MODEL SPECIFICATION FOR HELICAL SOIL NAILS

EARTH RETENTION APPLICATIONS

# SCOPE

## The work consists of designing, furnishing and installing helical soil nails and load transfer devices for helical soil nail walls or slopes according to the project Plans and these specifications.

## The parties and contract terms referred to in this specification are as follows:

### 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.

### The Soil Nail Designer is the individual or firm generally hired by the Installing Contractor to design the helical soil nails.

### The Installing Contractor installs and tests (if necessary) the helical soil nails, and possibly performs other tasks associated with the project.

### The Plans refer to the contract documents; including but not limited to the drawings and specifications for the project.

## Helical soil nail walls or slopes are built from the top down in existing ground. The work consists of the following items as shown on the Plans:

### Excavating in staged lifts in accordance with federal, state or local safety guidelines

### Installing helical soil nails to the specified minimum length, orientation and minimum final termination torque

### Providing and placing drainage elements at the specified locations

### Placing wall or slope face steel reinforcement, attaching bearing plates and connection devices and applying shotcrete or other specified facing over the reinforcement

## The work may include helical soil nail load testing.

## The Owner will be responsible for obtaining right-of-way or easement access permits necessary for the helical soil nail installation.

## Unless otherwise noted, the Installing Contractor shall provide all labor, tools, equipment and materials necessary to accomplish the work.

## The Owner will provide suitable access to the construction site for the Installing Contractor’s personnel and equipment.

## 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.

## The Owner will be responsible for overall construction oversight to preclude the development of unsafe conditions.

## The Owner will be responsible for a horizontal field survey of the helical soil nail locations prior to helical soil nail installation and an elevation survey to determine soil nail shaft cutoff height subsequent to helical soil nail installation.

## The work does not include any post-construction monitoring of soil nail performance unless specifically noted otherwise in the contract documents.

# references

## American Institute of Steel Construction (AISC)

### AISC 360: Specification for Structural Steel Buildings

## American Society for Testing and Materials (ASTM)

### ASTM A29: Steel Bars, Carbon and Alloy, Hot-Wrought

### ASTM A36: Carbon Structural Steel

### ASTM A123: Zinc Coating (Hot-Dip) on Iron and Steel Products

### ASTM A153: Zinc Coating (Hot-Dip) on Iron and Steel Hardware

### ASTM A185: Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete

### ASTM A572: High-Strength Low-Alloy Columbian-Vanadium Structural Steel

### ASTM A615: Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

### ASTM B633: Electrodeposited Coatings of Zinc on Iron and Steel

### ASTM B695: Coatings of Zinc Mechanically Deposited on Iron and Steel

### ASTM D1785: Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

## Federal Highway Administration (FHWA)

### FHWA Geotechnical Engineering Circular No. 7, “Soil Nail Walls”

## International Code Council Evaluation Services (ICC-ES)

### Acceptance Criteria 358 (AC358): Acceptance Criteria for Helical Pile Systems and Devices

## Society of Automotive Engineers (SAE)

### SAE J429: Mechanical and Material Requirements for Externally Threaded Fasteners

# DEFINITIONS

## The following terms apply to helical soil nails:

### 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.

### Bearing Stratum: The soil layer (or layers) that provides helical soil nail end bearing capacity through load transfer from the helical plates.

### Crowd: Axial compressive force applied to the helical soil nail shaft as needed during installation to ensure the soil nail advances at a rate approximately equal to the helix pitch for each revolution.

### 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.

### 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).

### Extension Section: Helical soil nail shaft sections connected to the lead section or other extension sections to advance the helix plates to the required bearing strata and nail length. Helical soil nail extension have helix plates.

### Factor of Safety: The ratio of the ultimate soil nail capacity or nominal resistance (strength) to the nominal or service load used in the design of any helical soil nail component or interface (Allowable Stress Design).

### Factored Load: The product of a nominal load and an applicable load factor (Load and Resistance Factor Design).

### Factored Resistance: The product of a nominal resistance and an applicable resistance factor (Load and Resistance and Factor Design).

### Geotechnical Capacity: The maximum load or the load at a specified limit state, that can be resisted through the soil nails interaction with the bearing soils (see also Ultimate Soil Nail Capacity).

### Helical Soil Nail: Consists of a central steel shaft with multiple helix-shaped bearing plates and a load transfer device that allows attachment to wall or slope facing components. Helical soil nails are installed into the ground by application of torque and axial compressive force (“crowd”).

### 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 soil nail’s longitudinal axis thus aiding in soil nail installation. The plate transfers axial load to the soil through bearing.

### Helix Pitch: The distance measured along the axis of the shaft between the leading and trailing edges of the helix plate.

### Lead Section: The first helical soil nail shaft component installed into the soil. It consists of multiple helical plates welded to a central steel shaft.

### Limit State: A condition beyond which a helical soil nail 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)).

### 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.

### 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).

### Load Test: A process to test the ultimate soil nail capacity and relation of applied load to soil nail head movement by application of a known load on the helical soil nail head and monitoring movement over a specific time period.

### 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 Load).

### Mechanical Strength: The maximum load or the load at a specified limit state that can be resisted by the structural elements of a helical soil nail.

### Net Deflection: The total deflection at the helical soil nail head minus the theoretical elastic deformation of the soil nail shaft during a load test.

### 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).

### Nominal Resistance: The soil nail capacity at a specified ultimate limit state (Load and Resistance Factor Design). See Ultimate Soil Nail Capacity.

### 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 Soil Nail Capacity.

### 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).

### Service Loads: See “Nominal Loads” above.

### Ultimate Soil Nail Capacity: The helical soil nail capacity based on the least capacity determined from applicable ultimate limit states for mechanical and geotechnical capacity.

# APPROVED HELICAL SOIL NAIL MANUFACTURERS

## Foundation Supportworks®, Inc., 12330 Cary Circle, Omaha, NE 68128; Phone: (800) 281-8545; Fax: (402) 393-4002.

## Due to the special requirements for design and manufacturing of helical soil nails, the soil nails shall be obtained from Foundation 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:

### Documentation of at least five years of production experience manufacturing helical soil nails,

### Documentation that the manufacturer’s helical soil nails have been used successfully in at least three engineered construction projects within the last three years,

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

### 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

# acceptable products

## Solid Square Shaft Helical Soil Nail Models HS150 and HS175 manufactured in accordance with the requirements of Sections 5 and 6 of this specification.

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

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

#### Helix pitch is 3-inches ± ¼-inch.

#### All helix plates have the same pitch.

#### Helix plates have generally circular edge geometry.

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

#### Helix plates are arranged along the shaft such that they all theoretically track the proceeding plate.

## Wall Reinforcement, Anchorage, Bearing Plates, Nuts and Washers

### The wall anchorage shall consist of a bearing plate, or other fabricated bearing device connected to the helical soil nail with threaded rod adaptors.

### A spherical seat nut or beveled washer and nut may be required at the connection of the helical soil nail to the bearing device to accommodate soil nail inclination per manufacturer recommendations.

### Bearing devices shall be fabricated from steel conforming to ASTM A36 or A572 specifications, or equivalent.

### Welded wire fabric shall conform to ASTM A185 or equivalent.

### Reinforcing steel shall conform to ASTM A615, Grade 420 deformed.

## Drainage Material

### Vertical Wall Drains: Provide prefabricated, fully wrapped preformed geocomposite drains as required and shown on the Plans. The drainage core shall be either a preformed grid of embossed plastic or a system of plastic pillars and interconnections forming a semi-rigid mat, not less than 0.25 inches or more than 0.50 inches thick. The core material, when covered with filter fabric, shall be capable of maintaining a drainage void for the entire length of the permeable liner. Preformed drains shall be no wider than 12 inches unless special methods are used to ensure adherence of the shotcrete to the fabric and to preclude the fabric from sagging under the weight of the shotcrete. They shall be suitably outletted or connected to a longitudinal drain at the base of the wall. When splicing of drains is required, full flow through the splice shall be maintained and splices shall be suitably protected from damage and contamination during subsequent shotcreting. The shotcrete shall be the full design thickness over the drain.

### Horizontal Drains: Provide as required and shown on the Plans, slotted and unslotted PVC pipe conforming to ASTM D1785 or equal. When horizontal drains are installed in bored holes, the Installing Contractor shall make provisions to assure that the drain-hole annulus does not collapse prior to the insertion of the slotted drain. Only the front 12 inches of drain pipe shall be unslotted.

## Shotcrete Wall Facing

### The Installing Contractor shall submit for approval by the Owner, materials, methods and control procedures for this work. Shotcrete design shall be in accordance with the shotcrete specifications in FHWA Geotechnical Engineering Circular No. 7, “Soil Nail Walls”, except as otherwise specified on the Plans. If facing material other than shotcrete is specified, the Installing Contractor shall submit for approval by the Owner, materials, methods and control procedures for this work.

## Materials Handling and Storage

### Store cement to prevent moisture degradation and partial hydration. Do not use cement that has become caked or lumpy. Store aggregates so that segregation and inclusion of foreign materials are prevented. Store un-galvanized helical soil nails on supports to keep the steel from contacting the ground. Light rust that has not resulted in pitting is acceptable for temporary applications.

# Helical Soil Nail Materials

## Model HS150 Helical Soil Nail System

### 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.

### 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.

### Helix Plate Material: The helix plates are factory welded to the lead or extension shaft sections. The helix plates have outer diameters of either 6 or 8-inches and are manufactured from 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. The helix plate finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.

### 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.

### Thread Rod Adapter: Thread rod adaptor HA150TRA is suitable for use with the HS150 shaft. Thread rod adapter finishes are either plain steel or hot-dip galvanized in accordance with ASTM A123. Adapter shaft coupling hardware is mechanically galvanized in accordance with ASTM B695.

## Model HS175 Helical Soil Nail System

### 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.

### 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

### Helix Plate Material: The helix plates are factory welded to the lead or extension shaft sections. The helix plates have outer diameters of either 6 or 8-inches and are manufactured from 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. The helix plate finish is either plain steel or hot-dip galvanized in accordance with ASTM A123

### 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 jam nuts. The bolts and nuts are mechanically galvanized in accordance with ASTM B695.

### Thread Rod Adapter: Thread rod adaptor HA175TRA is suitable for use with the HS175 shaft. Thread rod adapter finishes are either plain steel or hot-dip galvanized in accordance with ASTM A123. Adapter shaft coupling hardware is mechanically galvanized in accordance with ASTM B695.

# design and performance requirements

## Helical soil nails shall be designed to support the specified load(s) as shown on the project Plans. The overall length, helix configuration and minimum torsional resistance of a helical soil nail shall be such that the required geotechnical capacity is developed by the helix plate(s) in an appropriate bearing stratum.

## All structural steel soil nail 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.

## Design of helical soil nail structures for excavation support, earth retention, slope stabilization, or other applications shall consider the following (at a minimum):

### Global and internal stability of the system

### Surcharge loads from adjacent structures or other loading that will be present during and/or after construction.

### Helical soil nail torque correlated bearing capacity (bond strength) & load transfer

### Structural capacity of individual helical soil nail components

### Construction sequencing

### Drainage conditions

### Serviceability

## The design of helical soil nail walls shall be in accordance with the FHWA Geotechnical Engineering Circular No. 7, “Soil Nail Walls”.

## Except where noted otherwise on the project Plans, all helical soil nails 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 for internal stability of the wall and slope stability at the elevation of the toe of the wall shall be used for temporary or permanent applications. Lower factors of safety may be considered if approved by the Owner. When an LRFD analysis is required, the Owner shall provide applicable soil nail design information including but not limited to; factored loads, resistance factors and/or the required ultimate soil nail capacity. Factors of safety (ASD) or resistance factors (LRFD) may require modification to meet specific deflection criteria stated on the Plans or drawings.

## The required ultimate torque-correlated capacity shall be verified at each soil nail location by monitoring and recording final installation torque and applying default torque correlations per ICC-ES AC358. Site specific torque correlation factors may be determined by field load testing as specified in Section 14.

## Except where noted otherwise on the project Plans, each soil nail shall be designed to meet a corrosion service life of 50 years in accordance with ICC-ES AC358.

## The soil nail design shall take into account group efficiency from soil nail spacing, soil stratification, and strain compatibility issues.

# qualifications of installing contractor and designer

## The Installing Contractor and/or Soil Nail 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.

## Evidence of Installing Contractor’s competence in the installation of helical soil nails shall be provided to the Owner’s satisfaction and may include any or all of the following:

### Helical soil nail manufacturer’s certificate of competency in installation of helical soil nails,

### A list of at least three projects completed within the previous three years wherein the Installing Contractor installed helical soil nails and/or helical tieback anchors in comparable soil conditions for the nominal loads similar to those shown on 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

### A letter from the helical soil nail manufacturer or manufacturer’s representative expressing ability and intent to provide on-site supervision of the soil nail installation.

## 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.

## Evidence of Soil Nail Designer’s competence shall be provided to the Owner’s satisfaction and may include any or all of the following:

### Registration as a Professional Engineer or recognition by the local jurisdictional authority,

### A list of at least three projects completed within the previous three years wherein the Soil Nail Designer designed helical soil nails similar to those shown in the project Plans. Such list to include names and phone numbers of those project representatives who can verify the Soil Nail Designer’s participation in those projects, and/or

### Recommendation from the soil nail manufacturer or manufacturer’s representative.

# pre-construction submittals

## Within 2 weeks of receiving the contract award, the Installing Contractor and/or helical Soil Nail Designer shall submit the following helical soil nail design documentation:

### Certification from the Soil Nail Designer that the proposed soil nails meet the requirements of this specification.

### Qualifications of the Installing Contractor and Soil Nail Designer per Section 8.

### Product designations for helical soil nail lead and extension sections and all ancillary products to be supplied at each helical soil nail location.

### Individual soil nail nominal loads, factors of safety, LRFD load and resistance factors and required ultimate torque-correlated capacities, where applicable.

### Individual soil nail loading or post-tensioning requirements (if any).

### Manufacturer’s published allowable system capacities for the proposed soil nail assemblies, including load transfer devices, if any.

### Calculated mechanical and theoretical geotechnical capacities including unit bond stress of the proposed soil nails.

### Minimum helical soil nail termination torque requirements.

### Maximum estimated installation torque and allowable installation torque rating of soil nail.

### Minimum and/or maximum embedment lengths or other site specific embedment length or depth requirements as may be appropriate for the site soil profiles.

### Inclination angle and location tolerance requirements.

### Load test procedures and failure criteria, if applicable.

### 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 soil nail installation starting date or as recommended by the equipment manufacturer.

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

# placement requirements

## Helical soil nails shall be installed within 3-inches of the indicated plan location.

## Helical soil nail shaft alignment shall be within 2-degrees of the inclination angle shown on the Plans.

## Soil nail wall bearing plate edge distance from face of wall shall be within 1-inch of the design placement as shown on the Plans.

# execution

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

## 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.

## 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.

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

## Installation of helical soil nails may be observed by the Owner for quality assurance purposes. The installing contactor shall give the Owner at least 24 hours’ notice prior to the soil nail installation operations.

## Construction Procedure

### The wall or slope is to be constructed from the top down as the soil in front of the wall is removed to specified depths and the helical soil nails are installed at each level.

### The exposed soil face shall be retained with a construction facing consisting of mesh reinforced shotcrete or other appropriate facing material. Drainage systems, when required, shall be installed prior to applying shotcrete or other facing material.

## Site Drainage Control

### Provide positive control and discharge of all surface water that will affect construction of the helical soil nail retaining wall or slope. Maintain all pipes and conduits used to control surface water during construction. Surface water drainage network shall be independent of the wall drainage network.

### Contact the Owner if unanticipated subsurface drainage structures are discovered during excavation.

## Excavation

### Excavation shall proceed in stages or lifts according to the Plans, exposing a minimum amount of soil face which will still allow for the installation of the helical soil nails and wall facing system while assuring stability of the excavated face.

### The Owner shall be responsible for providing the necessary survey and alignment control during excavation of each lift and for performing the excavation in a manner which will allow for construction of the wall facing to the specified minimum thickness and to the line and grade indicated on the Plans. The Installing Contractor shall be responsible for locating and installing the helical soil nails within the allowable tolerances in this specification or on the Plans, and for performing the excavation and nail installation in a manner which will allow for constructing the wall facing to the specified minimum thickness and to the line and grade indicated on the Plans.

### The Owner shall perform the excavation for the soil nail wall under the direction of the Installing Contractor. Care shall be taken to excavate to the final wall face using procedures that: (1) prevent over-excavation; (2) prevent ground loss, swelling, air slaking, or loosening; (3) prevent loss of support for completed portions of the wall; (4) prevent loss of soil moisture at the face; and (5) prevent ground freezing.

### The exposed unsupported final excavation face cut height shall not exceed the vertical nail spacing plus the required reinforcing lap or the short-term stand-up height of the ground, whichever is less. Excavation to the next level shall not proceed until helical soil nail installation, reinforced shotcrete or other wall or slope facing placement, attachment of bearing plates and connection means and nail testing has been completed and accepted in the current lift. Shotcrete shall have cured for at least 72 hours or attained at least its specified 3-day compressive strength before excavating the next lift.

## Helical Soil Nail Installation

### Installing Contractor shall determine the installation method necessary to achieve the helical soil nail pullout resistance specified herein or on the Plans, in accordance with the helical soil nail acceptance criteria in the Helical Soil Nail Testing section. Install sacrificial helical soil nails for verification testing using the same equipment, methods, nail inclination and soil nail models as planned for the production soil nails.

### No installation of production helical soil nails will be permitted until successful pre-production verification testing of nails is completed and approved by the Owner. The number and location of the verification tests will be as indicated on the Plans or specified herein.

### During installation of the helical soil nails, the torque required to install each soil nail shall be monitored and recorded. The installation records shall include the following information:

#### Date and time of installation

#### Gear motor make and model

#### Location of helical soil nail and nail identification number

#### Actual helical soil nail model and configuration

#### Quantity and length of lead and extension sections installed

#### Installation torque log taken in minimum 5-foot increments of the total soil nail length and the final installation torque

#### Actual inclination of the soil nail

#### Comments pertaining to interruptions, obstructions, or other relevant information

### When the final installation torque readings at the planned helical soil nail lengths do not achieve the minimum final torque requirements per the design or Plans, the Owner shall be notified to make recommendations for adding soil nails or extending the non-conforming soil nail to greater lengths.

### Helical soil nail installation shall be terminated when the planned length is achieved as long as the final installation torque requirements per the design are met. When the maximum torque rating of the helical soil nail shaft is achieved prior to reaching the design length, the Soil Nail Designer shall be notified to make design recommendations to the Owner.

### The installation of the helical soil nails shall be made at the locations, inclinations, and lengths shown on the Plans or as directed by the Owner. The installation techniques and equipment used shall be such that it is consistent with the geotechnical, logistical, environmental, and load carrying conditions of the project.

### The helical soil nail sections shall be engaged and advanced into the soil in a smooth, continuous manner at a rate of rotation less than 25 rpm. Sufficient crowd shall be applied to advance the helical soil nail sections at a rate approximately equal to the pitch of the helix plate per revolution. The rate of rotation and magnitude of crowd shall be adjusted for different soil conditions and depths. Extension sections shall be provided to obtain the required minimum overall nail length.

### Helical soil nails that encounter unanticipated obstructions during installation shall be relocated as approved by the Owner’s representative.

# installation record submittals

## The Installing Contractor shall provide the Owner, or his authorized representative, copies of individual helical soil nail installation records within 24 hours after each soil nail installation is completed. Formal copies shall be submitted within 30 days following the completion of the helical soil nail installation. These installation records shall include the information listed in Section 11.9.3.

# HELICAL SOIL NAIL TESTING

## If helical soil nail testing is required, the Installing Contractor shall furnish all labor, equipment and pre-production helical soil nails necessary to accomplish the testing as shown in the approved soil nail design documentation. Installing Contractor shall apply the specified loads for the specified durations and record the specified data, for the specified number of soil nails. No deviations from the test plan(s) will be allowed without explicit approval in writing from the Owner. Testing of any helical soil nail shall not be performed until the shotcrete facing has cured for at least 72 hours or attained at least the specified 3-day compressive strength. Helical soil nails may be tested immediately after installation without a shotcrete facing as long as precautions to maintain face stability are made (i.e., temporary lagging, etc.).

## The test equipment shall consist of:

### A calibrated dial gauge capable of measuring to 0.001-of-an inch shall be used to measure movement.

### A hydraulic cylinder and gauge calibrated as a unit shall be used to apply the test load. The pressure gauge shall be graduated in 100 psi increments or less and used to measure the applied load.

### A reaction frame shall be used to distribute the load to the wall or slope facing without causing excessive deformation to the testing equipment or cracking in the facing.

## Apply and measure the test load with the hydraulic cylinder and pressure gauge. The stroke of the hydraulic cylinder shall have sufficient travel to allow the test to be done without resetting the equipment. Measure the soil nail head movement with the dial gauge. The dial gauge shall have sufficient travel to allow the test to be done without having to reset the gauge. Support the gauge independently from the hydraulic cylinder, wall, or reaction frame.

## Pre-production verification testing of sacrificial test helical soil nails shall be performed prior to installation of production helical nails to verify the Installing Contractor’s installation methods and nail pullout resistance. The verification testing shall consist of:

### Install sacrificial test helical nails as per Helical Soil Nail Installation Section 11.9.

### Perform a minimum of two verification tests for each significantly different soil strata within the bearing zones of the proposed helical soil nails.

### Sacrificial helical test nails shall have lengths of shaft without helix plates (smooth shaft) in addition to the test nail with helix plates. The length of smooth shaft is to be located nearest to the wall or slope face and shall be at least three feet long. The quantity of helix plates along the test nail shaft shall be determined based on the diameter of the helix plates used and the soil nail shaft torsional rating such that the torque rating of the shaft and the helical nail structural capacity is not exceeded during installation and testing.

### Isolate the test nail from the shotcrete facing and/or reaction frame used during testing.

### Submit the proposed location and length of shaft sections with and without helix plates prior to testing to the Owner for review and approval in accordance with the Pre-Construction Submittals Section 9.

### The Design Test Load (DTL) shall be determined by the Owner taking into consideration the required ultimate soil nail capacity in the test region, or the helical soil nail with the highest load as determined by the internal and external stability analysis.

### Verification test nails shall be incrementally loaded to a maximum test load of 200% of the DTL in accordance with the following loading schedule. The helical soil nail head movements shall be recorded at each load increment.

**Verification Test Loading Schedule**

Load Hold Time

AL (0.05 DTL max.) 1 minute

0.25DL 10 minutes

0.50DL 10 minutes

0.75DL 10 minutes

1.00DL 10 minutes

1.25DL 10 minutes

1.50DL (Creep Test) 60 minutes

1.75DL 10 minutes

2.00DL 10 minutes

The alignment load (AL) should be the minimum load required to align the testing apparatus and should not exceed 5% of the DTL. Dial gages should be set to “zero” after the alignment load has been applied. Each load increment shall be held for at least 10 minutes. The verification test helical soil nail shall be monitored for creep at 1.50 DTL. Nail movements during the creep portion of the test shall be measured and recorded at 1 minute, 2, 3, 5, 6, 10, 20, 30, 50, and 60 minutes.

## Proof testing of production helical soil nails shall be performed on three percent (1 in 33) or more of the production helical soil nails in each horizontal row or a minimum of 1 nail per row. The quantity and size of helix plates along the soil nail shaft shall be determined such that the torque strength rating and allowable helical nail structural capacity is not exceeded during installation and testing. The minimum length of the proof tested production helical soil nail is 7 feet. The following requirements for proof testing shall be followed:

### The DTL shall be determined as shown in Section 14.4.6

### Proof tests shall be performed by incrementally loading the helical soil nail to a maximum test load of 150% of the DTL in accordance with the following loading schedule. At load increments other than the maximum test load, the load shall be held long enough to obtain a stable reading. A stable reading is defined as less than 0.010 inches of movement between readings taken two minutes apart. The helical soil nail head movements shall be recorded at each load increment.

**Proof Test Loading Schedule**

Load Hold Time

AL (0.05 DTL max.) Until Stable

0.25DL Until Stable

0.50DL Until Stable

0.75DL Until Stable

1.00DL Until Stable

1.25DL Until Stable

1.50DL (Max. Test Load) See Below

The alignment load (AL) should be the minimum load required to align the testing apparatus and should not exceed 5% of the Design Test Load (DTL). The verification test helical soil nail shall be monitored for creep at 1.50 DTL. At the discretion of the Owner, either 10 minute or 60 minutes creep tests shall be performed at the maximum test load (1.5 DTL). The creep period shall start as soon as the maximum test load is applied, and the helical nail movement shall be measured and recorded at 1 minute, 2, 3, 5, 6, and 10 minutes. Where the helical nail movement between 1 minute and 10 minutes exceeds 0.08 inches the maximum test load shall be maintained until the helical nail movement is less than 0.08 inches for any one log cycle increment (i.e., 2 minutes and 20 minutes, etc.).

## A helical soil nail shall be considered acceptable when the following criteria are met:

### For verification tests, a total creep movement of less than 0.08 inches per log cycle of time between the 6 and 60 minute readings, and the creep rate is linear or decreasing throughout the creep test load hold period.

### For proof tests, a total creep movement of less than 0.08 inches is measured between the 1 and 10 minute readings, or a total creep movement of less than 0.08 inches is measured between the subsequent log cycles, and the creep rate is linear or decreasing throughout the creep test load hold period.

### For verification and proof tests, a pullout failure does not occur at the maximum test load. Pullout failure is defined as the load which results in continued pullout (creep) movement of the test helical soil nail.

## If the pre-production verification test nail does not meet the criterion in Section 13.6, it shall be rejected and the Installing Contractor shall propose alternative methods and install replacement verification test helical nails. Successful proof tested helical soil nails meeting the above test acceptance criteria may be used as production nails, provided the number of helix plates on the test nail is such that the helical nail length is equal to or greater than the specified length. If the production proof test nail does not meet this criterion, it shall become sacrificial and shall be replaced with an additional production helical nail installed.

## The Owner may require the Installing Contractor to replace some or all of the installed production soil nails between a failed proof test soil nail and the adjacent passing proof test nail. Or, the Owner may require the installation and testing of additional proof test helical nails to verify that adjacent previously installed production nails have sufficient load carrying capacity.

# Cleanup

## 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.