# SOIL NAIL RETAINING WALLS (5-16-17)

## General

Construct soil nail retaining walls consisting of soil nails spaced at a regular pattern and connected to a cast-in-place reinforced concrete face. A soil nail consists of a steel bar grouted in a drilled hole inclined at an angle below horizontal. Use shotcrete for temporary support of excavations during construction. Design and construct soil nail retaining walls based on actual elevations and wall dimensions in accordance with the contract and accepted submittals. Use a prequalified Anchored Wall Contractor to construct soil nail retaining walls. Define “soil nail wall” as a soil nail retaining wall and “Soil Nail Wall Contractor” as the Anchored Wall Contractor installing soil nails and applying shotcrete. Define “nail” as a soil nail and “concrete facing” as a cast-in-place reinforced concrete face.

## Materials

### Refer to the *Standard Specifications*.

|  |  |
| --- | --- |
| **Item** | **Section** |
| Geosynthetics | 1056 |
| Joint Materials | 1028 |
| Masonry | 1040 |
| Neat Cement Grout, Type 2 | 1003 |
| Portland Cement Concrete, Class A | 1000 |
| Reinforcing Steel | 1070 |
| Select Material, Class VI | 1016 |
| Shotcrete | 1002 |
| Shoulder Drain Materials | 816-2 |
| Steel Plates | 1072-2 |
| Welded Stud Shear Connectors | 1072-6 |

Provide Class VI select material (standard size No. 57 stone) for leveling pads.

Provide soil nails consisting of grouted steel bars and nail head assemblies. Use epoxy coated or encapsulated deformed steel bars that meet AASHTO M 275 or M 31, Grade 60 or 75. Splice bars in accordance with Article 1070-9 of the *Standard Specifications*. Provide epoxy coated bars that meet Article 1070-7 of the *Standard Specifications*.

For encapsulated bars, use nonperforated corrugated HDPE sheaths at least 0.04" thick that meet AASHTO M 252. Provide at least 0.4" of grout cover between bars and sheathing and at least 0.8" of grout cover between sheathing and drill hole walls.

Fabricate centralizers from schedule 40 PVC plastic pipe or tube, steel or other material not detrimental to steel bars (no wood). Size centralizers to position bars within 1" of drill hole centers and allow tremies to be inserted to ends of holes. Use centralizers that do not interfere with grout placement or flow around bars. Centralizers are required both inside and outside sheaths for encapsulated nails.

Provide nail head assemblies consisting of nuts, washers and bearing plates with welded stud shear connectors. Use steel plates for bearing plates and steel washers and hex nuts recommended by the Soil Nail Manufacturer.

Provide Type 3 material certifications for soil nail materials in accordance with Article 106-3 of the *Standard Specifications*. Store steel materials on blocking at least 12" above the ground and protect it at all times from damage; and when placing in the work make sure it is free from dirt, dust, loose mill scale, loose rust, paint, oil or other foreign materials. Load, transport, unload and store soil nail wall materials so materials are kept clean and free of damage. Do not crack, fracture or otherwise damage grout inside sheaths of encapsulated nails. Bent, damaged or defective materials will be rejected.

## Preconstruction Requirements

### Soil Nail Wall Surveys

The Retaining Wall Plans show a plan view, typical sections, details, notes and an elevation or profile view (wall envelope) for each soil nail wall. Before beginning soil nail wall design, survey existing ground elevations shown in the plans and other elevations in the vicinity of soil nail wall locations as needed. For proposed slopes above or below soil nail walls, survey existing ground elevations to at least 10 ft beyond slope stake points. Based on these elevations, finished grades and actual soil nail wall dimensions and details, submit revised wall envelopes for acceptance. Use accepted wall envelopes for design.

### Soil Nail Wall Designs

For soil nail wall designs, submit 11 copies of working drawings and 3 copies of design calculations and a PDF copy of each at least 30 days before the preconstruction meeting. Do not begin soil nail wall construction until a design submittal is accepted.

Use a prequalified Anchored Wall Design Consultant to design soil nail walls. Provide designs sealed by a Design Engineer approved as a Geotechnical Engineer (key person) for the Anchored Wall Design Consultant.

Design soil nail walls in accordance with the plans and allowable stress design method in the *FHWA Geotechnical Engineering Circular No. 7 “Soil Nail Walls”* (Publication No. FHWA-IF-03-017) unless otherwise required. Design soil nail walls for seismic if walls are located in seismic zone 2 based on Figure 2-1 of the *Structure Design Manual*.

Design soil nails that meet the following unless otherwise approved:

* 1. Horizontal and vertical spacing of at least 3 ft,
	2. Inclination of at least 12° below horizontal,
	3. Clearance between ends of bars and drill holes of at least 6" and
	4. Diameter of 6" to 10".

Four inch diameter soil nails may be approved for nails in rock at the discretion of the Engineer. Do not extend nails beyond right-of-way or easement limits. If existing or future obstructions such as foundations, guardrail, fence or handrail posts, pavements, pipes, inlets or utilities will interfere with nails, maintain a clearance of at least 6" between obstructions and nails.

When noted in the plans, design soil nail walls for a live load (traffic) surcharge of 250 lb/sf. For steel beam guardrail with 8 ft posts above soil nail walls, analyze walls for a horizontal load of 300 lb/ft of wall. For concrete barrier rail above soil nail walls, analyze walls for a horizontal load of 500 lb/ft of wall.

Provide wall drainage systems consisting of geocomposite sheet drains, an aggregate shoulder drain and outlet components. Place sheet drains with a horizontal spacing of no more than 10 ft and center drains between adjacent nails. Attach sheet drains to excavation faces and connect drains to aggregate leveling pads. Locate a continuous aggregate shoulder drain along the base of concrete facing in front of leveling pads. Provide aggregate shoulder drains and outlet components in accordance with Standard Drawing No. 816.02 of the *Roadway Standard Drawings*.

Use shotcrete at least 4" thick and reinforce shotcrete with #4 waler bars around nail heads. Two waler bars (one on each side of nail head) in the horizontal and vertical directions are required for a total of 4 bars per nail.

Use No. 57 stone for aggregate leveling pads. Use 6" thick leveling pads beneath concrete facing. Unless required otherwise in the plans, embed top of leveling pads at least 12" below bottom of walls shown in the plans.

Use concrete facing with the dimensions shown in the plans and attach facing to nail heads with welded stud shear connectors. When concrete barrier rail is required above soil nail walls, use concrete barrier rail with moment slab as shown in the plans.

Submit working drawings and design calculations including unit grout/ground bond strengths for acceptance in accordance with Article 105-2 of the *Standard Specifications*. Submit working drawings showing plan views, wall profiles with nail locations including known test nail locations, typical sections and details of nails, drainage, shotcrete, leveling pads and concrete facing. If necessary, include details on working drawings for concrete barrier rail with moment slab and obstructions extending through walls or interfering with nails, barriers or moment slabs. Submit design calculations for each wall section with different surcharge loads, geometry or material parameters. At least one analysis is required for each wall section with different nail lengths.

When designing soil nail walls with computer software other than SnailWin, use SnailWin version 3.10 or later, developed by the California Department of Transportation (CALTRANS) to verify the design. Use SnailWin in accordance with the following:

1. Pre-factored yield stress (150, 75 or 60 ksi) and punching shear for reinforcement (nail) strengths,
2. Allowable bond strengths for bond stress,
3. Default value of 1.0 for bond stress factor and
4. Pullout controls for all nails, i.e., yield stress or punching shear do not control.

Determine Tmax-s from SnailWin as shown in Table D.4 of FHWA GEC 7 and use the factored maximum design nail force (Tmax-s/0.55) for design. At least one SnailWin analysis is required per 100 ft of wall length with at least one analysis for the wall section with the longest nails. Submit electronic SnailWin input files and PDF output files with design calculations.

### Soil Nail Wall Construction Plan

Submit 4 copies and a PDF copy of a soil nail wall construction plan at least 30 days before the preconstruction meeting. Do not begin soil nail wall construction until the construction plan submittal is accepted. Provide detailed project specific information in the soil nail wall construction plan that includes the following:

* 1. Overall description and sequence of soil nail wall construction;
	2. List and sizes of excavation equipment, drill rigs and tools, tremies and grouting equipment;
	3. Procedures for excavations, drilling and grouting, soil nail and wall drainage system installation and facing construction;
	4. Details of shotcrete equipment and application including mix process, test panels, thickness gauges and shooting methods;
	5. Shotcrete nozzleman with certification in accordance with Article 1002-1 of the *Standard Specifications*;
	6. Plan and methods for nail testing with calibration certificates dated within 90 days of the submittal date;
	7. Examples of construction and test nail records to be used in accordance with Sections 4.0(F) and 5.0(E) of this provision;
	8. Approved packaged grout or grout mix design with acceptable ranges for flow and density that meets Section 1003 of the *Standard Specifications*;
	9. Shotcrete mix design that meets Section 1002 of the *Standard Specifications*; and
	10. Other information shown in the plans or requested by the Engineer.

If alternate construction procedures are proposed or necessary, a revised soil nail wall construction plan submittal may be required. If the work deviates from the accepted submittal without prior approval, the Engineer may suspend soil nail wall construction until a revised plan is accepted.

### Preconstruction Meeting

Before starting soil nail wall construction, hold a preconstruction meeting to discuss the construction, inspection and testing of the soil nail walls. If this meeting occurs before all soil nail wall submittals have been accepted, additional preconstruction meetings may be required before beginning construction of soil nail walls without accepted submittals. The Resident or Bridge Maintenance Engineer, Bridge Construction Engineer, Geotechnical Operations Engineer, Contractor and Soil Nail Wall Contractor Superintendent will attend preconstruction meetings.

## Construction Methods

Control drainage during construction in the vicinity of soil nail walls. Direct run off away from soil nail walls and areas above and behind walls.

Notify the Engineer before blasting in the vicinity of soil nail walls. Perform blasting in accordance with the contract. Unless required otherwise in the plans, install foundations located behind soil nail walls before beginning wall construction.

Install soil nail walls in accordance with the accepted submittals and as directed. Do not excavate behind soil nail walls. If overexcavation occurs, repair walls with an approved method and a revised soil nail wall design or construction plan may be required.

### Excavation

Excavate for soil nail walls from the top down in accordance with the accepted submittals. Excavate in staged horizontal lifts with no negative batter (excavation face leaning forward). Excavate lifts in accordance with the following:

* 1. Heights not to exceed vertical nail spacing,
	2. Bottom of lifts no more than 3 ft below nail locations for current lift and
	3. Horizontal and vertical alignment within 2" of location shown in the accepted submittals.

Remove any cobbles, boulders, rubble or debris that will protrude more than 2" into the required shotcrete thickness. Rocky ground such as colluvium, boulder fills and weathered rock may be difficult to excavate without leaving voids.

Apply shotcrete to excavation faces within 24 hours of excavating each lift unless otherwise approved. Shotcreting may be delayed if it can be demonstrated that delays will not adversely affect excavation stability. If excavation faces will be exposed for more than 24 hours, use polyethylene sheets anchored at top and bottom of lifts to protect excavation faces from changes in moisture content.

If an excavation becomes unstable at any time, suspend soil nail wall construction and temporarily stabilize the excavation by immediately placing an earth berm up against the unstable excavation face. When this occurs, repair walls with an approved method and a revised soil nail wall design or construction plan may be required.

Do not excavate the next lift until nail installations and testing and shotcrete application for the current lift are accepted and grout and shotcrete for the current lift have cured at least 3 days and 1 day, respectively.

### Soil Nails

Install soil nails in the same way as acceptable test nails. Drill and grout nails the same day and do not leave drill holes open overnight.

Control drilling and grouting to prevent excessive ground movements, damaging structures and pavements or fracturing rock and soil formations. If ground heave or subsidence occurs, suspend soil nail wall construction and take corrective action to minimize movement. If property damage occurs, make repairs with an approved method and a revised soil nail wall design or construction plan may be required.

#### Drilling

Use drill rigs of the sizes necessary to install soil nails and with sufficient capacity to drill through whatever materials are encountered. Drill straight and clean holes with the dimensions and inclination shown in the accepted submittals. Drill holes within 6" of locations and 2° of inclination shown in the accepted submittals unless otherwise approved.

Stabilize drill holes with temporary casings if unstable, caving or sloughing material is anticipated or encountered. Do not use drilling fluids to stabilize drill holes or remove cuttings.

#### Steel Bars

Center steel bars in drill holes with centralizers. Securely attach centralizers along bars at no more than 8 ft centers. Attach uppermost and lowermost centralizers 18" from excavation faces and ends of holes.

Do not insert steel bars into drill holes until hole locations, dimensions, inclination and cleanliness are approved. Do not vibrate, drive or otherwise force bars into holes. If a steel bar cannot be completely and easily inserted into a drill hole, remove the bar and clean or redrill the hole.

#### Grouting

Remove oil, rust inhibitors, residual drilling fluids and similar foreign materials from holding tanks/hoppers, stirring devices, pumps, lines, tremie pipes and any other equipment in contact with grout before use. Measure grout temperature, density and flow during grouting with at least the same frequency grout cubes are made for compressive strength. Perform density and flow field tests in the presence of the Engineer in accordance with American National Standards Institute/American Petroleum Institute Recommended Practice 13B-1 (Section 4, Mud Balance) and ASTM C939 (Flow Cone), respectively.

Inject grout at the lowest point of drill holes through tremies, e.g., grout tubes, casings, hollow-stem augers or drill rods, in one continuous operation. Fill drill holes progressively from ends of holes to excavation faces and withdraw tremies at a slow even rate as holes are filled to prevent voids in grout. Extend tremies into grout at least 5 ft at all times except when grout is initially placed in holes.

Provide grout free of segregation, intrusions, contamination, structural damage or inadequate consolidation (honeycombing). Cold joints in grout are not allowed except for test nails. Remove any temporary casings as grout is placed and record grout volume for each drill hole.

#### Nail Heads

Weld stud shear connectors to bearing plates of nails in accordance with Article 1072-6 of the *Standard Specifications*. Install nail head assemblies after shotcreting. Before shotcrete reaches initial set, seat bearing plates and tighten nuts so plates contact shotcrete uniformly. If uniform contact is not possible, install nail head assemblies on mortar pads so nail heads are evenly loaded.

### Wall Drainage Systems

Install wall drainage systems as shown in the accepted submittals and in accordance with Section 816 of the *Standard Specifications*. Before installing shotcrete reinforcement, place geocomposite sheet drains with the geotextile side against excavation faces. For highly irregular faces and at the discretion of the Engineer, sheet drains may be placed after shotcreting over weep holes through the shotcrete. Hold sheet drains in place with anchor pins so drains are in continuous contact with surfaces to which they are attached and allow for full flow the entire height of soil nail walls. Discontinuous sheet drains are not allowed. If splices are needed, overlap sheet drains at least 12" so flow is not impeded. Connect sheet drains to aggregate leveling pads by embedding drain ends at least 4" into No. 57 stone.

### Shotcrete

Clean ungrouted zones of drill holes and excavation faces of loose materials, mud, rebound and other foreign material. Moisten surfaces to receive shotcrete. Install shotcrete reinforcement in accordance with the contract and accepted submittals. Secure reinforcing steel so shooting does not displace or vibrate reinforcement. Install approved thickness gauges on 5 ft centers in the horizontal and vertical directions to measure shotcrete thickness.

Apply shotcrete in accordance with the contract, accepted submittals and Subarticle 1002-3(F) of the *Standard Specifications*. Use approved shotcrete nozzlemen who made satisfactory preconstruction test panels to apply shotcrete. Direct shotcrete at right angles to excavation faces except when shooting around reinforcing steel. Rotate nozzle steadily in small circular patterns and apply shotcrete from bottom of lifts up.

Make shotcrete surfaces uniform and free of sloughing or sagging. Completely fill ungrouted zones of drill holes and any other voids with shotcrete. Taper construction joints to a thin edge over a horizontal distance of at least the shotcrete thickness. Wet joint surfaces before shooting adjacent sections.

Repair surface defects as soon as possible after shooting. Remove any shotcrete which lacks uniformity, exhibits segregation, honeycombing or lamination or contains any voids or sand pockets and replace with fresh shotcrete to the satisfaction of the Engineer. Protect shotcrete from freezing and rain until shotcrete reaches initial set.

### Leveling Pads and Concrete Facing

Construct aggregate leveling pads at elevations and with dimensions shown in the accepted submittals. Compact leveling pads with a vibratory compactor to the satisfaction of the Engineer.

Construct concrete facing in accordance with the accepted submittals and Section 420 of the *Standard Specifications*. Do not remove forms until concrete attains a compressive strength of at least 2,400 psi. Unless required otherwise in the plans, provide a Class 2 surface finish for concrete facing that meets Subarticle 420-17(F) of the *Standard Specifications*. Construct concrete facing joints at a spacing of 10 ft to 12 ft unless required otherwise in the plans. Make 1/2" thick expansion joints that meet Article 420-10 of the *Standard Specifications* for every third joint and 1/2" deep grooved contraction or sawed joints that meet Subarticle 825-10(B) or 825-10(E) respectively for the remaining joints. Stop reinforcing steel for concrete facing 2" on either side of expansion joints.

If a brick veneer is required, construct brick masonry in accordance with Section 830 of the *Standard Specifications*. Anchor brick veneers to soil nail walls with approved brick to concrete type anchors in accordance with the manufacturer’s instructions. Space anchors no more than 16" apart in the vertical direction and no more than 32" apart in the horizontal direction with each row of anchors staggered 16" from the row above and below.

Seal joints above and behind soil nail walls between concrete facing and slope protection with silicone sealant.

### Construction Records

Provide 2 copies of soil nail wall construction records within 24 hours of completing each lift. Include the following in construction records:

* + - 1. Names of Soil Nail Wall Contractor, Superintendent, Nozzleman, Drill Rig Operator, Project Manager and Design Engineer;
			2. Wall description, county, Department’s contract, TIP and WBS element number;
			3. Wall station and number and lift location, dimensions, elevations and description;
			4. Nail locations, dimensions and inclinations, bar types, sizes and grades, corrosion protection and temporary casing information;
			5. Date and time drilling begins and ends, steel bars are inserted into drill holes, grout and shotcrete are mixed and arrives on-site and grout placement and shotcrete application begins and ends;
			6. Grout volume, temperature, flow and density records;
			7. Ground and surface water conditions and elevations if applicable;
			8. Weather conditions including air temperature at time of grout placement and shotcrete application; and
			9. All other pertinent details related to soil nail wall construction.

After completing each soil nail wall or stage of a wall, provide a PDF copy of all corresponding construction records.

* 1. **Nail Testing**

Test soil nails in accordance with the contract and as directed. “Verification tests” are performed on nails not incorporated into soil nail walls, i.e., sacrificial nails and “proof tests” are performed on nails incorporated into walls, i.e., production nails. Define “verification test nail” and “proof test nail” as a nail tested with either a verification or proof test, respectively. Define “test nails” as verification or proof test nails.

Verification tests are typically required for at least one nail per soil type per soil nail wall or 2 nails per wall, whichever is greater. Proof tests are typically required for at least one nail per nail row per soil nail wall or at least 5% of production nails, whichever is greater. More or less test nails may be required depending on subsurface conditions encountered. The Engineer will determine the number and locations of verification and proof tests required. The approximate known test nail locations are shown in the plans.

Do not test nails until grout and shotcrete attain the required 3 day compressive strength. Do not install any production nails until verification tests are accepted.

### Test Equipment

Use the following equipment to test nails:

1. Two dial gauges with rigid supports,
2. Hydraulic jack and pressure gauge,
3. Jacking block or reaction frame and
4. Electrical resistance load cell (verification tests only).

Provide dial gauges with enough range and precision to measure the maximum test nail movement to 0.001". Use pressure gauges graduated in 100 psi increments or less. Submit identification numbers and calibration records for load cells, jacks and pressure gauges with the soil nail wall construction plan. Calibrate each jack and pressure gauge as a unit.

Align test equipment to uniformly and evenly load test nails. Use a jacking block or reaction frame that does not damage or contact shotcrete within 3 ft of nail heads. Place dial gauges opposite each other on either side of test nails and align gauges within 5° of bar inclinations. Set up test equipment so resetting or repositioning equipment during nail testing is not needed.

### Test Nails

Test nails include both unbonded and bond lengths. Grout only bond lengths before nail testing. Provide unbonded and bond lengths of at least 3 ft and 10 ft, respectively.

Steel bars for production nails may be overstressed under higher test nail loads. If necessary, use larger size or higher grade bars with more capacity for test nails instead of shortening bond lengths to less than the minimum required.

### Verification Tests

Install verification test nails with the same equipment, installation methods and drill hole diameter and inclination as production nails.

Determine maximum bond length for verification test nails (LBVT) using the following:

LBVT ≤ (CRT × At × fy) / (QALL × 3)

Where,

LBVT = bond length (ft),

CRT = reduction coefficient, 0.9 for Grade 60 and 75 bars or 0.8 for Grade 150 bars,

At = bar area (in2),

fy = bar yield stress (ksi) and

QALL = allowable unit grout/ground bond strength (kips/ft).

Determine design test load for verification test nails (DTLVT) based on as-built bond length and allowable unit grout/ground bond strength using the following:

DTLVT = LBVT × QALL

Where,

DTLVT = design test load (kips).

Perform verification tests by incrementally loading nails to failure or a load of 300% of DTLVT based on the following schedule:

|  |  |
| --- | --- |
| **Load** | **Hold Time** |
| AL\* | 1 minute |
| 0.25 DTLVT | 10 minutes |
| 0.50 DTLVT | 10 minutes |
| 0.75 DTLVT | 10 minutes |
| 1.00 DTLVT | 10 minutes |
| 1.25 DTLVT | 10 minutes |
| 1.50 DTLVT | 60 minutes (creep test) |
| 1.75 DTLVT | 10 minutes |
| 2.00 DTLVT | 10 minutes |
| 2.50 DTLVT | 10 minutes |
| 3.00 DTLVT | 10 minutes |
| AL\* | 1 minute |

\* Alignment load (AL) is the minimum load needed to align test equipment and should not exceed 0.05 DTLVT.

Reset dial gauges to zero after applying alignment load. Record test nail movement at each load increment and permanent set after load is reduced to alignment load. Monitor verification test nails for creep at the 1.5 DTLVT load increment. Measure and record movement during creep test at 1, 2, 3, 5, 6, 10, 20, 30, 50 and 60 minutes. Repump jack as needed to maintain load during hold times.

### Proof Tests

Determine maximum bond length for proof test nails (LBPT) using the following:

LBPT ≤ (CRT × At × fy) / (QALL × 1.5)

Where variables are defined in Section 5.0(C) above.

Determine design test load for proof test nails (DTLPT) based on as-built bond length and allowable unit grout/ground bond strength using the following:

DTLPT = LBPT × QALL

Where variables are defined in Section 5.0(C) above.

Perform proof tests by incrementally loading nails to failure or a load of 150% of DTLPT based on the following schedule:

|  |  |
| --- | --- |
| **Load** | **Hold Time** |
| AL\* | Until movement stabilizes |
| 0.25 DTLPT | Until movement stabilizes |
| 0.50 DTLPT | Until movement stabilizes |
| 0.75 DTLPT | Until movement stabilizes |
| 1.00 DTLPT | Until movement stabilizes |
| 1.25 DTLPT | Until movement stabilizes |
| 1.50 DTLPT | 10 or 60 minutes (creep test) |
| AL\* | 1 minute |

\* Alignment load (AL) is the minimum load needed to align test equipment and should not exceed 0.05 DTLPT.

Reset dial gauges to zero after applying alignment load. Record test nail movement at each load increment and monitor proof test nails for creep at the 1.5 DTLPT load increment. Measure and record movement during creep test at 1, 2, 3, 5, 6 and 10 minutes. If test nail movement between 1 and 10 minutes is greater than 0.04", maintain the 1.5 DTLPT load increment for an additional 50 minutes and record movement at 20, 30, 50 and 60 minutes. Repump jack as needed to maintain load during hold times.

### Test Nail Acceptance

Submit 2 copies of test nail records including load versus movement and time versus creep movement plots within 24 hours of completing each verification or proof test. The Engineer will review the test nail records to determine if test nails are acceptable. Test nail acceptance is based in part on the following criteria.

1. For verification tests, total movement during creep test is less than 0.08" between the 6 and 60 minute readings and creep rate is linear or decreasing throughout hold time.
2. For proof tests, total movement during creep test is less than 0.04" between the 1 and 10 minute readings or less than 0.08" between the 6 and 60 minute readings and creep rate is linear or decreasing throughout hold time.
3. Total movement at maximum load exceeds 80% of the theoretical elastic elongation of the unbonded length.
4. Pullout failure does not occur at or before the 2.0 DTLVT or 1.5 DTLPT load increment. Define “pullout failure” as the inability to increase load while movement continues. Record pullout failure load as part of test nail data.

For proof test nails, maintain stability of unbonded lengths for subsequent grouting. If a proof test nail is accepted but the unbonded length cannot be satisfactorily grouted, do not incorporate the proof test nail into the soil nail wall and add another production nail to replace the test nail.

If the Engineer determines a verification test nail is unacceptable, revise the soil nail design or installation methods. Submit a revised soil nail wall design or construction plan for acceptance and provide acceptable verification test nails with the revised design or installation methods.

If the Engineer determines a proof test nail is unacceptable, either perform additional proof tests on adjacent production nails or revise the soil nail design or installation methods for the production nails represented by the unacceptable proof test nail as determined by the Engineer. Submit a revised soil nail wall design or construction plan for acceptance, provide an acceptable proof test nail with the revised design or installation methods and install additional production nails for the nails represented by the unacceptable proof test nail.

After completing nail testing for each soil nail wall or stage of a wall, provide a PDF copy of all corresponding test nail records.

* 1. **Measurement and Payment**

*Soil Nail Retaining Walls* will be measured and paid in square feet. Soil nail walls will be measured as the square feet of wall face area with the pay height equal to the difference between top of wall and top of leveling pad elevations. Define “top of wall” as top of concrete facing.

The contract unit price for *Soil Nail Retaining Walls* will be full compensation for providing designs, submittals, labor, tools, equipment and soil nail wall materials, excavating, hauling and removing excavated materials, installing soil nails, grouting, shotcreting and supplying wall drainage systems, leveling pads, concrete facing and any incidentals necessary to construct soil nail walls. The contract unit price for *Soil Nail Retaining Walls* will also be full compensation for brick veneers, if required. No additional payment will be made and no extension of completion date or time will be allowed for repairing property damage, overexcavations or unstable excavations, unacceptable test nails or thicker shotcrete or concrete facing.

The contract unit price for *Soil Nail Retaining Walls* does not include the cost for ditches, fences, handrails, barrier or guardrail associated with soil nail walls as these items will be paid for elsewhere in the contract.

*Soil Nail Verification Tests* and *Soil Nail Proof Tests* will be measured and paid in units of each. Soil nail testing will be measured as the number of initial verification or proof tests performed. The contract unit prices for *Soil Nail Verification Tests* and *Soil Nail Proof Tests* will be full compensation for initial nail testing. No payment will be made for subsequent nail testing performed on the same or replacement test nails.

Payment will be made under:

|  |  |  |
| --- | --- | --- |
| **Pay Item** |  | **Pay Unit** |
| Soil Nail Retaining Walls | Square Foot |
| Soil Nail Verification Tests | Each |
| Soil Nail Proof Tests | Each |

**PE SEAL NAME**

**PE #**