Iowa Department of Transportation

SPECIAL PROVISIONS
FOR
LAUNCHED SOIL NAIL WALL

Lee County
NHSN-027-1(1)--2R-56

Effective Date
July 17, 2012

THE STANDARD SPECIFICATIONS, SERIES 2009, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

090217.01 DESCRIPTION.

A. This work consists of constructing a permanent launched soil nail wall as specified herein and as shown on the plans. The Contractor shall furnish all labor, materials, and equipment required to complete the work. The Contractor shall select the excavation, launching pressure, and grouting methods and to meet the performance requirements specified herein or shown on the plans.

B. The work shall include excavating in staged lifts in accordance with the approved Contractor's plan; detailing the launching of the soil nails and drains; pressure grouting the nails to densify the surrounding ground, fill any voids/slip surfaces encountered, and increase bond capacity; inserting an inner bar immediately after grouting; providing and installing the specified drainage features including launched horizontal drains to act as tensile reinforcement and reduce water pressures in the soil; providing and installing bearing plates, nuts, and other required miscellaneous materials; and constructing the required shotcrete face.

090217.02 MATERIALS.

A. Soil Nails.

1. Nail Outer Tube.

a. Steel tubular shells: 1.5 inch O.D. ASTM A-513 Type I or ASTM A500B welded seam mild steel tubes manufactured with ASTM A36 steel, continuous without splices or welds, new, straight, undamaged. Steel tips are machined from 1.25 inch mild steel ingots and welded to the penetrating end of the tube with a 0.25 inch fillet weld sufficient to resist installation stresses.

- Nominal length: 20 feet
- Wall thickness: 0.120 inches
- Cross sectional area: 0.52 in^2
- Moment of inertia: 0.125 in^4
- Yield strength: Fy = 36 ksi

- Ultimate strength: Fu = 58 ksi
- Young's Modulus 29 x 10^3 ksi
- Tube yield strength: 18.7 kips – Solid-walled tube
- Tube yield strength: 17.1 kips – Perforated tube (see below)
- Corrosion resistance: For permanent application, the steel tube shall be zinc or zinc-aluminum mischmetal alloy (galfan) hot dip galvanized to produce a rough coat with a plurality of surficial asperities and an average minimum coating thickness of at least 1.8 mils. With the exception of the roughness of the coat, hot-dipped galvanization should be as per ASTM A385.
- Perforations: Pressure-grouted nails – 3/8 inch diameter holes drilled or burned at 6 inch spacing on one wall along the distal 5 feet of nail. Every other hole is rotated 90 degrees about the longitudinal axis of the nail.

b. Fiberglass Tube: 1.5 inch O.D. Extren 625 structural tubes manufactured by Strongwell, Inc. (or approved equal). Tubes are manufactured using a continuous pultrusion process with linear and radial fiberglass reinforcements embedded in a vinyl ester resin system with a UV inhibitor and a surface veil to protect against glass fibers penetrating the resin surface and to increase corrosion and UV resistance.

- Resin type and grade: Vinyl ester resin with UV inhibitor
- Density: 0.062 – 0.070 lbs/in^3
- Wall thickness: 0.25 inches
- Cross sectional area: 0.98 in^2
- Moment of Inertia: 0.199 in^4
- Yield Strength: 30 ksi - Lengthwise ultimate tensile stress at room temperature (ASTM D-638)
- Young's Modulus: 2.8 x 10^3 ksi – at room temperature
- Tube Yield Strength: 29.4 kips – Solid-walled tube at room temperature (Approximately 0.1% axial strain per lineal foot of tube)
- Tube Yield Strength: 26.6 kips – Perforated tube at room temperature (Approximately 0.1% axial strain per lineal foot of tube)
- Corrosion Resistance: Resistant to acids, bases, chlorides, sulfates, and sulfides. Not resistant to very high concentrations (i.e. immersion) in BTEX compounds (Benzene, Toluene, Ethyl Benzene, and Xylene)
- Perforations: Pressure-grouted nails – 3/8 inch diameter holes drilled or burned at 6 inch spacing on one wall along the distal 5 feet of nail. Holes are kept in a single line to prevent cutting multiple strands of glass fiber.
- Horizontal drains - 1/4 inch diameter holes drilled or burned at 12 inch spacing along the distal 10 feet of nail. Holes are kept in a single line to prevent cutting multiple strands of glass fiber.

2. Nail Inner Bar.
AASHTO M31/ASTM A615, Grade 420 or 520, ASTM A 722 for Grade 1035. Deformed bar, continuous without splices or welds, new, straight, undamaged, bare, or epoxy-coated as shown on the Plans.

3. Fusion Bonded Epoxy Coating for inner bar.
ASTM A 775. Minimum 12 mils thickness electrostatically applied. Bend test requirements are waived.

B. Launched Soil Nail Appurtenances.

1. Centralizer.
Not Required.

2. **Nail Grout.**
   Neat cement or sand/cement mixture with a minimum 3 day compressive strength of 1500 psi and a minimum 28 day compressive strength of 3000 psi, per AASHTO T106/ASTM C109. Water/Cement Ratio = 0.40 - 0.60 (typically 5 gallons of water per 94 pound bag of cement).

3. **Fine Aggregate.**
   AASHTO M6/ASTM C33.

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

5. **Admixtures.**
   AASHTO M194/ASTM C494. Admixtures that 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.

C. Bearing Plates and Nuts.

1. **Bearing Plates.**
   AASHTO M183/ASTM A36.

2. **Nuts.**
   AASHTO M291, grade B, hexagonal.

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

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

F. Geocomposite Sheet Drain.
Manufactured with a drainage core (e.g., geonet) and a drainage geotextile attached to or encapsulating the core. Drainage core to be manufactured from long chain synthetic polymers composed of at least 85% by mass of polypropylenes, polyester, polyamine, polyvinyl chloride, polyolefin, or polystyrene and having a minimum compressive strength of 40 psi when tested in accordance with ASTM D 1621 Procedure A. The drainage core with the geotextile fully encapsulating the core shall have a minimum flow rate of 1 liter per second per meter of width tested in accordance with ASTM D 4716. The test conditions shall be under an applied load of 10 psi at a gradient of 1.0 after a 100 hour seating period.

G. Shotcrete.

1. Furnish shotcrete complying with the requirements of ACI 506.2, "Specifications for Materials, Proportioning and Application of Shotcrete", except as otherwise specified. Shotcreting consists applying of one or more layers of concrete conveyed through a hose pneumatically projected at a high velocity against a prepared surface. Produce shotcrete by either a wet-mix or a dry-mix process. The wet-mix process consists of thoroughly mixing all the ingredients except accelerating admixtures, but including the mixing water, introducing the mixture into the delivery equipment and delivering it, by positive displacement, to the nozzle. Air jet the wet-mix shotcrete from the nozzle at high velocity onto the surface. The dry-mix process consists of producing shotcrete by delivering the dry ingredients conveyed pneumatically with the mixing water introduced at the nozzle. For additional descriptive information, refer to the American Concrete Institute ACI 506R "Guide to Shotcrete."

2. Use materials for shotcrete conforming to the following requirements.
- **a.** Cement. AASHTO M85/ ASTM C150, Type I, II, III or V.
- **b.** Fine Aggregate. AASHTO M6/ASTM C33 clean, natural.
- **c.** Coarse Aggregate. AASHTO M80, Class B for quality.
- **d.** Water. Clean and Potable. AASHTO M157/ASTM C94.
- **e.** Chemical Admixtures.
  - **1)** Accelerator Fluid type, applied at nozzle, meeting requirements of AASHTO M194/ASTM C494/ASTM C1141.
  - **2)** Water-reducer and Superplastisizer. AASHTO M194/ASTM C494 Type A, C, D, E, F, or G.
  - **3)** Retarders. AASHTO M194/ ASTM C494 Type B or D.
- **f.** Mineral Admixtures.
  - **1)** Fly Ash. AASHTO M295/ASTM C618 Type F or C, cement replacement up to 35% by weight of cement.
  - **2)** Silica Fume. ASTM C1240, 90% minimum silicon dioxide solids content, not to exceed 12% by weight of cement.
- **g.** Prepackaged Shotcrete. ASTM C928.

3. Deliver, store, and handle materials to prevent contamination, segregation, corrosion or damage. Store liquid admixtures to prevent evaporation and freezing.

4. Obtain Engineer's approval for the proposed mix design and method of placement prior to beginning shotcrete placement.

5. Use aggregate for shotcrete meeting the strength and durability requirements of AASHTO, as applicable, and the following gradation requirements:

Sieve Size	Percent Passing by Weight
½"	100
3/8"	90-100
No. 4	70-85
No. 8	50-70
No. 16	35-55
No. 30	20-35
No. 50	8-20
No. 100	2-10

6. Proportion the shotcrete to be pumpable with the concrete pump furnished for the work, with a cementing materials content of at least 24.3 pounds per cubic foot and water/cement ratio not greater than 0.50. Do not use admixtures unless approved by the Engineer. Thoroughly mix admixtures into the shotcrete at the rate specified by the manufacturer. Use only accelerators compatible with the cement used, non-corrosive to steel, and not promoting other detrimental effects such as cracking or excessive shrinkage. The maximum allowable chloride ion content of all ingredients is 0.10% when tested to AASHTO T260.

7. Provide shotcrete with a design compressive strength of 2000 psi in 3 days and 4000 psi in 28 days.

8. Batch aggregate and cement by weight or by volume in accordance with the requirements of ASTM C94 or AASHTO M241/ASTM C685. Use mixing equipment that thoroughly blends the materials in sufficient quantity to maintain placing continuity. Produce ready mix shotcrete complying with AASHTO M157. Batch, deliver, and place shotcrete within 90 minutes of mixing. The use of retarding admixtures may extend application time beyond 90 minutes if approved by the Engineer.

090217.03 CONSTRUCTION.

A. Submittals.

1. The Contractor shall submit a brief description of at least three projects, including the owning agency's name, address, and current phone number; location of project; project contract value; and scheduled completion date and actual completion date for the project.

2. At least 10 calendar days before starting soil nail work, identify the engineer, on-site supervisors, and launcher operators assigned to the project, and submit a summary of each individual's experience. Only those individuals designated as meeting the qualifications requirements shall be used for the project. The Contractor cannot substitute for any of these individuals without written approval of the Engineer. The Engineer shall approve or reject the Contractor qualifications and staff within 5 working days after receipt of the submission. Work shall not be started on any soil nail wall nor materials ordered until the Contractor's qualifications have been approved by the Engineer. The Engineer may suspend the work if the Contractor substitutes unqualified personnel for approved personnel during construction. If work is suspended due to the substitution of unqualified personnel, the Contractor shall be fully liable for additional costs resulting from the suspension of work and no adjustment in contract time resulting from the suspension of the work will be allowed.

3. The Contractor is responsible for providing the necessary survey and alignment control during the excavation for each lift, locating nail locations and verifying limits of wall/slope installation. At least 10 days before starting launched soil nail work, submit a construction plan to the Engineer that includes the following.

- **a.** The start date and proposed detailed wall construction sequence.
- **b.** Launching and grouting methods and equipment.
- **c.** Nail grout mix design, including compressive strength test results (per AASHTO T106/ASTM C109) supplied by a qualified independent testing lab verifying the specified minimum 3 day and 28 day grout compressive strengths. Previous test results for the same grout mix completed within one year of the start of grouting may be submitted for verification of the required compressive strengths.
- **d.** Nail grout placement procedures and equipment.
- **e.** Shotcrete materials and methods.
- **f.** Launched Soil Nail testing methods and equipment setup.
- **g.** Identification number and certified calibration records for each test jack and pressure gauge to be used. Jack and pressure gauge shall be calibrated as a unit. Calibration records shall include the date tested, the device identification number, and the calibration test results and shall be certified for an accuracy of at least 2% of the applied certification loads by a qualified independent testing laboratory within 360 days prior to submittal.
- **h.** Manufacturer Certificates of Compliance for materials to be used.

4. The Engineer shall approve or reject the Contractor's construction plan within 5 working days after the submission. Approval of the construction plan does not relieve the Contractor of his responsibility for the successful completion of the work.

B. Storage and Handling.

Store and handle all material in a manner to avoid damage or corrosion.

C. Excavation.

1. The height of exposed unsupported final excavation face cut shall not exceed twice the vertical nail spacing plus the required reinforcing lap plus the distance above the upper row of nails or the short-term stand-up height of the ground, whichever is less. Complete excavation to the final wall excavation line and apply shotcrete in the same work shift, unless otherwise approved by the Engineer. Application of the shotcrete may be delayed up to 24 hours if the

contractor can demonstrate that the delay will not adversely affect the excavation face stability.

2. Excavation of the next-lower lift shall not proceed until nail installation, reinforced shotcrete placement, and attachment of bearing plates and nuts, have been completed and accepted in the current lift.

D. Nail Installation.

1. Launch 20 foot long nails with sufficient pressure to embed as specified below. Nails are to be installed at locations identified on the plans. Driven or drilled nails will not be allowed.
- **a.** The average penetration length of the soil nails shall not be less than 8 feet. The penetration length is the length from the undisturbed ground surface (not including vegetation) to the tip of the embedded nail. The average shall be based on each group of 20 contiguous nails.
- **b.** The minimum penetration length of any individual nail shall not be less than 5 feet.

2. The inclination of the soil nails shall be 15 degrees subhorizontal plus or minus 5 degrees. Due to site obstructions, the inspector may accept up to one nail per group of 20 contiguous nails that varies by more than 5 degrees but not more than 10 degrees.

E. Grouting.

1. After the nail bar is launched into the slope, pump grout under pressure through a hose connected to the top of the outer tube until the grout completely fills the tube, exits the perforations on the nail, and either:
- Exits the ground at the nail penetration site or through adjacent nails; or
- Five 90 lb bags of cement are pumped into a single nail.

2. Grout each nail in one continuous operation to avoid cold joints in the grout.

F. Nail Testing.

1. Perform proof tests on production nails at locations selected by the Engineer. Testing of any nail shall not be performed until the nail grout has cured for at least 72 hours or attained at least the specified 3 day compressive strength. Testing may be conducted prior to 72 hours with the approval of the Engineer at the risk to the Contractor.

2. Testing equipment shall include one dial gauge, dial gauge support, jack and pressure gauge, and a reaction frame. The pressure gauge shall be graduated in 75 psi increments or less. Measure the nail head movement with a dial gauge capable of measuring to 0.001 inch.

G. Proof Testing of Production Nails.

1. The Engineer shall determine the locations and number of proof tests prior to nail installation. Production proof test nails shall have both bonded and unbonded lengths. The bonded length of the soil nail during proof tests, LBPT, shall be the actual embedment length. The unbonded length of the test nails shall be the distance from the ground surface to the launched nail and jack connection. The unbonded length of the test nails shall be at least 1.5 feet.

The length LBPT max is defined as:
$L_{BVTmax} = (C_R \times A_t \times f_Y) / (Q_{ALL} \times FS_{Tproof})$

where,

C_R = Reduction coefficient. Use C_R = 0.9 for Grade 60 and 75 bars. Use C_R = 0.8 for Grade 150 bars;
A_t = Nail bar cross-sectional area;
f_Y = Nail bar yield tensile strength;
Q_{ALL} = Allowable pullout resistance per unit length ($Q_{ALL} = Q_u/FS_P$), as specified herein or in plans; and
FS_{Tproof} = Factor of safety against tensile failure during proof tests.

The maximum bonded length shall be preferably based on production nail maximum bar grade. Provide larger bar sizes, if required, to meet the 10 foot minimum test bonded length requirement at no additional cost.

The Design Test Load (DTL) shall be determined as follows:

$DTL = L_{BVT} \times Q_{ALL}$

DTL shall be calculated based on as-built bonded lengths.

2. Perform proof tests by incrementally loading the proof test nails to 150% of the DTL in accordance with the following loading schedule. Record the soil nail movements at each load increment.

Table 090217.03-1: Proof Test Loading Schedule

Load	Hold Time
0.05 DTL max.	Until Movement Stabilizes
0.25 DTL	Until Movement Stabilizes
0.50 DTL	Until Movement Stabilizes
0.75 DTL	Until Movement Stabilizes
1.00 DTL	Until Movement Stabilizes
1.25 DTL	Until Movement Stabilizes
1.50 DTL (Creep Test)	See Below

The alignment load (AL) should be the minimum load required to align the testing apparatus and should not exceed 5% of the DTL. Dial gauges should be set to “zero” after the alignment load has been applied.

3. The creep period shall start as soon as the maximum test load (1.50 DTL) is applied and the nail movement shall be measured and recorded at 1, 2, 3, 5, 6, and 10 minutes. Where the nail movement between 1 minute and 10 minutes exceeds 0.04 inches, maintain the maximum test load for an additional 50 minutes and record movements at 20, 30, 50, and 60 minutes. Maintain all load increments within 5% of the intended load.

H. Test Nail Acceptance Criteria.
A test nail shall be considered acceptable when the following criteria are met:

1. For proof tests, the total creep movement is less than 0.04 inches during the 10 minute readings or the total creep movement is less than 0.08 inches during the 60 minute readings and the creep rate is linear or decreasing throughout the creep test load hold period.

2. A pullout failure does not occur at 1.5 DTL test load under proof testing. Pullout failure is defined as the inability to further increase the test load while there is continued pullout movement of the test nail. Record the pullout failure load as part of the test data.

I. Test Nail Rejection.
For 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. 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.

J. Wall Drainage Network.
Install geocomposite drain strips centered between the columns of nails as shown in the contract documents. The drain strips shall be at least 6 inches wide and placed with the geotextile side against the ground. Secure the strips to the excavation face and prevent shotcrete from contaminating the geotextile. Drain strips will be vertically continuous. Make splices with a 6 inch minimum overlap such that the flow of water is not impeded. Repair any damage to the geocomposite drain strip, which may interrupt the flow of water. All elements of the drainage network shall be installed prior to shotcreting.

K. Shotcrete Facing.
Shotcrete finish shall be either an undisturbed gun finish as applied from the nozzle or a rod, broom, wood float, rubber float, steel trowel or rough screeded finish as shown on the Plans.

L. Acceptance.
Material for the launched soil nail retaining wall will be accepted based on the manufacturer production certification or from production records. Construction of the launched soil nail retaining wall will be accepted based on visual inspection and the relevant production testing records.

090217.04 METHOD OF MEASUREMENT.

A. Launched Soil Nails.
Measure launched soil nails by each.

B. Structure Excavation.
Measure excavation for the soil nail wall as the theoretical plan volume in cubic yards within the structure excavation limits shown on the plans. This will be the excavation volume within the zone measured from top to bottom of shotcrete wall facing and extending out horizontally in front of the plan wall final excavation line. Additional excavation beyond the Plan wall final excavation line resulting from irregularities in the cut face, excavation overbreak or inadvertent excavation will not be measured. No measurement will be made for using temporary stabilizing berms.

C. Wall Face (Shotcrete).
Measure shotcrete by the square foot of wall face. Measurement will be made on the vertical plane of front face accepted in the final work. No measurement or payment will be made for additional shotcrete or CIP concrete needed to fill voids created by irregularities in the cut face, excavation overbreak or inadvertent excavation beyond the Plan final wall face excavation line, or failure to construct the facing to the specified line and grade and tolerances. The final pay quantity shall include all structural shotcrete, admixtures, reinforcement, welded wire mesh, wire holding devices, wall drainage materials, bearing plates and nuts, testing and reporting required by the Plans and this Specification. The final pay quantity shall be the design quantity increased or decreased by any changes authorized by the Engineer.

D. Verification Nail Testing.
Measure tested nails by each.

E. Launched Horizontal Drains.
Measure launched horizontal drains by each.

090217.05 BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid for at the contract unit price per unit of measurement for the pay items listed below that are shown on the bid schedule. Payment will be full compensation for the work prescribed in this section.