Model Specification:
CHANCE® HELICAL PULLDOWN™ Micropiles for Structural Support

Preface

Types of Specifications

The three types of specifications that are used for HELICAL PULLDOWN™ Micropile (HPM) projects are:

Open Specifications: The Contractor is given the responsibility for the scope and design of the HPM installation. In addition, the construction, capacity, and performance of the HPM are the sole responsibility of the Contractor. This specification assumes that the Owner or Designer has provided the required structural loads. This specification type is most common for securing bids on temporary projects, and is not recommended for permanent applications.

Performance Specifications: The Contractor is given the responsibility for certain design and/or construction procedures, but must demonstrate to the Owner through testing and/or mutually agreed upon acceptance criteria that the production piles meet or exceed the specified performance parameters. This specification assumes that the location and the required loads of the HPM have been specified. The Contractor and Owner share the responsibility for the work.

Prescriptive Specifications: The Owner has the sole responsibility for the scope and design of the HPM installation and specifies the procedures that must be followed. Prescriptive specifications mandate the Owner to be responsible for the proper performance of the production piles. The Contractor is responsible for fulfilling the obligations/details as specified in the construction documents.

Performance specifications are the most common and allow certified Contractors to use their unique installation methods and experience for any given site conditions. Owners receive the benefit of value engineering, which can result in lower costs.

The Owner, Designer, and Contractor will be jointly responsible for the design, installation, acceptance, and performance of HPM's. The installation of an HPM requires specialized equipment, techniques, and trained work crews. Every detail of the work cannot be specified, and every potential problem cannot be anticipated. Therefore, a contractor trained and certified by A. B. Chance Company must be selected.

A list of the major tasks to be performed on an HPM project is shown in Table-1 of the Model Specifications. The Owner or his representative should select the type of specification and procurement method. The responsible party for each task must be identified and mutually agreed upon at the earliest point in the contracting process. The completed Table-1 should be included in the construction documents. The process of continuous communication between all the parties involved is essential to achieve a satisfactory result. Clear communication and close cooperation are particularly important in the start-up phase and in testing. In addition, a timely preparation and review of all submittals is critical.

This model specification can be adapted to each of the three types of specifications. However, it is primarily written for the performance type. The identity of the "Contractor" and the "Owner" is always well defined, unlike that of the "Designer" or "Engineer". For example, the "Engineer" may be an employee(s) of the Contractor, or a third party consultant hired to secure a lower cost alternative during the bidding process. In contrast, the "Engineer" may be the Owner, an employee(s) of the Owner, or a representative hired by the Owner. It is recommended that the Engineer be a third party agency employed by the Owner to serve in the owner's best interests during the various stages of the contract.

For purposes of this Model Specification, the subject is a high capacity HELICAL PULLDOWN™ Micropile installed using the apparatus and methods detailed in patent U.S. 5,707,180. At present, maximum working or design loads are in the 100 ton range. The HPM consists of helical bearing plate(s) attached at the tip of a high strength central steel shaft surrounded by a column of grout, gravity-fed from the surface into the annulus formed by the displacement of soil around the central steel shaft. The central steel shaft is intended to accept most of the applied load. The grout columns are typically 4 to 10 inches in diameter and will accept load directly axially and/or laterally to provide structural support. Additional steel reinforcement consisting of re-bar or casing can be incorporated into the HPM to increase its load carrying capacity.

It is suggested that the specification writer accurately and completely modify this model to suit his/her particular case.

Items in italics may be considered as "Commentary" and as such may be deleted or retained to suit the needs of the specification writer.

These general references provide additional background to HELICAL PULLDOWN™ Micropile technology:

- A. B. Chance Company, *HELICAL PULLDOWN™ Micropiles Training Manual*, Copyright 2000 Hubbell, 210 North Allen St., Centralia, MO 65240
- Vickars Developments Co. LTD., *PULLDOWN™ Pile Manual*, 6220 9th Ave., Burnaby, B.C. Canada V3N 2T6
- Vickars, R. A., and Clemence, Samuel P., *Performance of Helical Piles with Grouted Shafts*, ASCE Geotechnical Special Publication No. 100, New Technological and Design Developments in Deep Foundations, Proceedings of Sessions of Geo-Denver 2000, pp. 327-341
- United States Patent 5,707,180, Method and Apparatus for Forming Piles In-Situ, Vickars, R. A., Vickars, J. C. T., Toebosch, Gary
- Hoyt, R.M. and Clemence, S.P., 1989. Uplift Capacity of Helical Anchors in Soil. *Proceedings of the 12th International Conference on Soil Mechanics and Foundation Engineering*, Vol. 2, pp. 1019-1022.

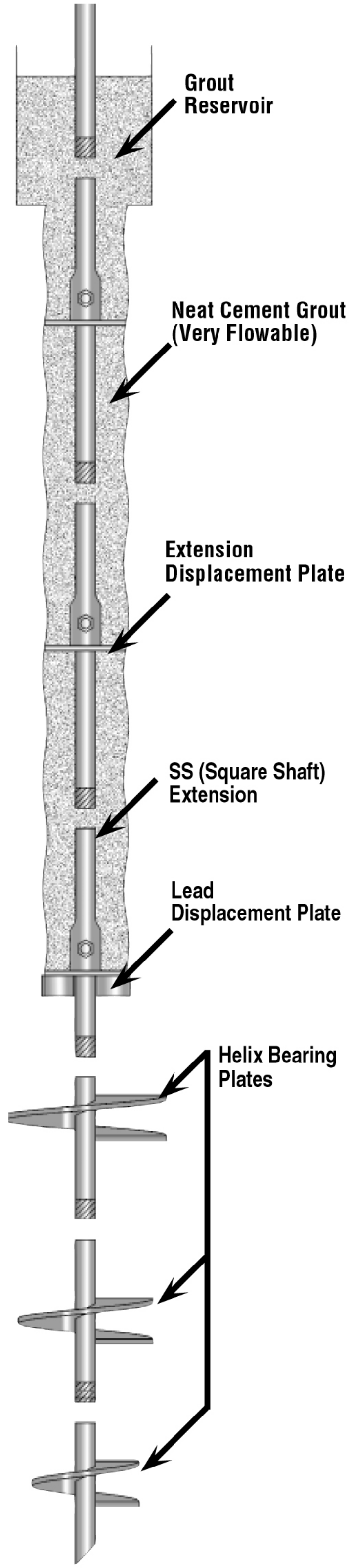

Figure-1 Typical Cross Section

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Model Specification:
CHANCE® HELICAL PULLDOWN™ Micropiles for Structural Support

1. GENERAL

1.1 Purpose of Specification

The purpose of this specification is to detail the furnishing of all designs, materials, tools, equipment, labor supervision, and installation techniques necessary to install HELICAL PULLDOWN™ Micropiles as detailed on the drawings, including pile-top details. This shall include provisions for load testing that may be part of the scope of work

Specifier Note: This specification may require modification to account for unusual and/or unforeseen site and subsurface conditions and the particular circumstances of the project.

1.2 Scope of Work

This work consists of furnishing all necessary engineering and design services (if required), supervision, labor, tools, materials, and equipment to perform all work necessary to install the HELICAL PULLDOWN™ Micropiles (HPM), at (location, City, State/Province) for (Company, State/Province or Private Authority) per the specifications described herein, and as shown on the drawings. The Contractor shall install a HPM that will develop the load capacities as detailed on the drawings. This may also include provisions for load testing to verify pile capacity and deflection, if part of the scope of work. The responsibilities and duties of the respective parties for this project are summarized in Table-1.

Table-1. Tasks and Responsibilities to be Allocated for HPM Work

TASK		RESPONSIBLE PARTY*
1	Site Investigation, Geotechnical Investigation, Site Survey, and potential work restrictions	
2	Type of specification, requirement for a pre-contract testing program, and procurement method	
3	Obtaining easements	
4	Overall scope of work, design of the piled structure – including design loads (vertical, horizontal, etc.), pile locations, and pile spacing and orientation	
5	Definition and qualification of safety factors	
6	Calculation/estimation of allowable structural and/or pile movement in service (acceptance criteria)	
7	Definition of service life (temporary – months or permanent - years) and required degree of corrosion protection based on site conditions	

8	Type and number of tests (pre-contract, pre-production and production)	
9	Minimum total pile length, depth to bearing stratum	
10	HELICAL PULLDOWN™ Micropile components and details	
11	Details of corrosion protection	
12	Details of pile connection to structure (e.g., for static and seismic conditions)	
13	Preparation of Drawings and test reports	
14	Evaluation of test results	
15	Construction methods, schedule, sequencing, and coordination of work	
16	Requirements of field production control, including logging of installation torque vs. installed depth	
17	Supervision of work	
18	Long-term monitoring	

* To be filled in by specification writer.

1.3 Qualifications of the HELICAL PULLDOWN™ Micropile Contractor

The HPM Contractor shall be experienced in performing design and construction of HELICAL PULLDOWN™ Micropiles and shall furnish all materials, labor, and supervision to perform the work. The Contractor shall be trained and certified by A. B. Chance Company in the proper methods of design and installation of the patented HPM system. The Contractor shall provide names of on-site personnel materially involved with the work, including those who carry documented certification from A. B. Chance Company. At a minimum, these personnel shall include foreman, machine operator, and project engineer/manager.

The HELICAL PULLDOWN™ Micropile Contractor shall not sublet the whole or any part of the contract without the express written permission of the Owner.

1.4 Related Project Specifications

To be determined by the specification writer.

1.5 Definitions

A partial list follows. The Owner may wish to add other specific, project-related items.

Admixture: Substance added to the grout to either control bleed and/or shrinkage, improve flowability, reduce water content, retard setting time, or resist washout.

Alignment Load (AL): A nominal load applied to a HPM during testing to keep the testing equipment correctly positioned and remove any slack in the reaction system.

Bearing Stratum:	Soil layer(s) of sufficient strength capable of resisting the applied axial load transferred by the HPM.
Bonded Length:	The length of the HPM grout column that is bonded to the soil and which is used to transfer the applied axial load to the surrounding soil.
Casing:	Steel or PVC pipe used during the installation process to stabilize the annular volume surrounding the central steel shaft. Depending on the details of the HPM construction and soil conditions, the casing may be extracted after grouting, or may remain partially or fully in place, as part of the final pile configuration.
Contractor:	The person/firm responsible for performing the HPM work.
Coupling:	Central steel shaft connection means formed as integral part of the plain extension shaft material. For SS & RS3500.300 anchors, couplings shall be hot upset forged sockets.
Creep:	The movement that occurs during the creep test of a HPM under a constant load.
Design Load (DL):	Maximum anticipated service load applied to the HPM. Also known as the working load (WL).
Elastic Movement:	The recoverable movement measured during a HPM test resulting from the elastic shortening or lengthening of the pile material.
Extension Displacement Plate (EDP):	A device to centrally locate the steel shaft within the annular volume and to assist in the downward flow of grout.
Grout (PULLDOWN):	Portland cement based grout that is gravity fed into the annular volume surrounding the central steel shaft during installation. The fine aggregate and admixtures provide flowability, resist washout, and provide additional corrosion protection. Provides the load transfer in skin friction to the surrounding soil along the length of the HPM.
Helical Extension:	Screw pier component installed immediately following the lead section, if required. This component consists of one or more helical plates welded to a central steel shaft.

HELICAL PULLDOWN™ Micropile: A small diameter, soil displacement, cast-in-place screw pier, in which most of the applied load is resisted by the central steel shaft and steel reinforcement, if installed. Load transfer to soil is both end bearing and friction. United States Patent 5,707,180, Method and Apparatus for Forming Piles In-Situ. A.k.a. HPM.

Helical Plate: Generally round steel plate formed into a ramped spiral. The helical shape provides the means to install the screw pier, plus the plate transfers load to soil in end-bearing. Helical plates are available in various diameters and thicknesses.

Lead Displacement Plate (LDP): Soil displacement means used to create the annular volume surrounding the central steel shaft. The plate diameters vary depending on the size of the central steel shaft, the pile design, the soils, and the applied load to the pile.

Lead Section: The first screw pier component installed into the soil, consisting of single or multiple helical plates welded to a central steel shaft. Helical plates provide end-bearing capacity.

Micropile: a.k.a. HPM

Net Settlement: The non-elastic (non-recoverable) movement of a HPM measured during load testing.

Overburden: Non-lithic material, natural or placed, typically of soft consistency or loose relative density, which overlies competent load bearing stratum.

Pile Cap: Connection means by which structural loads are transferred to the HPM. The type of connection varies depending upon the requirements of the project and type of HPM material used.

Care must be used in the design of pile caps to ensure adequate structural load transfer. Design constraints such as expansive soils, compressible soils, and seismic loads must be accounted for in pile cap design.

Plain Extension: Central steel shaft without helical plates. It is installed following the installation of the lead section or helical extension (if used). The units are connected with integral couplings and bolts. Plain extensions are used to extend the helical plates beyond the specified minimum depth and into competent load bearing stratum.

Preloading:	Also known as prestressing, load is applied to the HPM prior to connection to structure, to minimize structural movement in service.
Proof Test:	Incremental loading of a HPM, holding for a period of time, and recording the total movement at each load increment.
Safety Factor:	The ratio of the ultimate capacity to the working or design load used for the design of any structural element.
Screw Pile/Pier:	A screw pile/pier is a bearing type foundation consisting of a lead section, helical extension (if so required by site conditions), plain extension section(s), and a pile cap.
Test Load (TL):	The maximum load applied to the HPM during testing.
Ultimate Capacity (UC):	Limit state based on the structural and/or geotechnical capacity of the HPM defined as the point at which no additional capacity can be justified.
Verification Test (VL):	Similar to a Proof Test except a cyclic loading method is used to analyze total, elastic, and net movement of the pile. Used for pre-contract or pre-production pile load tests.
Working Load (WL):	Equivalent term for Design Load.

1.6 Allowable Tolerances

The tolerances quoted in this section are suggested maximums. The actual values established for a particular project will depend on the structural application and site conditions.

1.6.1 Centerline of piling shall not be more than 3 inches from indicated plan location.

1.6.2 Pile plumbness shall be within 2° of design alignment.

1.6.3 Top elevation of pile shall be within +1 inch to -2 inches of the design vertical elevation.

1.6.4 Centerline of central steel shaft shall not be more than 3/4 inches from the centerline of the pile.

1.7 Quality Assurance

1.7.1 HELICAL PULLDOWN™ Micropiles shall be installed by authorized A. B. Chance Company certified Contractors. These Contractors shall have satisfied the certification requirements relative to the technical aspects of the product and installation procedures as therein specified.

Certification documents shall be provided upon request to the Owner or their representative.

1.7.2 The certified Contractor shall employ an adequate number of skilled workers who are experienced in the necessary crafts and who are familiar with the specified requirements and methods needed for proper performance of the work of this specification.

1.7.3 All HPMs shall be installed in the presence of a designated representative of the Owner unless said representative informs the Contractor otherwise. The designated representative shall have the right to access to any and all field installation records and test reports.

1.7.4 Screw pier components of HPMs as specified therein shall be manufactured by a facility whose quality systems comply with ISO (International Organization of Standards) 9001 requirements. Certificates of Registration denoting ISO Standards Number shall be presented upon request to the Owner or their representative.

1.7.5 Hubbell Power Systems/A. B. Chance Company provides a standard one-year warranty on materials and workmanship of the product. Any additional warranty provided by the Contractor shall be issued as an addendum to this specification.

1.7.6 Design of HPMs shall be performed by an entity as required in accordance with existing local code requirements or established local practices. This design work may be performed by a licensed professional engineer, a certified A. B. Chance certified Contractor, or designer depending upon local requirements or practices.

1.8 Design Criteria

1.8.1 HELICAL PULLDOWN™ Micropiles shall be designed to meet the specified loads and acceptance criteria as shown on the drawings. The calculations and drawings required from the Contractor or Engineer shall be submitted to the Owner for review and acceptance in accordance to Section 3.1 "Construction Submittals".

1.8.2 The allowable working load on the HPM shall not exceed the following values:

1.8.2.1 For compression loads:

$$P_{allowc} = (0.33 * f_c * A_{grout}) + (0.4 * f_{ycase} * A_{case}) + (0.4 * f_{yshaft} * A_{shaft})$$

Where: P_{allowc} = allowable working load in compression (kip)
f_c = compressive strength of grout (ksi)
A_{grout} = area of grout (in.^{2})
f_{ycase} = yield strength of casing (ksi)
A_{case} = area of steel case (with corrosion allowance if required) (in.^{2})
f_{yshaft} = minimum yield strength of central steel shaft (ksi)
A_{shaft} = area of central steel shaft (in.^{2})

The minimum yield strength of the central steel shaft is as follows:

Type SS5: 70 ksi; Type SS150, SS175, SS200, SS225: 90 ksi; Type RS3500.300: 50 ksi. Ultimate concrete strain rate (0.003 in/in) may reduce the maximum useable strength of the central steel shaft and case below their specified yield strength.

These allowable working loads may be reduced by the allowable load capacity per helix plate(s) – depending on what fraction of the total load is transferred to the soil in end bearing. It is recommended to use the allowable helix capacities per screw pier type as published by A. B. Chance Company (shown in Table-A of the Appendix).

1.8.2.2 For tension loads:

$$P_{allowt} = 0.5 * S_{ut}$$

Where: P_{allowt} = allowable working load in tension (kip)
S_{ut} = Minimum ultimate tensile strength of central steel shaft segment (at coupling joint) (kip)

It is recommended to use the minimum ultimate tensile strengths as published by A. B. Chance Company (shown in Table-A of the Appendix).

These allowable working loads may be reduced by the allowable load capacity per helix plate(s) – depending on what fraction of the total load is transferred to the soil in end bearing. It is recommended to use the allowable helix capacities per screw pier type as published by A. B. Chance Company (shown in Table-A of the Appendix).

1.8.3 The ultimate structural capacity shall be determined as:

1.8.3.1 For compression loads:

$$P_{ultc} = (0.85 * f_c * A_{grout}) + (f_{ycase} * A_{case}) + (f_{yshaft} * A_{shaft})$$

Where: P_{ultc} = ultimate structural capacity in compression (kip)
f_c = compressive strength of grout (ksi)
A_{grout} = area of grout (in.^{2})
f_{ycase} = yield strength of casing (ksi)
A_{case} = area of steel case (with corrosion allowance if required) (in.^{2})
f_{yshaft} = minimum yield strength of central steel shaft (ksi)
A_{shaft} = area of central steel shaft (in.^{2})

The minimum yield strength of the central steel shaft is as follows:
Type SS5: 70 ksi; Type SS150, SS175, SS200, SS225: 90 ksi; Type RS3500.300: 50 ksi. Ultimate concrete strain rate (0.003 in/in) may reduce the maximum useable strength of the central steel shaft and case below their specified yield strength.

The ultimate structural capacity may be reduced by the ultimate load capacity per helix plate(s) – depending on what fraction of the total load is transferred to the soil in end bearing. It is recommended to use the ultimate helix capacities per screw pier type as published by A. B. Chance Company (shown in Table-A of the Appendix).

1.8.3.2 For tension loads:

$$P_{ultt} = S_{ut}$$

Where: P_{ultt} = ultimate structural capacity in tension (kip)
S_{ut} = Minimum ultimate tensile strength of central steel shaft segment (at coupling joint) (kip)

It is recommended to use the minimum ultimate tensile strengths as published by A. B. Chance Company (shown in Table-1 of the Appendix).

The ultimate structural capacity may be reduced by the ultimate load capacity per helix plate(s) – depending on what fraction of the total load is transferred to the soil in end bearing. It is recommended to use the ultimate helix capacities per screw pier type as published by A. B. Chance Company (shown in Table-A of the Appendix).

1.8.4 Lateral Load and Bending: Where lateral or base shear loads are indicated on the plans, the bending moment from said loads shall be determined using lateral load analysis program such as LPILE or equal commercially available software. The required soil parameters (c,f, g, and k_s) for use with LPILE or equal shall be provided in the geotechnical reports. The Owner shall determine the allowable response to lateral loads. The combined bending and axial load factor of safety of the HPM shall be as determined by the Owner.

It is recommended to list below each load combination and required factor of safety for this specific project.

1.8.5 Expansive Soils: HPMs used in areas where expansive soils are present may require the use of special construction methods to mitigate possible shrink/swell effects. HPM shafts should be isolated from the concrete footing if said footing is in contact with the expansive soil.

1.8.6 Down-Drag/Negative Skin Friction: HPMs used in areas where compressible or decomposing soils overlie bearing stratum, or where expansive or frozen soils can cause pile jacking, HPM shafts should be provided with a no-bond zone along a specified length to prevent load transfer that may adversely affect pile capacity. Alternately, HPM's can be provided with sufficient axial load capacity to resist down drag/negative skin friction forces.

1.8.7 The HPM attachment (pile cap) shall distribute the design load (DL) to the concrete foundation such that the concrete bearing stress does not exceed those in the ACI Building Code and the stresses in the steel plates/welds does not exceed AISC allowable stresses for steel members.

1.8.8 The HPM capacity in soil (either in skin friction or end-bearing) shall not be relied upon from the following soil layers as defined in the geotechnical reports:

The overall length and installed torque of an HPM shall be specified such that the required in-soil capacity is developed by skin friction between grout and soil over a suitable length and by end-bearing on the helical plate(s) in an appropriate strata(s).

It is recommended that the theoretical end-bearing capacity of the helical plates be determined using HeliCAP™ Engineering Software or equal commercially available software. The required soil parameters (c, f, g, or N-values) for use with HeliCAP™ or equal shall be provided in the geotechnical reports. The Owner shall determine the allowable response to axial loads.

HELICAL PULLDOWN™ Micropiles are primarily end-bearing foundation elements, but can develop significant secondary capacity by skin friction. Note that screw piers are not suited for solid, competent rock, but the helical plates can penetrate into dense bearing soils. It is recommended that HPMs be installed to a specified minimum torque and depth to ensure the helical plates are terminated in bearing soils. Appropriate and repeatable installation techniques and pile termination criteria must be identified and verified in the field.

1.8.9 Corrosion Protection

This section is optional (see below). Provisions of this section and Section 4.12 below may not be required in the Specification. If this section is not used, then Section 4.12 should likewise be deleted. The degree and extent of corrosion protection must be specified by the Owner (Table-1).

Corrosion protection is a function of structure type, service life, loading condition, and the overall aggressiveness of the project soils. The need for corrosion protection of HPM's subjected to tension loads must be carefully determined and specified as necessary.

Corrosion resistant coatings (i.e. epoxy, plastic sheath) on the lead section are impractical due to abrasive action wearing off the coating as the soil flows over the helical plates and around the central steel shaft. Hot dip galvanization is the only practical means to provide a corrosion resistant coating capable of withstanding the rigors of installation. Casing is typically not provided with corrosion resistant coatings for the same reasons. Extension sections are typically hot-dip galvanized, but other coatings can be specified.

The following requirements are typical. The specifier should review and edit as appropriate for the project.

Structure Type: ___________________________ *(e.g. temporary, permanent) with a temporary structure being defined within a specified time frame (i.e. months rather than years). In general, permanent structures have a service life greater than 24 months.*

Temporary structures do not require corrosion protection.

Service Life: ______________________________*(years) a typical service life of 50 years should be used* *unless otherwise specified. If the service life of a temporary HPM is likely to be extended due to construction delays, it should be considered permanent.*

For a service life of less than 20 years in non-aggressive soil, corrosion protection is not recommended.

Corrosion protection requirements for the various HPM elements shall be provided meeting the requirements of Table-2 for:

Loading Type: ______________________________
to be filled in by the Specifier with optional location limits defined (e.g. Tension, Compression, or both).

Soil: _______________________________________ *Aggressive or Non-Aggressive with optional location and elevation limits defined by the Specifier.*

For guidance on aggressiveness classification, see Table B in the Appendix. It is recommended to retain the services of a corrosion design professional for very aggressive soils.

TABLE-2

CORROSION PROTECTION				
LOADING	**TENSION**[1]		**COMPRESSION**	
SOIL	**AGGRESSIVE**[2]	**NON-AGGRESSIVE**	**AGGRESSIVE**[2]	**NON-AGGRESSIVE**
STEEL CASING (if used)	Steel casing not recommended for tension load capacity	Steel casing not recommended for tension load capacity	Minimum 1/8" corrosion loss on outside The Specifier may use a different corrosion loss per AASHTO, ASCE, or FHWA Standards.	None The Specifier may use a corrosion loss per AASHTO, ASCE, or FHWA Standards.
CENTRAL STEEL SHAFT (Lead Section)	a. Galvanization OR b. Minimum 1/8" corrosion loss on outside	a. Bare steel OR b. Galvanization OR c. Minimum 1/8" corrosion loss on outside	a. Galvanization OR b. Minimum 1/8" corrosion loss on outside	a. Bare steel OR b. Galvanization OR c. Minimum 1/8" corrosion loss on outside
CENTRAL STEEL SHAFT (Extension Section)	a. Galvanization OR b. Epoxy coating AND	a. Bare steel OR b. Galvanization OR	a. Galvanization OR b. Epoxy coating AND	a. Grout cover[3]

	Grout cover[3] The Specifier may elect to use a grout case (i.e., PVC).	c. Epoxy coating AND Grout cover[3]	Grout cover[3] The Specifier may elect to use a grout case (i.e., PVC).	

NOTES:
Lettered items are options.
For guidance on aggressiveness classification, see Table B of the Appendix.

1. Sustained tension or temporary tension (wind, seismic, impact) on life critical structural. For temporary tension on normal structures, corrosion protection under Compression is often used.
2. Corrosion protection shall extend 15'-0 below corrosive material.
3. Minimum 1" in soil. If protective coatings (galvanization, epoxy) are provided in compression, minimum cover may be 0.25" in soil.

1.9. Ground Conditions

The Geotechnical Report, including logs of soil borings as shown on the boring location plan, shall be considered to be representative of the in-situ subsurface conditions likely to be encountered on the project site. Said Geotechnical Report shall be the used as the basis for HELICAL PULLDOWN™ Micropile design using generally accepted engineering judgement and methods.

If soil borings are not available, it is suggested to install a screw pier at various locations on the project site. Using the well-known installed torque vs. capacity attribute of screw piers, a presumptive soil profile can be generated.

The Geotechnical Report shall be provided for purposes of bidding. If during HPM installation, subsurface conditions of a type and location are encountered of a frequency that were not reported, inferred and/or expected at the time of preparation of the bid, the additional costs required to overcome such conditions shall be considered as extras to be paid for.

All available information related to subsurface and general site conditions should be made available to all bidders at the time of bid preparation. It is not reasonable to expect bidders to conduct supplemental site investigations at their own risk and cost prior to bidding, unless the specific contract requirements call for it (Table-1) and provide for appropriate compensation. A mandatory site visit and pre-bid meeting should be held so that the details of the project and the specifications can be thoroughly discussed. These steps will help avoid technical and contractual problems developing during the execution of the work, and will help all parties manage their respective risk.

2 REFERENCED CODES AND STANDARDS

Standards listed by reference, including revisions by issuing authority, form a part of this specification section to the extent indicated. Standards listed are identified by issuing authority, authority abbreviation, designation number, title, or other designation established by issuing authority. Standards subsequently referenced herein are referred to by issuing authority abbreviation and standard designation. In case of conflict, the particular requirements of this specification shall prevail. The latest publication as of the issue of this specification shall govern, unless indicated otherwise.

2.1 American Society for Testing and Materials (ASTM):

2.1.1 ASTM A29/A29M Steel Bars, Carbon and Alloy, Hot-Wrought and Cold Finished.
2.1.2 ASTM A36/A36M Structural Steel.
2.1.3 ASTM A53 Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
2.1.4 ASTM A153 Zinc Coating (Hot Dip) on Iron and Steel Hardware.
2.1.5 ASTM A775 Electrostatic Epoxy Coating
2.1.6 ASTM A193/A193M Alloy-Steel and Stainless Steel Bolting Materials for High Temperature Service.
2.1.7 ASTM A252 Welded and Seamless Steel Pipe Piles.
2.1.8 ASTM A320/A320M Alloy-Steel Bolting Materials for Low Temperature Service.
2.1.9 ASTM A500 Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
2.1.10 ASTM A572 HSLA Columbium-Vanadium Steels of Structural Quality.
2.1.11 ASTM A618 Hot-Formed Welded and Seamless High-Strength Low-Alloy Structural Tubing.
2.1.12 ASTM A656 Hot-Rolled Structural Steel, High-Strength Low-Alloy Plate with Improved Formability.
2.1.13 ASTM A1018 Steel, Sheet and Strip, Heavy Thickness Coils, Hot Rolled, Carbon, Structural, High-Strength, Low-Alloy, Columbium or Vanadium, and High-Strength Low-Alloy with Improved Formability.
2.1.14 ASTM C33 Concrete Aggregates.
2.1.15 ASTM C109 Compressive Strength of Hydraulic Cement Mortar.
2.1.16 ASTM C150 Portland Cement.
2.1.17 ASTM C494 Chemical Admixtures for Concrete.
2.1.18 ASTM C618 Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
2.1.19 ASTM C1240 Silica Fume for Use as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar, and Grout
2.1.20 ASTM C1107 Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
2.1.21 ASTM D1143 Method of Testing Piles Under Static Axial Compressive Load.
2.1.22 ASTM D1784 Specification for Rigid Poly Vinyl Chloride (PVC) Compounds and Chlorinated Poly Vinyl Chloride (CPVC) Compounds.
2.1.23 ASTM D1785 Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
2.1.24 ASTM D3034 Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
2.1.25 ASTM D3689 Method of Testing Individual Piles Under Static Axial Tensile Load.
2.1.26 ASTM D3966 Standard Test Method for Piles Under Lateral Load.

2.2 American Welding Society (AWS):

2.2.1 AWS D1.1 Structural Welding Code – Steel.
2.2.2 AWS D1.2 Structural Welding Code – Reinforcing Steel.

2.3 American Society of Civil Engineers (ASCE):

2.3.1 ASCE 20-96 Standard Guidelines for the Design and Installation of Pile Foundations.

2.4 Deep Foundations Institute (DFI):

2.4.1 *Guide to Drafting a Specification for High Capacity Drilled and Grouted Micropiles for Structural Support*, 1st Edition, Copyright 2001 by the Deep Foundation Institute (DFI).

2.5 Post Tensioning Institute (PTI):

2.5.1 *Recommendations for Prestressed Rock and Soil Anchors*, Third Edition, Copyright 1996 By the Post-Tensioning Institute.

2.6 Society of Automotive Engineers (SAE):

2.6.1 SAE J429 Mechanical and Material Requirements for Externally Threaded Fasteners.

3 SUBMITTALS

3.1 Construction Submittals

3.1.1 The Contractor or Engineer shall prepare and submit to the Owner, for review and approval, working drawings and design calculations for the HELICAL PULLDOWN™ Micropile foundation intended for use at least 14 calendar days prior to planned start of construction (but note also Paragraph 3.1.9). All submittals shall be signed and sealed by a Registered Professional Engineer currently licensed in the State/Province of ________________________.

3.1.2 The Contractor shall submit a detailed description of the construction procedures proposed for use to the Owner for review. This shall include a list of major equipment to be used.

3.1.3 The Working Drawings shall include the following:

3.1.3.a HPM number, location and pattern by assigned identification number
3.1.3.b HPM design load
3.1.3.c Type and size of central steel shaft

Type SS5/SS150 – 1-1/2" RCS, Type SS175 – 1-3/4" RCS, Type SS200 – 2" RCS, Type SS225 – 2-1/4" RCS, Type RS3500.300 – 3-1/2" OD pipe.

3.1.3.d Helix configuration (number and diameter of helical plates)
3.1.3.e Minimum effective installation torque
3.1.3.f Displacement plates/centralizers and their location
3.1.3.g Minimum overall length
3.1.3.h Inclination of HPM
3.1.3.i Grout column length
3.1.3.j Minimum cased length, if applicable
3.1.3.k Grout column diameter(s)
3.1.3.l Cut-off elevation
3.1.3.m HPM attachment to structure relative to grade beam, column pad, etc.

If the number of helical plates per HPM required for the project is not shown on the Working Drawings, the Contractor shall have the option of performing subsurface tests using methods subject to the review and acceptance of the Owner. The data collected along with other information pertinent to the project site shall be used to determine the required helix configuration.

3.1.4 The Contractor shall submit shop drawings for all HPM components, including casing components and pile top attachment to the Owner for review and approval. This includes HPM lead and extension section identification (manufacturer's catalog numbers).

Shop drawings for HPM components, including pile top attachments, can be obtained from A. B. Chance, their certified Distributors, or directly from www.abchance.com.

3.1.5 If required, the Contractor shall submit certified mill test reports for the central steel shaft, as the material is delivered, to the Owner for record purposes. The ultimate strength, yield strength, % elongation, and chemistry composition shall be provided.

3.1.6 The Contractor shall submit the grout materials to be used, and the means for mixing and placing the grout to the Owner for approval. This submittal shall include technical data that is representative of typical values.

Technical data for grout materials are available from the manufacturer. Typical properties provided are compressive strength, density, flow, expansion/shrinkage, working time, and yield. Grout used for HELICAL PULLDOWN™ Micropiles typically contains Portland cement, silica fume and other additives.

3.1.7 The Contractor shall submit plans for pre-production (optional) and production testing for the HPMs to the Owner for review and acceptance prior to beginning load tests. The purpose of the test is to determine the load versus displacement response of the HELICAL PULLDOWN™ Micropile and provide an estimation of ultimate capacity.

It is the responsibility of the structural engineer of record to establish acceptance criteria for HPM verification load tests, which can be incorporated into the project specific specification. Load testing also provides the means to verify the empirical ratio between the ultimate capacity and the average installing torque of the HPM for a specific project site.

3.1.8 The Contractor shall submit to the Owner copies of calibration reports for each torque indicator and all load test equipment to be used on the project. The calibration tests shall have been performed within one year of the date submitted. HPM installation and testing shall not proceed until the Owner has received the calibration reports. These calibration reports shall include, but are not limited to, the following information:

3.1.8.a Name of project and Contractor
3.1.8.b Name of testing agency
3.1.8.c Identification (serial number) of device calibrated
3.1.8.d Description of calibrated testing equipment
3.1.8.e Date of calibration
3.1.8.f Calibration data

Load test equipment includes load cylinders, pressure gauges, and load transducers. A. B. Chance Mechanical Dial Torque Indicator (SKU C303-1340) is calibrated prior to final assembly. Its torsion bar design eliminates the need for annual re-calibration.

3.1.9 Work shall not begin until all the submittals have been received and approved by the Owner. The Contractor shall allow the Owner a reasonable time to review, comment, and return the submittal package after a complete set has been received. All costs associated with incomplete or unacceptable submittals shall be the responsibility of the Contractor.

3.2 Installation Records (see page 35 for sample Installation Log)

The Contractor shall provide the Owner copies of HPM installation records within 24 hours after each installation is completed. Records shall be prepared in accordance with the specified division of responsibilities as noted in Table-1. Formal copies shall be submitted on a weekly basis. These installation records shall include, but are not limited to, the following information:

3.2.1 Name of project and Contractor
3.2.2 Name of Contractor's supervisor during installation
3.2.3 Date and time of installation
3.2.4 Name and model of installation equipment
3.2.5 Type of torque indicator used
3.2.6 Location of HPM by assigned identification number
3.2.7 Actual HPM type and configuration – including lead section (number and size of helical plates), number and type of extension sections (manufacturer's SKU numbers)
3.2.8 HPM installation duration and observations
3.2.9 Total length of installed HPM
3.2.10 Cut-off elevation
3.2.11 Inclination of HPM
3.2.12 Installation torque at one-foot intervals for the final 10 feet
3.2.13 Grout quantities pulled-down on a per section basis
3.2.14 Actual grout column diameter and length
3.2.15 Comments pertaining to interruptions, obstructions, or other relevant information
3.2.16 Rated load capacities

3.3 Test Reports (see page 36 for sample Test Report Log)

The Contractor shall provide the Owner copies of field test reports within 24 hours after completion of the load tests. Records shall be prepared in accordance with the specified division of responsibilities as noted in Table-1. Formal copies shall be submitted within a reasonable amount of time following test completion. These test reports shall include, but are not limited to, the following information (note Section 6 – Pile Load Tests):

3.3.1 Name of project and Contractor
3.3.2 Name of Contractor's supervisor during installation
3.3.3 Name of third party test agency, if required
3.3.4 Date, time, and duration of test
3.3.5 Location of HPM by assigned identification number
3.3.6 Type of test (i.e. tension or compression)
3.3.7 Description of calibrated testing equipment and test set-up

3.3.8 Actual HPM type and configuration – including lead section, number and type of extension sections (manufacturer's SKU numbers)
3.3.9 Steps and duration of each load increment
3.3.10 Cumulative pile-head movement at each load step
3.3.11 Comments pertaining to test procedure, equipment adjustments, or other relevant information
3.3.12 Signed by third party test agency rep., registered professional engineer, or as required by local jurisdiction

3.4 Closeout Submittals

3.4.1 Warranty: Warranty documents specified herein
3.4.1.a Project Warranty: Refer to Conditions of the Contract for project warranty provisions

Coordinate the warranty period stated herein with the project warranty as stated in the Contract documents.

Warranty Period: (*Specify Term*) years commencing on date of Substantial Completion

3.4.1.b Manufacturer's Warranty: Submit, for Owner's Acceptance, manufacturer's standard warranty document executed by authorized company official. Manufacturer's warranty is in addition to, and not a limitation of, other rights the Owner may have under Contract Document.

4 PRODUCTS AND MATERIALS

4.1 Central Steel Shaft:

The central steel shaft, consisting of lead sections, helical extensions, and plain extensions, shall be Type SS or RS3500.300 as manufactured by the A. B. Chance Company (Centralia, MO).

4.1.1 *SS5 1-1/2" Material*: Shall be hot rolled Round-Cornered-Square (RCS) solid steel bars meeting dimensional and workmanship requirements of ASTM A29. The bar shall be modified medium carbon steel grade (similar to AISI 1044) with improved strength due to fine grain size.

4.1.1.a Torsional strength rating = 5,700 ft-lb
4.1.1.b Minimum yield strength = 70 ksi

4.1.2 *SS150 1-1/2"; SS175 1-3/4"; SS200 2"; SS225 2-1/4" Material*: Shall be hot rolled Round-Cornered-Square (RCS) solid steel bars meeting the dimensional and workmanship requirements of ASTM A29. The bar shall be High Strength Low Alloy (HSLA), low to medium carbon steel grade with improved strength due to fine grain size.

4.1.2.a Torsional strength rating: SS150 = 7,000 ft-lb; SS175 = 10,500 ft-lb; SS200 = 16,000 ft-lb; SS225 = 21,000 ft-lb
4.1.2.b Minimum yield strength = 90 ksi

4.1.3 *RS3500.300 3-1/2" OD Material*: Shall be structural steel tube or pipe, seamless or straight-seam welded, per ASTM A53, A252, ASTM A500, or ASTM A618. Wall thickness is 0.300" (schedule 80).

4.1.3.a Torsional strength rating = 13,000 ft-lb
4.1.3.b Minimum yield strength = 50 ksi

4.2 Helical Bearing Plate:

Shall be hot rolled carbon steel sheet, strip, or plate formed on matching metal dies to true helical shape and uniform pitch. Bearing plate material shall conform to the following ASTM specifications:

4.2.1 *SS5 Material*: Per ASTM A572, or A1018, or A656 with minimum yield strength of 50 ksi. Plate thickness is 3/8".
4.2.2 *SS150 and SS175 Material*: Per ASTM A656 or A1018 with minimum yield strength of 80 ksi. Plate thickness is 3/8".
4.2.3 *SS200 and SS225 Material*: Per ASTM A656 or A1018 with minimum yield strength of 80 ksi. Plate thickness is 1/2".
4.2.4 *RS3500.300 Material*: Per ASTM A36, or A572, or A1018, or A656, depending on helix diameter, per the minimum yield strength requirements cited above. Plate thickness is 3/8".

4.3 Bolts:

The size and type of bolts used to connect the central steel shaft sections together shall conform to the following ASTM specifications:

4.3.1 *SS5 and SS150 1-1/2" Material*: 3/4" diameter bolt per ASTM A320 Grade L7.
4.3.2 *SS175 1-3/4" Material*: 7/8" diameter bolt per ASTM A193 Grade B7.
4.3.3 *SS200 2" Material*: 1-1/8" diameter bolt per ASTM A193 Grade B7.
4.3.4 *SS225 2-1/4" Material*: 1-1/4" diameter bolt per ASTM A193 Grade B7.
4.3.5 *RS3500.300 3-1/2" OD Material*: 3/4" diameter bolts (3 per coupling) per SAE J429 Grade 5.

4.4 Couplings:

Shall be formed as integral part of the plain and helical extension material. For Type SS material, the couplings shall be hot upset forged sockets. For Type RS3500.300 material, the couplings shall be hot forge expanded sockets.

4.5 Displacement Plates/Centralizers

Displacement plates (lead or extension plates) shall be fabricated from steel or other material (not wood) that will not affect the structural integrity of the central steel shaft or grout column.

4.6 Plates, Shapes, or Pier Caps:

Structural steel plates and shapes for HPM top attachments shall conform to ASTM A36 or ASTM A572 Grade 50.

4.7 Pipe/Casing:

If steel casing is relied upon to carry compression or lateral loads, or to stiffen the HPM, the casing/pipe shall conform to the ASTM specifications as cited in paragraph 4.7.1. If PVC casing is relied upon for grout containment, fissured or void-filled soils, or as a bond breaker, the casing/pipe shall conform to the ASTM specifications as cited in paragraph 4.7.2.

4.7.1 Shall meet or exceed the physical and general requirements of ASTM A53 Type E or S Grade B, A252 Grade 2, A500 Grade B, or ASTM A618.
4.7.2 Shall meet the physical and general requirements of ASTM D1784, D1785, and D3034.

4.8 Water

Water for mixing grout shall be potable, clean and free from impurities, which may be detrimental to grout or steel. Potable water shall be available in quantities sufficient to mix grout and for equipment clean-up.

4.9 Cement

Cement for HELICAL PULLDOWN™ Micropile grout shall be Portland cement conforming to ASTM C150 Type I or Type II. Pre-packaged, non-shrink cement grouts shall be subject to the review and acceptance of the Owner, and shall conform to the requirements of ASTM C1107.

4.10 Admixtures

Admixtures are generally not required for PULLDOWN™ Micropile grouts. However, project specific soil conditions and loads may require high performance grout properties attainable with admixtures. For example, silica fume resists segregation and washout by improving bond between the cement particles. Its small particle size and shape improves flowability and reduces porosity – which leads to durable, high strength grout with increased chemical and electrical resistance. Fly ash improves pumpability, improves compressive strength, and reduces grout cost.

Chemical admixtures for grout shall conform to the requirements of ASTM C494. Chemical admixtures which control bleed water, improve consistency, reduce water/cement ratio, and retard set may be used in the grout subject to the review and acceptance of the Owner. Expansive admixtures can be used to fill confined areas of the central steel shaft coupling joints, or to compensate for drying shrinkage. Accelerators shall not be permitted. Chemical admixtures, if used, shall be compatible with the central steel shaft and mixed in accordance with the grout manufacturer's recommendations.

Mineral admixtures for grout shall conform to the requirements of ASTM C618 (coal fly ash) or C1240 (silica fume). Mineral admixtures, which provide thixotropic consistency, reduce porosity, increase compressive strength, and resist segregation may be used in the grout subject to the review and acceptance of the Owner. Mineral admixtures, if used, shall be compatible with the central steel shaft and mixed in accordance with the grout manufacturer's recommendations.

Grout specimen testing is generally not required for production piles, but is required for pre-production tests to evaluate the quality and strength of the grout mix. If required, a strength test shall be the average of the strength of two specimens made from the same sample of grout as used for production HPMs and tested at 28 days or at the test age designated for determination of compressive strength. The specimens shall be made and cured under field conditions in accordance with ASTM C31 and tested in accordance with ASTM C39.

4.11 Aggregate

Sand fillers may be used in the grout mix as an extender with large diameter grout columns, subject to the approval of the Owner. Use fine sand only. Medium or coarse sand shall not be permitted. Small diameter grout columns shall not include aggregate.

4.12 Corrosion Protection (Optional)

The corrosion protection requirements, if any, are identified in Section 1.8.7. The Specifier may elect to delete this section entirely if no corrosion protection materials are required such as for compression piles in non-aggressive ground.

4.12.1 Epoxy Coating: If used, the thickness of coating applied electrostatically to the central steel shaft shall be 7-12 mils. Epoxy coating shall be in accordance with ASTM A775. Bend test requirements are not required. Coupling bolts, nuts, and displacement plates are not required to be epoxy coated.

4.12.2 Galvanization: If used, all A. B. Chance Type SS material shall be hot-dipped galvanized in accordance with ASTM A153 after fabrication. All A. B. Chance Type RS3500.300 material shall be hot-dipped galvanized in accordance with ASTM A123 after fabrication.

5 EXECUTION

5.1 Site Conditions

5.1.1 Prior to commencing HELICAL PULLDOWN™ Micropile installation, the Contractor shall inspect the work of all other trades and verify that all said work is completed to the point where HPMs may commence without restriction.

5.1.2 The Contractor shall verify that all HPMs may be installed in accordance with all pertinent codes and regulations regarding such items as underground obstructions, right-of-way limitations, utilities, etc.

5.1.3 In the event of a discrepancy, the Contractor shall notify the Owner. The Contractor shall not proceed with HPM installation in areas of discrepancies until said discrepancies have been resolved. All costs associated with unresolved discrepancies shall be the responsibility of the Owner.

5.2 Installation Equipment

5.2.1 Shall be rotary type, hydraulic power driven torque motor with clockwise and counter-clockwise rotation capabilities. The torque motor shall be capable of continuous adjustment to revolutions per minute (RPM's) during installation. Percussion drilling equipment shall not be permitted. The torque motor shall have torque capacity 15% greater than the torsional strength rating of the central steel shaft to be installed.

Helical screw piers should be installed with high torque, low RPM torque motors, which allow the helical screw plates to advance with minimal soil disturbance.

5.2.2 Equipment shall be capable of applying adequate down pressure (crowd) and torque simultaneously to suit project soil conditions and load requirements. The equipment shall be capable of continuous position adjustment to maintain proper HPM alignment.

5.3 Installation Tooling

5.3.1 Shall consist of a Kelly Bar Adapter (KBA) and Type SS or RS3500.300 drive tool as manufactured by A. B. Chance Company and used in accordance with the manufacturer's written installation instructions.

Installation tooling should be maintained in good working order and safe to operate at all times. Flange bolts and nuts should be regularly inspected for proper tightening torque. Bolts, connecting pins, and retainers should be periodically inspected for wear and/or damage and replaced with identical items provided by the manufacturer. Heed all warning labels. Worn or damaged tooling should be replaced.

5.3.2 A torque indicator shall be used during HPM installation. The torque indicator can be an integral part of the installation equipment or externally mounted in-line with the installation tooling. Torque indicators are available from A. B. Chance Company.

5.3.2.a Shall be capable of providing continuous measurement of applied torque throughout the installation.

5.3.2.b Shall be capable of torque measurements in increments of at least 500 ft-lb

5.3.2.c Shall be calibrated prior to pre-production testing or start of work. Torque indicators which are an integral part of the installation equipment, shall be calibrated on-site. Torque indicators which are mounted in-line with the installation tooling, shall be calibrated either on-site or at an appropriately equipped test facility. Indicators that measure torque as a function of hydraulic pressure shall be calibrated at normal operating temperatures.

5.3.2.d Shall be re-calibrated, if in the opinion of the Owner and/or Contractor reasonable doubt exists as to the accuracy of the torque measurements.

5.4 Installation Procedures

5.4.1 <u>*Central Steel Shaft:*</u>

5.4.1.a The HPM installation technique shall be such that it is consistent with the geotechnical, logistical, environmental, and load carrying conditions of the project.

5.4.1.b The lead section shall be positioned at the location as shown on the working drawings. Battered HPMs can be positioned perpendicular to the ground to assist in initial advancement into the soil before the required batter angle shall be established. The HPM sections shall be engaged and advanced into the soil in a smooth, continuous manner at a rate of rotation of 5 to 20 RPM's. Extension sections shall be provided to obtain the required minimum overall length and installation torque as shown on the working drawings. Connect sections together using coupling bolt and nut torqued to 40 ft-lb

5.4.1.c Sufficient down pressure shall be applied to uniformly advance the HPM sections approximately 3 inches per revolution. The rate of rotation and magnitude of down pressure shall be adjusted for different soil conditions and depths.

5.4.1.d A lead displacement plate (LDP) of appropriate diameter shall be positioned on the central steel shaft at the location necessary to install the grout column as shown on the working drawings. The LDP shall not be located closer than 12 inches above the top helical plate. Additional LDP's or extension displacement plates (EDP) shall be positioned on the central steel shaft at regular intervals – typically at every coupling joint. Displacement plates shall not be spaced more than 7-ft. apart. Displacement plates shall permit the free flow of grout without misalignment of the central steel shaft.

5.4.2 *Grout*

5.4.2.a Grout shall be mixed with equipment capable of providing a steady supply at the required level of production. The water – cement ratio for neat cement grouts is typically between 0.4 and 0.5. When using a pre-packaged grout, the recommended water-cement ratios listed in the mixing instructions on the package shall be followed.

Typical water-cement ratio for pre-mixed microsil grouts is 0.2 - 0.3. Over-watering will result in reduced compressive strengths, increased shrinkage, and reduced physical properties. Best results are obtained when the grout is mixed with colloidal or high shear mixers, which provide complete wetting of the cement particles.

5.4.2.b The grout shall be placed via a gravity fed reservoir located at the surface. The reservoir shall consist of a temporary casing or form, which is capable of containing liquid grout. The reservoir shall be appropriately sized (diameter and length) to accommodate the soil conditions and grout column diameter. The grout shall be placed in reservoir immediately prior to the advancement of the first LDP into the soil. The volume of grout contained in the reservoir shall be maintained at a level sufficient to maintain positive hydrostatic pressure on the grout column.

5.4.2.c Grout placement shall continue until the minimum grout column length has been achieved as shown on the working drawings. Volume measurements shall be taken throughout the installation in order to determine the actual grout column diameter.

5.4.2.d Grout shall be allowed to attain the minimum design strength prior to being loaded.

5.4.3 *Casing*

5.4.3.a If required, casing shall be installed in segments corresponding to the sections of the central steel shaft.

5.4.3.b The casing shall be advanced into the soil via direct connection with lead and extension displacement plates.

5.4.3.c Each casing segment shall be filled with grout immediately after placement.

Vertically installed HELICAL PULLDOWN™ Micropiles subjected to lateral loads may require steel casing reinforcement. The lateral load analysis as detailed in Section 1.8.4 of the specification can be used to determine the required diameter and length of the steel case reinforcement.

5.5 Termination Criteria

5.5.1 The torque as measured during the installation shall not exceed the torsional strength rating of the central steel shaft.

5.5.2 The minimum installation torque and minimum overall length criteria as shown on the working drawings shall be satisfied prior to terminating the HELICAL PULLDOWN™ Micropile.

5.5.3 If the torsional strength rating of the central steel shaft and/or installation equipment has been reached prior to achieving the minimum overall length required, the Contractor shall have the following options:

5.5.3.a Terminate the installation at the depth obtained subject to the review and acceptance of the Owner, or:

5.5.3.b Remove the existing HPM and install a new one with fewer and/or smaller diameter helical plates. The new helix configuration shall be subject to review and acceptance of the Owner. If re-installing in the same location, the top-most helix of the new HPM shall be terminated at least (3) three feet beyond the terminating depth of the original HPM.

It is generally not recommended to re-use HPM shaft material after it has been permanently twisted during a previous installation.

5.5.4 If the minimum installation torque as shown on the working drawings is not achieved at the minimum overall length, and there is no maximum length constraint, the Contractor shall have the following options:

5.5.4.a Install the HPM deeper using additional extension sections, displacement plates, casing if required, and grout, or:

5.5.4.b Remove the existing HPM and install a new one with additional and/or larger diameter helical plates. The new helix configuration shall be subject to review and acceptance of the Owner. If re-installing in the same location, the top-most helix of the new HPM shall be terminated at least (3) three feet beyond the terminating depth of the original HPM.

5.5.4.c De-rate the load capacity of the HPM and install additional pile(s). The de-rated capacity and additional pile location shall be subject to the review and acceptance of the Owner.

5.5.5 If the HPM is refused or deflected by a subsurface obstruction, the installation shall be terminated and the pile removed. The obstruction shall be removed, if feasible, and the HPM reinstalled. If obstruction can't be removed, the HPM shall be installed at an adjacent location, subject to review and acceptance of the Owner.

5.5.6 The average torque for the last three feet of penetration shall be used as the basis of comparison with the minimum installation torque as shown on the working drawings. The average torque shall be defined as the average of the last three readings recorded at one-foot intervals.

The average torque can be empirically related to the HPM's ultimate capacity in end-bearing. This well-known attribute of screw piers can be used as a production control method to indicate the pile's end-bearing capacity.

6 MICROPILE LOAD TESTS

6.1 Pre-Production Pile Tests (Optional)

Load tests shall be performed to verify the suitability and capacity of the proposed HELICAL PULLDOWN™ Micropile, and the proposed installation procedures prior to installation of production piles. ___________ sacrificial test piles with reaction anchors shall be constructed immediately prior to the start of work on the production HPMs. The Owner shall determine the number of pre-production test piles, their location, acceptable load and movement criteria, and the type(s) of load direction (i.e., tension, compression, or both). Additional purpose of pre-production tests is to empirically verify the ultimate capacity to the average installing torque of the screw pier foundation for the project site.

Pre-production pile installation methods, procedures, equipment, and overall length shall be identical to the production piles to the extent practical except where approved otherwise by the Owner.

The Contractor shall submit for review and acceptance the proposed HPM load testing procedure. The pre-production test proposal shall be in general conformance with ASTM D1143 and/or D-3689, and shall provide the minimum following information:

- Type and accuracy of load equipment
- Type and accuracy of load measuring equipment
- Type and accuracy of pile-head deflection equipment
- General description of load reaction system, including description of reaction anchors
- Calibration report for complete load equipment, including hydraulic jack, pump, pressure gauge, hoses, and fittings.

The following test procedure shall be considered to meet the minimum requirements. It is not intended to preclude local building codes, which may mandate other requirements, such as full 24-hour load tests.

If the pre-production test fails to meet the design requirements, the Contractor shall modify the HPM design and/or installation methods and retest the modified pile, as directed by the Owner. *For prescriptive specifications, the Engineer will define the appropriate modifications.*

6.2 Load Test Procedures

The hydraulic jack shall be positioned at the beginning of the test such that the unloading and repositioning of the jack during the test shall not be required. The jack shall also be positioned co-axial with respect to the pile-head so as to minimize eccentric loading. The hydraulic jack shall be capable of applying a load not less than two times the proposed design load (DL).

An alignment load (AL) shall be applied to the HPM prior to setting the deflection measuring equipment to zero or a reference position. The AL shall be no more than 10% of the design load (i.e., 0.1 DL). After AL is applied, the test set-up shall be inspected carefully to ensure it is safe to proceed.

Axial pile load tests shall be conducted by loading the HPM in step-wise fashion as shown in Table-3 to the extent practical. Pile-head deflection shall be recorded at the beginning of each step and after the end of the hold time. The beginning of the hold time shall be defined as the moment when the load equipment achieves the required load step.

Test loads shall be applied until continuous jacking is required to maintain the load step or until the test load increment equals 200% of the design load (DL) (i.e., 2.0 DL), whichever occurs first. The observation period for this last load increment shall be 10 minutes. Displacement readings shall be recorded at 1, 2, 3, 4, 5 and 10 minutes (load increment maxima only).

The applied test load shall be removed in four approximately equal decrements per the schedule in Table-3. The hold time for these load decrements shall be 1 minute, except for the last decrement, which shall be held for 5 minutes.

This cyclic loading method will permit the analyses of the total, elastic, and net movements, since they can be separated and studied. For special test piles not to be used later in service, further load cycles may be conducted to provide an estimation of the ultimate capacity.

Table-3. Steps for Pre-Production Load Testing

LOAD STEP	HOLD TIME (MINUTES)
AL	2.5 Min.
0.20 DL	2.5 Min.
0.40 DL	2.5 Min.
0.50 DL	2.5 Min.
0.20 DL	1.0 Min.
AL	1.0 Min.
0.40 DL	1.0 Min.
0.60 DL	2.5 Min.
0.80 DL	2.5 Min.
1.0 DL	2.5 Min.
0.5 DL	1.0 Min.
0.2 DL	1.0 Min.
AL	1.0 Min.
0.5 DL	1.0 Min.
1.0 DL	1.0 Min.
1.2 DL	2.5 Min.
1.4 DL	2.5 Min.
1.6 DL	2.5 Min.
1.8 DL	2.5 Min.
2.0 DL	10 Min.
1.5 DL	1.0 Min
1.0 DL	1.0 Min
0.5 DL	1.0 Min
AL	5.0 Min

AL = Alignment Load; DL = Design Load

6.3 Acceptance Criteria for HPM Verification Load Tests

Both of the following criteria must be met for approval:

1. The HPM shall sustain the compression and tension design capacities (1.0 DL) with no more than ____ in. (mm) total vertical movement of the pile-head as measured relative to the top of the HPM prior to the start of testing.
2. Failure does not occur at the 2.0 DL maximum compression and tension test loads. The failure load shall be defined by one of the following definitions – whichever results in the lesser load:
   - The point at which the movement of the HPM tip exceeds the elastic compression/tension of the pile shaft by 0.08 B, where B is defined as the diameter of the largest helix. *(Note that tension loads are limited to the minimum ultimate tensile strength of the coupling joint(s) of the central steel shaft. It is recommended to use the minimum ultimate tensile strengths as published by A. B. Chance Company (shown in Table-A of the Appendix).*
   - The point at which the slope of the load versus deflection (at end of increment) curve exceeds 0.05 inches/kip.

The Contractor shall provide the Owner copies of field test reports confirming HPM configuration and construction details within 24 hours after completion of the load tests. Formal copies shall be submitted as per Section 3.3. This written documentation will either confirm the load capacity as required on the working drawings or propose changes based upon the results of the pre-production tests.

When a HPM fails to meet the acceptance criteria, modifications shall be made to the design, the construction procedures, or both. These modifications include, but are not limited to, de-rating the HPM load capacity, modifying the installation methods and equipment, increasing or decreasing the grout column diameter, increasing the minimum effective installation torque, changing the helix configuration, increasing the grout column length, or changing the HPM material (i.e., central steel shaft, grout mix, etc.). Modifications that require changes to the structure shall have prior review and acceptance of the Owner. The cause for any modifications of design or construction procedures shall be decided in order to determine any additional cost implications.

6.4 Production Pile Testing

(This may be the only type of load test conducted, depending on project conditions.)

The Contractor shall perform proof tests on a minimum of ___% of the total production HPMs. The piles to be tested will be selected by the Owner. At the Contractor's suggestion, but with the Owner's permission, tension tests may be performed in lieu of compression tests up to 1.00 DL for HPMs with sufficient structural tension capacity. *The requirements of Table-4 may be regarded as a minimum, however, it is not recommended to test production piles to values of up to 2.0 DL unless the pile's failure load is significantly higher than 2.0 DL. The maximum production pile test load shall be determined by the Owner. For example, ASTM D1143 stipulates testing to 2.0 DL.*

The test sequence shall be as shown in Table-4 to the extent practical.

Table-4. Steps for Production Load Testing

LOAD STEP	HOLD TIME (MINUTES)
AL	0 Min.
0.20 DL	2.5 Min.
0.40 DL	2.5 Min.
0.60 DL	2.5 Min.
0.80 DL	2.5 Min.
1.00 DL	5 Min.
0.60 DL	1 Min.
0.40 DL	1 Min.
0.20 DL	1 Min.
AL	5 Min.

AL = Alignment Load; DL = Design Load

The acceptance criteria for production piles shall be per Section 6.3 Item 1.

If a production HPM that is tested fails to meet the acceptance criteria, the Contractor shall be directed to proof test another HPM in the vicinity. For failed piles and further construction of other piles, the Contractor shall modify the design, the construction procedure, or both. These modifications include, but are not limited to, installing replacement HPMs, modifying the installation methods and equipment, increasing or decreasing the grout column diameter, increasing the minimum effective installation torque, changing the helix configuration, increasing the grout column length, or changing the HPM material (i.e., central steel shaft, grout mix, etc.). Modifications that require changes to the structure shall have prior review and acceptance of the Owner. Any modifications of design or construction procedures shall be at the Contractor's expense.

6.5 Lateral Testing

If required, lateral load tests shall be conducted in accordance with ASTM D3966. If a production pile is to be lateral load tested, care must be taken not to cause permanent damage – which can reduce its axial load capacity. The acceptance criteria as selected by the Owner, typically expressed as a maximum total movement at a specific load, must be realistic in its magnitude so as not to potentially damage the structure. It is suggested that lateral loads be resisted through some other means, such as soil anchors, battered piles, or enlarged concrete pile caps/grade beams.

7 MEASUREMENT AND PAYMENT

HPM work can be paid for in different ways, reflecting the relative risk to be accepted by the Owner and the Contractor. However, the following items are common and standard.

QUANTITY	DESCRIPTION	UNIT
1	Mobilization/Demobilization	Lump sum
1	Conduct pre-production test pile program of declared scope	Lump sum
	Test Production Pile	Per pile
-	Obstructions	Per hour or Force Account
As required	HPM Installation	As below

- *Per Unit Length*: HPMs meeting the design capacity shall be paid for per lineal foot below grade.
- *Per Pile*: HPMs meeting the design capacity shall be paid for on a "per pile" basis (no allowance for changes in length relative to that originally bid).
- *Per Pile with Add/Deduct*: HPMs meeting the design capacity shall be paid for on a "per pile" basis, with a predetermined length, and an add/deduct amount per lineal foot to accommodate field changes.
- *Lump Sum*: The whole HPM project shall be paid for on a "lump sum" basis (no allowance for changes due to additional pile length relative to that originally bid).

END OF SPECIFICATION

APPENDIX

TABLE A
Hubbell Power Systems, Inc./CHANCE
Mechanical Strength Ratings – Helical Screw Piles

RATING TYPE	CENTRAL STEEL SHAFT FAMILY					
	SS5 1-1/2" RCS	**SS150 1-1/2" RCS**	**SS175 1-3/4" RCS**	**SS200 2" RCS**	**SS225 2-1/4" RCS**	**RS3500.300 3-1/2" O.D Pipe**
Torsional Strength Rating (ft-lb)	5,500	7,000	10,500	16,000	21,000	13,000
Ultimate Tension Capacity for Axially Loaded Pile (kip)	70	70	100	150	200	100

NOTE: Actual installed capacities are dependent on existing soil conditions.

APPENDIX

TABLE B
Guidance of Ground Aggressiveness Classification

Soil tests may be performed to measure the aggressiveness of the soil environment, especially if field observations indicate corrosion of existing structures. The most common and simplest tests are for electrical resistivity, pH, chloride, and sulfates. The designation for these tests and the critical values defining whether an aggressive soil environment exists, are as shown below. Per FHWA-RD-89-198, the ground is considered aggressive if any one of these indicators shows critical values.

Property	Test Designation	Critical Values
Resistivity	ASTM G 57 AASHTO T-288	below 2,000 ohm-cm
pH	ASTM G 51 AASHTO T-289	below 5
Sulfate	ASTM D 516M ASTM D 4327	above 200 ppm
Chloride	ASTM D 512 ASTM D 4327 AASHTO T-291	above 100 ppm
Organic Content	AASHTO T-267	1% max

HELICAL PULLDOWN™ Micropile Installation Log

Page(s):_____ of _____

Project Name: ____
Contractor: ____
Name & Model of Installation Equip: ______________________________

Project No:________________________
Project Address:
____
____
____
Project Type:__________________________
(New Construction/Remedial Repair)
Termination/Bracket:____________________
On-Site Supervisor: ____________________
Total Length of HPM: ___________________
Inclination of HPM: ____________________
Comments: ____________________________
____
____

Date: __________________
Time: __________________
Time to Install: ________________________
Micropile Location No: __________________
Shaft Type/Size:________________________
____
____
Helix Configuration: ____________________
Grout Column Diameter: ________ (inches):
Sleeve/Unsleeved (circle)
Sleeve Depth: __________ (feet)
Torque Indicator Type: __________________
Cut-off Elevation: ______________________

Micropile Installation

Depth (feet)	Torque (ft-lb)	Grout Flow (volume/shaft length)

Depth (feet)	Torque (ft-lb)	Grout Flow (volume/shaft length)

A. B. CHANCE CO.

WORKSHEET FOR AXIAL COMPRESSION/TENSION LOAD TEST
HELICAL PULLDOWN™ Micropiles

PROJECT NAME: ____

CONTRACTOR: ____

ON-SITE SUPERVISOR (during installation): ___________________________

TEST AGENCY (if required): ______________________________________

HPM SHAFT TYPE/SIZE: ____

____

HELIX CONFIGURATION: ____

GROUT COLUMN DIA: ___________ **SLEEVE/UNSLEEVED (DIA):** __________

DESCRIPTION OF TEST EQUIP & SET-UP: ____________________________

____

____

LOAD SCHEDULE: ____

COMMENTS: ____

____

____

SHEET __ **OF** __ **:**

DATE OF TEST: ________________

TIME: _______________________

DURATION OF TEST: ____________

MICROPILE LOCATION No: _______

TYPE OF TEST: **(TENSION OR COMPRESSION)**

____

TESTED BY: ____________________

____

____

OBSERVED BY: _________________

____

____

AUTHORIZED SIGNATURE: ___________

____

			DIAL INDICATOR READINGS								ALL DIALS	TRANSIT	
JACK PRESSURE (PSI)	APPLIED LOAD (KIPS)	TIME ELAPSED (MIN.)	DIAL A READING (IN.)	DIAL A DEFLECTION (IN.)	DIAL B READING (IN.)	DIAL B DEFLECTION (IN.)	DIAL C READING (IN.)	DIAL C DEFLECTION (IN.)	DIAL D READING (IN.)	DIAL D DEFLECTION (IN.)	AVERAGE DEFLECTION (IN.)	SCALE READING (IN.)	DEFLECTION (IN.)
0	0			0		0		0		0			0