SECTION 02526

SOIL NAIL DESIGN/BUILD SPECIFICATION

1.0 DESCRIPTION

A. This work shall consist of designing, constructing, and warranting a permanent soil nail stabilization wall. The soil nail installer shall furnish all design, stamped plans, labor, materials and equipment required for completing the work. The soil nail installer shall select the drilling or launching method and equipment, final hole diameter(s) and grouting procedures, wire mesh and/or shotcrete facing type and post tensioning of wire mesh facing.

1.1 SCOPE OF WORK:

A. This project provides for the design/build construction new soil nail walls at the proposed John R. Lewis Elementary School, in Brookhaven, Georgia. The wall will also require wire mesh or shotcrete facing as determined by the Architect and design/build contractor. The design/build contractor is responsible for obtaining retaining wall permits as required by the City of Brookhaven.

1.2 QUALIFICATIONS OF SOIL NAIL INSTALLER:

A. The soil nail installer shall be selected from the following list of pre-approved Contractors:

**GeoStabilization International.**
2841 North Avenue
Grand Junction, CO 81501
P: 303.909.6083
Contact: Colby Barrett
E: colby@gsi.us

**Hayward Baker**
515 Nine North Court
Alpharetta, GA 3000
Ph: 770.442.1801
Contact: Ryan Smith
E: rtsmith@haywardbaker.com

**Schnabel Foundation Company**
1654 Lower Roswell Road
Marietta, GA 30068
P: 770-971-6455

OR

The soil nail installer shall demonstrate to the satisfaction of Owner that the soil nail installer’s team is qualified to perform the work under this Contract and therefore responsible. The soil nail installer may be a prime contractor or a subcontractor. For the soil nail installer’s team to be responsible, the soil nail installer, and designated key personnel must demonstrate an appropriate level of experience, technical competence, and successful past performance of work. An entity of the soil nail installer’s team may perform more than one function. The
information requested in this section will assist Owner in making such determination.

B. In the event Owner finds the soil nail installer’s qualification information lacking or if Owner determines that the soil nail installer, and/or project team member(s) are not qualified, Owner may reject the soil nail installer, meet with the soil nail installer, or request additional information. Timeliness of Contract Execution is critical to the success of this project; therefore, Owner may give a soil nail installer limited or no opportunity and time to remedy a matter(s) of responsibility before rejecting the bid and going to the next low bidder. Such decisions are the sole discretion of the Owner.

C. Owner reserves the right to contact references and investigate past performance and qualifications of the soil nail installer, and project team members, including contacting third parties and/or the references provided by the soil nail installer. References may be asked to describe their experience with project team members, the soil nail installer, and/or member of the Joint Venture (JV) or other similar Business Organizational Structure (BOS) such as a partnership or limited liability partnership. Information may be solicited and evaluated on the following subjects: type and features of work; overall quality of project performance and quality of work; experience and technical knowledge and competence of the soil nail installer and Project Team Member; ability, capacity and skill to perform the Work; compliance with laws, ordinances, and contract provisions; and other information as deemed necessary by Owner. Poor reference(s) may be justification to determine a soil nail installer is not responsible.

D. To assist Owner in the review of the soil nail installer’s qualifications, the soil nail installer shall provide the information requested below.

E. The soil nail installer shall demonstrate that its team possesses the following required elements of responsibility:
   1. Have successfully engineered and constructed no less than fifty projects within the last five years, for which the soil nail installer successfully stabilized an active landslide or actively failing wall structure using tensile elements. NOTE: To qualify, at least one of the projects noted above shall have utilized the same key personnel (for items F.1 “b” thru “d” noted in section F below) as those proposed for this project.

F. Soil nail installer shall also demonstrate or provide:
   1. The names of the following key project team members:
      a. Project Manager
      b. Project Superintendent, if different than the Project Manager
      c. Soil Nail Installer
      d. Shotcrete installers (including copies of current ACI nozzleman certifications)
      e. Licensed Professional Engineer
G. Proposed key team members shall demonstrate their experience with the elements listed in Section 1-02.1 A. These key personnel and shall actively participate in the Project for its duration. Replacement of these key personnel will only be permitted with the prior written approval of the Engineer. Proposed replacements shall demonstrate their experience with the elements listed in the previous sections. All team members must be employed by the soil nailing installer; consultants or manufacturer’s representatives may not be used to satisfy the requirements of this section.

H. Submittal Instructions:
1. Selected bidder(s) shall submit qualification information of the soil nail installer within 3 business days from Owner’s request for qualification information. Owner may at its sole discretion grant soil nail installer additional time to provide information if the circumstances justify such extension.
2. Soil nail contractors shall submit as part of the bid process a detailed cross section and limit-equilibrium slope stability analysis for the tallest wall section (H=40-ft) with nail spacing and length. The stability analysis must show that recommended soil properties and all factors of safety noted in the design requirements (Section 1.03) have been met.
3. Soil nail contractors shall provide written documentation verifying they have proper equipment and ability to verify and test nail pullout per the installation requirements as noted in Section 1.05.
4. Soil nail contractor shall submit engineering design/analysis of the MSE wall stabilization system to the site design professional for review prior to installation. Said engineering design/analysis may include but not be limited to: calculations, data files, drawings, etc.

1.3 DESIGN REQUIREMENTS:

A. The soil nail installer will be responsible for the engineering design/analysis of the MSE wall stabilization system. Materials and components selected will meet a minimum 75-year design life. Designs will include consideration of appropriate loadings, geometry, and material properties associated with the native soils, backfill, reinforcement connections, facing, and other design elements. MSE wall repair shall be designed to provide minimum factors of safety using the soil parameters as noted below:

Fs=1.5 for global stability    Fs=1.8 for yield strength    Fs=2.0 for bond strength

<table>
<thead>
<tr>
<th>Soil Zone</th>
<th>Friction Angle, $\phi'$</th>
<th>COHESION, $c'$</th>
<th>Unit Weight, $\gamma_m$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforced Backfill</td>
<td>30°</td>
<td>0 psf</td>
<td>120 pcf</td>
</tr>
<tr>
<td>Retained Soil</td>
<td>30°</td>
<td>0 psf</td>
<td>120 pcf</td>
</tr>
<tr>
<td>Foundation Soil</td>
<td>30°</td>
<td>50 psf</td>
<td>120 pcf</td>
</tr>
</tbody>
</table>
B. In addition, any soil nail/facing components must be designed and safety factors applied in accordance with current engineering practices including FHWA Geotechnical Engineering Circular No. 7 except as provided below. Evaluation of slope stability will be performed by a Registered Professional Engineer in the State of Georgia with a background in geotechnical engineering and submitted as part of the design submittals. Plans and working drawings will be submitted by the soil nail installer at least 10 days prior to construction. The design shall be prepared, reviewed, signed and sealed by a Registered Professional Engineer in the State of Georgia. The design engineer must be a permanent member of the soil nail contractor’s staff. Consultants and manufacturer’s representatives may not be used to satisfy the requirements of this section.

1.4 MATERIALS:

A. Soil nails shall be furnished complete and with all accessories, and shall be a standard product of a company regularly engaged in their manufacture. When required, a certificate of compliance and copies of the certified mill report of the soil nail steel, will verify that the nails conform to the requirements of this specification. The materials specified below shall be used for construction of soil nail assemblies and test soil nail assemblies.

B. Reinforcing Steel shall be either:
   1. Solid reinforcing steel bar that conforms to ASTM A615 (grade 75) or ASTM A722 (grade 150). Bars will have a continuous rolled-in pattern of thread like deformations along their length.
   2. Self-drilling Hollow Core Bar consisting of high-grade hollow core steel bar with continuous threaded surface for mechanical coupling, supplied in various lengths.
   3. SuperNails consisting of hollow grade A-36 steel Outer Tubes with a wall thickness of 0.120 inches, a minimum outside diameter of 1.5 inches. Outer Tubes shall be grouted full depth with neat cement grout. An Inner Bar consisting of #6 deformed bar shall be placed full depth inside the Outer Tube immediately after grouting.

C. Corrosion Protection shall be protected by one or more of the following methods:
   1. Epoxy coating conforming to ASTM A934, ASTM A775, or AASHTO M284
   2. Encapsulated in cement grout
   3. Zinc metalized or hot dip galvanized conforming to ASTM A153
   4. Appropriate thickness of sacrificial steel in accordance with current FHWA guidance (note that if sacrificial steel is used, calculations must be submitted with any working drawings).

D. Bearing Plates shall be made from steel conforming to ASTM A36 and painted to match the block color. Grout shall be placed on all four sides of the bearing plates.
E. Hex nuts shall be heavy duty, hexagonal type as per manufacturer’s standard specifications. Hex nuts shall be tapped oversize when additional corrosion protection of epoxy coating is specified. The hex nuts shall be capable of developing 100% of the minimum ultimate tensile strength of the bars.

F. Splice couplers, when required, shall be capable of developing 100% of the minimum ultimate tensile strength of the bars. Couplers shall be tapped oversize when additional corrosion protection of epoxy coating is specified.

G. Centralizers shall be manufactured from PVC and installed as noted on the contract drawings. Centralizers may be omitted if self-drilling hollow core anchors or SuperNails are installed.

H. Wire Mesh Surface treatment shall be Galfan coated high capacity (greater than 5,000 lbs/ft) rockfall mesh post-tensioned to a value determined by the soil nail installer’s engineer.

I. Shotcrete: 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.
   1. 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. Materials for shotcrete shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Component</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>AASHTO M85/ASTM C150, Type I, II, III or V.</td>
</tr>
<tr>
<td>Fine Aggregate</td>
<td>AASHTO M6/ASTM C33 clean, natural.</td>
</tr>
<tr>
<td>Coarse Aggregate</td>
<td>AASHTO M80, Class B for quality</td>
</tr>
<tr>
<td>Water</td>
<td>Clean and Potable. AASHTO M157/ASTM C94</td>
</tr>
<tr>
<td>Chemical Admixtures</td>
<td>Fluid type, applied at nozzle, meeting requirements of AASHTO M194/ASTM C494/ASTM C1141.</td>
</tr>
<tr>
<td>Accelerator</td>
<td>AASHTO M194/ASTM C494 Type A, C, D, E, F, or G Super-plastisizer</td>
</tr>
<tr>
<td>Water-reducer and</td>
<td></td>
</tr>
<tr>
<td>Retarders</td>
<td>AASHTO M194/ASTM C494 Type B or D.</td>
</tr>
</tbody>
</table>
Mineral Admixtures

Fly Ash AASHTO M295/ASTM C618 Type F or C, cement replacement up to 35 percent by weight of cement.

Silica Fume ASTM C1240, 90 percent minimum silicon dioxide solids content, not to exceed 12 percent by weight of cement.

Welded Wire Fabric AASHTO M55/ASTM A185 or A497.

Prepackaged Shotcrete AASHTO M55/ASTM A185 or A497.

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:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>½-inch</td>
<td>100</td>
</tr>
<tr>
<td>3/8-inch</td>
<td>90-100</td>
</tr>
<tr>
<td>No. 4</td>
<td>70-85</td>
</tr>
<tr>
<td>No. 8</td>
<td>50-70</td>
</tr>
<tr>
<td>No. 16</td>
<td>35-55</td>
</tr>
<tr>
<td>No. 30</td>
<td>20-35</td>
</tr>
<tr>
<td>No. 50</td>
<td>8-20</td>
</tr>
<tr>
<td>No. 100</td>
<td>2-10</td>
</tr>
</tbody>
</table>

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.
9. Premixed and packaged shotcrete mix may be provided for on-site mixing. Use packages containing materials conforming to the Materials section of this Appendix.

10. Placing time limit after mixing is per the manufacturers’ recommendations.

1.4 INSTALLATION:

A. Nails may be installed using drilling methods or ballistic launching. Typical soil nail wall construction sequence should be as follows:
   1. Soil nail walls shall be constructed from top down with staged excavation (where required) at each tier of nails.
   2. Install and test pre-production verification nails to confirm design bond strength.
   3. Excavate the first lift of soil nails (applies to blowout section of MSE wall).
   4. Drill, insert and grout first lift of soil nails.
   5. Fabricate C-Channel bearing plate to vertical dimensions required at lift.
   6. Install geotextile, welded wire mesh, and vertical C-channel. Secure C-channel to nail head and attach U-bolts to C-channels at the elevations shown for geogrid anchor pipes. Install anchor pipes.
      ➢ Repeat step 3 through 6 until final soil nail wall height is achieved.
      ➢ Appropriate pullout testing will be required. A nail verification testing plan should be included in the design submittals.

B. Verification Nail Testing:
   1. Pre-production verification shall be performed on 2 soil nails installed with No.7 bars prior to installation of production nails to verify nail pullout resistance. The owner’s on-site engineering representative and wall contractor shall select location of pre-production test nails. Pre-production test nails shall have a bonded length between 9 and 12-feet.
   2. The Design Test Load (DTL) During Verification Testing Shall Be Determined As Follows.

      \[
      \begin{align*}
      DTL &= L_{bv} \times Q_d \\
      L_{bv} &= \text{maximum verification test nail bonded length} \\
      Q_d &= \text{design pullout resistance} = 2.0 \text{ kip/foot} \\
      MTL &= 2 \times DTL
      \end{align*}
      \]

   3. Test Loading Shall Be Performed In Accordance With The Following Schedule:

      | Load | Hold Time |
      |------|-----------|
      | AL (0.05 DTL) | 1 minute  |
0.25 DTL 10 minutes
0.50 DTL 10 minutes
0.75 DTL 10 minutes
1.00 DTL 10 minutes
1.25 DTL 10 minutes
1.50 DTL 60 minutes
1.75 DTL 10 minutes
2.00 DTL (MTL) 10 minutes

a. The alignment load (AL) should be the minimum load required to align the testing apparatus and should not exceed 5 percent of the DTL.

b. Each load increment shall be held at least 10-minutes. The verification test nail shall be monitored for creep at the 1.50 DTL load increment. Nail movements during the creep portion of the test shall be measured and recorded at 1, 2, 3, 4, 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.

4. Verification Test Nail Acceptance Criteria.
   a. A total creep movement of less than 0.08-inch per log cycle of time between 6 and 60-minute readings and the creep rate is linear or decreasing throughout the creep test load hold period.
   b. A pullout failure does not occur at the maximum test load. A pullout failure is defined as the load at which attempts to increase the test load result in continued pullout movement of the test nail. The pullout failure load shall be recorded as part of the test data.
   c. The total measured movement at the maximum test load exceeds 80-percent of the theoretical elastic elongation of the test nail unbounded length.

C. Proof Nail Testing:

1. Proof testing shall be performed on 10 soil nails selected by the owner’s on-site engineering representative and wall contractor. Proof test nails shall have both a bonded and temporary unbounded length. Before testing, only the unbonded length shall be grouted. The temporary unbounded length shall be at least 3.0-feet. The bonded length shall be between 10-feet and 20-feet.

2. The Design Test Load (DTL) During Proof Testing Shall Be Determined As Follows.

\[ DTL = L_{bp} \times Q_d \]

\[ L_{bp} = \text{as built bonded test length} \]

\[ Q_d = \text{design pullout resistance} = 2.0 \text{ kip/foot} \]

3. Test Loading Shall Be Performed In Accordance With The Following Schedule:

<table>
<thead>
<tr>
<th>Load</th>
<th>Hold Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25 DTL</td>
<td>10 minutes</td>
</tr>
<tr>
<td>0.50 DTL</td>
<td>10 minutes</td>
</tr>
<tr>
<td>0.75 DTL</td>
<td>10 minutes</td>
</tr>
<tr>
<td>1.00 DTL</td>
<td>10 minutes</td>
</tr>
<tr>
<td>1.25 DTL</td>
<td>10 minutes</td>
</tr>
<tr>
<td>1.50 DTL</td>
<td>60 minutes</td>
</tr>
<tr>
<td>1.75 DTL</td>
<td>10 minutes</td>
</tr>
<tr>
<td>2.00 DTL (MTL)</td>
<td>10 minutes</td>
</tr>
</tbody>
</table>
The alignment load (AL) should be the minimum load required to align the testing apparatus and should not exceed 5 percent of the DTL.

All load increments shall be maintained within 5 percent of the intended load. Depending on performance, either 10 or 60-minute creep test shall be performed at the maximum test load (1.5 DTL). The creep period shall start as soon as the maximum test load is applied and the nail movement shall be measured and recorded at 1, 2, 3, 4, 5, 6 and 10 minutes. Where the nail movement between 1 and 10 minutes exceeds 0.04-inch, maximum test load shall be maintained and additional 50-minutes and movements shall be recorded at 20, 30, 50 and 60-minutes.

4. **Proof Test Nail Acceptance Criteria.**
   a. A total creep movement of less than 0.04-inch is measured between the 1 and 10 minute reading at 1.5 DTL or a total creep movement of less than 0.08-inch is measured between the 6 and 60-minute reading and the creep rate is linear or decreasing throughout the creep test load hold period.
   b. A pullout failure does not occur at the maximum test load. A pullout failure is defined as the load at which attempts to increase the test load result in continued pullout movement of the test nail. The pullout failure load shall be recorded as part of the test data.
   c. The total measured movement at the maximum test load exceeds 80-percent of the theoretical elastic elongation of the test nail unbounded length.

1.6 **SAFETY:**

A. Soil Nail Installer shall be responsible for meeting all federal, state, and local safety code requirements to include OHSA requirements.

1.7 **WARRANTY:**

A. Soil nail installer shall warrant the stability of the repaired section for a period of not less than five (5) years and provide performance warranty to the owner at the time of bid submittal. This warranty statement shall be jointly endorsed by the contractor and the contractor’s design engineer.

1.8 **PAYMENT:**
A. Method of payment for the MSE wall stabilization system will be lump sum and paid as item soil nail and facing system complete. The pay item includes payment for all portions of the soil nail system including, but not limited to, engineering design, analysis, anchoring connections, facing, and all related materials, labor, inspection, construction, installation, warranty, and warranty correction associated with the wall system.

END OF SECTION