the structure to be lifted at loads much lower than the piers experienced during installation. Typical minimum specified factors of safety commonly range from 1.5 to 2.0, but in the field, observed factors of safety can be as high as 3.0. Because of this relationship between installation forces and lift forces, it's common to promote push piers by stating that each pier is essentially load tested during installation.

Hydraulic cylinder installing a 2-7/8 inch push pier.

Foundation Supportworks® has push pier products with diameters of 2-7/8, 3-1/2, and 4 inches and can achieve allowable capacities up to 44,000 pounds per pier. The two case studies in this newsletter highlight push pier installations that had some unique challenges. Contact Foundation Supportworks® or a local Foundation Supportworks® installing contractor to assist you with your next potential push pier project.



Kyle Olson, P.E.
Senior Structural Engineer

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FOUNDATION NATION™
FSI NEWSLETTER FOR DESIGN PROFESSIONALS
Quarterly Newsletter • Issue 15
Spring 2013

Contact Information:
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FOUNDATION SUPPORTWORKS

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CASE STUDIES

Model 350 Push Piers

Commercial

Project: Leavenworth Lofts ● **Location:** Omaha, NE
Foundation Supportworks® Dealer/Installer: Foundation Supportworks® by Thrasher

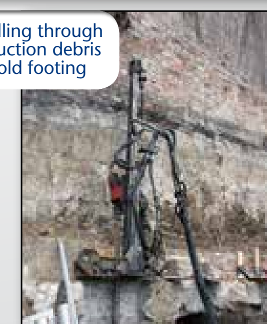
Challenge: A building was razed southwest of the intersection of Leavenworth Street and 14th Street for the construction of a new apartment building. Removal of the structure exposed the east exterior basement level wall of the Leavenworth Lofts, a five-story (plus basement) office/warehouse building constructed in 1915 and recently renovated to living space. The two structures were built right up to the common property line such that the exterior walls were in contact. After removal of most of the foundation wall of the other building, a one and one-half inch wide separation was observed in the brick wall of the Lofts over a length of 60 feet. Any additional length of crack extending to the north of that exposed was covered by foundation wall remnants on the exterior and plywood panels and electric meters on the interior. Based on the cracking pattern, it was estimated that approximately 80 feet of a middle section of the wall had settled. The crack extended completely through the two-foot two-inch wide multi-wythe brick wall. The settled section of the basement wall of the Lofts needed to be stabilized before the last section of foundation wall remnants could be removed and construction could begin on the new apartment building. The closest test boring completed for the new apartment building encountered fill soils to a depth of 13 feet, soft to stiff lean clay and loose sand to a depth of 38 feet, and stiff to hard sandy lean clay (glacial till) to the bottom of the boring at 65.5 feet.

Solution: The structural engineer recommended hydraulically-driven push piers to stabilize the settled section of wall. Push pier systems can achieve relatively high capacities with the versatility to be installed in limited access areas like the basement of the Lofts. The design included 36 Model 350 (3.5-inch OD by 0.165-inch wall) hydraulically driven push piers paired on opposite sides of the wall and spaced at four feet center to center. Each pier was to achieve a design working load of 32 kips. The crack in the brick wall was tuck-pointed and the mortar allowed to cure before installing piers. The first phase of pier installation stabilized the southern length of the settled section of wall. With the first phase complete, the general contractor removed the remaining sections of foundation wall. The 18 pier locations on the exterior of the Lofts required pre-drilling to a depth of ten to 15 feet to allow the push piers to penetrate the old footing and construction debris in the fill soils. The 36 piers were installed to an average depth of 44 feet below the bottom of the footing to bear within the glacial till. The piers were driven to loads exceeding 1.5 times the design working load and then filled with concrete. At the end of the second phase, the 36 piers were fitted with hydraulic cylinders connected in series and reloaded to 32 kips to ensure uniform loading on each pier.

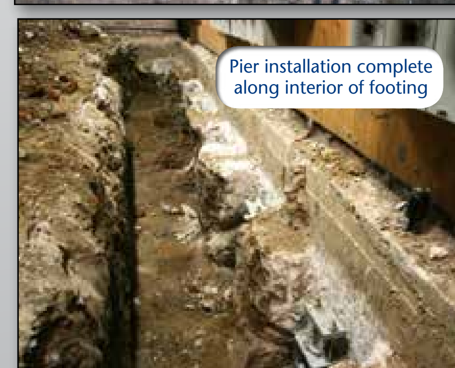
Project Summary

(36) Foundation Supportworks® Model 350 Push Piers, Installed to an Average Depth of 44 feet Below Bottom of Existing Footing, Design Working Loads of 32 kips

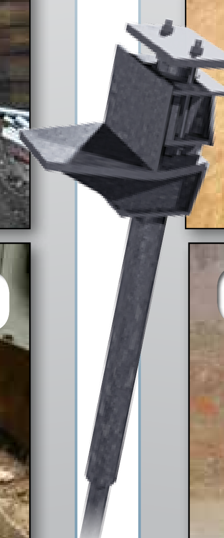

East wall of Leavenworth Lofts; foundation wall remnants in bottom right corner


Pre-drilling through construction debris and old footing


Driving 3.5-inch O.D. piers


Pier installation complete along interior of footing

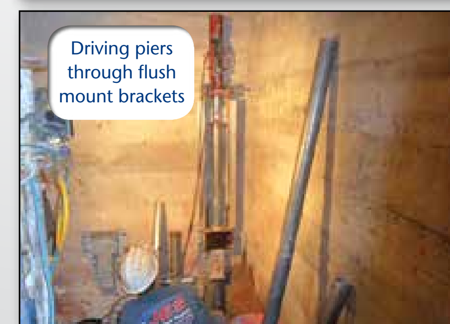

Interior and exterior pier installation complete; applying uniform load to each pier with hydraulic cylinders

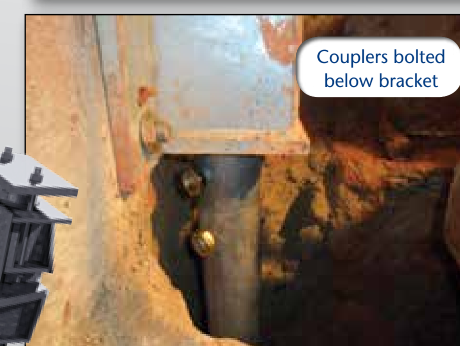


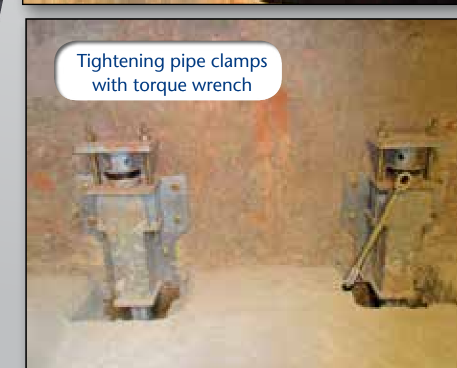
Model 288 Push Piers (Modified)

Commercial


Working conditions within crawl space


Driving piers through flush mount brackets


Couplers bolted below bracket


Tightening pipe clamps with torque wrench


One area of completed project; new concrete floor poured

Project: Browne Education Campus ● **Location:** Washington, D.C.
Foundation Supportworks® Dealer/Installer: JES Construction, Inc.

Challenge: The original school building and gymnasium on the Browne Education Campus were constructed around 1920. The north and west walls of the gymnasium were experiencing differential movements, evident by cracks in the poured concrete foundation walls and cracks and separations in the interior and exterior brickwork. It was reported that a water main leak had occurred near the area of observed distress in the north wall. Test borings completed north of the north wall of the gymnasium encountered sand, silt and lean clay fill to depths of five to 8.5 feet over plastic (fat) clay to the maximum completed depths of 50 feet. A boring off the southwest corner of the gymnasium sampled fat clay from the surface to 30 feet. Excess water from the water main leak likely weakened some of the foundation soils, resulting in building settlement. Fat clay soils also experience volume changes with changes in moisture content; i.e., they will swell when wetted and shrink when dried. Some of the building movement and distress was also likely the result of seasonal wet/dry cycles of the foundation soils. The active zone for seasonal moisture variations for the clay soils in this area is believed to be seven to eight feet below the ground surface. Stabilizing the structure with traditional concrete underpinning was ruled out because of existing utilities, limited working space and shoring required for deep excavations. A deep foundation was proposed to be installed within the crawl space beneath the gymnasium floor. Helical piles could provide resistance to the design compression and tension loads for the project, but would be difficult to install within areas of limited access and head room.

Solution: A test push pier with the standard Model 288 system was installed to evaluate drive loads and anticipated pier depths. A modified hydraulically-driven push pier system was then proposed to support the design working loads of 31 kips in compression and seven to 11 kips in tension. The uplift capacity and some of the compression capacity of the pier were calculated using side/skin friction of the pier shaft within the native soils below the active zone. The push pier tube was fabricated from FSI Model 287 helical pile shaft material (2.875-inch OD by 0.203-inch wall) with specially designed bolted couplers. Holes were cored through the 12-inch thick concrete footing at center to center spacings of three feet. Flush-mount brackets were attached to the poured concrete perimeter foundation walls with adhesive anchors. As the pier sections were advanced through the bracket, one 0.75-inch bolt was installed on each side of the coupler. The 39 piers were advanced to achieve the specified minimum depth of 30 feet and the specified minimum drive load of 48 kips. Actual depths ranged from 30 to 45 feet. Pipe clamps were placed at the tops of the piers above the brackets to resist the tension loads.

Project Summary

(39) Foundation Supportworks® Model 288 Push Piers (Modified), Installed to Depths of 30 to 45 feet, Design Working Loads of 31 kips (Compression) and 7 to 11 kips (Tension)