

# MODEL SPECIFICATION FOR HELICAL ANCHOR FOUNDATIONS TENSION APPLICATIONS

## 1 SCOPE

- 1.1 The work consists of designing, furnishing and installing helical anchors and load transfer devices used to support tension loads according to the project Plans and these specifications.
- 1.2 The parties and contract terms referred to in this specification are as follows:
  - 1.2.1 The Owner is the person or entity that owns the facility or will own the facility once it is completed. The Owner may have contractual agreements with, and be represented by, other parties such as engineers, architects or contractors that perform services under the direction of the Owner. Where Owner is used in this specification, it refers to the Owner or the Owner's contracted representatives separate from the Installing Contractor.
  - 1.2.2 The Anchor Designer is the individual or firm generally hired by the Installing Contractor to design the helical anchors.
  - 1.2.3 The Installing Contractor installs and tests (if necessary) the helical anchors, and possibly performs other tasks associated with the project.
  - 1.2.4 The Plans refer to the contract documents; including but not limited to the drawings and specifications for the project.
- 1.3 The work may include helical anchor load testing.
- 1.4 The Owner will be responsible for obtaining any right-of-way or easement access permits necessary for the helical anchor installation.
- 1.5 Unless otherwise noted, the Installing Contractor shall provide all labor, tools, equipment and materials necessary to accomplish the work.
- 1.6 The Owner will provide suitable access to the construction site for the Installing Contractor's personnel and equipment.
- 1.7 Unless specifically noted otherwise in the contract documents, the Owner will remove and replace any structures, utilities, pavements, landscaping or other surficial improvements in the work area as necessary to facilitate the work.
- 1.8 The Owner will be responsible for overall construction oversight to preclude the development of unsafe conditions.
- 1.9 The Owner will be responsible for a horizontal field survey of the helical anchor locations prior to helical anchor installation and a post installation survey to determine anchor shaft cutoff lengths (if necessary).
- 1.10 The work does not include any post-construction monitoring of anchor performance unless specifically noted otherwise in the contract documents.

## 2 REFERENCES

- 2.1 American Institute of Steel Construction (AISC)
  - 2.1.1 AISC 360: Specification for Structural Steel Buildings
- 2.2 American Society for Testing and Materials (ASTM)
  - 2.2.1 ASTM A29: Steel Bars, Carbon and Alloy, Hot-Wrought
  - 2.2.2 ASTM A36: Carbon Structural Steel

- 2.2.3 ASTM A123: Zinc Coating (Hot-Dip) Coatings on Iron and Steel Products
- 2.2.4 ASTM A153: Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- 2.2.5 ASTM A307: Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength
- 2.2.6 ASTM A325: Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
- 2.2.7 ASTM A500: Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
- 2.2.8 ASTM A513: Electric-Resistance Welded Carbon and Alloy Steel Mechanical Tubing
- 2.2.9 ASTM A572: High-Strength Low-Alloy Columbian-Vanadium Structural Steel
- 2.2.10 ASTM B633: Electrodeposited Coatings of Zinc on Iron and Steel
- 2.2.11 ASTM B695: Coatings of Zinc Mechanically Deposited on Iron and Steel
- 2.2.12 ASTM D3689: Deep Foundations Under Static Axial Tensile Load
- 2.3 International Code Council Evaluation Services (ICC-ES)
  - 2.3.1 Acceptance Criteria 358 (AC358): Acceptance Criteria for Helical Pile Systems and Devices
- 2.4 Society of Automotive Engineers (SAE)
  - 2.4.1 SAE J429: Mechanical and Material Requirements for Externally Threaded Fasteners

### **3 DEFINITIONS**

- 3.1 The following terms apply to helical anchors used to support tension loads:
  - 3.1.1 Allowable Stress Design: A structural and geotechnical design methodology that states that the summation of the actual estimated loads (nominal loads) must be less than or equal to the allowable design load (required strength). Allowable loads are obtained by dividing a nominal resistance (strength) by an appropriate factor of safety.
  - 3.1.2 Bearing Stratum: The soil layer (or layers) that provides the helical anchor end-bearing capacity through load transfer from the helical plates.
  - 3.1.3 Crowd: Axial compressive force applied to the helical anchor shaft as needed during installation to ensure the anchor advances at a rate approximately equal to the helix pitch for each revolution.
  - 3.1.4 Design Loads: A generic and ambiguous term used to describe any load used in design. It is not specific to factored or unfactored loads or any particular design methodology. It is a term; therefore, that should be avoided when specifying load requirements. FSI recommends using the term service load, nominal load or factored load, as described herein, where applicable.
  - 3.1.5 Design Strength: A term used in structural design which is defined as the product of the nominal strength and the applicable resistance factor. An equivalent term typically used in geotechnical design is, also sometimes referred to as factored resistance (Load and Resistance Factor Design).
  - 3.1.6 Extension Section: Helical anchor shaft sections connected to the lead section or other extension sections to advance the helix plates to the required bearing depth. Plain extensions (without helix plates) or helical extensions (with one or more helix plates) may be used depending upon soil conditions or project requirements.
  - 3.1.7 Factor of Safety: The ratio of the ultimate anchor capacity or nominal resistance (strength) to the nominal or service load used in the design of any helical anchor component or interface (Allowable Stress Design).

- 3.1.8 Factored Load: The product of a nominal load and an applicable load factor (Load and Resistance Factor Design).
- 3.1.9 Factored Resistance: The product of a nominal resistance and an applicable resistance factor (Load and Resistance and Factor Design).
- 3.1.10 Geotechnical Capacity: The maximum load or the load at a specified limit state, that can be resisted through the anchors interaction with the bearing soils (see also Ultimate Anchor Capacity).
- 3.1.11 Helical Anchor: Consists of a central steel shaft with one or more helix-shaped bearing plates and a load transfer device (bracket) that allows attachment to structures. Helical anchors are installed into the ground by application of torque and axial compressive force ("crowd").
- 3.1.12 Helix (Helical) Plate: Generally round steel plate formed into a helical spiral and welded to the central steel shaft. When rotated in the ground, the helix shape provides thrust along the anchor's longitudinal axis thus aiding in anchor installation. The plate transfers axial load to the soil through bearing.
- 3.1.13 Helix Pitch: The distance measured along the axis of the shaft between the leading and trailing edges of the helix plate.
- 3.1.14 Lead Section: The first helical anchor shaft component installed into the soil. It consists of one or more helical plates welded to a central steel shaft.
- 3.1.15 Limit State: A condition beyond which a helical anchor component or interface becomes unfit for service and is judged to no longer be useful for its intended function (serviceability limit state) or to be unsafe (ultimate limit state (strength)).
- 3.1.16 Load and Resistance Factor Design: A structural and geotechnical design methodology that states that the Factored Resistance (Design Strength) must be greater than or equal to the summation of the applied factored loads.
- 3.1.17 Load Factor: A factor that accounts for the probability of deviation of the actual load from the predicted nominal load due to variability of material properties, workmanship, type of failure and uncertainty in the prediction of the load (Load and Resistance Factor Design).
- 3.1.18 Load Test: A process to test the ultimate anchor capacity and relation of applied load to anchor head movement by application of a known load on the helical anchor head and monitoring movement over a specific time period.
- 3.1.19 Loads: Forces that result from the weight of all building materials, occupants and their possessions, environmental effects, differential movement, and restrained dimensional changes. Permanent loads are those loads in which variations over time are rare or of small magnitude. All other loads are variable loads (see also Nominal Loads).
- 3.1.20 Mechanical Strength: The maximum load or the load at a specified limit state that can be resisted by the structural elements of a helical anchor.
- 3.1.21 Net Deflection: The total movement at the anchor head minus the theoretical elastic deformation of the anchor shaft during a load test.
- 3.1.22 Nominal Loads: The magnitude of the loads specified, which include dead, live, soil, wind, snow, rain, flood and earthquakes (also referred to as service loads or working loads).
- 3.1.23 Nominal Resistance: The anchor capacity at a specified ultimate limit state (Load and Resistance Factor Design). See Ultimate Anchor Capacity.
- 3.1.24 Nominal Strength: A term used in structural design which is defined as the structure or member capacity at a specified strength limit state. See Ultimate Anchor Capacity.
- 3.1.25 Resistance Factor: A factor that accounts for the probability of deviation of the actual resistance (strength) from the predicted nominal resistance (strength) due to variability

of material properties, workmanship, type of failure and uncertainties in the analysis (Load and Resistance Factor Design).

3.1.26 Service Loads: See "Nominal Loads" above.

3.1.27 Ultimate Anchor Capacity: The helical anchor capacity based on the least capacity determined from applicable ultimate limit states for mechanical and geotechnical capacity.

#### **4 APPROVED HELICAL ANCHOR MANUFACTURERS**

4.1 Supportworks®, Inc., 11850 Valley Ridge Drive, Papillion, NE 68046; Phone: (800) 281-8545; Fax: (402) 393-4002.

4.2 Due to the special requirements for design and manufacturing of helical anchors, the anchors shall be obtained from Supportworks®, Inc., or other qualified manufacturer with an approved equivalent product. A request to substitute any other manufactured helical product must be submitted to the Owner for review not less than seven (7) calendar days prior to the bid date. The request must include:

4.2.1 Documentation of at least five years of production experience manufacturing helical anchors,

4.2.2 Documentation that the manufacturer's helical anchors have been used successfully in at least five engineered construction projects within the last three years,

4.2.3 Product acceptance by the local building code official(s) having jurisdiction over the project, and/or

4.2.4 Current ICC-ES product evaluation report or complete description of product testing and manufacturing quality assurance programs used to assess and maintain product quality and determine product mechanical strength and geotechnical capacity.

#### **5 ACCEPTABLE PRODUCTS FOR TENSION ONLY APPLICATIONS**

5.1 Solid Square Shaft Helical Anchor Models HA150 and HA175 manufactured in accordance with the requirements of Sections 5 and 7 of this specification.

5.1.1 Solid round corner square shaft helical anchors may be used for tension only applications.

5.1.2 Helix plates shall meet the following geometry and spacing criteria to minimize soil disturbance:

5.1.2.1 True helix-shaped plates that are normal to the shaft such that the leading and trailing edges are within ¼-inch of parallel.

5.1.2.2 Helix pitch is 3-inches  $\pm$  ¼-inch.

5.1.2.3 All helix plates have the same pitch.

5.1.2.4 Helix plates have generally circular edge geometry.

5.1.2.5 Helix spacing along the shaft shall be between 2.4 and 3.6 times the helix diameter.

5.1.2.6 Helix plates are arranged along the shaft such that they all theoretically track the same path as the proceeding plate.

#### **6 ACCEPTABLE PRODUCTS FOR COMBINED COMPRESSION AND TENSION APPLICATIONS**

6.1 Hollow Round Shaft Helical Pile/Anchor Models HP237, HP287, HP288, HP350, HP450, HP662 and HP700 manufactured in accordance with the requirements of Sections 6 and 7 of this specification.

6.1.1 Hollow round shaft helical piles/anchors shall be used in applications of alternating compression and tension loads. During compression loading, round shaft helical

piles/anchors are generally more resistant to bending or buckling over solid square shaft counterparts due to superior cross-sectional properties and coupling details.

- 6.1.2 During compression loading, pile/anchor shaft sections shall be in full, direct contact within couplings so as to remove coupling bolts and coupling welds from the “in-service” axial load path.
- 6.1.3 Pile/anchor shafts and couplings shall have a fit-up tolerance of 1/16-inch or less.
- 6.1.4 Helix plates shall meet the following geometry and spacing criteria to minimize soil disturbance:
  - 6.1.4.1 True helix-shaped plates that are normal to the shaft such that the leading and trailing edges are within ¼-inch of parallel.
  - 6.1.4.2 Helix pitch is 3-inches  $\pm$  ¼-inch.
  - 6.1.4.3 All helix plates have the same pitch.
  - 6.1.4.4 Helix plates have generally circular edge geometry.
  - 6.1.4.5 Helix spacing along the shaft shall be between 2.4 and 3.6 times the helix diameter.
  - 6.1.4.6 Helix plates are arranged along the shaft such that they all theoretically track the same path as their proceeding plate.

## 7 **MATERIALS**

### 7.1 Model HA150 Helical Anchor System

- 7.1.1 Central Steel Shaft: The central steel shaft of the lead and extension sections are 1.50-inch, solid, round-corner square (RCS) hot-rolled steel bars conforming to ASTM A29 with a minimum yield strength of 90 ksi and a minimum tensile strength of 115 ksi. The shaft finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
- 7.1.2 Shaft Coupling Material: The extension shaft sections have an internally forged upset socket coupling at one end. Since the socket coupling is internally forged from the parent shaft material, the material properties of the coupling are similar to the central steel shaft. The shaft coupling finish is either plain steel or hot-dip galvanized in accordance with ASTM A123
- 7.1.3 Helix Plate Material: The helix plates are factory welded to the shaft lead or extension shaft sections. Helix plates with outer diameters of 6, 8, 10, 12 or 14-inches are either 0.375 or 0.500-inches thick and 16-inch diameter helix plates are 0.500-inches thick. The helix plates are manufactured with ASTM A572 Grade 50 steel with a minimum yield strength of 50 ksi and a minimum tensile strength of 65 ksi. The helix plate finish is either plain steel or hot-dip galvanized in accordance with ASTM A123
- 7.1.4 Shaft Coupling Hardware: The lead and extension shaft sections are coupled with one (1) bolt and nut per coupled shaft section. The coupling hardware consists of 0.750-inch standard hex bolts conforming to SAE J429 Grade 8 and jam nuts. The bolts and nuts are mechanically galvanized in accordance with ASTM B695.
- 7.1.5 Brackets: New construction bracket HA150NCB and thread rod adaptor HA150TRA are suitable for tension applications with the HA150 shaft. Bracket finishes are either plain steel or hot-dip galvanized in accordance with ASTM A123. Bracket shaft coupling hardware finishes are mechanically galvanized in accordance with ASTM B695.

### 7.2 Model HA175 Helical Anchor System

- 7.2.1 Central Steel Shaft: The central steel shaft of the lead and extension sections are 1.75-inch, solid, round-corner square (RCS) hot-rolled steel bars conforming to ASTM A29 with a minimum yield strength of 90 ksi and a minimum tensile strength of 115 ksi. The shaft finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.

- 7.2.2 Shaft Coupling Material: The extension shaft sections have an internally forged upset socket coupling at one end. Since the socket coupling is internally forged from the parent shaft material, the material properties of the coupling are similar to the central steel shaft. The shaft coupling finish is either plain steel or hot-dip galvanized in accordance with ASTM A123
- 7.2.3 Helix Plate Material: The helix plates are factory welded to the lead or extension shaft sections. Helix plates with outer diameters of 6, 8, 10, 12 or 14-inches are either 0.375 or 0.500-inches thick and 16-inch diameter helix plates are 0.500-inches thick. The helix plates are manufactured with ASTM A572 Grade 50 steel with a minimum yield strength of 50 ksi and a minimum tensile strength of 65 ksi. The helix plate finish is either plain steel or hot-dip galvanized in accordance with ASTM A123
- 7.2.4 Shaft Coupling Hardware: The lead and extension shaft sections are coupled with two (2) bolts and nuts per coupled shaft section. The coupling hardware consists of 0.750-inch standard hex bolts conforming to SAE J429 Grade 8 and standard hex jam nuts. The bolts and nuts are mechanically galvanized in accordance with ASTM B695.
- 7.2.5 Brackets: New construction bracket HA175NCB and thread rod adaptor HA175TRA are suitable for tension applications with the HA175 shaft. Bracket finishes are either plain steel or hot-dip galvanized in accordance with ASTM A123. Bracket shaft coupling hardware finishes are mechanically galvanized in accordance with ASTM B695.

### 7.3 Model HP237 Helical Pile/Anchor System

- 7.3.1 Central Steel Shaft: The central steel shaft of the lead and extension sections are 2.375-inch outer diameter by 0.154-inch nominal wall thickness, hollow structural section in conformance with ASTM A500 Grade B or C with a minimum yield strength of 60 ksi and a minimum tensile strength of 70 ksi. The shaft finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
- 7.3.2 Shaft Coupling Material: The shaft coupling material is factory welded to the extension shaft and consists of 2.750-inch outer diameter by 0.156-inch nominal wall thickness, hollow structural section in conformance with ASTM A513 Type 5, Grade 1026 with a minimum yield strength of 70 ksi and a minimum tensile strength of 80 ksi. The shaft coupling finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
- 7.3.3 Helix Plate Material: The helix plates are factory welded to the lead or extension shaft sections and consist of either 0.313 or 0.375-inch thick ASTM A572 Grade 50 steel with a minimum yield strength of 50 ksi and a minimum tensile strength of 65 ksi. Helix plate outer diameters are 6, 8, 10, 12 or 14-inches. The helix plate finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
- 7.3.4 Shaft Coupling Hardware: The lead and extension shaft sections are coupled with two (2) bolts and nuts per coupled shaft section. The coupling hardware consists of 0.625-inch standard hex bolts conforming to ASTM A325 and heavy hex jam nuts. The bolts and nuts are hot-dip galvanized in accordance with ASTM A153.
- 7.3.5 Brackets: New construction bracket HP238NCB shall be used for both tension and compression applications with the HP237 shaft. Bracket finishes are either plain steel or hot-dip galvanized in accordance with ASTM A123. Bracket hardware finishes are hot-dip galvanized in accordance with ASTM A153.

### 7.4 Model HP287 and Model HP288 Helical Pile/Anchor Systems

- 7.4.1 Central Steel Shaft: The central steel shaft of the lead and extension sections are 2.875-inch outer diameter by 0.203-inch nominal wall thickness (HP287) or 0.276-inch nominal wall thickness (HP288), hollow structural section in conformance with ASTM A500 Grade B or C with a minimum yield strength of 60 ksi and a minimum tensile

strength of 70 ksi. The shaft finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.

- 7.4.2 Shaft Coupling Material: The shaft coupling material is factory welded to the extension shaft and consists of 3.500-inch outer diameter by 0.281-inch nominal wall thickness, hollow structural section in conformance with ASTM A513 Type 5, Grade 1026 with a minimum yield strength of 70 ksi and a minimum tensile strength of 80 ksi. The shaft coupling finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
- 7.4.3 Helix Plate Material: The helix plates are factory welded to the lead or extension shaft sections. Helix plates with outer diameters of 6, 8, 10, 12 or 14-inches are either 0.375 or 0.500-inches thick and 16-inch diameter helix plates are 0.500-inches thick. The helix plates are manufactured with ASTM A572 Grade 50 steel with a minimum yield strength of 50 ksi and a minimum tensile strength of 65 ksi. The helix plate finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
- 7.4.4 Shaft Coupling Hardware: The lead and extension shaft sections are coupled with two (2) bolts and nuts per coupled shaft section. The coupling hardware consists of 0.750-inch standard hex bolts conforming to SAE J429 Grade 8 and standard jam nuts. The bolts and nuts are zinc coated in accordance with ASTM B633.
- 7.4.5 Brackets: New construction brackets HP288NCB or HP288NCB8 shall be used for both tension and compression applications with the HP287 or HP288 shafts. Bracket finishes are either plain steel or hot-dip galvanized in accordance with ASTM A123. Bracket hardware finishes are zinc coated in accordance with ASTM B633.

## 7.5 Model HP350 Helical Pile/Anchor System

- 7.5.1 Central Steel Shaft: The central steel shaft of the lead and extension sections are 3.500-inch outer diameter by 0.340-inch nominal wall thickness, hollow structural section in conformance with ASTM A500 Grade B or C with a minimum yield strength of 65 ksi and a minimum tensile strength of 75 ksi. The shaft finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
- 7.5.2 Shaft Coupling Material: The shaft coupling material consists of 4.250-inch outer diameter by 0.344-inch nominal wall thickness, hollow structural section in conformance with ASTM A513 Type 5, Grade 1026 with a minimum yield strength of 70 ksi and a minimum tensile strength of 80 ksi. The shaft coupling finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
- 7.5.3 Helix Plate Material: The helix plates are factory welded to the lead or extension shaft sections. Helix plates with outer diameters of 6, 8, 10, 12 or 14-inches are either 0.375 or 0.500-inches thick and 16-inch diameter helix plates are 0.500-inches thick. The helix plates are manufactured with ASTM A572 Grade 50 steel with a minimum yield strength of 50 ksi and a minimum tensile strength of 65 ksi. The helix plate finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
- 7.5.4 Shaft Coupling Hardware: The lead and extension shaft sections are coupled with four (4) bolts and nuts per coupled shaft section. The coupling hardware consists of 1.000-inch standard hex bolts conforming to SAE J429 Grade 5 and standard hex jam nuts. The bolts and nuts are zinc coated in accordance with ASTM B633.
- 7.5.5 Brackets: New construction brackets HP350NCB or HP350NCB8 shall be used for both tension and compression applications. Bracket finishes are either plain steel or hot-dip galvanized in accordance with ASTM A123. Bracket hardware finishes are zinc coated in accordance with ASTM B633.

## 7.6 Model HP450 Helical Pile/Anchor System

- 7.6.1 Central Steel Shaft: The central steel shaft of the lead and extension sections are 4.500-inch outer diameter by 0.337-inch nominal wall thickness, hollow structural section in conformance with ASTM A500 Grade B or C with a minimum yield strength

of 50 ksi and a minimum tensile strength of 60 ksi. The shaft finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.

- 7.6.2 Shaft Coupling Material: The shaft coupling material consists of 3.750-inch outer diameter by 0.500-inch nominal wall thickness, hollow structural section in conformance with ASTM A513 Type 5, Grade 1026 with a minimum yield strength of 70 ksi and a minimum tensile strength of 80 ksi. The shaft coupling finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
- 7.6.3 Helix Plate Material: The helix plates are factory welded to the lead or extension shaft sections. Helix plates with outer diameters of 8, 10, 12 or 14-inches are either 0.375 or 0.500-inches thick and 16-inch diameter helix plates are 0.500-inches thick. The helix plates are manufactured with ASTM A572 Grade 50 steel with a minimum yield strength of 50 ksi and a minimum tensile strength of 65 ksi. The helix plate finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
- 7.6.4 Shaft Coupling Hardware: The lead and extension shaft sections are coupled with four (4) bolts and nuts per coupled shaft section. The coupling hardware consists of 1.125-inch standard hex bolts conforming to SAE J429 Grade 5 and standard hex jam nuts. The bolts and nuts are zinc coated in accordance with ASTM B633.
- 7.6.5 Brackets: New construction bracket HP450NCB8 shall be used for both tension and compression applications with the HP450 shaft. Bracket finishes are either plain steel or hot-dip galvanized in accordance with ASTM A123. Bracket hardware finishes are zinc coated in accordance with ASTM B633.

## 7.7 Model HP662 Helical Pile/Anchor System

- 7.7.1 This section is for general information purposes only. Larger diameter product lines, such as Model HP662, are typically customized on a project specific basis.
  - 7.7.1.1 Central Steel Shaft: The central steel shaft of the lead and extension sections are 6.625-inch outer diameter by 0.280-inch nominal wall thickness, hollow structural section in conformance with ASTM A500 Grade B or C with a minimum yield strength of 60 ksi and a minimum tensile strength of 70 ksi. The shaft finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
  - 7.7.1.2 Shaft Coupling Material: The shaft coupling material consists of 6.000-inch outer diameter by 0.375-inch nominal wall thickness, hollow structural section in conformance with ASTM A513 Type 5, Grade 1026 with a minimum yield strength of 70 ksi and a minimum tensile strength of 80 ksi. The shaft coupling finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
  - 7.7.1.3 Helix Plate Material: The helix plates are factory welded to the lead or extension shaft sections. Helix plates with outer diameters of 10, 12 or 14-inches are either 0.375 or 0.500-inches thick; 16-inch diameter helices are 0.500-inches thick. Helix plates are manufactured with ASTM A572 Grade 50 steel with a minimum yield strength of 50 ksi and a minimum tensile strength of 65 ksi. The helix plate finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
  - 7.7.1.4 Shaft Coupling Hardware: The lead and extension shaft sections are coupled with four (4) bolts and nuts per coupled shaft section. The coupling hardware consists of 1.750-inch standard hex bolts conforming to SAE J429 Grade 5 and standard hex nuts. The bolts and nuts are zinc coated in accordance with ASTM B633.

## 7.8 Model HP700 Helical Pile/Anchor System

- 7.8.1 This section is for general information purposes only. Larger diameter product lines, such as Model HP700, are typically customized on a project specific basis.



- 7.8.1.1 Central Steel Shaft: The central steel shaft of the lead and extension sections are 7.000-inch outer diameter by 0.362-inch nominal wall thickness, hollow structural section in conformance with ASTM A252 Grade 3 with a minimum yield strength of 60 ksi and a minimum tensile strength of 70 ksi. The shaft finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
- 7.8.1.2 Shaft Coupling Material: The shaft coupling material consists of 7.750-inch outer diameter by 0.313-inch nominal wall thickness, hollow structural section in conformance with ASTM A513 Type 5, Grade 1026 with a minimum yield strength of 70 ksi and a minimum tensile strength of 80 ksi. The shaft coupling finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
- 7.8.1.3 Helix Plate Material: The helix plates are factory welded to the lead or extension shaft sections. Helix plates with outer diameters of 10, 12 or 14-inches are either 0.375 or 0.500-inches thick; 16-inch diameter helices are 0.500-inches thick. Helix plates are manufactured with ASTM A572 Grade 50 steel with a minimum yield strength of 50 ksi and a minimum tensile strength of 65 ksi. The helix plate finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.
- 7.8.1.4 Shaft Coupling Hardware: The lead and extension shaft sections are coupled with four (4) bolts and nuts per coupled shaft section. The coupling hardware consists of 2.000-inch heavy hex bolts conforming to ASTM A307 and heavy hex nuts. The bolts and nuts are zinc coated in accordance with ASTM B633.

## **8 DESIGN AND PERFORMANCE REQUIREMENTS**

- 8.1 Helical anchors shall be designed to support the specified tension load(s) as shown on the project Plans. The overall length, helix configuration and minimum torsional resistance of a helical anchor shall be such that the required geotechnical capacity is developed by the helix plate(s) in an appropriate bearing stratum.
- 8.2 All structural steel anchor components shall be designed within the limits provided by the American Institute of Steel Construction (AISC) Specification for Structural Steel Buildings (AISC-360). Either Allowable Stress Design (ASD) or Load and Resistance Factor Design (LRFD) are acceptable methods of analysis. Product testing in accordance with ICC-ES Acceptance Criteria 358 may also be considered as an acceptable means of establishing system capacities.
- 8.3 Except where noted otherwise on the project Plans, all anchors shall be installed to provide an ultimate torque-correlated capacity based on an ASD or LRFD analysis. For ASD, a minimum factor of safety of 2 applied to the service or nominal loading shall be required. When an LRFD analysis is required, the Owner shall provide applicable anchor design information including but not limited to; factored loads, resistance factors and/or the required ultimate anchor capacity. Factors of safety (ASD) or resistance factors (LRFD) may require modification to meet specific deflection criteria stated on the Plans or drawings
- 8.4 The required ultimate torque-correlated capacity shall be verified at each anchor location by monitoring and recording the final installation torque and applying default torque correlations per ICC-ES AC358. Site specific torque correlation factors may be determined by field tension load testing as specified in Section 15.
- 8.5 Except where noted otherwise on the project Plans, each anchor shall be designed to meet a corrosion service life of 50 years in accordance with ICC-ES AC358.
- 8.6 The anchor design shall take into account group efficiency from anchor spacing, soil stratification, and strain compatibility issues.

## **9 QUALIFICATIONS OF INSTALLING CONTRACTOR AND ANCHOR DESIGNER**

- 9.1 The Installing Contractor and/or Anchor Designer shall submit to the Owner, a proposal including the documentation required in this Section. Work shall not begin until all the submittals have been received and approved by the Owner. All costs associated with incomplete or unacceptable submittals shall be the responsibility of the Installing Contractor.
- 9.2 Evidence of Installing Contractor's competence in the installation of helical anchors shall be provided to the Owner's satisfaction and may include any or all of the following:
  - 9.2.1 Anchor manufacturer's certificate of competency in installation of helical anchors,
  - 9.2.2 A list of at least three projects completed within the previous three years wherein the Installing Contractor installed helical anchors similar to those shown in the project Plans. Such list to include names and phone numbers of those project representatives who can verify the Installing Contractor's participation in those projects, and/or
  - 9.2.3 A letter from the anchor manufacturer or manufacturer's representative expressing ability and intent to provide on-site supervision of the anchor installation.
- 9.3 A listing of all safety violations lodged against the Installing Contractor within the previous three years and the current status or final resolutions thereof. Descriptions of safety improvements instituted within the previous three years may also be submitted, at the Installing Contractor's discretion.
- 9.4 Evidence of Anchor Designer's competence shall be provided to the Owner's satisfaction and may include any or all of the following:
  - 9.4.1 Registration as a Professional Engineer or recognition by the local jurisdictional authority,
  - 9.4.2 A list of at least three projects completed within the previous three years wherein the Anchor Designer designed helical anchors similar to those shown in the project Plans. The list shall include names and phone numbers of those project representatives who can verify the Anchor Designer's participation in those projects, and/or
  - 9.4.3 Recommendation from the anchor manufacturer or manufacturer's representative.

## **10 PRE-CONSTRUCTION SUBMITTALS**

- 10.1 Within 2 weeks of receiving the contract award, the Installing Contractor and/or Anchor Designer shall submit the following helical anchor design documentation:
  - 10.1.1 Certification from the Anchor Designer that the proposed anchors meet the requirements of this specification.
  - 10.1.2 Qualifications of the Installing Contractor and Anchor Designer per Section 9.
  - 10.1.3 Product designations for helical lead and extension sections and all ancillary products to be supplied at each helical anchor location.
  - 10.1.4 Individual anchor nominal loads, factors of safety, LRFD load and resistance factors and required ultimate torque-correlated capacities, where applicable.
  - 10.1.5 Individual anchor loading requirements (if any).
  - 10.1.6 Manufacturer's published allowable system capacities for the proposed anchor assemblies, including load transfer devices.
  - 10.1.7 Calculated mechanical and theoretical geotechnical capacity of anchors.
  - 10.1.8 Minimum anchor termination torque requirements.
  - 10.1.9 Maximum estimated installation torque and allowable installation torque rating of anchor.
  - 10.1.10 Minimum and/or maximum embedment lengths or other site specific embedment depth requirements as may be appropriate for the site soil profiles.
  - 10.1.11 Inclination angle and location tolerance requirements.

10.1.12 Load test procedures and failure criteria, if applicable.

10.1.13 Copies of certified calibration reports for torque measuring equipment and load test measuring equipment to be used on the project. The calibrations shall have been performed within one year of the proposed helical anchor installation starting date or as recommended by the equipment manufacturer.

10.1.14 Provide proof of insurance coverage as stated in the general specifications and/or contract.

## **11 PLACEMENT REQUIREMENTS**

11.1 Helical anchors shall be installed within 3-inches of the indicated plan location.

11.2 Helical anchor shaft alignment shall be within 2-degrees of the inclination angle shown on the Plans.

11.3 Top elevation of helical anchors shall be within 2-inches of the design vertical elevation

## **12 ANCHOR INSTALLATION**

12.1 Installing Contractor shall furnish and install all helical anchors per the project Plans and approved anchor design documentation. In the event of conflict between the project Plans and the approved anchor design documentation, the Installing Contractor shall not begin construction on any affected items until such conflict has been resolved.

12.2 The Installing Contractor shall conduct their construction operations in a manner to insure the safety of persons and property in the vicinity of the work. The Installing Contractor's personnel shall comply with safety procedures in accordance with OSHA standards and any established project safety plan.

12.3 The Owner shall request marking of underground utilities by an underground utility location service as required by law, and the Installing Contractor shall avoid contact with all marked underground facilities.

12.4 The portion of the construction site occupied by the Installing Contractor, including equipment and material stockpiles shall be kept reasonably clean and orderly.

12.5 Installation of helical anchors may be observed by representatives of the Owner for quality assurance purposes. The Installing Contractor shall give the Owner at least 24 hours' notice prior to the anchor installation operations.

12.6 The helical anchor installation technique shall be such that it is consistent with the geotechnical, logistical, environmental, and load carrying conditions of the project. The lead section shall be positioned at the appropriate site survey stake location as determined from the plan drawings.

12.7 The helical anchor sections shall be advanced into the soil in a continuous manner at a rate of rotation less than 25 revolutions per minute (rpm). Sufficient crowd shall be applied to advance the helical anchor sections at a rate approximately equal to the pitch of the helix plate per revolution. The rate of rotation and magnitude of down pressure shall be adjusted for different soil conditions and depths. Extension sections shall be provided to obtain the required minimum overall length and minimum torsional resistance as shown on the project Plans.

## **13 TERMINATION CRITERIA**

13.1 The minimum final torsional resistance and/or any required anchor length and embedment depth criteria, as specified in the Pre-Construction Submittals, must be satisfied prior to terminating the anchor installation. In the event any helical anchor fails to meet these production quality control termination criteria, the following remedies may be suitable if authorized by the Owner:

13.1.1 If the installation fails to meet the minimum torsional resistance criterion at the minimum embedment length:

- 13.1.1.1 Continue the installation to greater depths until the torsional resistance criterion is met, provided that, if a maximum length constraint is applicable, continued installation does not exceed said maximum length constraint, or
- 13.1.1.2 Demonstrate acceptable anchor performance through anchor load testing, or
- 13.1.1.3 Replace the anchor with one having a different helix plate configuration. The replacement anchor must not exceed any applicable maximum embedment length criteria and either: (A) be embedded to a length that places the last helix plate at least three times its own diameter beyond the depth of the first helix plate of the replaced anchor and meet the minimum torsional resistance criterion; or (B) pass anchor load testing criteria.
- 13.1.2 If the torsional resistance during installation reaches the helical anchor's allowable torque rating prior to satisfaction of the minimum embedment length criterion:
  - 13.1.2.1 Terminate the installation at the depth obtained, or
  - 13.1.2.2 Replace the anchor with one having a shaft with a higher torsional strength rating. The replacement anchor must be installed to satisfy the minimum embedment length criterion. It must also be embedded to a length that places the last helix plate at least three times its own diameter beyond the depth of the first helix plate of the replaced anchor without exceeding any applicable maximum embedment length requirements and it must meet the minimum final torsional resistance criterion, or
  - 13.1.2.3 Replace the anchor with one having a different helix plate configuration. The replacement anchor must be installed to satisfy the minimum embedment length criterion. It must also be embedded to a length that places the last helix plate at least three times its own diameter beyond the depth of the first helix plate of the replaced anchor without exceeding any applicable maximum embedment length requirements, and it must meet the minimum final torsional resistance criterion.
- 13.1.3 If the installation reaches a specified maximum embedment length without achieving the minimum torsional resistance criterion:
  - 13.1.3.1 If allowed, remove and reinstall the anchor at a position at least three times the diameter of the largest helix plate away from the initial location. Original embedment length and torsional resistance criteria must be met. The anchor repositioning may require the installation of additional helical anchors with nominal loads adjusted for these spacing changes, or
  - 13.1.3.2 Demonstrate acceptable anchor performance through anchor load testing, or
  - 13.1.3.3 De-rate the load capacity of the helical anchor based on default or site specific torque correlation factors and install additional anchors as necessary.
  - 13.1.3.4 Replace the anchor with one having a different helix plate configuration. The replacement anchor must be installed to satisfy the minimum and/or maximum embedment length criterion and it must meet the minimum final torsional resistance criterion.
- 13.1.4 If a helical anchor fails to meet the acceptance criteria in an anchor load test:
  - 13.1.4.1 Install the anchor to a greater depth and installation torque and re-test; provided that, if a maximum embedment length constraint is applicable, continued installation will not exceed said maximum length constraint, or
  - 13.1.4.2 Replace the anchor with one having more and/or larger helix plates. The replacement anchor must be embedded to a length that places the last helix

plate at least three times its own diameter beyond the depth of the first helix plate of the replaced anchor without exceeding any applicable maximum embedment length requirements. The replacement anchor must be re-tested, or,

- 13.1.4.3 De-rate the load capacity of the helical anchor based on the results of the load test and install additional anchors. Additional anchors must be installed at positions that are at least three times the diameter of the largest helix plate away from any other anchor locations.

- 13.1.5 If a helical anchor fails a production quality control criterion as described in this Section or for any reason other than described in this Section, any proposed remedy must be approved by the Owner prior to initiating its implementation at the project site.

## **14 INSTALLATION RECORD SUBMITTALS**

- 14.1 The Installing Contractor shall provide the Owner copies of the individual helical anchor installation records within 24 hours after each installation is completed. Formal copies shall be submitted within 30 days following the completion of the helical anchor installation. These installation records shall include, but are not limited to, the following information:

- 14.1.1 Date and time of installation
- 14.1.2 Location of helical anchor and anchor identification number
- 14.1.3 Installed helical anchor model and configuration
- 14.1.4 Termination depth, anchor head depth, and length of installed anchor
- 14.1.5 Actual inclination of the anchor
- 14.1.6 Final torsional resistance
- 14.1.7 Calculated geotechnical capacity based on final torsional resistance
- 14.1.8 Comments pertaining to interruptions, obstructions, or other relevant information

## **15 FIELD TENSION LOAD TESTING**

- 15.1 If field tension load testing is required, the Installing Contractor shall furnish all labor, equipment and pre-production helical anchors necessary to accomplish the testing as shown in the approved anchor design documentation. Installing Contractor shall apply the specified loads for the specified durations and record the specified data, for the specified number of anchors. No deviations from the test plan(s) will be allowed without explicit approval in writing from the Owner. Anchor testing shall be in general accordance with the ASTM D3689 quick test method and the following criteria:

- 15.1.1 Failure criteria shall be in accordance with AC358 and is when plunging occurs or when the net deflection exceeds 10% of the average helix plate diameter, whichever occurs first.
- 15.1.2 An alignment load equal to 5% of the anticipated failure load or maximum anticipated test load may be applied prior to the start of the test to take out slack in the load test frame.
- 15.1.3 Loading increments shall be performed at 5% of the anticipated failure load or maximum anticipated test load with a minimum hold time of 4 minutes at each increment.
- 15.1.4 Upon completion of the maximum test load hold increment, the anchor shall be unloaded in 5 to 10 even increments with minimum hold times of 4 minutes at each increment.

- 15.2 Installing Contractor shall provide the Owner copies of raw field test data within 24 hours after the completion of each load test. Formal test reports shall be submitted within 30 days following test completion. Formal test reports shall include the following information:

- 15.2.1 Name of project and Installing Contractor's representative(s) present during load testing.
- 15.2.2 Name of manufacturer's representative(s) present during load testing, if any.
- 15.2.3 Name of third party test agency and personnel present during load testing, if any.
- 15.2.4 Date, time, duration and type of the load test.
- 15.2.5 Unique test identifier and map showing the test anchor location.
- 15.2.6 Anchor model and installation information including shaft type, helix configuration, lead and extension section quantities and lengths, final anchor tip depth, installation date, total test anchor length and final termination torque.
- 15.2.7 Calibration records for applicable anchor installation and test equipment.
- 15.2.8 Tabulated test results including cumulative anchor head movement, loading increments and hold times.
- 15.2.9 Plots showing load versus anchor head movement for each loading/unloading interval.

## **16 CLEANUP**

- 16.1 Within one week of completion of the work, the Installing Contractor shall remove any and all material, equipment, tools, debris or other items belonging to the Installing Contractor or used under the Installing Contractor's direction.