



**INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS  
UNIFORM EVALUATION SERVICES**

**EVALUATION CRITERIA FOR**

**HELICAL PILES FOR USE UNDER THE IRC**

**EC 027-2017  
(Adopted \_\_\_\_ 2017)**

**1.0 INTRODUCTION**

Helical piles are widely used in residential construction regulated under the IRC as foundation elements to transfer loads from new and existing buildings to the ground below. These foundation elements are installed to support residential structures, additions to residential structures, and ancillary and accessory structures such as sheds, decks, and porches.

- 1.1 Purpose:** The intent of this criteria is to provide an acceptable path to justify recognition of helical piles in evaluation reports reviewed and issued by an independent evaluation agency as an alternative to the IRC prescriptive foundation and footing requirements. This criteria provide for determination of the support capacity of helical piles in residential applications when supplemental geotechnical evaluation is available, and for increased safety factor adjustments when no evaluation is available. In either case, a registered design professional shall review the relevant information and determine safe bearing values for the helical piles using appropriate safety factors. When supplemental geotechnical information is considered in the design, the higher degree of certainty of sub-surface conditions allow for higher loading to be assigned to each pile. When supplemental geotechnical evaluation is not available, a degree of certainty is still available for bearing capacity determination, but in this case a higher safety factor may be appropriate. In both cases, soil bearing data that is based on the correlation between installation torque and bearing capacity, is acquired by the installation technician, analyzed by a design professional, and provided to the building official for approval.

Helical piles may be considered by building officials, in accordance with IRC Sections R403.1 and R104.11, as other approved structural systems for use as foundations to support exterior walls and loads determined in accordance with IRC Section R301, and to transmit these loads to the ground. Building officials may approve helical piles based on test data, calculations, and other documentation, such as evaluation reports, relating to their load carrying capacity.

- 1.2 Scope:** This evaluation criteria applies to helical piles used in residential occupancies built under the 2015, 2012, and 2009 International Residential Codes for recognition in an evaluation report issued by an approved evaluation agency accredited in accordance with ISO/IEC 17065. The foundation systems under this criteria are limited to vertical helical piles subject to maximum 30 kips (133 kN) allowable axial loading and are limited to use in Seismic Design Categories A, B, and C. The allowable lateral load resistance capacity of helical piles shall be determined by a registered design professional in a manner acceptable to the building official.

- 1.3 Definitions:** For terms not defined in this section, applicable codes, or referenced standards shall have the ordinary accepted definition for the context for which they are intended.

**1.3.1 Helical Pile Foundation (HPF):** A factory-manufactured steel foundation that consists of a steel shaft, single or multiple steel helices (e.g. bearing plates), and a steel cap or bracket that connects the shaft to the structure above. Each bearing plate is pitched into a screw thread pattern. The HPF may or may not have shaft extensions and manufactured shaft

couplings that connect individual shaft sections together. HPF's are rotated into the ground using torsion applied by a calibrated machine until a desired bearing depth and installation torque is achieved.

- 1.3.2 HPF Cap:** A factory-manufactured steel device that connects the HPF shaft to the structure above. The cap may be bolted, welded, screwed, encased in concrete, or otherwise attached to the HPF shaft and structure above such that it applies concentric axial loads to the HPF shaft. Generally, HPF caps are used for new construction applications.
- 1.3.3 HPF Bracket:** A factory-manufactured steel device that connects the HPF shaft to the structure above. The bracket may be bolted, welded, screwed, or otherwise attached to the HPF shaft and structure such that eccentric axial loads are applied to the HPF shaft and/or structure. Generally, HPF brackets are used for repair or strengthening of existing structures and placement to achieve concentric loading is not possible.
- 1.3.4 Conventional Design:** Determination of HPF design capacities using accepted engineering standards and methods such as ACI 318, AISC 360, and the National Design Specification for Wood Construction (NDS).
- 1.3.5 Torque Correlation:** An empirical relationship between installation energy and HPF capacity, whereby the HPF ultimate geotechnical bearing capacity is proportional to the installation torque needed to drive (or twist) the HPF into the ground. The torque correlation factor, also known as the torque-to-capacity ratio, is determined for each HPF system in accordance with Section 4.3.4.

## 2.0 REFERENCED STANDARDS

Standards shall be applied consistent with the specific edition of the code(s) for which the Evaluation Report is prepared unless otherwise approved by UES.

### 2.1 American Concrete Institute

- Building Code Requirements for Structural Concrete, ACI 318-14
- Building Code Requirements and Specification for Masonry Structures, ACI 530-13

### 2.2 American Society for Testing and Materials

- Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products, ASTM A123-15
- Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel, ASTM B633-15
- Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel, ASTM B695-04(2016)
- Standard Test Methods for Deep Foundations Under Static Axial Compressive Load, ASTM D1143-07(2013)
- Standard Test Methods for Deep Foundations Under Static Axial Tensile Load, ASTM D3689-07(2013)

### 2.3 International Code Council

- International Residential Code, IRC, 2015, 2012, 2009
- International Building Code, IBC, 2015, 2012, 2009

### 2.4 American Institute of Steel Construction

- Specification for Structural Steel Buildings, AISC 360-10

### 2.5 American Wood Council

- National Design Specification (NDS) for Wood Construction, ANSI AWC NDS-2015

### 2.6 American Iron and Steel Institute

- North American Specification for The Design of Cold-Formed Steel Structural Members, AISI S100-12

### 3.0 BASIC INFORMATION

**3.1 Description:** The following information and data shall be submitted for review and evaluation for recognition of HPF systems in an evaluation report:

**3.1.1 Product Description:** A complete description of the helical piles and accessories shall be submitted. The description shall include all models and specifications such as shaft lengths and diameters, helix sizes, helix pitches and leading edge configurations, as well as extension and coupler descriptions and specifications, and models and specifications for the HPF caps and brackets. The applicable steel standards and specifications such as steel thicknesses, galvanization specifications, and welding specifications shall also be provided.

**3.1.2 Installation Instructions:** The manufacturer's published installation instructions shall be provided. The description shall include all applicable installation requirements and descriptions of the installation machinery. The instructions shall require that installers be trained and approved by the helical pile system manufacturer.

**3.1.3 Packaging and Identification:** The method of identifying the HPF systems shall be submitted. At minimum, the company name, product name, model number, evaluation report number and evaluation agency mark of conformity shall be included in the product identification.

**3.2 Test Reports:** Reports shall be provided justifying the geotechnical capacities of the HPF systems based on the torque correlation factors achieved in field-testing. Tests may also be used as alternatives to engineering calculations to justify the capacities of various structural elements in the systems. A testing plan shall be submitted to the evaluation agency for approval.

Test reports shall include all relevant data in accordance with the standards and the testing and performance requirements in Section 4 of this criteria.

**3.3 Testing Laboratories:** Laboratories shall be accredited as complying with ISO/IEC Standard 17025 for the testing conducted and reported (i.e. the laboratory's scope of accreditation shall include helical pile quality and capacity determination). The laboratory's accreditation shall be issued by an accreditation body conforming to ISO/IEC 17011 and that is a signatory of the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement (MRA).

**3.4 Product Sampling:** The test specimens shall be sampled or verified by an accredited inspection agency or testing laboratory. The sampled product shall be representative of the production ongoing after the sampling has taken place. The product specifications shall be within the tolerance limits reported in the quality documentation and the relevant standards.

### 4.0 TESTING AND PERFORMANCE REQUIREMENTS

**4.1 General:** Testing and analysis shall be carried out on the HPF systems to determine their capacity to withstand the rigors of installation and their capacity to perform as intended to support the structures once installed. The load from the supported structure is transferred to each element of the HPF system, in turn, beginning with the HPF cap or bracket connecting the structure to the helical pile shaft, then through the shaft and couplings or extensions (if any), to the weld connecting the helix to the pile shaft, through the helix, and finally to the supporting soil. This load path is valid whether the loads are in tension or in compression. The capacity of the HPF shall be based on the capacity of the weakest of the load transfer elements in the HPF system load path. Testing shall be performed and reported by testing agencies specifically accredited for the types of tests required by this criteria. Testing shall be provided in accordance with Section 1.3.1.3.2 of ASCE-7, and analysis shall be provided by registered design professionals in accordance with Section 1.3.1.3.1 of ASCE 7. The maximum allowable capacity of each of the elements of the system shall be determined and included in the evaluation report, for use by the installer, and for verification by the building official.

Capacity determination shall consider any effects of corrosion on the system. The helical piles shall be designed so that the effects of corrosion shall not reduce the base steel integrity beyond 67 percent at the end of the 50 year projected service life of the structure. A zinc coating inside and out in accordance with ASTM A123 is considered acceptable protection for a ¼-inch-thick-wall tubular steel helical pile.

**4.2 Capacity determined by analysis:** The capacity of some of the elements may be determined by conventional analysis in lieu of testing. Where testing is used to qualify these elements, the testing shall be in accordance with a testing plan approved by the evaluation agency. For these elements, the design loads shall be determined using the applicable provisions of the IRC, IBC, and ASCE 7 and AISC 360, and analysis shall be done in accordance with the applicable design standard. These elements include the HPF cap or bracket and its connection to the supported structure, the shaft in pure compression and tension, the coupling and its connection to both upper and lower shaft sections, and the weld connecting the helix to the shaft. The axial compression capacity analyses shall account for any eccentricity due to manufacturing tolerances in the coupling and coupling rigidity.

**4.2.1 Analysis:** Allowable ASD capacities for the structural elements (i.e., HPF caps or brackets, connections, shafts, couplings, helices, welds, etc.) in the HPF systems shall be based on engineering analysis incorporating the applicable safety factors described in the relevant codes and standards listed below, or equivalent, and in the relevant sections of this criteria. Justification for the torque correlation factors shall be provided. The material standards used for analysis of elements of the support systems described in this criteria, are those incorporated by reference in the IRC, and include AISC 360, ACI 318, ACI 530, ANSI AWC NDS, AISI S100.

**4.3 Capacity determined by testing:** The following aspects of the HPF system are required to be determined through testing: the strength of the helix, the maximum installation torque rating for the helical pile system, and the HPF system torque correlation factor (see Section 4.3.5).

**4.3.1 Coupling Rigidity:** Coupling rigidity shall be determined by examining the difference in deflections between a HPF shaft containing couplings to one without couplings. The shafts shall be 10 feet in length. The shaft with couplings shall have the maximum number of couplings that could occur in use for this length of pile. One end of the shafts shall be connected to achieve a fixed-end condition, and a test load equal to 0.4 percent of the tested ultimate HPF shaft axial capacity shall be applied perpendicular to the shaft axis at the opposite (free) end. The load at the end of the shaft containing couplings shall be applied in the direction that produces the greatest deflection. The total lateral deflection of the shafts at the free end shall be compared. The coupling eccentricity shall be equal to the difference in the deflections of the two shafts. Couplings fully welded in accordance with the applicable codes shall be considered to develop no significant eccentricity to the HPF shaft.

**4.3.2 Helix Capacity:** Helix capacity shall be determined to qualify the weld connection between the helix and the shaft as well as the capacity of the helical plate to carry the building loads and transfer these loads to the soil. If the helix material strength, steel thickness, weld specification, and helix pitch are substantially similar, helix capacity tests may be performed using the model with the largest helix diameter; each smaller helix size is then permitted to have the same rated capacity as that of the helix size tested.

Helix capacity is tested by applying a load through the shaft to the helix plate, which reacts against a specially constructed jig that matches the helix shape. The reaction against the helix plate at 2/3 the helix radius from the pile axis (or 1/3 the helix radius from its outer edge) simulates the reaction of the soil encountered in use. The helix capacity test shall be required to be run in one axial direction only, provided the helix is similarly welded on both sides. Helix capacity ratings shall be based upon a minimum factor of safety, SF=3.0.

**4.3.3 Validation of Torque Rating:** The torsion capacity of the model specific helical pile

assembly shall be determined through testing to provide a maximum installation torque to which the helical pile may be subjected.

Each test sample shall be a minimum of 5 feet (1.5 m) in length, have a helix, a coupling (if couplings are included in the application), and the manufacturer recommended pile installation attachment system (drive pins, for example). The testing agency shall record the actual sample dimensions including length, cross-section, and minimum yield and ultimate stresses as reported in the mill certificates for the steel used to manufacture the HPF systems. At a minimum, the sample set shall include at least one each of the helix sizes submitted for approval. For each sample, the failure torque and failure mechanism shall be recorded. Each test result shall be reduced by a rational analysis comparing the sample cross sectional and strength properties to the minimums permitted by the manufacturer's quality program. For example, if bolt hole deformation at the drive pins in a HSS shaft controls the test capacity, then the test result shall be adjusted by comparing AISC 360 Section J7 for the tested sample to the minimums permitted by the manufacturer. The maximum installation torque rating shall not be greater than that determined by Section 1.3.1.3.1 of ASCE 7.

- 4.3.4 Geotechnical Load-Bearing Capacity:** Determination of the torque correlation factor,  $K_t$  (ft-1), for each shaft diameter shall be based on the average of the full-scale load test results using a minimum safety factor,  $SF=2.0$  for compression, and  $SF=3.0$  for tension, and  $K_t$  shall not exceed the maximum value obtained using the following formula based on the shaft diameter,  $D_s$ :

$K_t = 22.285 \times D_s^{-0.9195}$  (from Helical Piles A Practical Guide To Design and Installation by Howard A. Perko, PhD, PE, John Wiley & Sons, Inc.)

- 4.3.5 Full Scale Load Testing:** For each shaft size for which recognition is sought, a minimum of three single helix full scale load tests shall be performed. If evaluation is sought for more than one helix size, there shall be at a minimum, one full scale load test per helix size. Testing shall include both compression and tension directions if both directions are being evaluated. The full-scale load tests may be performed in any soil type (i.e. clay, sand, or weathered bedrock). All test piles shall be installed to at least 90percent of the maximum shaft torque rating and to a depth not less than 5 feet (1.5 m) or to a depth needed to include a coupling if couplings are included in the application.

A testing plan shall be submitted to the evaluation agency for review and acceptance. The plan shall include compressive and tensile load capacity determination in general agreement with ASTM D1143 and ASTM D3689, respectively. The test plan shall be developed using the methods laid-out in Helical Piles - A Practical Guide to Design and Installation by Howard A. Perko, PhD, PE, John Wiley & Sons, Inc. or equivalent. The pile capacities shall be evaluated using the Modified Davisson Offset Limit.

## 5.0 DESIGN [how to apply the ratings determined above in the field]

The load bearing capacity of the helical pile depends partly on the bearing capacity of the various soils at the locations where the supported structures are situated, and partly on the capacity of the pile assembly itself. The soil bearing capacity is arrived at by applying the torque correlation factor to the torque required to install the pile in the soil at the structure location. The model of helical pile is chosen based on its capacity and the capacity of each element in the helical pile assembly to support the demand load from the supported structure. The installer then installs the helical pile until the required minimum depth and torque are reached.

- 5.1 Design Loads:** The design of helical pile foundations begins with determination of the demand loads. The structural loads shall be determined in accordance with Section R301 of the IRC using appropriate load combinations shown in the IBC or ASCE 7. The demand loads shall be included in the pile capacity reports given to the building official.
- 5.2 Cap or Bracket Capacity:** The capacity of the HPF cap connecting the supported structure to the pile shaft shall be determined by analysis using accepted engineering standards and practice. Connection

of the pile cap to the supported structure and to the helical pile shaft shall be considered in the design.

- 5.3 Shaft Structural Capacity:** The ASD shaft axial capacity shall be determined using accepted engineering analysis and shall account for corrosion loss. The steel used in helical pile shafts shall not be stressed more than  $0.5 F_y \leq 32,000$  psi (220.6 MPa).

Portions of helical pile shafts not buried in the ground, or piles extending through water or fluid soils shall be designed as columns. Pile heads shall be considered free, pinned, or fixed depending on the specific conditions of connections to the structure they support. Any soil other than fluid soil shall be deemed to afford sufficient lateral support to prevent buckling and to permit the design of the shaft as fully braced. When shafts extend in air, water, or fluid soils they shall be considered fixed and laterally supported at a point 5 feet (1524 mm) into stiff soil or 10 feet (3048 mm) into soft soil. Distances to fixity shorter than this may be permitted if based upon analysis by a design professional and subject to the approval of the building official. Pile axial structural capacity shall take into account coupling eccentricity and rigidity. Welds in compression shall be considered and worst-case situations due to manufacturing tolerances shall be analyzed.

The axial tension capacity analysis of the helical pile shall account for any reduced steel cross section where bolts, pins, etc., are used in the coupler connection. Welds in tension shall be considered and worst-case situations due to manufacturing tolerances shall be analyzed.

- 5.4 Coupling Capacity:** The capacity of the coupling when subjected to compression, tension, shear, and bending loads shall be determined by conventional analysis using the net section of the steel or by a testing plan accepted by the certification body. Coupling rigidity shall be considered in axial buckling evaluations. Coupling rigidity is to be determined by testing per Section 4.3.1.

- 5.5 Soil Bearing Capacity:** The soil in which the helix is installed shall be undisturbed native soils or engineered fill. Where compressible, expansive, or otherwise shifting soils are known to be present at the site, these soils shall be removed or helices shall be extended below the zone of deleterious materials. In accordance with IRC Section R401.4, the building official may require a soil test where the presence of questionable soil characteristics soils is likely.

The allowable axial soil bearing load,  $P_a$ , shall not exceed the allowable geotechnical resistance determined as follows:

$$P_a = P_u / FS$$

Where  $P_u$  is the least ultimate capacity determined by torque correlation (i.e.,  $K_t \times \text{Final Torque}$ ) or area of helices times the ultimate bearing capacity of the layer in which they are bearing.

- 5.5.1 Capacity determination where supplemental geotechnical information is not available:** Where there is no evidence of questionable soils at the level of the helix in the helical pile installation, torque correlation alone may be used to provide sufficient evidence of compression geotechnical capacity when the helical piles are installed. A minimum Safety Factor (FS) of 3 shall be applied to determine the compressive load bearing capacity of the pile.

**Exception:** Where the helical piles are installed to support decks, accessory structures, or additions of 600 square feet (55.7 m<sup>2</sup>) or less for light-frame construction a minimum Safety Factor of 2 shall be applied for compression loads.

- 5.5.2 Compression capacity determination when supplemental geotechnical information is available:** Where soil bearing characteristics are known due to the availability of supplemental geotechnical information and helix sizes are based upon this information and torque is also monitored during installation, the Safety Factor for compressive loading shall be a minimum of 2.

- 5.5.3 Tension capacity determination:** Helical pile tension capacity shall be determined using a Safety Factor of 3 or greater. Helices shall be embedded to a minimum depth at which a shallow pull out failure does not control the tension capacity. An uppermost helix depth of 12 times the average helix diameter (12D) shall be considered sufficient embedment

in all cases. At shallower depths, tension capacity shall be verified by analysis considering the weight of soil above the uppermost helix.

- 5.6 Pile Lateral Capacity:** The allowable lateral load capacity of each pile is out of the scope of this criteria. The lateral load capacity may be determined by site specific load testing. As an alternative, capacity may be determined using an acceptable analysis method. Where field tests are required to confirm the capacity of a helical pile installation, these tests shall be supervised by a registered design professional.
- 5.7 Required Field Reporting:** HPF systems shall be installed by installers who are trained and approved by the HPF system manufacturer, using manufacturer-approved equipment. The equipment calibration shall be recent. Installers shall record all pile locations and types including shaft diameters, helix sizes, embedment depths, and final torque readings. In addition, for at least one out of every ten piles in multi-pile installations, a torque profile shall be recorded. A field report containing this information, along with relevant details of the supported structure, the types of HPF caps or brackets used, and details of all field connections, including field welds, shall be reviewed by a registered design professional, and submitted to the building official for approval.

## 6.0 QUALITY CONTROL

- 6.1** Quality documentation complying with the UES Minimum Requirements for Listee's Quality Assurance System (UES-010) shall be submitted. A complete description shall be provided of the quality management system used in the factory to manufacture the helical piles to meet minimum specifications and tolerances.
- 6.2** A complete description shall be provided of the quality management system used in the field to achieve a reliable allowable bearing capacity for each pile, and the oversight mechanisms used by the manufacturer to monitor this system.
- 6.3** The quality management system shall include a method to calibrate the torque indicators and verify calibration of the installation equipment to validate the axial capacities of the piles based on the recognized torque correlation factors per Section 4.3.4.
- 6.4** Inspections of manufacturing facilities are required for this product, by agencies accredited for the required tasks in accordance with ISO/IEC 17020, ISO/IEC Guide 65, or ISO/IEC 17065.

## 7.0 EVALUATION REPORT RECOGNITION

Evaluation reports shall include the following information:

- 7.1** The evaluation report shall include a statement that the helical piles shall be installed to a depth below frost line and to a minimum depth not less than 5 feet (1.5 m).
- 7.2** The evaluation report shall include a statement that the allowable compressive load on the helical piles shall not exceed 30 kips (133 kN).
- 7.3** The evaluation report shall tabulate the maximum allowable loads and optionally LRFD loads.
- 7.4** The evaluation report shall state that in accordance with IRC Section R401.4, the building official may require a soil test where the presence of questionable soil characteristics such as expansive, compressible, or shifting soils is likely, based on quantifiable data.
- 7.5** Drainage shall be directed away from the pile support locations. Where helical piles are installed on or adjacent to slopes, the negative effects of drainage, erosion, and shallow failures shall be avoided in accordance with R403.1.7.
- 7.6** The evaluation report shall include a statement that portions of helical pile shafts not buried in the ground shall be designed as columns in accordance with IBC.
- 7.7** The evaluation report shall include a statement that lateral load capacity may be determined by site specific load testing or using another analysis method acceptable to the building official.

- 7.8** The evaluation report shall state that the helical piles shall be installed in accordance with the manufacturer's installation instructions by manufacturer certified installers.
- 7.9** The evaluation report shall state that the trained and approved installer shall submit an engineering field report to the building official within 10 days after helical pile installation. The report shall describe the type of project, sketch or drawing of the support situation with dimensions, pile shaft and helix sizes, height of the top of the shaft, bracket or cap system used, final depth of the helix, torque readings, safe allowable load geotechnical capacity based upon torque correlation factor, and other relevant notes or comments as needed.
- 7.10** The evaluation report shall state that the supported structure shall be adequately anchored to the tops of the helical piles.
- 7.11** The evaluation report shall state that the use of the piles in seismic design categories D0, D1, D2, and E is out of scope of this criteria.
- 7.12** The evaluation report shall state that where field tests are required to confirm the capacity of a helical pile installation, these tests shall be supervised by a registered design professional.
- 7.13** The evaluation report shall state that the spacing between helical piles shall be minimum 3 times the diameter of the largest helix in adjacent piles. The pile shaft shall be within 3 degrees of vertical when installation is complete.
- 7.14** The evaluation report shall include a statement informing designers, users, and building officials that the capacity of the supported structure to span the distance between helical piles is outside the scope of the report.