

The ultimate pile capacity is then typically divided by a factor of safety of 2.0 to determine the allowable capacity. Lower



Figure 3: Torsion testing of shaft and helix plate

factors of safety may be considered for non-critical structures or temporary applications. Higher factors of safety may be considered for critical structures, for structures particularly sensitive to movement, where soil conditions suggest that creep movement may be a concern, or when soil conditions are not clearly defined.

In side-load retrofit applications, the Model 288 helical pile system has an allowable mechanical capacity of 29,000 pounds. For these cases, the designer would select the lowest of the allowable mechanical capacity, the allowable torque-rated capacity, or the allowable calculated soil capacity by the individual bearing method or cylindrical shear method (See the FSI Technical



Figure 4: Side-load retrofit system against block of concrete



Figure 5: Full-scale field tension test

respectively. Submitting for and receiving evaluation reports speaks of a certain level of manufacturer competency in design, fabrication and quality control measures. Ultimately, knowing that certain manufacturers design and test their products in accordance with accepted standards provides peace of mind to specifying engineers, architects and contractors that the products can achieve the claimed capacities.

There are dozens of small shops throughout the United States and Canada that claim to manufacture helical piles. However, to date, only five helical pile manufacturers, including Foundation Supportworks®, have submitted product design information and test results to the ICC-ES for product evaluation. Three have submitted to the CCMC.

Manual for more information). Evaluation reports through the CCMC and the ICC-ES provide recognition of products that are code-compliant with either the Canadian National Building Code or the International Building Code,



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FSI RECEIVES EVALUATION REPORT From CCMC

Jeff Kortan, P.E. • Director of Engineering

On November 7, 2011, Foundation Supportworks®, Inc. received an evaluation report through the Canadian Construction Materials Centre (CCMC) for “Foundation Supportworks® Helical Foundation Systems and Devices” (See Figure 1). FSI’s Model 288 (2.875-inch OD by 0.276-inch wall) helical pile system is the first of FSI’s growing helical product line to be submitted for CCMC evaluation. Canadian contractors within the FSI network use the Model 288 system more than any of the other available shaft sizes. FSI currently offers 1.5-inch and 1.75-inch square bar and 2.875-inch to 4.5-inch OD round shaft options. These products are considered “in-stock” items, with larger shaft sizes available upon request for special projects. Within Evaluation Report 13556-R, the CCMC provides the opinion that the Model 288 system, when used in accordance with the conditions and limitations stated in the report, complies with the Canadian

National Building Code 2010. The CCMC acknowledged that design and testing guidelines already existed for helical foundation systems. In June 2007, the International Code Council Evaluation Service, LLC (ICC-ES) approved AC358, Acceptance Criteria for Helical Foundation Systems and Devices. The ICC-ES, along with a committee of helical pile manufacturers, wrote AC358 to provide standards for how helical foundation systems should be designed and tested to determine conservative, yet appropriate system capacities. Interested parties can download a free copy of AC358 from www.icc-es.org.



Figure 2: Torsion testing of shaft and coupling



Figure 1: Evaluation Report CCMC 13556-R

Product testing was completed at independent laboratories recognized by the CCMC. Foundation Supportworks® then submitted design calculations, test results and other supplemental information for product evaluation. See Figures 2 through 5 for photos of some of the product testing. It has long been understood that the compression and tension capacities of smaller-shaft helical piles can be related to the installation torque. The Model 288 has an ultimate torque-rated capacity of 71,000 pounds (316 kN) based on the equation:

$$Q = K_t \times T$$

Where,
 Q = Ultimate Pile Capacity (lb or kN)
 K_t = Default Torque Correlation Factor for 2.875-inch OD Shaft (9 ft⁻¹ or 29.5 m⁻¹)
 T = Maximum Rated Installation Torque for Model 288 Shaft (7,900 ft-lb or 10,711 N-m)

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CASE STUDIES

New Construction Helical Piles

Project: Maryhill Manor Additions ● **Location:** Enderlin, ND
Foundation Supportworks® Dealer/Installer: Innovative Foundation Supportworks®

Challenge: Maryhill Manor is a long-term care facility that provides 24-hour nursing and personal care services. The project included two major building additions to the north and east of the existing single-story, slab-on-grade structure. The geotechnical exploration included nine test borings completed to depths up to 51 feet. The soils within the upper approximate 14 feet of the profile were described as sandy and clayey fill, very loose to loose sand, soft to medium stiff clay and topsoil/swamp organic deposits. Medium dense sand and gravel was encountered between about 14 feet and 21 feet over very stiff to hard sandy lean clay (glacial till) to the bottoms of the test borings. Groundwater was observed at depths ranging from six to eight feet. Support of the additions on shallow spread footings was considered, but then dismissed due to the presence of the highly variable, undocumented fill soils and the weak native soils. In order to minimize anticipated structural settlements, the foundations and floor slabs of the additions were planned with support on deep piles penetrating these upper soils.

Solution: Designs for the foundations and structural slabs included a total of 80 Model 288 (2.875-inch OD by 0.276-inch wall) and Model 349 (3.5-inch OD by 0.300-inch wall) hollow round shaft helical piles. With design working loads ranging from 10 kips to 45 kips, helix plate configurations varied from double 8"-10" lead sections to triple 10"-12"-14" leads followed by a single 14" plate on the first extension. Model 288 helical piles were utilized to support design working loads up to 35 kips and the Model 349 helical piles were utilized to support the design working loads of 40 and 45 kips. Two pile load tests were completed, one in each area of the two major additions. In each area, the HP349 shaft with the quad-helix plate configuration was tested. Net deflections, total head movement minus elastic compression, of the test piles were 0.06-inch and 0.38-inch at the design working load of 45 kips. These measured deflections were less than the specified maximum net deflection of 0.5-inch. The test piles and the production piles were advanced to depths of 18 to 29 feet below the proposed finish floor elevations to bear within the medium dense sand and gravel or the very stiff to hard glacial till. The helical piles were installed to torque-correlated ultimate capacities of at least twice the design working loads (FOS ≥ 2). Load testing and production pile installation were completed in two phases, but were finished within a total of only eight days.

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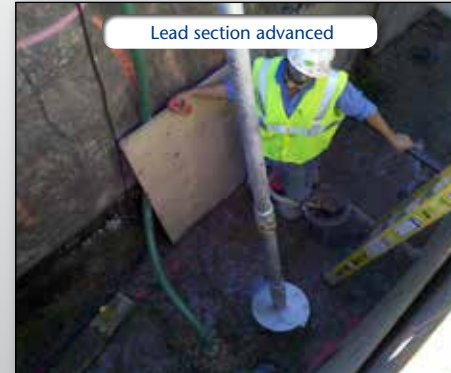


Load frame centered over pile



Completed pile installation

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Lead section advanced



Pile installation complete

Model 288 Helical Piles

Project: Blount Street Substation ● **Location:** Madison, WI
Foundation Supportworks® Dealer/Installer: Foundation Supportworks® of Wisconsin

Challenge: The Blount Street Substation project included the installation of a new underground transmission line. Upon completion of the new underground line, an existing high-voltage overhead line would be decommissioned. The work included installation of 1) a poured concrete thrust block to encase an 8-inch diameter cable pipe and 2) a poured concrete spread footing to support new superstructure. While excavating for the 9-foot deep thrust block, the contractor uncovered soft, wet peat soils. A geotechnical investigation then included one soil boring advanced to a depth of 21.5 feet. The soil profile was described as loose to very loose silty sand fill from the surface to a depth of 9 feet, very loose clayey silt from 9 to 13 feet and soft to medium stiff silty clay from 13 feet to the bottom of the boring at 21.5 feet. Standard Penetration Test (SPT) blow count values throughout the explored profile ranged from "Hammer Weight" to 5 blows per foot. The thrust block and spread footing were redesigned with deep foundation support. The thrust block redesign required four piles with ultimate compressive capacities of 17 kips/pile. The spread footing (pile cap) redesign required three piles with ultimate compressive capacities of 43 kips/pile and ultimate tensile capacities of 34 kips/pile. The piles would be installed below overhead transmission lines carrying 69,000 volts and 137,000 volts of electricity. Although several deep foundation systems were considered, helical piles were selected as the ideal option given the extreme limited access and the ability to quickly mobilize equipment and product to the job site. Helical piles were to extend to depths necessary to provide torque-correlated ultimate capacities exceeding the design loads.

Solution: Seven Model 288 (2 7/8-inch OD by 0.276-inch wall) round shaft helical piles were installed with 10"-12"-14" triple-helix lead sections. Four helical piles were installed in the 9-foot deep thrust block pit to an average length of 28 feet and an average torque-correlated ultimate capacity of 24.3 kips. Three piles were installed in the pile cap at a 6V:1H batter angle to allow for proper spacing at the anticipated depth of the helix plates. The three piles were installed to an average length of 44 feet and an average torque-correlated ultimate capacity (compression and tension) of 64 kips. Foundation Supportworks® of Wisconsin installed the seven piles in one day.

Model 288 Helical Piles

Project: Tyson Foods ● **Location:** Dakota City, NE
Foundation Supportworks® Dealer/Installer: Foundation Supportworks® by Thrasher

Challenge: A two-story building addition with a partial basement was planned at the existing Tyson Foods facility. The addition had approximate plan dimensions of 60 feet by 90 feet. Construction details included steel framing and precast concrete panels with wall loads on the order of 8 kips per linear foot. The project area was surrounded by existing structures to the north, east and south and a railroad spur to the west. The processing plant is located within the alluvial plain of the Missouri River. Sub-surface conditions at the site were determined with four test borings completed to depths ranging from 20 to 70 feet. Groundwater was encountered at depths ranging from 35 to 40 feet. A generalized subsurface profile consists of fill soils over weak clays and silts over loose to dense sand to the bottoms of the borings. The fill varied from clay to sand to crushed gravel and extended to depths of 7 to 15 feet below the surface. The weak alluvial clays and silts extended to depths of 30 to 35 feet.

Solution: The design team considered options of over-excavation with soil replacement, auger-cast piles and helical piles to provide support for the new addition. The over-excavation and backfill option was quickly dismissed due to the depth of excavation necessary and the risk of undermining existing foundations. Limited access to and within the project area, as well as overhead obstacles including power lines, piping and conveyor systems would hinder installation of auger-cast piles. Helical piles were selected as the ideal foundation support option given the smaller installation equipment required. This equipment could easily maneuver within the limited area and also below or around the overhead obstacles.

The foundation design included 89 Foundation Supportworks® Model 288 helical piles. The pile configuration consisted of 2.875-inch OD by 0.276-inch wall hollow round shaft with 10"-12"-14" triple-helix lead sections. Due to soil variability across the site, 14"-14" double-helix extensions were added to minimize installation depths. The piles were installed to depths ranging from 33 to 65 feet, with an average depth of 53 feet. Ultimate pile capacities determined by correlation to installation torque, were at least 70 kips (FOS ≥ 2).

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Helical piles advanced



Grade beam excavation with helical piles

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Advancing helical pile



Setting cap plate on the retrofit bracket assembly

New Construction & Retrofit Helical Piles

Project: Boulder Rural Fire Station ● **Location:** Boulder, CO
Foundation Supportworks® Dealer/Installer: Complete Basement Systems

Challenge: The Boulder Rural Fire Department planned to renovate an older office building to serve as a fire station. The project included construction of a new stair tower and building addition, as well as remodeling the interior of the existing structure. New foundations were needed to support the addition. The addition and renovation also created new loads on existing grade beams. The existing office building was supported on drilled concrete piers. Two test borings were completed to depths of 30 and 35 feet. A generalized subsurface profile consisted of three feet of sandy clay fill over 20 to 23 feet of silty, sandy clay over claystone bedrock. The existing fill soils and the deeper sandy clay were determined to be unsuitable to support the new foundation loads. Even though the silty, sandy clay was described as having a relatively low expansive potential, layers of moderately expansive clay soils could exist within this stratum. The silty, sandy clay was also relatively weak near the encountered groundwater depth of six feet.

Solution: Foundation recommendations in the geotechnical report included drilled concrete piers with helical piles as an alternative foundation type. Helical piles were ultimately selected as the more economical solution due to the high groundwater table and the anticipated need for casing of the drilled concrete piers. Three new construction helical piles and five retrofit helical piles were proposed to support design working loads ranging from 15 to 25 kips. The five retrofit piles would support new loads on the existing grade beam and drilled pier foundation system. The uppermost helix plate along the pile shaft was specified at a depth of at least 20 feet. The new construction and retrofit helical piles consisted of the Model 288 (2.875" OD by 0.276" wall) hollow round shaft with 10"-12" double-helix lead sections. The piles were installed to depths of 25 feet and to torque values correlating to ultimate pile capacities of at least twice the design working loads (FOS ≥ 2). The retrofit bracket assemblies included external sleeves around the pile shaft to resist the bending forces generated by the side-load condition. The eight helical piles were installed in one day despite snowy conditions, low temperatures (12° F) and dealing with groundwater within excavations.