

# ICC-ES Evaluation Report

**ESR-3074**

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**DIVISION: 31 00 00—EARTHWORK**  
**Section: 31 63 00—Bored Piles**
**REPORT HOLDER:**
**FOUNDATION SUPPORTWORKS, INC.**  
 12330 CARY CIRCLE  
 OMAHA, NEBRASKA 68128  
 (800) 281-5845  
[www.foundationssupportworks.com](http://www.foundationssupportworks.com)  
[jeff.kortan@foundationssupportworks.com](mailto:jeff.kortan@foundationssupportworks.com)
**EVALUATION SUBJECT**
**FOUNDATION SUPPORTWORKS HELICAL  
FOUNDATION SYSTEMS**
**1.0 EVALUATION SCOPE**
**Compliance with the following code:**

 2006 *International Building Code*® (IBC)

**Properties evaluated:**

- Structural
- Geotechnical

**2.0 USES**

Foundation Supportworks, Inc. (FSI), Model HP288 Helical Foundation Systems are used either to underpin foundations of existing structures or to form deep foundations for new structures, and are designed to transfer axial compression and axial tension loads from the supported structures to suitable soil bearing strata.

**3.0 DESCRIPTION**
**3.1 General:**

The FSI Model HP288 helical foundation systems consist of a central lead shaft with one or more helical-shaped steel bearing plates, extension shafts, which may or may not consist of helical bearing plates, shaft couplings that connect multiple shaft sections, and a bracket that allows for attachment to the supported structure. The shafts with helix bearing plates are screwed into the ground by application of torsion and the shaft is extended until a desired depth and/or a suitable soil or bedrock bearing stratum is reached.

**3.2 System Components:**

The FSI Model HP288 helical foundation systems include a lead shaft (HP288L), extension shafts (HP288E), Type A side-load brackets (FS288B and FS288BL), and Type B direct-load brackets (HP288NCB and HP288NCB8), for attachment to concrete foundations.

**3.2.1 Helical Lead Sections and Extensions:** The FSI helical pile lead sections consist of one or more helical-shaped circular steel plates welded to a central steel shaft. The depth of the helical piles in soil is typically extended by adding one or more steel shaft extensions that are mechanically connected together by couplings, to form one, continuous steel pile.

The central steel shaft of the lead and extension sections is a round, 2<sup>7</sup>/<sub>8</sub>-inch-outside-diameter (73 mm), 0.276-inch-nominal-wall-thickness, hollow structural section. The various shaft lead and extension configurations are listed in Table 4.

Each helical steel bearing plate (helix) is 0.375 inch (9.5 mm) thick, and has a 3-inch (76 mm) pitch and spiral edge geometry with an outer diameter of 8, 10, 12 or 14 inches (203, 254, 305 or 356 mm). The helices are welded to the helical shaft. The lead helix is located about 4 inches from the tip of the shaft lead section. The extensions may consist of the shaft only or include helix plates.

The extension section couplings consist of a round, 6-inch-long (152.4 mm), 3<sup>1</sup>/<sub>2</sub>-inch-outside-diameter (89 mm), 0.281-inch-nominal-wall-thickness, hollow structural section outer sleeve, and two 3/4-inch-diameter (19.1 mm) standard hex threaded bolts and matching standard hex jam nuts. The pipe sleeve is factory-welded to the end of the extension section. (See Figure 3.)

**3.2.2 Brackets:** Brackets are constructed with factory-welded steel plate and steel pipe components. The different brackets are described in Sections 3.2.2.1 through 3.2.2.2.

**3.2.3 Retrofit Bracket Assemblies FS288B and FS288BL:** The FS288B and FS288BL bracket assemblies are designed for use with the HP288 helical shaft and are used to transfer axial compressive loading from existing concrete foundations to the HP288 helical piles. The bracket assembly consists of an FS288B or FS288BL bracket, an external pipe sleeve (FS288ES30 or FS288ES48), a cap plate (FS288C), two threaded rods and matching nuts. (See Figure 1.)

The FS288B and FS288BL brackets are constructed from factory-welded, 0.250-inch-, 0.375-inch- and 0.500-inch-thick (6.4 mm, 9.5 mm, and 12.7 mm) steel plates.

The external sleeve (FS288ES30) is manufactured from a 30-inch-long (762 mm), 3<sup>1</sup>/<sub>2</sub>-inch-outside-diameter (89 mm) and 0.216-inch-nominal-wall-thickness pipe with a factory-welded end ring which consists of a 3/4-inch-long (19.1 mm), 4.0-inch-outside-diameter (102 mm) and 0.226-inch-nominal-wall-thickness pipe. The FS288ES48 external sleeve is identical to the FS288ES30 except that the FS288ES48 is 48 inches (1219 mm) long.

The FS288C cap plate assembly is manufactured from a  $\frac{1}{2}$ -inch-long (12.7 mm),  $3\frac{1}{2}$ -inch-outside-diameter (89 mm), 0.216-inch-nominal-wall-thickness steel pipe that is factory-welded to a 1-inch-thick (25.4 mm), 5-inch-wide (127 mm), 9-inch-long (229 mm) steel plate. The cap plate is attached to the retrofit bracket with two  $\frac{3}{4}$ -inch-diameter-by-16-inch-long (19.1 mm by 406 mm) threaded rods, and matching  $\frac{3}{4}$ -inch (19.1 mm) heavy hex nuts. (See Figure 1.)

**3.2.3.1 New Construction Brackets HP288NCB and HP288NCB8:** HP288NCB and HP288NCB8 brackets are designed for embedment in cast-in-place concrete foundations. The brackets are used to support axial tensile and compressive loads that are concentric with the longitudinal axis of the shaft. (See Figure 2.)

The HP288NCB bracket is manufactured from a 5.06-inch-long (128.5 mm),  $3\frac{1}{2}$ -inch-outside-diameter (89 mm), 0.250-inch-nominal-wall-thickness steel pipe sleeve which is factory-welded to a  $\frac{3}{4}$ -inch-thick (19.1 mm), 6-inch-square (152 mm) steel cap plate. The bracket is attached to the shaft with two  $\frac{3}{4}$ -inch-diameter (19.1 mm) standard hex threaded bolts and with matching  $\frac{3}{4}$ -inch (19.1 mm) standard hex jam nuts. (See Figure 2.)

The HP288NCB8 bracket is identical to the HP288NCB bracket except that the HP288NCB8 cap plate is an 8-inch-square (203 mm) steel plate. (See Figure 2.)

### 3.3 Material Specifications:

**3.3.1 Lead and Extension Shafts:** The leads and extensions are carbon steel round structural tubes that conform to ASTM A500, Grade B or C, having a minimum yield strength of 60 ksi (413 MPa) and a minimum tensile strength of 70 ksi (483 MPa). The shaft finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.

#### 3.3.2 Shaft Coupling:

**3.3.2.1 Pipe Sleeves:** The sleeves are carbon steel round structural tubing that conforms to ASTM A513, Type 5, Drawn Over a Mandrel (DOM), Grade 1026, having a minimum yield strength of 70 ksi (483 MPa) and a minimum tensile strength of 80 ksi (552 MPa). The sleeve finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.

**3.3.2.2 Bolts and Nuts:** The steel coupling bolts are  $\frac{3}{4}$ -10 UNC 2A standard hex bolts conforming to SAE J429, Grade 8, having a minimum yield strength of 130 ksi (896 MPa) and a minimum tensile strength of 150 ksi (1034 MPa). The matching steel nuts are  $\frac{3}{4}$ -10 UNC 2B standard hex jam nuts, conforming to SAE J995, Grade 5. The bolts and nuts are zinc-coated in accordance with ASTM B633, with coating classification Fe/Zn 8.

**3.3.3 Helix Plates:** The steel plates conform to ASTM A572, Grade 50, having a minimum yield strength of 50 ksi (345 MPa) and a minimum tensile strength of 65 ksi (448 MPa). The helix finish is the same as that of the shaft to which the helix is factory-welded.

#### 3.3.4 Retrofit Bracket Assemblies FS288B and FS288BL:

**3.3.4.1 FS288B and FS288BL Brackets:** The steel plates used in the brackets conform to ASTM A36, having a minimum yield strength of 36 ksi (248 MPa) and a minimum tensile strength of 58 ksi (400 MPa). The bracket finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.

**3.3.4.2 FS288ES30 and FS288ES48 Sleeves:** The carbon steel structural round tubing, used for the 30-inch- and 48-inch-long (762 mm and 1219 mm) sleeves,

conforms to ASTM A500, Grade B or C, having a minimum yield strength of 50 ksi (345 MPa) and a minimum tensile strength of 62 ksi (427 MPa). The  $\frac{3}{4}$ -inch-long (19.1 mm) steel ring (collar) conforms to ASTM A53, Types E and S, Grade B, having a minimum yield strength of 35 ksi (241 MPa) and a minimum tensile strength of 60 ksi (413 MPa). The sleeve finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.

**3.3.4.3 FS288C Cap Plate Assembly:** The  $\frac{1}{2}$ -inch-long (12.7 mm) steel pipe conforms to ASTM A53, Types E and S, Grade B, having a minimum yield strength of 35 ksi (241 MPa) and a minimum tensile strength of 60 ksi (413 MPa). The steel cap plate conforms to ASTM A572, Grade 50, having a minimum yield strength of 50 ksi (345 MPa) and a minimum tensile strength of 65 ksi (448 MPa). The cap plate assembly finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.

**3.3.4.4 Threaded Rods and Nuts:** The  $\frac{3}{4}$ -inch-diameter steel threaded rods conform to ASTM A193, Grade B7, having a minimum yield strength of 105 ksi (724 MPa) and a minimum tensile strength of 125 ksi (862 MPa). The matching  $\frac{3}{4}$ -inch-diameter steel heavy hex nuts conform to ASTM A563 Grade DH or DH3, or ASTM A194 Grade 2H. The threaded rods and nuts are zinc-coated in accordance with ASTM B633, with coating classification Fe/Zn 8.

#### 3.3.5 New Construction Brackets HP288NCB and HP288NCB8:

**3.3.5.1 Plates:** The steel plates conform to ASTM A36, having a minimum yield strength of 36 ksi (248 MPa) and a minimum tensile strength of 58 ksi (400 MPa). The plate finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.

**3.3.5.2 Pipe Sleeves:** The pipe sleeves are steel round structural tubes that conform to ASTM A513, Type 5, Drawn Over a Mandrel (DOM), Grade 1026, having a minimum yield strength of 70 ksi (483 MPa) and a minimum tensile strength of 80 ksi (552 MPa). The sleeve finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.

**3.3.5.3 Bolts and Nuts:** The steel bolts and nuts are those described in Section 3.3.2.2.

## 4.0 DESIGN AND INSTALLATION

### 4.1 Design:

**4.1.1 General:** Structural calculations (analysis and design) and drawings, prepared by a registered design professional, must be approved by the code official for each project, and must be based on accepted engineering principles as described in IBC Section 1604.4, and must conform to IBC Section 1808. The design method for the steel components is Allowable Strength Design (ASD), described in IBC Section 1602 and AISC 360-05 Section B3.4. The structural analysis must consider all applicable internal forces due to applied loads, structural eccentricity, and maximum spans between helical foundations. The result of this analysis, and the structural capacities, shall be used to select a helical foundation system.

The ASD capacities of FSI helical foundation system components are indicated in Tables 1 through 4. The geotechnical analysis must address the suitability of the helical foundation system for the specific project. It must also address the center-to-center spacing of the helical piles, considering both effects on the supported

foundation and structure and group effects on the pile-soil capacity. The analysis must include estimates of the axial tension and/or compression capacities of the helical piles, whatever is relevant for the project, and the expected total and differential foundation movements due to single pile or pile group, as applicable.

A written report of the geotechnical investigation must be submitted to the code official as one of the required submittal documents, prescribed in IBC Section 106, at the time of the permit application. The geotechnical report must include, but need not be limited to, the following information:

1. A plot showing the location of the soil investigation.
2. A complete record of the soil boring and penetration test logs and soil samples.
3. A record of soil profile.
4. Information on groundwater table, frost depth and corrosion-related parameters, as described in Section 5.5 of this report.
5. Soil properties, including those affecting the design such as support conditions for the piles.
6. Recommendations for design criteria, including but not limited to mitigations of effects of differential settlement and varying soil strength, and effects of adjacent loads.
7. Field inspection and reporting procedures (to include procedures for verification of the installed bearing capacity when required).
8. Load test requirements.
9. Any questionable soil characteristics and special design provisions, as necessary.

**4.1.2 Bracket Capacity (P1):** Only the localized limit state of concrete bearing strength in compression has been evaluated for this evaluation report. All other limit states related to the concrete foundation, such as those limit states described in ACI 318 Appendix D, punching (two-way) shear, beam (one-way) shear, and flexural (bending) related limit states, have not been evaluated for this evaluation report. The concrete foundation must be designed and justified to the satisfaction of the code official with due consideration to all applicable limit states, and the direction and eccentricity of applied loads, including reactions provided by the brackets acting on the concrete foundation. (See Tables 1, 2 and 3.)

**4.1.3 Shaft Capacity (P2):** The tops of shafts must be braced as prescribed in IBC Section 1808.2.5. In accordance with IBC Section 1808.2.9, any soil other than fluid soil must be deemed to afford sufficient lateral support to prevent buckling of systems that are braced. When piles are standing in air, water or fluid soils, the unbraced length is defined as the length of pile that is standing in air, water or fluid soils plus an additional 5 feet (1524 mm) when embedded into firm soil, or an additional 10 feet (3048 mm) when embedded into soft soil. Firm soils are defined as any soil with a Standard Penetration Test (SPT) blow count of five or greater. Soft soil is defined as any soil with an SPT blow count greater than zero and less than five. Fluid soil is defined as any soil with an SPT blow count of zero [weight of hammer (WOH) or weight of rods (WOR)]. The SPT blow counts must be determined in accordance with ASTM D1586. For fully braced conditions where the pile is installed in accordance with IBC section 1808.2.5 and piles do not stand in air, water, or fluid soils, the allowable shaft capacities must not exceed the maximum design loads

shown in Tables 1, 2 and 4. Shaft capacities of helical foundation systems in air, water or fluid soils must be determined by a registered design professional. The ASD shaft tension capacities are shown in Tables 3 and 4, the ASD shaft compression capacities are shown in Tables 1, 2 and 4, and the shaft torsional rating is shown in Table 4.

The elastic shortening/lengthening of the pile shaft will be controlled by the applied loads and the mechanical and geometrical properties of the 2<sup>7</sup>/<sub>8</sub>-inch-diameter (73 mm) round structural tubing and the shaft coupling. The shaft elastic shortening or lengthening can be determined from the equation:

$$\Delta_{shaft} = \frac{P \times L}{A \times E} \quad (\text{Eq. 1})$$

where:

- $\Delta_{shaft}$  = change in shaft length due to elastic shortening or lengthening (inches)
- P = applied axial compression or tension load (lbf)
- L = pile shaft length (inches)
- A = shaft cross-sectional area (in<sup>2</sup>) (see Table 5)
- E = shaft steel modulus of elasticity (psi) (see Table 5)

**4.1.4 Helix Plate Capacity (P3):** The allowable axial compression and tension load capacities (P3) for each individual helical plate diameter (8, 10, 12 or 14 inches) is 55 kips (244.6 kN). (See Tables 1, 2, 3 and 4.) For helical piles with more than one helix, the allowable helix capacity (P3) for the helical foundation system may be taken as the sum of the allowable capacity of each individual helix.

**4.1.5 Soil Capacity (P4):** The allowable axial compressive or tensile soil capacity (P4) can be estimated by a registered design professional in accordance with a site-specific geotechnical report, as described in Section 4.1.1, or by the torque correlation method, which can be described as follows:

$$Q_{ult} = K_t T \quad (\text{Eq. 2})$$

$$Q_{all} = 0.5 Q_{ult} \quad (\text{Eq. 3})$$

Where:

$Q_{ult}$  = Ultimate axial tensile or compressive capacity (lbf or N) of the helical piles. For axial tension, pile ultimate axial load capacity must be limited to 55.1 kips (245.0 kN).

$Q_{all}$  = Allowable axial tensile or compressive capacity (P4) (lbf or N) of the helical piles. For axial tension, pile allowable axial load capacity must be limited to 27.6 kips (122.5 kN).

$K_t$  = Torque correlation factor. (See Table 4.)

T = Final installation torque, which is the final torque reading during the field installations (lbf-ft or N-m).

**4.1.6 Foundation System:** The ASD allowable capacity of the FSI helical foundation system in tension and compression depends upon the analysis of interaction of brackets, shafts, helical plates and soils; must be the lowest value of P1, P2, P3 and P4; and must be no larger than 60 kips (266.9 kN).

## 4.2 Installation:

**4.2.1 General:** The FSI helical foundation systems must be installed by FSI trained and certified installers. The FSI helical foundation systems must be installed in accordance with this section (Section 4.2), site-specific approved construction documents (engineering drawings

and specifications), and the manufacturer's written installation instructions. In case of conflict, the most stringent requirement governs.

**4.2.2 Helical Pile Installation:** The helical piles are typically installed using hydraulic rotary motors having forward and reverse capabilities. The foundation piles must be aligned both vertically and horizontally as specified in the approved plans. The helical piles must be installed in a continuous manner with the pile advancing at a rate equal to at least 85 percent of the helix pitch per revolution at the time of final torque measurement. Installation speeds must be limited to less than 25 revolutions per minute (rpm). The lead and extension sections must be attached to the drive head with a product adaptor supplied by FSI. Torque readings must be taken at minimum intervals corresponding to each lead or extension section length and at final termination depth. The lead and extension sections are connected with the coupling bolts and nuts described in Section 3.2.1, and tightened to a snug-tight condition as defined in Section J3 of AISC 360-05. The final installation torque must equal or exceed that as specified by the torque correlation method, to support the allowable design loads of the structure using a torque correlation factor ( $K_t$ ) of  $9 \text{ ft}^{-1}$  ( $29.5 \text{ m}^{-1}$ ). The installation torque must not exceed 7,898 ft-lbs (10 708 N-m). See Section 5.0 for further installation conditions of use.

#### 4.2.3 Retrofit Bracket Installation:

1. An area must be excavated to expose the footing with an excavation approximately 3 feet (914 mm) square and with a depth of about 13 inches (330 mm) below the bottom of the footing. The soil is removed below the bottom of the footing to about 9 inches (229 mm) from the footing face in the area where the bracket bearing plate will be placed. The vertical and bottom faces of the footing must, to the extent possible, be smooth and at right angles to each other for the mounting of the support bracket.
2. Notching of footings may be needed to place the retrofit bracket directly under the wall/column. Notching must be performed, however, only with the acceptance of the registered design professional and the approval of the code official.
3. The bearing surfaces of the concrete (bottom and side of footing) must be prepared so that they are smooth and free of all soil, debris and loose concrete so as to provide a full and firm contact of the retrofit bracket plates.
4. The edge of the lead section shaft must be located about  $1\frac{1}{2}$  inches (38 mm) from the bottom edge of the footing with a required angle of inclination of  $3.0 \pm 1.0$  degrees from the vertical. Installation must be as described in Section 4.2.2.
5. When the final bearing depth is reached, the pile shafts are cut to approximately 13 inches (330 mm) above the bottom of footing.
6. The external sleeve must be placed through the bracket body and over the shaft. Once under the footing, the bracket must be rotated 180 degrees toward the footing. The bracket must be raised up to the footing and held in place while the thread rods and cap plate are attached.
7. The cap plate and all thread rods and tightening nuts must be installed to snug the bracket to the bottom of the footing.

8. Soil must be placed and compacted adequately up to the bottom of the bracket prior to structural lift or load transfer.
9. A lift cylinder can be used to lift the structure to desired elevation and to transfer the designated portion of the foundation load to the helical pile system.
10. Lifting of the existing foundation structure must be verified by the registered design professional and is subject to approval of the code official to ensure that the foundation and superstructure are not overstressed.
11. Field installation logs must be completed and excavation pits or trenches must be backfilled and compacted. Proper compaction procedures must comply with the approved construction documents for any site-specific requirement. When possible or as required by the approved construction document, grades or other means must be constructed to allow proper, positive surface drainage away from the structure.

#### 4.2.4 New Construction Bracket Installation:

1. The helical pile must be installed in accordance with Section 4.2.2 with an allowable angular tolerance of  $\pm 1$  degree from the vertical.
2. The top of pile elevation must be established and must be consistent with the specified elevation. If necessary, the pile can be cut off in accordance with the manufacturer's instructions at the required elevation.
3. The new construction bracket must be placed over the top of the pile, with the bracket cap plate in full, direct contact (bearing) with the top of the pile shaft.
4. If the pile is used to resist tension forces, the new construction bracket must be embedded with proper distance into the footing or grade beam as required to resist the tension loads as determined by a registered design professional, and must be through-bolted to the helical pile shaft with two bolts and matching nuts as specified in Sections 3.2.2.2 and 3.3.5.3, and installed to a snug-tight condition in accordance with Section 4.2.2. Refer to Tables 2 and 3 for the proper embedded edge distance requirements for the shaft and bracket.

#### 4.3 Special Inspection:

Continuous special inspection in accordance with IBC Section 1704.9 must be provided for the installation of foundation piles and foundation brackets. Where on-site welding is required, inspection in accordance with Section 1704.3 of the IBC is also required. Items to be confirmed by the special inspector include, but are not limited to, the following:

- Verification of the manufacturer
- Manufacturer's certification of installers
- Product identification, including for lead sections, couplings, extension sections, brackets, bolts/threaded rods and nuts
- Written installation procedures
- The installation torque and depth of the helical foundation system
- Inclination and horizontal position/location of helical piles
- Tightness of all bolts/threaded rod assemblies

- Verification of full contact between a new bracket cap plate and the top of the pile shaft
- Verification of full contact between shaft sections within the coupling for pile supporting compression load only;
- Verification of full-surface contact of retrofit brackets with concrete
- Compliance of the installation with the approved construction documents and this evaluation report.

In lieu of continuous special inspection, periodic special inspection in accordance with IBC Section 1702.1 is permitted, provided that all of the following requirements are satisfied: (1) The installers are certified by the manufacturer, and evidence of installer training and certification by the report holder is provided to the code official. (2) Structural observations in accordance with IBC Section 1709 are provided. (3) A periodic inspection schedule, as part of the statement of special inspection prepared by a registered design professional, is submitted to and approved by the code official. As a minimum, the periodic inspection schedule must include, but not be limited to, the following:

1. Before the start of work: Verify manufacturer, verify installer's certification by the manufacturer, and confirm helical pile and bracket configuration compliance with the approved construction documents and this evaluation report.
2. Installation of first helical foundation system: Verify that the location, installation torque, and depth of helical piles comply with the approved construction documents and this evaluation report. Verify that the installers keep an installation log.
3. First connection to building structure: Verify that installation of brackets complies with the approved construction documents and this evaluation report.
4. End of work: Verify that the installation log complies with requirements specified in the approved construction documents. Verify that installation of all structural connections complies with approved construction documents and this evaluation report.

## 5.0 CONDITIONS OF USE

The Foundation Supportworks, Inc. (FSI), Model HP288 Helical Foundation Systems described in this report comply with, or are suitable alternatives to what is specified in, the code noted in Section 1.0 of this report, subject to the following conditions:

- 5.1 The FSI helical foundation systems are manufactured, identified and installed in accordance with this report, approved construction documents (engineering drawings and specifications), and the manufacturer's written installation instructions. In case of conflict, the most stringent requirement governs.
- 5.2 The FSI helical foundation systems have been evaluated for support of structures assigned to Seismic Design Categories A, B and C in accordance with IBC Section 1613. Helical foundation systems that support structures assigned to Seismic Design Category D, E or F, or that are located in Site Class E or F, are outside the scope of this report, and are subject to the approval of the code official, based upon submission of an engineering design in accordance with the code by a registered design professional.
- 5.3 Installations of the helical foundation systems are limited to regions of concrete members where

analysis indicates no cracking occurs at service load levels.

- 5.4 Both the retrofit and new construction brackets must be used only to support structures that are laterally braced as defined in IBC Section 1808.2.5.
- 5.5 The helical foundation systems must not be used in soil conditions that are indicative of a potential pile deterioration or corrosion situation as defined by the following: (1) soil resistivity of less than 1,000 ohm-cm; (2) soil pH of less than 5.5; (3) soils with high organic content; (4) soil sulfate concentrations greater than 1,000 ppm; (5) soils located in a landfill; or (6) soil containing mine waste.
- 5.6 Zinc-coated steel and bare steel components must not be combined in the same system. All helical foundation components must be galvanically isolated from concrete reinforcing steel, building structural steel, or any other metal building components.
- 5.7 The new construction helical piles (piles with new construction brackets) must be installed vertically plumb into the ground with a maximum allowable angle of inclination tolerance of  $0^\circ \pm 1^\circ$ .
- 5.8 The retrofit helical piles must be installed at a maximum angle of inclination of  $3.0 \pm 1.0$  degrees from the vertical.
- 5.9 Special inspection is provided in accordance with Section 4.3 of this report.
- 5.10 Engineering calculations and drawings, in accordance with recognized engineering principles as described in IBC Section 1604.4, and prepared by a registered design professional, are provided to, and approved by, the code official.
- 5.11 The adequacy of the concrete structures that are connected to the FSI brackets must be verified by a registered design professional, in accordance with applicable code provisions, such as Chapter 15 of ACI 318 and Chapter 18 of IBC. The adequacy is subject to the approval of the code official.
- 5.12 A geotechnical investigation report for each project site must be provided to the code official for approval in accordance with Section 4.1.1 of this report.
- 5.13 When using the alternative basic load combinations prescribed in Section 1605.3.2, the allowable stress increases permitted by material chapters of the IBC (including Chapter 18) or the referenced standards are prohibited.
- 5.14 The minimum helical pile center-to-center spacing must be four times the average helical bearing plate diameters. For piles with closer spacing, the pile allowable load reductions due to pile group effects must be included in the geotechnical report described in Section 4.1.1 of this report, and must be considered in the pile design by a registered design professional. The spacing is subject to the approval of the code official.
- 5.15 For piles supporting tension loads, the piles must be installed such that the minimum depth from the ground surface to the uppermost helix is 12D, where D is the diameter of the largest helix.
- 5.16 Piles supporting compression loads must be installed such that the minimum depth from the bottom of the pile-supported footing to the uppermost helix is no less than 5 feet (1524 mm). For compression piles with a shallower helix depth, the actual helix depth must be considered in the pile

design by a registered design professional. The depth is subject to approval of the code official.

- 5.17 Compliance with IBC Section 1808.2.23.1.1 for buildings assigned to Seismic Design Category (SDC) C, and with IBC Section 1808.2.7 for all buildings, is outside the scope of this evaluation report. Such compliance must be addressed by a registered design professional for each site, and the work of the design professional is subject to approval of the code official.
- 5.18 Requirements listed in the footnotes to Tables 1, 2, 3, and 4 must be satisfied.
- 5.19 The FSI helical foundation systems are manufactured at the following facilities: Distefano Technology & Manufacturing Company, 3838 South 108<sup>th</sup> Street, Omaha, Nebraska; Behlen Manufacturing Company, 4025 East 23<sup>rd</sup> Street, Columbus, Nebraska; and TSA Manufacturing, 14901 Chandler Road, Omaha, Nebraska.

Manufacturing is done under a quality control program with inspections by Benchmark Consulting & Inspection, L.L.C. (AA-660).

**6.0 EVIDENCE SUBMITTED**

Data in accordance with the ICC-ES Acceptance Criteria for Helical Foundation Systems and Devices (AC358), dated June 2007.

**7.0 IDENTIFICATION**

The FSI helical foundation system components described in this report are identified by labels that include the report holder's name (Foundation Supportworks, Inc.); the name and address of Distefano Technology & Manufacturing Company, Behlen Manufacturing Company, or TSA Manufacturing; the product name; the model number (HP288); the part number; the evaluation report number (ESR-3074); and the name of the inspection agency (Benchmark Consulting & Inspection, L.L.C., AA-660).

**TABLE 1—HP288 (WITH RETROFIT BRACKETS) ASD COMPRESSION CAPACITIES**

Bracket Part No. <sup>1</sup>	Sleeve Part No. <sup>1</sup>	HP288 Bracket Description	Allowable Compression Capacity (kips)				
			Bracket (P1) <sup>2</sup>	Shaft (P2) <sup>3</sup>	Helix (P3) <sup>4</sup>	Soil (P4) <sup>5</sup>	Foundation System <sup>6</sup>
FS288B	FS288ES30	Standard Bracket w/30" Sleeve	24.9	60	55	35.5	24.9
FS288B-G	FS288ES30-G		27.9	60	55	35.5	27.9
FS288B	FS288ES48	Standard Bracket w/48" Sleeve	31.4	60	55	35.5	31.4
FS288B-G	FS288ES48-G		35.1	60	55	35.5	35.1
FS288BL	FS288ES30	Low Profile Bracket w/30" Sleeve	25.3	60	55	35.5	25.3
FS288BL-G	FS288ES30-G		28.2	60	55	35.5	28.2

For SI: 1 inch = 25.4 mm, 1 kip = 1000 lbf = 4.448 kN.

<sup>1</sup>Part numbers with "G" suffix indicate hot-dip galvanized coating. Part numbers without a "G" suffix indicate plain steel.

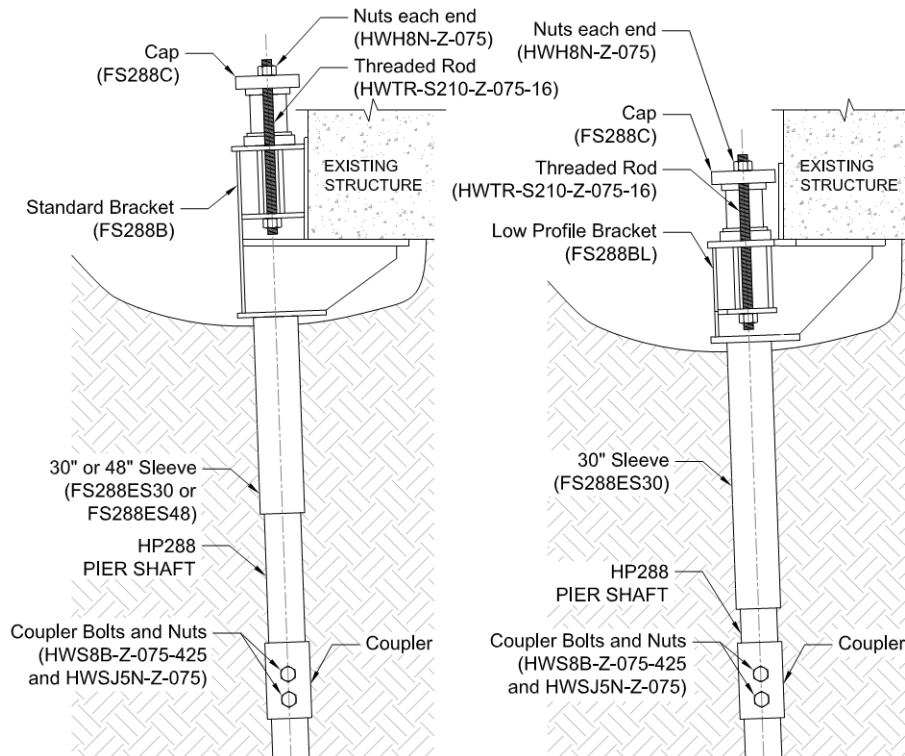
<sup>2</sup>Bracket capacity is based on full scale load tests per AC358 with an installed 5'-0" unbraced pile length per IBC 1808.2.9.2, having a maximum of one coupling.

<sup>3</sup>Shaft capacity is applicable only to the foundation systems that are fully braced as described in Section 4.1.3.

<sup>4</sup>Helix capacity is based on a single helix plate with outer diameter of 8, 10, 12 or 14 inches (203, 254, 305 or 356 mm).

<sup>5</sup>Soil capacity is based on torque correlation per Section 4.1.5 of this report, with piles installed at the maximum torsion rating.

<sup>6</sup>Foundation system allowable capacity is based on the lowest of P1, P2, P3 and P4.



**FIGURE 1—HP288 RETROFIT BRACKET AND SHAFT ASSEMBLIES**

**TABLE 2—HP288 (WITH NEW CONSTRUCTION BRACKETS) ASD COMPRESSION CAPACITIES<sup>7</sup>**

Bracket Part No. <sup>1</sup>	Bearing Plate Dimensions (in)	Minimum Concrete Compressive Strength (psi)	Edge Distance "A" (in)	Allowable Compression Capacity (kips)				
				Bracket (P1) <sup>2</sup>	Shaft (P2) <sup>3</sup>	Helix (P3) <sup>4</sup>	Soil (P4) <sup>5</sup>	Foundation System <sup>5</sup>
HP288NCB or HP288NCB-G	6 x 6 x 0.75	2500	3	30.6	60	55	35.5	30.6
			≥ 4	40.8	60	55	35.5	35.5
		3000	≥ 3	36.7	60	55	35.5	35.5
HP288NCB8	8 x 8 x 0.75	2500	≥ 4	43.1	60	55	35.5	35.5
HP288NCB-G	8 x 8 x 0.75	2500	≥ 4	46.5	60	55	35.5	35.5

For SI: 1 inch = 25.4 mm, 1 kip = 1000 lbf = 4.448 kN.

<sup>1</sup>Part numbers with "G" suffix indicate hot-dip galvanized coating. Part numbers without a "G" suffix indicate plain steel.

<sup>2</sup>Bracket capacity is based on localized limit state of concrete bearing only. All other limit states related to the concrete foundation, such as punching shear, have not been evaluated in this evaluation report.

<sup>3</sup>Shaft capacity is applicable only to the foundation systems that are fully braced as described in Section 4.1.3.

<sup>4</sup>Helix capacity is based on a single helix plate with outer diameter of 8, 10, 12 or 14 inches (203, 254, 305 or 356 mm).

<sup>5</sup>Soil capacity is based on torque correlation per Section 4.1.5 of this report, with piles installed at the maximum torsion rating.

<sup>6</sup>Foundation system allowable capacity is based on the lowest of P1, P2, P3 and P4.

<sup>7</sup>Reduction of plain concrete thickness described in Section 22.4.8 of ACI 318 is assumed not applicable.

**TABLE 3—HP288 (WITH NEW CONSTRUCTION BRACKETS) ASD TENSION CAPACITIES<sup>6</sup>**

Bracket Part No. <sup>1</sup>	Bearing Plate Dimensions (in)	Minimum Concrete Compressive Strength (psi)	Edge Distance "A" (in)	Allowable Tension Capacity (kips)				
				Bracket (P1) <sup>2,7</sup>	Shaft (P2)	Helix (P3) <sup>3</sup>	Soil (P4) <sup>4</sup>	Foundation System <sup>5</sup>
HP288NCB or HP288NCB-G	6 x 6 x 0.75	2500	3	22.4	34.1	55	27.6	22.4
			≥ 4	29.9	34.1	55	27.6	27.6
		3000	3	26.9	34.1	55	27.6	26.9
			≥ 4	34.1	34.1	55	27.6	27.6
		3500	≥ 3	31.4	34.1	55	27.6	27.6
HP288NCB8	8 x 8 x 0.75	2500	≥ 4	34.1	34.1	55	27.6	27.6
HP288NCB-G	8 x 8 x 0.75	2500	≥ 4	38.2	38.2	55	27.6	27.6

For SI: 1 inch = 25.4 mm, 1 kip = 1000 lbf = 4.448 kN, 1 psi = 6.895 kPa.

<sup>1</sup>Part numbers with "G" suffix indicate hot-dip galvanized coating. Part numbers without a "G" suffix indicate plain steel.

<sup>2</sup>Bracket capacity is based on localized limit state of concrete bearing only. All other limit states related to the concrete foundation, such as punching shear, have not been evaluated in this evaluation report.

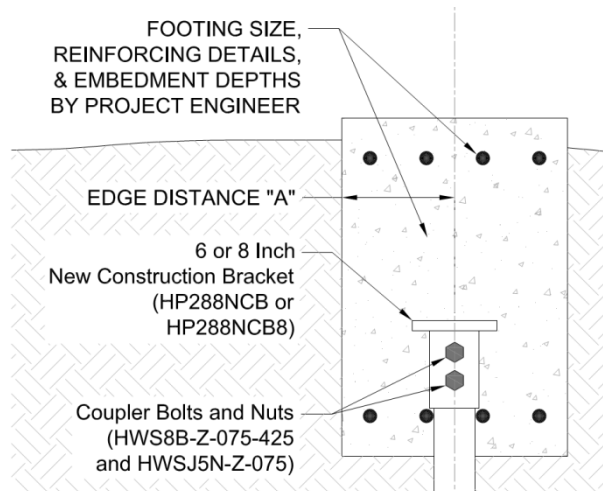
<sup>3</sup>Helix capacity is based on a single helix plate with outer diameter of 8, 10, 12 or 14 inches (203, 254, 305 or 356 mm).

<sup>4</sup>Soil capacity is based on torque correlation per Section 4.1.5 of this report, with piles installed at the maximum torsion rating.

<sup>5</sup>Foundation system allowable capacity is based on the lowest of P1, P2, P3 and P4.

<sup>6</sup>Reduction of plain concrete thickness described in Section 22.4.8 of ACI 318 is assumed not applicable.

<sup>7</sup>Bolts must be installed in accordance with Sections 3.2.2.2 and 4.2.4 of this report.



**FIGURE 2—HP288 NEW CONSTRUCTION BRACKET ASSEMBLY**

TABLE 4—HP288 LEAD AND EXTENSION ASD TENSION AND COMPRESSION CAPACITIES<sup>1,6</sup>

Lead/Extension Part No.	Net Shaft Length "L" (in)	Helix Diameter (in)				(P2) <sup>2</sup> Shaft Comp. (kips)	(P2) Shaft Ten. (kips)	(P3) <sup>3</sup> Helix (kips)	K <sub>t</sub> (ft <sup>-1</sup> )	Shaft Torsion Rating <sup>4</sup> (lbf-ft)	(P4) <sup>5</sup> Torque Correlated Soil Capacity (kips)	
		A	B	C	D						Com.	Ten.
HP288L5H8-3850	60	8	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L5H0-3850	60	10	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L5H2-3850	60	12	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L5H4-3850	60	14	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L5H80-3850	60	8	10	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L5H02-3850	60	10	12	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L5H24-3850	60	12	14	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L7H8-3850	84	8	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L7H0-3850	84	10	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L7H2-3850	84	12	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L7H4-3850	84	14	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L7H80-3850	84	8	10	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L7H02-3850	84	10	12	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L7H24-3850	84	12	14	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L7H802-3850	84	8	10	12	--	60	34.1	55	9	7898	35.5	27.6
HP288L7H024-3850	84	10	12	14	--	60	34.1	55	9	7898	35.5	27.6
HP288L0H80-3850	120	8	10	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L0H02-3850	120	10	12	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L0H24-3850	120	12	14	--	--	60	34.1	55	9	7898	35.5	27.6
HP288L0H802-3850	120	8	10	12	--	60	34.1	55	9	7898	35.5	27.6
HP288L0H024-3850	120	10	12	14	--	60	34.1	55	9	7898	35.5	27.6
HP288L0H8024-3850	120	8	10	12	14	60	34.1	55	9	7898	35.5	27.6
HP288E3H4-3850	30	14	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288E4H4-3850	42	14	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288E5H4-3850	54	14	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288E7H4-3850	78	14	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288E0H4-3850	114	14	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288E7H44-3850	78	14	14	--	--	60	34.1	55	9	7898	35.5	27.6
HP288E0H44-3850	114	14	14	--	--	60	34.1	55	9	7898	35.5	27.6
HP288E3	30	--	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288E5	54	--	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288E7	78	--	--	--	--	60	34.1	55	9	7898	35.5	27.6
HP288E0	114	--	--	--	--	60	34.1	55	9	7898	35.5	27.6

For SI: 1 inch = 25.4 mm, 1 kip = 1000 lbf = 4.448 kN, 1lbf-ft = 1.356 N-m.

<sup>1</sup>Part numbers with "G" suffix indicate hot-dip galvanized coating. Part numbers without a "G" suffix indicate plain steel.

<sup>2</sup>Shaft compression capacity (P2) is based on that the foundation system is fully braced as described in Section 4.1.3.

<sup>3</sup>Helix capacity (P3) is applicable to both tension and compression loading and is based on a single helix plate with outer diameter of 8, 10, 12 or 14 inches (203, 254, 305 or 356 mm).

<sup>4</sup>Shaft torsion rating is the maximum torsion that can be applied to the shaft during the helical pile installation.

<sup>5</sup>Torque correlated soil capacity (P4) is applicable to both tension and compression loading and is based on torque correlation per Section 4.1.5, with piles installed at the maximum torsion rating.

<sup>6</sup>For piles with extension(s), shaft coupling(s) must be installed in accordance with Sections 3.2.1 and 4.2.2 of this report.

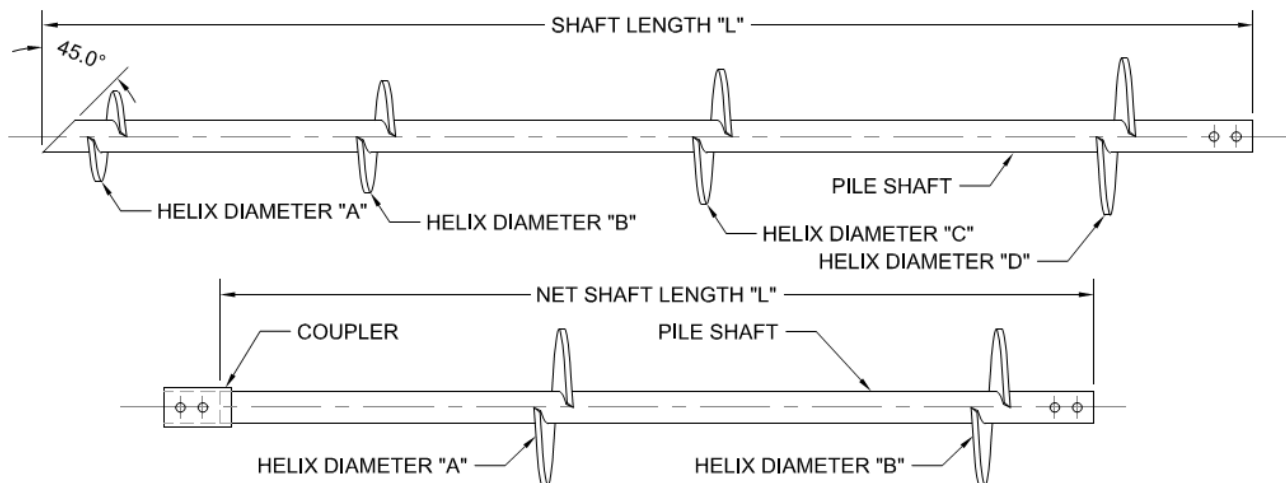


FIGURE 3—TYPICAL HP288 SHAFT LEAD AND EXTENSION SECTIONS AND HELIX PLATES



TABLE 5—MECHANICAL PROPERTIES OF 2.875-INCH DIAMETER HELICAL SHAFTS

Mechanical Properties	Un-corroded	After 50 Year Corrosion Loss	
	Plain Steel	Plain Steel	Hot-dip Galvanized Steel
Steel Minimum Yield Strength, $F_y$	60 ksi	60 ksi	60 ksi
Steel Minimum Ultimate Strength, $F_u$	70 ksi	70 ksi	70 ksi
Modulus of Elasticity, $E$	29,000 ksi	29,000 ksi	29,000 ksi
Nominal Wall Thickness	0.276 in.	0.276 in.	0.276 in.
Design Wall Thickness	0.257 in.	0.221 in.	0.247 in.
Outside Diameter, OD	2.875 in.	2.839 in.	2.865 in.
Inside Diameter, ID	2.361 in.	2.397 in.	2.371 in.
Cross Sectional Area, $A$	2.11 in <sup>2</sup>	1.82 in <sup>2</sup>	2.03 in <sup>2</sup>
Moment of Inertia, $I$	1.83 in <sup>4</sup>	1.57 in <sup>4</sup>	1.76 in <sup>4</sup>
Radius of Gyration, $r$	0.93 in.	0.93 in.	0.93 in.
Elastic Section Modulus, $S$	1.27 in <sup>3</sup>	1.10 in <sup>3</sup>	1.23 in <sup>3</sup>
Plastic Section Modulus, $Z$	1.77 in <sup>3</sup>	1.52 in <sup>3</sup>	1.70 in <sup>3</sup>

For **SI**: 1 inch = 25.4 mm, 1 ksi = 6.895 MPa, 1lbf-ft = 1.356 N-m, 1 lbf = 4.448 N.