ITEM 554.10NN 17 – SOIL NAIL WALL SYSTEM (TEMPORARY)
ITEM 554.11NN 17 – SOIL NAIL WALL SYSTEM (PERMANENT)

DESCRIPTION
Based on the design information shown in the contract documents, design, furnish, install, and test a soil nail wall system at the location shown on the Plans.

The Contractor or Subcontractor performing this work must have had prior experience installing soil nail walls, as described in this specification.

MATERIALS
Provide materials meeting the following requirements:

Solid Bar Nail Tendons: Provide clean, straight, rust-free bar tendons meeting AASHTO M31 of grade 420 or 520. The deformed bar, continuous without splices or welds, undamaged, bare or epoxy coated or encapsulated (as shown on the approved Shop Drawings), shall be threaded a minimum of 150 mm 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., Dywidag or Williams continuous threadbars) or may be cut into a reinforcing bar. If threads are cut into a reinforcing bar, the bar shall be sized based on the net throat of the threads.

Epoxy Coating: Provide epoxy coating conforming to the requirements of §709-04, Epoxy- Coated Bar Reinforcement. The Bend Test requirements are waived.

Encapsulation: Provide a minimum 1 mm thick corrugated HDPE tube conforming to AASHTO M252 or corrugated PVC tube conforming to ASTM D1784, Class 13464-B. Encapsulation shall provide at least 5 mm of grout cover over the nail bar and be resistant to ultraviolet light degradation, normal handling stresses, and grouting pressures. Factory fabrication of the encapsulation is preferred. Upon the Engineer's approval, the encapsulation may be field fabricated if done in strict accordance with the manufacturer's recommendations.

Centralizers: Provide centralizers manufactured from Schedule 40 PVC pipe or tube, steel, or any material not detrimental to the nail steel (except that wood shall not be used) and approved by the Engineer.

Nail Grout: Provide materials conforming to the following requirements for grout manufacture:

Portland Cement, Type 2	-	§701-01
Flyash	-	§711-10
Grout Sand	-	§703-04
Water	-	§712-01

Admixtures: 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. Acceptance will be based on the manufacturer's name appearing on the Department's Approved List. Accelerators and expansive admixtures are not permitted. Admixtures shall be compatible with the grout and mixed in accordance with the manufacturer's recommendations.

DISAPPROVED BY EI 08-046

ITEM 554.10NN 17 – SOIL NAIL WALL SYSTEM (TEMPORARY)
ITEM 554.11NN 17 – SOIL NAIL WALL SYSTEM (PERMANENT)

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

Shotcrete: Provide shotcrete conforming to the requirements of Section 583- Shotcrete.

Welded Wire Fabric: Provide welded wire fabric conforming to the requirements of §709-02, Wire Fabric For Concrete Reinforcement. Acceptance will be based on the manufacturer's name appearing on the Department's Approved List.

Reinforcing Bars for Shotcrete Facing: Provide No. 16 reinforcing bars for shotcrete facing conforming to the requirements of §709-01, Bar Reinforcement, Grade 420. Acceptance will be based on the manufacturer's name appearing on the Department's Approved List.

Bearing Plates / Nuts: Provide bearing plates conforming to the requirements of §715-01, Structural Steel, ASTM A36M. Provide hexagonal nuts conforming to AASHTO M 291M, fitted with beveled washers or spherical seat to provide uniform bearing.

Geotextile Drainage: Provide geotextile drainage conforming to the requirements of the Geotextile Drainage portions of Section 207- Geotextiles and Prefabricated Composite Drains for Structures. Acceptance will be based on the manufacturer's name appearing on the Department's Approved List.

Geocomposite Drainage Strip: Provide geocomposite drainage strips conforming to the requirements of the Prefabricated Composite Structural Drain portions of Section 207- Geotextiles and Prefabricated Composite Drains for Structures. Acceptance will be based on the manufacturer's name appearing on the Departments Approved List.

Drainage Aggregate: Provide drainage aggregate conforming to the requirements of the Underdrain Filter, Type I portions of Section 605- Underdrains.

PVC Connector and Drain Pipes: Provide schedule 40 PVC connector and drain pipes conforming to the requirements of §706-15, PVC Plastic Drain Pipe System.

SUBMISSIONS:

A. Prior Experience

Submit as proof to the Deputy Chief Engineer Technical Services (D.C.E.T.S.): (1) the names of three projects for which the Contractor or subcontractor performing the work have successfully installed soil nails within the past five years, (2) the foreman and drill rig operators for this work have at least three years of experience, on at least three projects, in the installation of soil nails and (3) written documentation listing at least five permanent structural shotcrete walls successfully completed within the past five years. Submit proof of prior experience with the subcontractor approval process.

B. Shop Drawings

Submit the design and methods of construction to the Deputy Chief Engineer Technical Services (D.C.E.T.S.) for approval. The design shall be accomplished by a Professional Engineer licensed to practice in New York State. The D.C.E.T.S. will require 20 working days to approve the submission after

DISAPPROVED BY EI 08-046

receipt of all pertinent information. No further work shall begin prior to the D.C.E.T.S.'s approval.

Determine the soil nail length and grid spacing necessary to develop adequate load capacity to satisfy nail testing acceptance criteria for the design parameters shown on the Plans. Provide the required partial safety factors, allowable strength factors, and minimum global stability soil factors of safety in accordance with FHWA's "Geotechnical Engineering Circular No. 7 Soil Nail Walls", Report No. FHWA-IF-03-017.

Provide shop drawings conforming to the size and type requirements as given in §718-01, under Working Drawings, A. Size and Type. No work shall begin prior to the receipt of the Engineer's approval.

Include the following:

1. The proposed start date and proposed detailed wall construction sequence including:

1A. Plan describing how surface water will be diverted, controlled and disposed of.

1B. Proposed methods and equipment for excavating the soil and/or rock to the staged excavation lifts indicated within the submitted design, including the proposed grade elevations for each excavation lift, shown on a wall elevation view.

1C. 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).

1D. Details of soil nail layout including lengths, grid spacing, encapsulation or epoxy coating details (if applicable) and design load (P) to resist design earth pressures.

1E. Proposed nail drilling methods and equipment including drillhole diameter and inclination proposed to achieve the specified pullout resistance values and any variation of these along the wall alignment.

2. Nail grout mix design/shotcrete mix design including:
   - Proportions of mix by weight and water-cement ratio.
   - Proposed admixtures, manufacturer, dosage, technical literature.

   Nail grout mix:
   - Compressive strength test results supplied by a qualified independent testing laboratory verifying a minimum 3-day compressive strength of 10.5 Mpa and a minimum 28-day compressive strength of 21 Mpa.

   Shotcrete mix:
   - Compressive strength test results supplied by a qualified independent testing laboratory verifying a minimum 3-day compressive strength of 14 Mpa and a minimum 28-day compressive strength of 28 Mpa.
   - Previous strength test results for the proposed mix designs completed within one year of the start of construction may be substituted for initial verification of the

DISAPPROVED BY EI 08-046

required compressive strengths at start of production work

3. Proposed nail grout placement procedures and equipment.

4. Proposed nail testing methods and equipment setup including:
   Details of jacking frame and appurtenant bracing.
   Details showing methods of isolating test nails during shotcrete application (i.e., methods to prevent bonding of the soil nail bar and the shotcrete facing during testing).
   Details showing methods of providing the temporary unbonded length and of grouting the temporary unbonded length of test nails after completion of testing.
   Equipment list.

5. Proposed methods of shotcrete placement, of controlling and maintaining facing alignment, and location and shotcrete thickness.

C. Certifications

Submit the following documentation to the Engineer at least 15 days prior to the planned start of the soil nail wall system construction:

1. Identification number and certified calibration records for each test jack and pressure gage 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 calibration test results and shall be certified for accuracy of at least 2 percent of the applied certification loads by a qualified independent testing laboratory within 90 days prior to submittal.

2. Manufacturer Certificates of Compliance for the soil nail centralizers, epoxy coating or encapsulation, bearing plates, nuts, welded wire fabric, rebar for shotcrete, and PVC drain piping.

3. Upon delivery of nail bars and soil nail bar couplers (if allowed) 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.

4. Written documentation of the finishers and nozzlemen's qualifications. Minimum qualifications include experience on at least three projects in the past three years in similar shotcrete application work. In addition, the nozzlemen must demonstrate the ability to satisfactorily place the shotcrete. This will be based on either previous ACI certification or satisfactory completion of preconstruction test panels.

DISAPPROVED BY EI 08-046

ITEM 554.10NN 17 M – SOIL NAILED WALL SYSTEM (TEMPORARY)
ITEM 554.11NN 17 M – SOIL NAILED WALL SYSTEM (PERMANENT)

CONSTRUCTION DETAILS

Prior to the start of the soil nailed wall installation, install a nail for preproduction verification testing. Install the nail at the location specified on the Plans or as directed by the Engineer. Install and test the nail in accordance with the requirements contained in this specification.

Provide positive control and discharge of all surface water that will affect the installation of the soil nail wall throughout the construction of the wall. Maintain all ditches, 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 as determined by the Engineer, remove surface water control pipes or conduits from the site.

Excavate lifts under the direction of the soil nail specialty Contractor. Excavate using procedures that prevent over-excavation, ground loss, swelling, air slaking or loosening, loss of support for completed portions of the wall, loss of soil moisture at the face, or ground freezing.

Drill holes for the soil nail installation. Core drilling, rotary drilling, or auger drilling may be used. Percussion drilling is prohibited unless approval for its use is granted by the D.C.E.T.S. Install casing as required to maintain a clean and open hole. Utilize a drill bit with a diameter not smaller than the specified hole diameter minus 3 mm. Extend the hole a minimum of 0.6 m beyond the nail length. Drill the holes to the inclination specified on the approved Shop Drawings within a three-degree tolerance.

Provide centralizers at a maximum of 3 m center-to-center spacing throughout the length of the nail to position the bar within 25 mm of the center of the hole and to provide a minimum 25 mm grout cover over bare or epoxy-coated bars or 12 mm grout cover over the encapsulation of an encapsulated nail. Size the centralizers to allow insertion of a tremie pipe to the bottom of the drillhole and to allow grout to freely flow up the drillhole. Provide a centralizer within 0.6 m of the top and bottom of the nail. Sag of the nail shall be taken into account when selecting centralizer diameter and spacing.

Insert the nail in the casing or hole after the hole is drilled to the final depth. Locate the nail within a 150 mm tolerance, in any direction. Location tolerances are applicable to only one nail and not accumulative over large wall areas.

Repair encapsulated nails that are damaged or defective in accordance with the manufacturer's recommendations or remove them from the site.

Provide grouting equipment capable of continuous mixing and producing grout free of lumps. Equip the grout pump with a grout pressure gage capable of measuring at least twice but not 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 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.

Perform the grouting operation after the nail is inserted. Grout each drillhole within 2 hours of completion of drilling, unless otherwise approved by the Engineer. To prevent air voids, fill the hole with grout progressively from the bottom to the top. Completely fill the drillhole in one continuous operation. Cold joints in the grout column are not allowed except at the top of the test-bond length of proof-tested production nails.

Maintain sufficient grout level within the casing to offset the external groundwater/soil pressure and prevent hole caving during casing removal for drillholes advanced by either cased or auger methods.

DISAPPROVED BY EI 08-046

Maintain grout head or grout pressures sufficient to ensure that the drillhole will be completely filled with grout and to prevent unstable soil or groundwater from contaminating or diluting the grout. Control grout pressures to prevent excessive ground heave or fracturing.

Remove the grout and nail if grouting is suspended for more than 30 minutes or does not satisfy the requirements of this specification or the approved Shop Drawings, and replace with fresh grout and undamaged nail bar at no additional cost.

Test nails as included in this specification.

Install and secure all elements of the wall drainage network as shown on the approved Shop Drawings or as required by the Engineer. Secure the geocomposite drainage strips tightly to the excavation face to prevent shotcrete from contaminating the ground side of the geotextile. Geocomposite drainage strips shall be continuous. Splices to the geocomposite drainage strips shall be made with a 300 mm minimum overlap such that the flow of water is not impeded. Install all elements of the drainage network, exclusive of the wall footing drains, prior to shotcreting. Clean the face of the excavation, and other surfaces to be shotcreted, of loose material, mud, rebound, overspray, or other foreign matter that could prevent or reduce shotcrete bond. Remove material that loosens as shotcrete is applied.

Provide shotcrete equipment capable of delivering the premixed material accurately, uniformly and continuously through the delivery hose. Control shotcrete application thickness, nozzle technique, air pressure, and rate of shotcrete placement to prevent sagging or sloughing of freshly applied shotcrete.

Ensure that the thickness of shotcrete satisfies the minimum requirements as shown on the approved Shop Drawings using shooting wires, thickness control pins, or other devices acceptable to the Engineer.

Repair shotcrete surface defects as soon as possible after placement. Remove and replace shotcrete which exhibits segregation, honeycombing, lamination, voids, or sand pockets. In-place shotcrete determined not to meet the specified strength requirements will be subject to remediation as determined by the Engineer.

Finish shotcrete with either an undisturbed gun finish as applied from the nozzle or a rough-screeded finish.

Attach a bearing plate and nut to each nail head as shown on the approved Shop Drawings. While shotcrete is still plastic and before its initial set, uniformly seat the plate on the shotcrete by hand-wrench tightening the nut. Where uniform contact between the plate and the shotcrete cannot be provided, set the plate in a bed of grout. After grout has set for 24 hours, hand-wrench tighten the nut. Ensure bearing plates with headed studs are in intimate contact with the construction facing and the studs are located within the tolerances specified herein.

Locate wire mesh, rebar, and headed studs on bearing plates within 15 mm horizontally from the Plan location. Locate headed studs within 6 mm of Plan location on bearing plate. Provide spacing between reinforcing bars within 25 mm of Plan dimensions. Provide reinforcing lap within 25 mm of the Plan dimensions. Provide a shotcrete thickness within 10 mm of the Plan dimensions. Locate nail head bearing plate within 10 degrees deviation from parallel to the wall face.

Do not excavate to the next lift until nail installation, reinforced shotcrete placement, attachment of bearing plates, and nuts and nail testing has been completed and accepted in the current lift. Ensure

DISAPPROVED BY EI 08-046

nail grout and shotcrete have cured for at least 72 hours or attained at least their specified 3-day compressive strength before excavating the next underlying lift.

Testing:

Perform preproduction verification, verification, and proof testing of designated test nails. Perform a preproduction verification test and verification tests on sacrificial test nails as described herein. Perform proof tests on production nails at locations selected by the Engineer and as described herein. Do not perform nail testing until the nail grout and shotcrete facing have cured for at least 72 hours and attained at least their 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 laboratory, verifying that the nail grout and shotcrete mixes being used will provide the specified 3-day compressive strength in the lesser time.

Provide a minimum 1 m temporary unbonded length in each test nail. Prior to testing, grout only the bonded length of the test nail. Determine the bonded length of the test nail based on the production nail bar grade and sized such that the allowable bar structural load is not exceeded during testing. The bond length shall not be less than 3 m.

The alignment load (AL) necessary to maintain position of the stressing and testing equipment shall not exceed 0.05 times the design load (P). Set dial gauges to "zero" after the alignment load has been applied.

The maximum test load shall not exceed 80 percent of the guaranteed ultimate tensile strength of the nail. Monitor the jack load with a load cell. Provide the Engineer with the calibration curve before start of testing.

Submit two copies of all test data to the Engineer.

A. 1. PreProduction Verification Test
Perform a preproduction verification test prior to installation of production nails to verify the Contractor's installation methods and nail pullout resistance. Testing requirements are contained in Section A.2. Verification Testing of this specification.

A. 2. Verification Testing
Perform a minimum of 2 verification tests in each different soil/rock unit and for each different drilling/grouting method proposed to be used, at each wall location. Verification test nails will be sacrificial and not incorporated as production nails. Bare bars can be used for the sacrificial verification test nails.

Incrementally load verification test nails to a maximum test load of 2 times the design load (P) in accordance with the following schedule. Record soil nail movements at each load increment.

Load	Hold Time
AL	1 minute
0.25 P	10 minutes
0.50 P	10 minutes
0.75 P	10 minutes
1.00 P	10 minutes
1.25 P	10 minutes
1.50 P (Creep Test)	60 minutes

DISAPPROVED BY EI 08-046

1.75 P	10 minutes
2.00 P	10 minutes

Monitor the verification test nail for creep at the 1.50 P load increment. Measure nail movements during creep portion of the test and record at 1 minute, 2, 3, 5, 6, 10, 20, 30, 50, and 60 minutes. Maintain load during the creep test within 2 percent of the intended load by use of the load cell.

The Engineer will review all verification tests to determine if the nail is acceptable. A nail will be accepted if the following three criteria are met:

1. A total creep movement of less than 2 mm 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. The total measured movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the test nail unbonded length.
3. A pullout failure does not occur at the maximum test load. 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.

B. Proof Testing

Perform proof testing on 5 percent (1 in 20) of the production nails in each row or a minimum of 1 per row. The locations shall be designated by the Engineer. A verification test nail successfully completed during production work shall be considered equivalent to a proof test nail and shall be accounted for in determining the number of proof tests required in that particular row.

Production proof test nails shorter than 4 m in length may be constructed with less than the minimum 3 m bond length with the unbonded length limited to 1 m.

Incrementally load the proof test nail to a maximum test load of 1.5 times the Design Load (P) in accordance with the following schedule. Record the soil nail movements at each load increment.

Load	Hold Time
AL	Minimum of 1 minute
0.25 P	Minimum of 1 minute
0.50 P	Minimum of 1 minute
0.75 P	Minimum of 1 minute
1.00 P	Minimum of 1 minute
1.25 P	Minimum of 1 minute
1.50 P (Max. Test Load)	See Below

Hold each load increment, except for the 1.5 (P) load, until the deflection stabilizes.

All load increments shall be maintained within 5 percent of the intended load. Depending on the performance, either 10-minute or 60-minute creep tests shall be performed at the maximum test load (1.50 P). 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 nail movement between 1 minute and 10 minutes exceeds 1mm, the maximum test load shall be maintained an additional 50 minutes and movements shall be recorded at 20 minutes, 30, 50, and 60 minutes.

DISAPPROVED BY EI 08-046

The Engineer will review all proof tests to determine if the nail is acceptable. A nail will be accepted if the following three criteria are met:

1. A total creep movement of less than 1 mm measured between the 1 and 10 minute readings or a total creep movement of less than 2 mm is measured between the 6 and 60 minute readings and the creep rate is linear or decreasing throughout the creep test load hold period.
2. The total measured movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the test nail unbonded length.
3. A pullout failure does not occur at the maximum test load. 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.

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 drillhole has not collapsed during testing.
2. The minimum required drillhole diameter has been maintained.
3. The specified corrosion protection is provided.
4. The test nail length is equal to or greater than the scheduled production nail length.

Test nails meeting the above 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.

For nails that the Engineer finds unacceptable, the Contractor shall submit a written proposal containing a suggested course of action.

METHOD OF MEASUREMENT

The unit of measurement for soil nail wall system shall be the number of square meters of wall satisfactorily installed between the payment lines shown on the Plans or as revised, in writing, by the Engineer.

BASIS OF PAYMENT

The unit price bid per square meter shall include the cost of furnishing all labor, equipment, materials, and tests required to design and construct the soil nail wall system including the wall drainage network and the temporary shotcrete construction facing.

Permanent wall facing will be paid for under separate item.

Note: NN denotes serialized pay item, see §101-02 Definition of Terms, Specifications.

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