

Revised: 2/24/2020

SECTION 900: Permanent Soil Nails

901 General

901.01 Description

The work shall consist of constructing soil nail retaining walls as specified herein and shown in the plans. The Contractor shall furnish all labor, materials, and equipment required for completing the work. The Contractor shall select the method of excavation, drilling method and equipment, final drill hole diameter(s), and grouting procedures to meet the performance requirements specified herein.

Soil nailing work shall include excavation; drilling soil nail drill holes to the specified minimum length and orientation indicated in the plans; providing, placing and grouting the nail bar tendons into the drill holes; placing drainage elements; applying shotcrete facing over the existing bin wall face corrugations; attaching bearing plates and nuts; performing nail testing, placing steel reinforcement; and casting the final cast-in-place (CIP) concrete facing.

The term "Soil Nail" as used in these specifications is intended as a generic term and refers to a reinforcing bar grouted into a drilled hole installed in any type of ground. Soil nail walls are built from the top down in existing ground. Soil properties, material strengths, design requirements and other criteria are shown in the plans.

901.02 Soil Nail Contractor's Experience Requirements and Submittal.

The soil nailing Contractor shall submit a project reference list verifying the successful construction completion of at least 5 soil nail retaining wall projects during the past 3 years totaling at least 1200 square feet of wall face area and the installation of at least 500 soil nails. At least 3 of these soil nailing projects shall include installing soil nail walls under the foundation of existing structures. A brief description of each project with the Owner's name and current phone number shall be included.

A Registered Professional Engineer employed by the soil nailing Contractor and having experience in the construction of permanent soil nail retaining walls on at least 3 completed projects over the past 3 years shall supervise the work. The on-site supervisor and drill rig operators shall have experience installing permanent soil nails on at least 5 projects over the past 5 years. The Contractor shall not use consultants or manufacturer's representatives to satisfy the requirements of this section. At least 30 calendar days before starting the wall construction, the soil nail Contractor shall submit 5 copies of the completed project reference list and a list identifying the supervising Engineer, drill rig operators, and on site supervisors assigned to the project. The personnel list shall contain a summary of each individual's experience and be complete enough for the Engineer to determine whether each individual satisfies the required qualifications. The Engineer will approve or reject the Contractor's qualifications within 15 calendar days after receipt of a complete submission. Work shall not be started nor materials ordered until the Engineer's written approval of the Contractor's qualifications is given.

Revised: 2/24/2020

The Engineer may suspend the work if the Contractor uses non-approved personnel. If work is suspended for use of non-approved personnel, no adjustment in contract costs or contract time attributed to the suspension will be made.

901.03 Construction Site Survey

Before bidding the work, the Contractor shall review the available subsurface information and visit the site to assess the site geometry, equipment access conditions, and location of existing structures and above ground facilities.

The Contractor is responsible for field locating and verifying the location of existing piles supporting the bridge and all utilities shown in the plans prior to starting the work and coordinating work on this wall with other new construction under this contract. Maintain uninterrupted service for those utilities designated to remain in service throughout the work. Notify the Engineer of any utility locations different from shown in the plans that may require nail relocations or wall design modification.

The department will pay for each abandoned soil nail at 50 percent of the production soil nail unit price. The payment for the abandoned soil nails include the cost of drilling, abandoning the hole, and grouting; including time, material and labor. For estimating purposes the Contractor shall assume that the wall will have 5 excavated soil nails that will have to be abandoned and relocated.

Prior to start of any wall construction activity, the Contractor shall notify the Engineer and inspect the site to observe, survey, benchmark, monument and videotape the pre-construction condition of the site, existing structures and facilities. During construction, the Contractor shall observe the conditions above the soil nail wall on a daily basis for signs of ground movement in the vicinity of the wall. Immediately notify the Engineer if signs of movements such as new cracks in structures, increased size of old cracks or separation of joints in structures, foundations, streets or paved and unpaved surfaces are observed. If the Engineer determines that the movements exceed ½ inch and require corrective action, the Contractor shall take corrective actions necessary to stop the movement or perform repairs. When due to the Contractor's methods or operations or failure to follow the specified/approved construction sequence, as determined by the Engineer, the costs of providing corrective actions will be borne by the Contractor. When due to differing site conditions, as determined by the Engineer, the costs of providing corrective actions will be paid as Extra Work.

901.04 Construction Submittals

Upon approval of the soil nailing Contractor's qualifications submittal set forth, submit 5 copies of the following information, in writing, to the Engineer for review and approval. Provide submittal item numbers 1 through 1.d at least 21 calendar days prior to initiating the soil nail wall construction and submittal items 2 through 6 at least 21 calendar days prior to start of soil nail installation or incorporation of the respective materials into the work:

1. The proposed start date and proposed detailed wall construction sequence including:
 - a. Plan describing how surface water will be diverted, controlled, and disposed of.

Revised: 2/24/2020

- b. Proposed methods and equipment for excavating the soil and/or rock to the proposed grade elevations shown on a wall elevation view.
 - c. Measures to ensure wall and slope stability during various stages of wall construction and excavation where discontinuous rows of nails will be installed (if applicable); information on space requirements for installation equipment; temporary shoring plans (if applicable); information on provisions for working in the proximity of underground facilities or utilities (if applicable).
 - d. Proposed nail drilling methods and equipment including final drill hole diameter proposed to achieve the specified Design Test Load (DTL) values and any variation of these along the wall alignment.
2. Nail grout mix design including:
 - i. Type of Portland cement.
 - ii. Aggregate source and gradation.
 - iii. Proportions of mix by weight and water-cement ratio.
 - iv. Manufacturer, brand name, and technical literature for proposed admixtures.
 - v. Compressive strength test results (per AASHTO T106/ASTM C109) supplied by a qualified independent testing lab which is certified by the Department verifying the specified minimum 3 and 28-day grout compressive strengths. Previous test results for the proposed grout mix completed within one year of the start of grouting may be submitted for initial acceptance of the required compressive strengths and start of production work.
 3. Proposed nail grout placement procedures and equipment.
 4. Proposed nail testing methods and equipment setup including:
 - i. Details of the jacking frame and appurtenant bracing.
 - ii. Details showing methods of providing the temporary unbonded length and of grouting the temporary unbonded length of test nails after completion of testing.
 - iii. Equipment list.
 5. Identification number and certified calibration records for each test jack and pressure gauge and load cell to be used. Jack and pressure gauge shall be calibrated as a unit. Calibration records shall include the date tested, device identification number, and the calibration test results and shall be certified for an accuracy of at least 2 percent of the applied certification loads by a qualified independent testing laboratory within 90 days prior to submittal.
 6. Manufacturer Certificates of Compliance for the soil nail centralizers, epoxy coating, or encapsulation.

The Engineer will approve or reject the Contractor's submittals within 21 calendar days after receipt of a complete submission. The Contractor will not be allowed to begin wall construction or incorporate materials into the work until the submittal requirements are satisfied and found acceptable to the Engineer. Changes or deviations from the approved submittals must be

Revised: 2/24/2020

resubmitted for approval. No adjustments in contract time will be allowed due to incomplete submittals.

Upon delivery of nail bars and soil nail bar couplers to the project site, provide certified mill test results for nail bars and couplers from each heat specifying the ultimate strength, yield strength, elongation and composition.

901.05 Pre-Construction Meeting

A pre-construction meeting will be scheduled by the Engineer and held prior to the start of wall construction. The Engineer, prime Contractor, soil nail specialty Contractor and geotechnical instrumentation specialist (if applicable) shall attend the meeting. The excavation Contractor, Contractor constructing the CIP facing and the survey Contractor, if different than the prime or soil nail specialty Contractor, shall also attend. Attendance is mandatory. The preconstruction meeting will be conducted to clarify the construction requirements for the work, to coordinate the construction schedule and activities, and to identify contractual relationships and delineation of responsibilities amongst the prime Contractor and the various Subcontractors - particularly those pertaining to wall excavation, nail installation and testing, excavation and wall alignment survey control, and shotcrete and CIP facing construction.

902 Materials

Furnish materials new and without defects. Remove defective materials from the job site at no additional cost or schedule. Materials for soil nail structures shall consist of the following:

Solid Bar Nail Tendons: AASHTO M31/ASTM A615, Grade 75. Deformed bar, continuous or spliced using approved bar couplers, new, straight, undamaged, bare or epoxy coated or encapsulated as shown in the plans. Thread a minimum of 6-inch on the wall anchorage end to allow proper attachment of bearing plate and nut. Threading may be continuous spiral deformed ribbing provided by the bar deformations (e.g. continuous thread bars) or may be cut into a reinforcing bar. If threads are cut into a reinforcing bar, provide the next larger bar number designation from that shown in the plans, at no additional cost.

Bar Couplers: Bar couplers shall develop the full ultimate tensile strength of the bar as certified by the manufacturer.

Encapsulation: Minimum 1-33 (0.04-in.) thick, corrugated, HDPE tube conforming to AASHTO M252 or corrugated PVC tube conforming to ASTM D1784, Class 13464-B.

Centralizers: Manufactured from Schedule 40 PVC pipe or tube, steel or other material not detrimental to the nail steel (wood shall not be used); securely attached to the nail bar; sized to position the nail bar within 0.5 inch of the center of the drill hole; sized to allow tremie pipe insertion to the bottom of the drill hole; and sized to allow grout to freely flow up the drill hole.

Revised: 2/24/2020

Nail Grout: Neat cement with a minimum 3-day compressive strength of 1000 psi and a minimum 28-day compressive strength of 3,000 psi per AASHTO T106/ASTM C109. The use of sand-cement grout is permitted.

Fine Aggregate: AASHTO M6/ASTM C33.

Portland Cement: AASHTO M85/ASTM C150, Type I, II, III, or V.

Admixtures: AASHTO M194/ASTM C494. Admixtures which control bleed, improve flowability, reduce water content, and retard set may be used in the grout subject to review and acceptance by the Engineer. Accelerators are not permitted. Expansive admixtures may only be used in grout used for filling sealed encapsulations. Admixtures shall be compatible with the grout and mixed in accordance with the manufacturer's recommendations.

Bearing Plate: AASHTO M183/ASTM A36

Nut: AASHTO M291, grade B, hexagonal, fitted with beveled washer or spherical seat to provide uniform bearing.

Shear Connectors: AASHTO Construction Specifications, Section 11.3.3.1.

Welded Wire Fabric: AASHTO M55/ASTM A185 or A497.

Reinforcing Steel: AASHTO M31/ASTM A615, Grade 420, deformed.

Drain Pipe: ASTM 1785 Schedule 40 PVC solid wall; cell classification 12454-B or 12354C, wall thickness SDR 35, with solvent weld or elastomeric joints.

Fittings: ASTM D3034, Cell classification 12454-B or C, wall thickness SDR 35, with solvent or elastomeric joints.

Flowable Fill: cement-aggregate mix with 28-day compressive strength between 30 to 100 psi per AASHTO T106/ASTM C109.

Film Protection: Polyethylene film per AASHTO M171.

902.01 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. Do not use the bottom 6-inch of aggregate piles in contact with the ground.

Store steel reinforcement on supports to keep the steel from contacting the ground. Damage to the nail steel as a result of abrasion, cuts, nicks, welds, and weld splatter shall be cause for rejection. Do not ground weld leads to nail bars. Protect nail steel from dirt, rust, and other deleterious

Revised: 2/24/2020

substances prior to installation. Heavy corrosion or pitting of nails shall be cause for rejection. Light rust that has not resulted in pitting is acceptable. Place protective wrap over anchorage end of nail bar to which bearing plate and nut will be attached to protect during handling, installation, grouting, and shotcreting.

903 Construction

903.01 Site Drainage Control

Provide positive control and discharge of all surface water that will affect construction of the soil nail retaining wall. Maintain all pipes or conduits used to control surface water during construction. Repair damage caused by surface water at no additional cost. Upon substantial completion of the wall, remove surface water control pipes or conduits from the site. Alternatively, with the approval of the Engineer, pipes or conduits that are left in place may be fully grouted and abandoned or left in a way that protects the structure and all adjacent facilities from migration of fines through the pipe or conduit and potential ground loss.

The regional groundwater table is anticipated to be at or below the level of the wall excavation based on the results of the geotechnical site exploration. Localized areas of perched water or seepage may be encountered during excavation at the interface of geologic units or from localized groundwater seepage areas. Immediately contact the Engineer if unanticipated existing subsurface drainage structures are discovered during excavation. Suspend work in these areas until remedial measures meeting the Engineer's approval are implemented. Capture surface water runoff flows and flows from existing subsurface drainage structures independently of the wall drainage network and convey them to an outfall structure or storm sewer, as approved by the Engineer. Cost of remedial measures required to capture and dispose of water resulting from encountering unanticipated subsurface drainage structures will be paid for as Extra Work.

903.02 Excavation

Coordinate the work and the excavation so the soil nail wall is safely constructed. Perform the wall construction and excavation sequence in accordance with the plans and approved submittals. No excavations steeper than those specified herein or shown in the plans will be made above or below the soil nail wall without written approval of the Engineer.

Excavation and Wall Alignment Survey Control. Unless specified otherwise, the Contractor shall provide survey reference and control points at or offset along the top of wall alignment at approximately 30 foot intervals prior to starting wall excavation. The Contractor shall then be responsible for providing the necessary survey and alignment control during excavation, locating and drilling each drill hole within the allowable tolerances, and for performing the wall excavation and nail installation in a manner which will allow for constructing the shotcrete construction facing to the specified minimum thickness and such that the finish CIP structural facing can be constructed to the specified minimum thickness and to the line and grade indicated in the plans. Where the as-built location of the front face of the shotcrete exceeds the allowable tolerance from the wall control line shown in the plans, the contractor will be responsible for determining and bearing the cost of remedial measures necessary to provide proper attachment of nail head bearing plate connections and satisfactory placement of the final facing, as called for in the plans.

Revised: 2/24/2020

Complete clearing, grubbing, grading, and excavation above and the wall before commencing wall excavation. Do not over-excavate the original ground behind the wall or at the ends of the wall, beyond the limits shown in the plans. Do not perform general roadway excavation that will affect the soil nail wall until wall construction starts. Roadway excavation shall be coordinated with the soil nailing work.

Soil Nail Wall Structure Excavation.

- A. Structure excavation in the vicinity of the wall face will require special care and effort compared to general earthwork excavation. The excavation Contractor should take this into account during bidding. The excavation for the soil nail wall shall be done under the direction of the soil nail specialist. The structure excavation pay limits are shown in the plans.
- B. Excavate for the 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. Costs associated with additional thickness of shotcrete or concrete or other remedial measures required due to irregularities in the cut face, excavation overbreak or inadvertent over excavation, shall be borne by the Contractor.
- C. Damage to existing structures or structures included in the work shall be repaired and paid by the Contractor.
- D. Following the installation of nails in the lowest row, excavate to the final wall face excavation line and clean the final excavation face of all loose materials, mud, rebound, and other foreign matter which could prevent or reduce shotcrete concrete bond. Ensure that installed nails and corrosion protection are not damaged during excavation. Repair or replace nails or corrosion protection damaged or disturbed during excavation to the Engineer's satisfaction, at no additional cost. Do not excavate until the nail grout has aged for at least 24 hours. Remove hardened nail grout protruding from the final wall excavation line more than 2 inches in a manner that prevents fracturing the grout at the nail head. Sledge hammer removal of the grout is not allowed. The use of hand held rock chippers is acceptable provided their use does not damage or disturb the remaining grout at the nail head, the nail bar or corrosion protection. Alternative excavation and soil nail installation methods that meet these objectives may be submitted to the Engineer for review in accordance with the Submittals section.
- E. Excavation shall not proceed until nail installation, shotcrete placement, attachment of bearing plates and nuts and nail testing has been completed and accepted. Nail grout and shotcrete shall have cured for at least 72 hours or attained at least their specified 3-day compressive strength before excavating. Excavating in less than 72 hours will only be allowed if the Contractor submits compressive strength test results, for tests performed by

Revised: 2/24/2020

a qualified independent testing lab, verifying that the nail grout and shotcrete mixes being used will provide the specified 3-day compressive strengths in the lesser time.

- F. Notify the Engineer immediately if raveling or local instability of the final wall face excavation occurs. Unstable areas shall be temporarily stabilized by means of buttressing the exposed face with an earth berm or other methods. Suspend work in unstable areas until remedial measures are developed.

Excavation Face Protrusions, Voids, or Obstructions. Remove all or portions of cobbles, boulders, rubble or other subsurface obstructions encountered at the wall final excavation face which will protrude into the design facing. Determine method of removal of face protrusions, including method to safely secure remnant pieces left behind the excavation face and for promptly backfilling voids resulting from removal of protrusions. Notify the Engineer of the proposed method(s) for removal of face protrusions at least 24 hours prior to beginning removal. Voids overbreak or over-excavation beyond the plan wall excavation line resulting from the removal of face protrusions or excavation operations shall be backfilled with shotcrete or concrete, as approved by the Engineer. Removal of face protrusions and backfilling of voids or over-excavation is considered incidental to the work. Cost due to removal of unanticipated man-made obstructions will be paid as Extra Work.

903.03 Nail Installation.

Verify the required drillhole diameter(s), drilling method, grout composition and installation method necessary to achieve the nail DTL specified in the plans, in accordance with the nail testing acceptance criteria in the Nail Testing section.

The Engineer may add, eliminate, or relocate nails to accommodate actual field conditions. Cost adjustments associated with these modifications shall be made in accordance with the General Provisions of the Contract. The cost of any redesign, additional material, or installation modifications resulting from actions of the Contractor shall be borne by the Contractor.

Drilling.

- A. The drill holes for the soil nails shall be made at the locations, orientations, and lengths shown in the plans or as directed by the Engineer. Select drilling equipment and methods suitable for the ground conditions shown in the boring logs. Select drill hole diameter(s) required to develop the specified DTL and to also provide a minimum 1-inch grout cover over bare or epoxy coated bars or minimum 0.5-inch grout cover over the encapsulation of encapsulated nails. A minimum required drill hole diameter is shown in the plans. It is the Contractor's responsibility to determine the final drill hole diameter(s) required to provide the specified DTL. Use of drilling muds such as bentonite slurry to assist in drill cutting removal is not allowed but air may be used. With the Engineer's approval, the Contractor may be allowed to use water or foam flushing upon successful demonstration, at the Contractor's cost, that the installation method still provides adequate nail DTL. If caving ground is encountered, use cased drilling methods to support the sides of the drill holes. Where hard drilling conditions such as rock, cobbles, boulders, or obstructions are

Revised: 2/24/2020

encountered, percussion or other suitable drilling equipment capable of drilling and maintaining stable drill holes through such materials, will be used at the Contractor's expense.

- B. Immediately suspend or modify drilling operations if ground subsidence is observed, if the soil nail wall is adversely affected, or if adjacent structures are damaged from the drilling operation. Immediately stabilize the adverse conditions at no additional cost.

Nail Bar Installation.

- A. Provide nail bars in accordance with the schedules included in the plans. Provide centralizers sized to position the bar within 1 inch of the center of the drill hole. Position centralizers as shown in the plans so their maximum center-to-center spacing does not exceed 10 feet. Also locate centralizers within 2 feet from the top and bottom of the drill hole. Securely attach centralizers to the bar so they will not shift during handling or insertion into the drill hole yet will still allow grout tremie pipe insertion to the bottom of drill hole and allow grout to flow freely up the hole.
- B. Inspect each nail bar before installation and repair or replace damaged bars. Check uncased drill holes for cleanliness prior to insertion of the soil nail bar. Insert nail bars with centralizers into the drill hole to the required length without difficulty and in a way that prevents damage to the drill hole, bar, or corrosion protection. Do not drive or force partially inserted soil nails into the hole. Remove nails which cannot be fully inserted to the design depth and clean the drill hole to allow unobstructed installation.
- C. When using cased or hollow stem auger drilling equipment which does not allow for the centralizers to pass through the casing or auger stem, the Contractor may delete the centralizers if the neat cement grout pumped through the casing is placed using grout pressures greater than 150 psi .

Nail Installation Tolerance.

- A. Nail location and orientation tolerances are:
 - i. Nail head location, deviation from plan design location; 6 inches any direction.
 - ii. Nail inclination, deviation from plan; + or - 3 degrees.
 - iii. Location tolerances are applicable to only one nail and not accumulative over large wall areas. Center nail bars within 1 inch of the center of the drill hole.
- B. Soil nails which do not satisfy the specified tolerances, due to the Contractor's installation methods, will be replaced at no additional cost. Backfill abandoned nail drill holes with tremied grout. Nails which encounter piling during drilling shall be relocated, as approved by the Engineer. Cost of drilling and backfilling drill holes abandoned due to unanticipated man-made obstructions will be paid as Extra Work.

903.04 Grouting

Revised: 2/24/2020

Grout Mix Design. Use a neat cement grout. Sand-cement grout is not permitted. Submit the proposed nail grout mix design to the Engineer for review and approval in accordance with the submittal section. The design mix submittal shall include compressive strength test results verifying that the proposed mix will have a minimum 3-day compressive strength of 1,000 psi and minimum 28-day compressive strength of 3,000 psi.

Grout Testing. Previous test results for the proposed grout mix completed within one year of the start of work may be submitted for initial **acceptance** of the required compressive strengths for installation of initial production soil nails. During production, nail grout shall be tested by the Contractor in accordance with AASHTO T106/ASTM C109 at a frequency of no less than one test for every 50 cubic yards of grout placed. Provide grout cube test results to the Engineer within 24 hours of testing.

Grouting Equipment. Grout equipment shall produce a uniformly mixed grout free of lumps and undispersed cement, and be capable of continuously agitating the mix. Use a positive displacement grout pump equipped with a pressure gauge that can measure at least twice but no more than three times the intended grout pressure. Size the grouting equipment to enable the entire nail to be grouted in one continuous operation. Place the grout within 60 minutes after mixing or within the time recommended by the admixture manufacturer, if admixtures are used. Grout not placed in the allowed time limit will be rejected.

Grouting Methods.

Refer to Item 866.05 for Installation and Grouting.

903.05 Nail Testing.

Refer to Sections 903.05.1 through 903.05.6 for conducting **verification** and proof testing on soil nails. **Verification tests** have to be conducted on **one sacrificial soil nail per row** of production soil nails or a minimum of 3 **verification** tests for each wall, and proof tests have to be conducted on five percent of the soil nails or a minimum of 11 proof tests for each wall.

Any soil nail shall only be subjected to either **verification** test or proof test but not both.

Do not perform nail testing until the nail grout and shotcrete facing have cured for at least 72 hours and attained at least the specified 3-day compressive strength. Testing in less than 72 hours will only be allowed if the Contractor submits compressive strength test results, for tests performed by a qualified independent testing lab certified by the Department, verifying that the nail grout and shotcrete mixes being used will provide the specified 3-day compressive strengths in the lesser time.

Testing Equipment.

Refer to Item 866.06 Testing of Ground Anchors for the testing equipment requirements and testing equipment setup.

Revised: 2/24/2020

Test Nail Unbonded Length. Provide temporary unbonded lengths for each test nail. Isolate the test nail bar from the shotcrete facing, existing bin wall face, and/or the reaction frame used during testing. Isolation of a test nail through the shotcrete wall facing and existing bin wall face shall not affect the location of the bearing plate. **Accepted proof test nails may be incorporated as production nails provided the temporary test unbonded length is fully grouted subsequent to testing. Verification test nails will be sacrificial and not incorporated as production nails.** Submit the proposed test nail isolation methods, methods for providing an unbonded test length and methods for grouting the unbonded length subsequent to testing to the Engineer for review and approval in accordance with the Submittals section. Where temporary casing of the unbonded length of test nails is provided, install the casing in a way that prevents any reaction between the casing and the grouted bond length of the nail and/or the stressing apparatus.

903.05.1 Pre-production Verification Testing of Sacrificial Test Nails: Pre-production verification testing shall be performed prior to installation of production nails to verify the Contractor's installation methods and nail pullout resistance. Perform pre-production verification tests at locations and elevations accepted by the Engineer. Perform a minimum of one verification test in each different soil/rock unit and for each different drilling/grouting method proposed to be used, at each row of production soil nails. Verification test nails will be sacrificial and not incorporated as production nails. Bare bars can be used for the sacrificial verification test nails.

Develop and submit the details of the verification testing arrangement including the method of distributing test load pressures to the excavation surface (reaction frame), test nail bar size, grouted drill hole diameter, and reaction frame dimensioning to the Engineer for acceptance in accordance with the construction submittal guidelines in Section 901.04. Construct verification test nails using the same equipment, installation methods, nail inclination, and drill hole diameter as planned for the production nails. Changes in the drilling or installation method may require additional verification testing as determined by the Engineer and shall be provided at no additional cost. Payment for additional verification tests required due to differing site conditions, if determined by the Engineer, shall be per the contract unit price.

Test nails shall have both bonded and temporary unbonded lengths. Prior to testing only the bonded length of the test nail shall be grouted. The temporary unbonded length of the test nail shall be at least 3 feet. The bonded length of the test nail shall be determined based on the production nail bar grade and size such that the allowable bar structural load is not exceeded during testing, but shall not be less than 10 feet. The maximum permissible bar structural load during testing shall not be greater than 90 percent of the yield strength for Grade 60 through Grade 100 bars, or 80 percent of the ultimate strength for Grade 150 bars. The Contractor shall provide larger verification test bar sizes, if required to safely accommodate the 10-foot minimum test bond length and testing to 2 times the allowable pullout resistance requirements, at no additional cost.

The maximum bonded length for verification testing L_{BVTmax} shall be determined by the following equation to avoid structurally overstressing the verification test nail bar:

$$L_{BVTmax} = C_{RT} \times A_t \times (f_y \text{ or } f_u) / (r_{po}), \text{ where:}$$

L_{BVTmax} = Maximum Verification Test Nail Bonded Length (ft). If L_{BVTmax} is less than 10.0 ft, then the size of the verification test nail bar shall be increased until L_{BVTmax} is at least 10.0 ft.

Revised: 2/24/2020

C_{RT} = reduction coefficient, 0.9 for Grade 60 to 100 bars or 0.8 for Grade 150 bars

A_t = cross-sectional area of the verification test nail bar (in²)

f_y = nominal yield resistance of the verification test nail bar (ksi) for Grade 60 to 100 bars

f_u = minimum ultimate tensile strength of the verification test nail bar (ksi) for Grade 150 bars

r_{po} = nominal load transfer rate (kips/ft) = $(\pi \times q_U \times D_{dh}) / 12$

q_U = nominal bond strength per unit area (ksf)

D_{dh} = drill hole diameter (in)

The Verification Test Load (VTL) during verification testing shall be determined by the following equation:

$$VTL = L_{BVT} \times r_{po} \text{ (kips/ft)} \geq 2.00 \text{ DTL}$$

L_{BVT} = Verification Test Nail Bonded Length (ft). L_{BVT} shall be between 10.0 ft and L_{BVTmax} .

Verification test nails shall be incrementally loaded to a maximum test load of the Verification Test Load (VTL) in accordance with the following loading schedule. The soil nail movements shall be recorded at each load increment at 1 minute, 2, 5, and 10 minutes.

VERIFICATION TEST LOADING SCHEDULE	
LOAD	HOLD TIME
AL (≤ 0.025 VTL)	1 minute
0.125 VTL	10 minutes
0.250 VTL	10 minutes
0.375 VTL	10 minutes
0.500 VTL	10 minutes
0.625 VTL	10 minutes
0.750 VTL (Creep Test)	60 minutes
0.875 VTL	10 minutes
1.00 VTL (Max. Test Load)	10 minutes
AL (≤ 0.025 VTL)	1 minute

The alignment load (AL) should be the minimum load required to align the testing apparatus and should not exceed 2.5 percent of VTL. Dial gauges 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 nail shall be monitored for creep at the 0.750 VTL load increment. 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. The load during the creep test shall be maintained within 2 percent of the intended load by use of the load cell.

Revised: 2/24/2020

At the end of the test, reduce the load back to AL, and record the permanent set of the soil nail.

903.05.2 Proof Testing of Production Nails: Perform proof testing on 5 percent (1 in 20) of the production nails in each nail row or minimum of 1 per row at locations accepted by the Engineer.

Production proof test nails shall have both bonded and temporary unbonded lengths. Prior to testing only the bonded length of the test nail shall be grouted. The temporary unbonded length of the test nail shall be at least 3 feet. The bonded length of the test nail shall be determined based on the production nail bar grade and size such that the allowable bar structural load is not exceeded during testing, but shall not be less than 10 feet. The maximum permissible bar structural load during testing shall not be greater than 90 percent of the yield strength for Grade 60 through Grade 100 bars, or 80 percent of the ultimate strength for Grade 150 bars.

The proof test bonded length L_{BPT} shall not exceed L_{BPTmax} , or the above minimum lengths, whichever is greater. However, production proof test nails shorter than 13 feet in length may be constructed with less than the minimum 10 feet bond length with the minimum unbonded length still limited to 3 feet. The maximum bonded length for proof testing L_{BPTmax} shall be determined by the following equation to avoid structurally overstressing the proof test nail bar:

$$L_{BPTmax} = C_{RT} \times A_t \times (f_y \text{ or } f_u) / (r_{po} \times 0.75), \text{ where:}$$

$$L_{BPTmax} = \text{Maximum Proof Test Nail Bonded Length (ft).}$$

C_{RT} , A_t , f_y , f_u , and r_{po} are as defined in Section 7.4.

The Proof Test Load (PTL) during proof testing shall be determined by the following equation:

$$PTL = L_{BPT} \times r_{po} \text{ (kips/ft)} \times 0.75 \geq 1.50 \text{ DTL}$$

$$L_{BPT} = \text{Proof Test Nail Bonded Length (ft).}$$

Proof tests shall be performed by incrementally loading the proof test nail to a maximum test load of the Proof Test Load (PTL) in accordance with the following loading schedule. The nail movement at each load increment shall be measured and recorded by the Engineer in the same manner as for verification tests. The test load shall be monitored by a jack pressure gauge with a sensitivity and range meeting the requirements of pressure gauges used for verification test nails. At load increments other than the maximum test load, the load shall be held long enough to obtain a stable reading.

PROOF TEST LOADING SCHEDULE	
LOAD	HOLD TIME
AL (≤ 0.025 PTL)	Until Stable
0.167 PTL	Until Stable
0.333 PTL	Until Stable
0.500 PTL	Until Stable
0.667 PTL	Until Stable
0.833 PTL	Until Stable

Revised: 2/24/2020

1.00 PTL (Max. Test Load)	See Below
AL (≤ 0.025 PTL)	Until Stable

The alignment load (AL) should be the minimum load required to align the testing apparatus and should not exceed 2.5 percent of PTL. Dial gauges should be set to “zero” after the alignment load has been applied.

All load increments shall be maintained within 5 percent of the intended load. Depending on performance, either 10 minute or 60 minute creep tests shall be performed at the maximum test load (PTL). The creep period shall start as soon as the maximum test load is applied and the nail movement shall be measured and recorded at 1 minute, 2, 3, 5, 6 and 10 minutes. Where the soil nail movement measured for the creep test between 1 minute and 10 minutes exceeds 0.04 inch, the maximum test load shall be maintained an additional 50 minutes and movements shall be recorded at 20 minutes, 30, 50 and 60 minutes.

At the end of the test, reduce the load back to AL, and record the permanent set of the soil nail.

903.05.3 Test Nail Acceptance Criteria: A test nail shall be considered acceptable when:

1. 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 is measured during creep testing and the creep rate is linear or decreasing throughout the creep test load hold period.
2. For proof tests, a total creep movement of less than 0.04 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 6 and 60 minute readings and the creep rate is linear or decreasing throughout the creep test load hold period.
3. The total measured movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the test nail unbonded length.
4. A pullout failure does not occur at PTL or before reaching VTL. Pullout failure is defined as the load at which attempts to further increase the test load simply result in continued pullout movement of the test nail. The pullout failure load shall be recorded as part of the test data. Alternately, with the acceptance of the Engineer, the Contractor may opt to increase the test load beyond VTL to determine pullout resistance for a verification test nail; in this event the test load shall not exceed the maximum permissible bar structural load.

Successful proof tested nails meeting the above test acceptance criteria may be incorporated as production nails, provided that (1) the unbonded length of the test nail drill hole has not collapsed during testing, (2) the minimum required drill hole diameter has been maintained, (3) the specified corrosion protection is provided, and (4) the test nail length is equal to or greater than the scheduled production nail length. Test nails meeting these requirements shall be completed by satisfactorily grouting up the unbonded test length. Maintaining the temporary unbonded test length for subsequent grouting is the Contractor’s responsibility. If the unbonded test length of production proof test nails cannot be satisfactorily grouted subsequent to testing, the proof test nail shall become sacrificial and shall be replaced with an additional production nail installed at no additional cost.

Revised: 2/24/2020

903.05.4 Test Nail Rejection: If a test nail does not satisfy the acceptance criteria, it will be rejected. The Contractor shall determine the cause for the failure.

903.05.5 Verification Test Nails: The Engineer will evaluate the results of each verification test. Installation methods which do not satisfy the nail testing requirements shall be rejected. The Contractor shall propose alternative methods and install replacement verification test nails. Replacement test nails shall be installed and tested at no additional cost.

903.05.6 Proof Test Nails: The Engineer may require the Contractor to replace some or all of the installed production nails between a failed proof test nail and the adjacent passing proof test nail. Alternatively, the Engineer may require the installation and testing of additional proof test nails to verify that adjacent previously installed production nails have sufficient load carrying capacity. Contractor modifications may include, but are not limited to; the installation of additional proof test nails; increasing the drill hole diameter to provide increased capacity; modifying the installation or grouting methods; reducing the production nail spacing from that shown on the Plans and installing more production nails at a reduced capacity; or installing longer production nails if sufficient right-of-way is available and the pullout capacity behind the failure surface controls the allowable nail design capacity. The nails may not be lengthened beyond the temporary construction easements or the permanent right-of-way on the Plans. Installation and testing of additional proof test nails or installation of additional or modified nails as a result of proof test nail failure(s) will be at no additional cost.

Nail Installation Records. Records documenting the soil nail wall construction will be maintained by the Engineer, unless specified otherwise. The Contractor shall provide with as-built drawings showing as-built nail locations and as-built shotcrete facing line and grade within 5 days after completion of the shotcrete facing and as-built CIP facing line and grade within 5 days after completion of the CIP facing.

904 Measurement

- A. The unit of measurement for production soil nails will be per each production soil nail. The unit price for each soil nail includes drilling through of any materials to be encountered, including soils, boulders, concrete, brick, rock, etc, grouting, reinforcement, casing, and all labor.
- B. Specified **verification** test soil nails will be measured on a unit basis for each **verification** test successfully completed. Specified proof test soil nails will be measured on a unit basis for each proof test successfully completed. Failed **verification** test nails or failed proof test nails or additional **verification** test nails installed to verify alternative nail installation methods proposed by the Contractor will not be measured.
- C. Structure Excavation for Soil Nail Wall will be measured as the theoretical plan volume in cubic yards within the structure excavation pay limits shown in the plans. This will be the

Revised: 2/24/2020

excavation volume within the zone measured from existing ground surface to bottom of wall facing and extending out 5 feet horizontally in front of the plan wall final face line. Additional excavation beyond the plan wall excavation zone resulting from irregularities in the cut face, excavation overbreak, or inadvertent excavation will not be measured.

- D. General roadway excavation will not be a separate wall pay item but will be measured and paid as part of the Item 203 Excavation pay item.
- E. The final pay quantities will be the design quantity increased or decreased by any changes authorized by the Engineer.

905 Payment

- A. The department will pay for accepted quantities of soil nails and soil nail wall structure excavation at the contract unit prices. Payment will be full compensation for all labor, equipment, materials, material tests, field tests, and incidentals necessary to acceptably fabricate and construct the soil nails and perform the structure excavation, including the excavation and wall alignment survey control, for the soil nail wall in accordance with all requirements of the contract. Payment will be made for each of the following bid items included in the bid form:

ITEM NUMBER	DESCRIPTION	UNIT
503	Unclassified Excavation, As Per Plan	CY
690	Special – MISC.: Shotcrete Facing to Fill Existing Bin Wall Corrugation, Inclusive.	SQ YD
690	Special – MISC.: Verification Test Nails	EACH
690	Special – MISC.: Proof Test Nails	EACH
690	Special – MISC.: Soil Nails, 15 kips Max. Test Load	EACH

- B. Payment will be full compensation for furnishing all labor, equipment, materials, material tests, field tests, and incidentals necessary to acceptably fabricate and construct the soil nails and perform the structure excavation, including the excavation and wall alignment survey control, and for constructing the soil nail walls in accordance with all requirements of the contract.