

## PROJECT SPECIAL PROVISIONS

### GEOTECHNICAL

#### **REINFORCED SOIL SLOPES:**

(11-20-12)

#### **Description**

Construct reinforced soil slopes (RSS) consisting of select material and geogrid reinforcement in the reinforced zone with permanent soil reinforcement matting on slope faces. Construct RSS in accordance with the contract and if included in the plans, Standard Drawing No. 1803.01. RSS are required to reinforce embankments and stabilize slopes at locations shown in the plans and as directed. Define “geogrids” as primary or secondary geogrids and “standard RSS” as a RSS that meets the standard reinforced soil slope drawing (Standard Drawing No. 1803.01).

#### **Materials**

Refer to Division 10 of the *Standard Specifications*.

<b>Item</b>	<b>Section</b>
Anchor Pins	1056-2
Select Material	1016
Shoulder and Slope Borrow	1019-2
Wire Staples	1060-8(D)

Unless required otherwise in the plans, use Class I, II or III select material in the reinforced zone for 1.5:1 (H:V) or flatter RSS. For RSS steeper than 1.5:1 (H:V), use Class I select material in the reinforced zone that meets Article 1019-2 of the *Standard Specifications* except for select material that meets AASHTO M 145 for soil classifications A-4 and A-5. Do not use A-4 or A-5 soil or Class II or III select material for RSS steeper than 1.5:1 (H:V).

Use permanent soil reinforcement matting on slope faces of RSS that meets the *Permanent Soil Reinforcement Mat* provision.

#### **(A) Geogrids**

Handle and store geogrids in accordance with Article 1056-2 of the *Standard Specifications*. Define “machine direction” (MD) and “cross-machine direction” (CD) for geogrids in accordance with ASTM D4439. Provide Type 1 material certifications for geogrid strengths in the MD and CD in accordance with Article 1056-3 of the *Standard Specifications*. Test geogrids in accordance with ASTM D6637.

Provide primary and secondary geogrids in accordance with Standard Drawing No. 1803.01 for standard RSS. Otherwise, provide primary and secondary geogrids with design strengths in accordance with the plans.

Use geogrids with a roll width of at least 4 ft. Use primary geogrids with an “approved” status code and secondary geogrids with an “approved” or “approved for provisional use” status code. Do not use geogrids with an “approved for provisional use” status code for primary geogrids.

Geogrids are approved for long-term design strengths for a 75-year design life in the MD and CD based on material type. The list of approved geogrids with long-term design

strengths is available from:

[www.ncdot.org/doh/operations/materials/soils/gep.html](http://www.ncdot.org/doh/operations/materials/soils/gep.html)

Define material type from the website above for select material as follows:

Material Type	Select Material
Borrow	Class I Select Material
Fine Aggregate	Class II or Class III Select Material

If an approved geogrid does not list long-term design strengths in the MD for the select material used, do not use the geogrid for primary geogrid. If an approved geogrid does not list long-term design strengths in the CD for the select material used, do not use the geogrid for secondary geogrid.

### Construction Methods

Before starting RSS construction, the Engineer may require a preconstruction meeting to discuss the construction and inspection of the RSS. If required, schedule this meeting after all material certifications have been submitted. The Resident or District Engineer, Roadway Construction Engineer, Geotechnical Operations Engineer, Contractor and RSS Contractor Superintendent will attend this preconstruction meeting.

Control drainage during construction in the vicinity of RSS. Direct run off away from RSS, select material and backfill. Contain and maintain select material and backfill and protect material from erosion.

Excavate as necessary for RSS in accordance with the contract. Maintain a horizontal clearance of at least 12" between the ends of primary geogrids and limits of reinforced zone as shown in the plans. When excavating existing slopes, bench slopes in accordance with Subarticle 235-3(A) of the *Standard Specifications*. Notify the Engineer when excavation is complete. Do not place primary geogrids until excavation dimensions and in-situ material are approved.

Place geogrids within 3" of locations shown in the plans and in slight tension free of kinks, folds, wrinkles or creases. Hold geogrids in place with wire staples or anchor pins as needed. Install geogrids with the orientation, dimensions and number of layers shown in the plans. Contact the Engineer when existing or future obstructions such as foundations, pavements, pipes, inlets or utilities will interfere with geogrids. If necessary, the top geogrid layer may be lowered up to 9" to avoid obstructions. Extend geogrids to slope faces.

Install primary geogrids with the MD perpendicular to the embankment centerline. The MD is the direction of the length or long dimension of the geogrid roll. Unless shown otherwise in the plans, do not splice or overlap primary geogrids in the MD so splices or overlaps are parallel to toe of RSS. Unless shown otherwise in the plans and except for clearances at the ends of primary geogrids, completely cover select material at each primary geogrid layer with geogrid so primary geogrids are adjacent to each other in the CD, i.e., perpendicular to the MD. The CD is the direction of the width or short dimension of the geogrid roll.

Install secondary geogrids with MD parallel to toe of RSS. Secondary geogrids should be continuous for each secondary geogrid layer. If secondary geogrid roll length is too short, overlap ends of secondary geogrid rolls at least 12" in the direction that select material will be placed to prevent lifting the edge of the top geogrid.

Place select material in the reinforced zone in 8" to 10" thick lifts and compact material in accordance with Subarticle 235-3(C) of the *Standard Specifications*. For RSS steeper than 1.5:1 (H:V), compact slope faces with an approved method. Do not use sheepsfoot, grid rollers or other types of compaction equipment with feet. Do not displace or damage geogrids when placing and compacting select material. End dumping directly on geogrids is not permitted. Do not operate heavy equipment on geogrids until they are covered with at least 8" of select material. To prevent damaging geogrids, minimize turning and avoid sudden braking and sharp turns with compaction equipment. Replace any damaged geogrids to the satisfaction of the Engineer. Construct remaining portions of embankments outside the reinforced zone in accordance with Section 235 of the *Standard Specifications*.

Plate slope faces of RSS with at least 6" of shoulder and slope borrow except when select material in the reinforced zone meets Article 1019-2 of the *Standard Specifications*. Install permanent soil reinforcement matting in accordance with the *Permanent Soil Reinforcement Mat* provision to minimize sloughing of RSS until vegetation is established. Seed slope faces and install permanent soil reinforcement matting as soon as possible to prevent erosion damage to slope faces of RSS. If damage occurs, repair RSS and reseed slope faces before installing matting.

#### **Measurement and Payment**

*Reinforced Soil Slopes* will be measured and paid in square yards. RSS will be measured along the slope faces of RSS before installing permanent soil reinforcement matting as the square yards of RSS. No payment will be made for repairing damaged RSS.

The contract unit price for *Reinforced Soil Slopes* will be full compensation for providing labor, tools, equipment and RSS materials, compacting select materials and supplying and placing geogrids, select material, shoulder and slope borrow and any incidentals necessary to construct RSS except for permanent soil reinforcement matting. The contract unit price for *Reinforced Soil Slopes* will also be full compensation for excavating and hauling and removing excavated materials to install RSS.

Permanent soil reinforcement matting will be measured and paid in accordance with the *Permanent Soil Reinforcement Mat* provision.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Reinforced Soil Slopes	Square Yard

**STANDARD SHORING:**

(1-17-12)

**Description**

Standard shoring includes standard temporary shoring and standard temporary mechanically stabilized earth (MSE) walls. At the Contractor's option, use standard shoring as noted in the plans or as directed. When using standard shoring, a temporary shoring design submittal is not required. Construct standard shoring based on actual elevations and shoring dimensions in accordance with the contract and Standard Drawing No. 1801.01 or 1801.02.

Define "standard temporary shoring" as cantilever shoring that meets the standard temporary shoring drawing (Standard Drawing No. 1801.01). Define "standard temporary wall" as a temporary MSE wall with geotextile or geogrid reinforcement that meets the standard temporary wall drawing (Standard Drawing No. 1801.02). Define "standard temporary geotextile wall" as a standard temporary wall with geotextile reinforcement and "standard temporary geogrid wall" as a standard temporary wall with geogrid reinforcement. Define "geosynthetics" as geotextiles or geogrids.

Provide positive protection for standard shoring at locations shown in the plans and as directed. See *Temporary Shoring* provision for positive protection types and definitions.

**Materials**

Refer to the *Standard Specifications*.

<b>Item</b>	<b>Section</b>
Anchor Pins	1056-2
Concrete Barrier Materials	1170-2
Flowable Fill, Excavatable	1000-6
Geotextiles	1056
Neat Cement Grout	1003
Portland Cement Concrete	1000
Select Material	1016
Steel Beam Guardrail Materials	862-2
Steel Sheet Piles and H-Piles	1084
Untreated Timber	1082-2
Welded Wire Reinforcement	1070-3
Wire Staples	1060-8(D)

Provide Type 6 material certifications for shoring materials. Use Class IV select material (standard size No. ABC) for temporary guardrail.

For drilled-in H-piles, use nonshrink neat cement grout or Class A concrete that meets Article 1000-4 of the *Standard Specifications* except as modified herein. Provide concrete with a slump of 6" to 8". Use an approved high-range water reducer to achieve this slump.

Based on actual shoring height, positive protection, groundwater elevation, slope or surcharge case and traffic impact at each standard temporary shoring location, use sheet piles with the minimum required section modulus or H-piles with the sizes shown in Standard Drawing No. 1801.01. Use untreated timber with a thickness of at least 3" and a bending stress of at least 1,000 psi for timber lagging.

**(A) Shoring Backfill**

Use Class II, Type 1, Class III, Class V or Class VI select material or material that meets AASHTO M 145 for soil classification A-2-4 with a maximum PI of 6 for shoring backfill except do not use the following:

- (1) A-2-4 soil for backfill around culverts,
- (2) A-2-4 soil in the reinforced zone of standard temporary walls with a back slope and
- (3) Class VI select material in the reinforced zone of standard temporary geotextile walls.

**(B) Standard Temporary Walls**

Use welded wire reinforcement for welded wire facing, struts and wires with the dimensions and minimum wire sizes shown in Standard Drawing No. 1801.02. Provide Type 2 geotextile for separation and retention geotextiles. Define “machine direction” (MD) and “cross-machine direction” (CD) for geosynthetics in accordance with ASTM D4439. Do not use more than 4 different reinforcement strengths for each standard temporary wall.

**(1) Geotextile Reinforcement**

Provide Type 5 geotextile for geotextile reinforcement with a mass per unit area of at least 8 oz/sy in accordance with ASTM D5261. Based on actual wall height, groundwater elevation, slope or surcharge case and shoring backfill type in the reinforced zone at each standard temporary geotextile wall location, provide geotextile reinforcement with wide width tensile strengths at ultimate in the MD as shown in Standard Drawing No. 1801.02. Also provide geotextile reinforcement with wide width tensile strengths at ultimate in the CD as shown in Standard Drawing No. 1801.02 if reinforcement is installed with the MD parallel to the wall face.

**(2) Geogrid Reinforcement**

Handle and store geogrids in accordance with Article 1056-2 of the *Standard Specifications*. Based on actual wall height, groundwater elevation, slope or surcharge case and shoring backfill type in the reinforced zone at each standard temporary geogrid wall location, provide geogrids for geogrid reinforcement with short-term design strengths in the MD as shown in Standard Drawing No. 1801.02. Also provide geogrids for geogrid reinforcement with short-term design strengths in the CD as shown in Standard Drawing No. 1801.02 if reinforcement is installed with the MD parallel to the wall face.

Use geogrids with a roll width of at least 4 ft and an “approved” or “approved for provisional use” status code. Geogrids are approved for short-term design strengths for a 3-year design life in the MD and CD based on material type. The list of approved geogrids with short-term design strengths is available from: [www.ncdot.org/doh/operations/materials/soils/gep.html](http://www.ncdot.org/doh/operations/materials/soils/gep.html)

Define material type from the website above for shoring backfill as follows:

<b>Material Type</b>	<b>Shoring Backfill</b>
Borrow	A-2-4 Soil
Fine Aggregate	Class II, Type 1 or Class III Select Material
Coarse Aggregate	Class V or VI Select Material

If an approved geogrid does not list a short-term design strength in the MD for the shoring backfill used, do not use the geogrid for geogrid reinforcement. If an approved geogrid does not list a short-term design strength in the CD for the shoring backfill used, do not install the geogrid with the MD parallel to the wall face.

### **Preconstruction Requirements**

#### **(A) Concrete Barrier**

Define “clear distance” behind concrete barrier as the horizontal distance between the barrier and edge of pavement. The minimum required clear distance for concrete barrier is shown in the plans. At the Contractor’s option or if the minimum required clear distance is not available, set concrete barrier next to and up against traffic side of standard shoring except for barrier above standard temporary walls. Concrete barrier with the minimum required clear distance is required above standard temporary walls.

#### **(B) Temporary Guardrail**

Define “clear distance” behind temporary guardrail as the horizontal distance between guardrail posts and standard shoring. At the Contractor’s option or if clear distance for standard temporary shoring is less than 4 ft, attach guardrail to traffic side of shoring as shown in the plans. Place ABC in clear distance and around guardrail posts instead of pavement. Do not use temporary guardrail above standard temporary walls.

#### **(C) Standard Shoring Selection Forms**

Before beginning standard shoring construction, survey existing ground elevations in the vicinity of standard shoring locations to determine actual shoring or wall heights (H). Submit a standard shoring selection form for each location at least 7 days before starting standard shoring construction. Standard shoring selection forms are available from: [www.ncdot.org/doh/preconstruct/highway/geotech/formdet/](http://www.ncdot.org/doh/preconstruct/highway/geotech/formdet/)

#### **(D) Preconstruction Meeting**

The Engineer may require a shoring preconstruction meeting to discuss the construction and inspection of the standard shoring. If required, schedule this meeting after all standard shoring selection forms have been submitted. The Resident, District or Bridge Maintenance Engineer, Bridge or Roadway Construction Engineer, Geotechnical Operations Engineer, Contractor and Shoring Contractor Superintendent will attend this preconstruction meeting.

### **Construction Methods**

Construct standard shoring in accordance with the *Temporary Shoring* provision.

#### **(A) Standard Temporary Shoring Installation**

Based on actual shoring height, positive protection, groundwater elevation, slope or surcharge case and traffic impact at each standard temporary shoring location, install piles with the minimum required embedment and extension for each shoring section in accordance with Standard Drawing No. 1801.01. For concrete barrier above and next to standard temporary shoring and temporary guardrail above and attached to standard temporary shoring, use "surcharge case with traffic impact" in accordance with Standard Drawing No. 1801.01. Otherwise, use "slope or surcharge case with no traffic impact" in accordance with Standard Drawing No. 1801.01. If refusal is reached before driven piles attain the minimum required embedment, use drilled-in H-piles with timber lagging for standard temporary shoring.

**(B) Standard Temporary Walls Installation**

Based on actual wall height, groundwater elevation, slope or surcharge case, geotextile or geogrid reinforcement and shoring backfill type in the reinforced zone at each standard temporary wall location, construct walls with the minimum required reinforcement length and number of reinforcement layers for each wall section in accordance with Standard Drawing No. 1801.02. For standard temporary walls with pile foundations in the reinforced zone, drive piles through reinforcement after constructing temporary walls.

For standard temporary walls with interior angles less than 90°, wrap geosynthetics at acute corners as directed by the Engineer. Place geosynthetics as shown in Standard Drawing No. 1801.02. Place separation geotextiles between shoring backfill and backfill, natural ground or culverts along the sides of the reinforced zone perpendicular to the wall face. For Class V or VI select material in the reinforced zone, place separation geotextiles between shoring backfill and backfill or natural ground on top of and at the back of the reinforced zone.

**Measurement and Payment**

Standard shoring will be measured and paid in accordance with the *Temporary Shoring* provision.

**SOIL NAIL SLOPE STABILIZATION****(SPECIAL)****1.0 GENERAL****A. Description**

A soil nail is defined as a steel bar grouted in a drilled hole inclined at an angle below horizontal. Soil nail slope stabilization consists of soil nails spaced at a regular pattern and connected to a flexible, steel wire mesh facing. Construct soil nail slope stabilization based on actual elevations and dimensions in accordance with this provision, the accepted submittals and the plans. For this provision, "Soil Nail Slope Stabilization Contractor" refers to the contractor installing the soil nails and applying the facing.

**2.0 SUBMITTALS**

Two submittals are required. These submittals include (1) Soil Nail Slope Stabilization Contractor personnel and experience and (2) soil nail slope stabilization installation and testing plan. Provide 11 hard copies of working drawings and 4 hard copies of the remaining submittals. Also, submit an electronic copy (pdf or jpeg format on CD or DVD) of each submittal. Allow 10 calendar days for the review of the Soil Nail Slope Stabilization Contractor personnel and experience submittal. After the personnel and experience submittal is accepted, submit the remaining submittals at least 30 calendar days before starting soil nail slope stabilization construction. Do not begin soil nail slope stabilization construction including sacrificial soil nails for verification tests until the installation and testing plan is accepted.

**A. Soil Nail Slope Stabilization Contractor Personnel and Experience Submittal**

Use a Soil nail slope stabilization Contractor prequalified by the Construction Unit of the Department for anchored retaining walls work (work code 3020). Submit documentation that the Soil Nail Slope Stabilization Contractor has successfully completed at least 5 soil nail retaining wall projects and 500 soil nails within the last 3 years with an exposed face area for all 5 walls of at least 10,000 ft<sup>2</sup> (930 m<sup>2</sup>). Documentation should include the General Contractor and Owner's name and current contact information with descriptions of each past project.

Provide the names of the Superintendent and Project Manager that will be assigned to this project. Submit documentation for these personnel verifying employment with the Soil Nail Slope Stabilization Contractor. Submit documentation that the Superintendent and Project Manager each have a minimum of 5 years experience in soil nail construction with past projects of scope and complexity similar to that anticipated for this project. Documentation should include resumes, references, certifications, project lists, experience descriptions and details, etc. Perform work with the personnel submitted and accepted. If personnel changes are required during construction, suspend soil nail slope stabilization construction until replacement personnel are submitted and accepted.



## B. Soil Nail Slope Stabilization Installation and Testing Plan Submittal

Submit detailed project specific information including the following.

1. Excavation methods and equipment.
2. List and sizes of proposed drilling rigs and tools, tremies and grouting equipment.
3. Sequence and step-by-step description of soil nail slope stabilization construction including details of drilling and grouting methods, soil nail installation and facing construction.
4. Examples of construction and test nail records to be provided in accordance with Sections 6.0 and 7.0, Item F, respectively.
5. Grout mix design including laboratory test results in accordance with the Grout for Structures Special Provision and acceptable ranges for grout flow and density.
6. Soil nail testing details, procedures and plan sealed by a Professional Engineer registered in North Carolina with calibration certificates within one year of submittal date in accordance with Section 7.0.
7. Other information shown on the plans or requested by the Engineer.

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

## 3.0 MATERIALS

Provide Type 3 Manufacturer's Certifications in accordance with Article 106-3 of the *Standard Specifications* for soil nail materials.

### A. Soil Nails

Store steel materials on blocking a minimum of 12" (300 mm) 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. Do not crack, fracture or otherwise damage grout inside sheathing of shop grouted encapsulated soil nails.

Use galvanized deformed steel bars meeting the requirements of AASHTO M31, Grade 75 (520) or M275. Splice bars in accordance with Article 1070-10 of the *Standard Specifications*. Minimum bar size allowed will be #6.

Fabricate bar centralizers from schedule 40 polyvinyl chloride (PVC) plastic pipe or tube, steel or other material not detrimental to steel bars (no wood). Size centralizers to

position the bar within 1" (25 mm) of the drill hole center and allow a tremie to be inserted to the bottom of the hole. Use centralizers that do not interfere with grout placement or flow around soil nail bars. For encapsulated bars, centralizers are required both inside and outside of encapsulation.

Use grout in accordance section 1003-3 of the *Standard Specifications*.

#### B. Wire Mesh, Connectors and Anchor Plates

At the Contractor's option, use galvanized steel plates recommended by the Wire Mesh/Net Manufacturer instead of anchor plates required above to anchor wire mesh or nets to excavation or slope faces.

Provide support ropes to suspend wire mesh or nets from rock anchors. At the Contractor's option and when noted in the plans, suspend wire mesh or nets from grouted rope anchors instead of rock anchors and connect rope anchors to support ropes with shackles.

Provide any wire mesh and net components or hardware not addressed in this provision in accordance with the Wire Mesh/Net Manufacturer's recommendations. Galvanize steel components not addressed in this provision in accordance with Section 1076 of the *Standard Specifications*.

#### Hardware

Use shackles that meet Federal Specification RR-C-271, Type IVA or IVB, Grade B, Class 2 or 3 with a zinc-coated finish. Use thimbles that meet Federal Specification FF-T-276, Type III and clamps, i.e., U-bolt wire rope clips that meet Federal Specification FF-C-450, Type I, Class 1. Provide shackles, thimbles and clamps of a size recommended by the Wire Mesh/Net Manufacturer.

#### Steel Wire and Wire Ropes

For double-twisted hexagonal mesh wires, use carbon steel wires that meet ASTM A641, Class 3 or A Coating or better with a tensile strength of 75,000 psi. For high-strength wires, use cold-drawn nonalloy or hard-drawn carbon steel wires that meet either of the following:

- (a) ASTM A764, Tensile Class I or II with coating that meets ASTM A856, Class 3 or A Coating or better or
- (b) European Standard EN 10264-2, Grade 1370 or better, Class A or B Coating.

Use galvanized stranded carbon steel wire ropes with a steel core (SC) that meet ASTM A1023 for wire ropes. Use wire ropes with an independent wire rope core (IWRC), 6×19 construction, at least 1/2" diameter and minimum breaking force recommended by the Wire Mesh/Net Manufacturer for boundary and support

ropes and rope anchors. Use wire ropes with 7×7 or 7×19 construction, at least 5/16" diameter and minimum breaking force recommended by the Wire Mesh/Net Manufacturer for lacing cables, seam and perimeter ropes and wire nets.

#### Wire Mesh

Provide high-strength mesh or double-twisted hexagonal mesh with wire ropes woven into mesh, if necessary for wire mesh. Use double-twisted hexagonal mesh that meets ASTM A975 and high-strength wires for high-strength mesh. Use boundary or perimeter ropes at ends of wires or fasten ends of wires together to prevent wire mesh from unraveling. Provide wire mesh types in accordance with the contract. Use wire mesh with properties that meet the following:

<b>WIRE MESH REQUIREMENTS</b>			
<b>Property</b>	<b>Requirement</b>		
	<b>Type 1</b>	<b>Type 2</b>	<b>Type 3</b>
Minimum Mesh Tensile Strength in Longitudinal Direction <sup>A</sup>	3,500 lb/ft	8,900 lb/ft	8,900 lb/ft
Minimum Mesh Tensile Strength in Transverse Direction <sup>B</sup>	1,400 lb/ft	3,400 lb/ft	6,200 lb/ft
Maximum Mesh Opening Width	4"		
Minimum Double-Twisted Hexagonal Mesh Wire Diameter	ASTM A975, Table 1 (8 by 10 mesh type)		
Minimum High-Strength Wire Diameter	0.079" (2 mm)	0.118" (3 mm)	0.157" (4 mm)

A. Direction of largest mesh opening

B. Direction perpendicular to longitudinal direction

Provide lacing cables, seam ropes, hog rings or connection clips to lace, seam or connect wire mesh sections together. Use fasteners, i.e., hog rings that meet ASTM A975 and connection clips consisting of high-strength wires with a wire diameter of at least 0.118" (3 mm). Weave lacing cables or seam ropes or install hog rings or connection clips in accordance with the plans and Wire Mesh Manufacturer's instructions.

#### 4.0 SOIL NAIL SLOPE STABILIZATION PRECONSTRUCTION MEETING

Before starting soil nail slope stabilization construction, conduct a preconstruction meeting to discuss the construction and inspection of the soil nail slope stabilizations. Schedule this meeting after all soil nail slope stabilization submittals have been accepted. The Resident or Bridge Maintenance Engineer, Bridge Construction Engineer, Geotechnical Operations Engineer, General Contractor and the Soil Nail Slope Stabilization Contractor Superintendent, and Project Manager will attend this preconstruction meeting.

## 5.0 CONSTRUCTION METHODS

Perform all necessary clearing and grubbing in accordance with Section 200 of the *Standard Specifications*. Perform any blasting in accordance with the contract special provisions. Do not excavate beyond the face of the soil nail slope stabilization.

Use equipment and methods reviewed and accepted in the installation and testing plan or approved by the Engineer. Inform the Engineer of any deviations from the accepted plan.

### A. Excavation

Construct the soil nail slope stabilization from the top down. Excavate in staged horizontal lifts with heights not to exceed the vertical soil nail spacing. The excavated surface must be to the grades of the project drawings for the slope. Do not excavate the slope more than 3 feet (1 m) below the level of the row of nails to be installed in that lift. Do not excavate a lift until nail installation and nail testing for the preceding lift are complete and acceptable to the Engineer. After a lift is excavated, clean the cut surface of all loose materials, mud, and other foreign material. The excavated face cannot be unprotected for more than 24 hours for any reason. Prior to advancing the excavation, allow nail grout on the preceding lift to achieve the required 3 day compressive strength.

If the excavation face becomes unstable at any time, suspend soil nail slope stabilization construction and temporarily stabilize the face by immediately placing an earth berm against the unstable face. Soil nail slope stabilization construction may not proceed until the conditions have been reviewed by the Engineer. A revised soil nail slope stabilization installation and testing plan submittal may be required after the slope conditions have been reviewed.

Take all necessary measures to ensure that installed nails are not damaged during excavation. Repair or replace to the satisfaction of the Engineer and at no cost to the Department nails that are damaged or disturbed during excavation.

### B. Installation of Wire Mesh and Bearing Plates

Prior to installing wire mesh, excavate depression around each nail location as shown in plans. Install wire mesh in accordance with the drawings and manufacturer's specifications, including any required overlapping.

Following soil installation, connect the bearing plates to the nails as shown on the plans and as directed by the Engineer. Replace bearing plates, nuts or washers that are damaged or defective as determined by the Engineer at no additional cost to the Department. Once the bearing plates and nuts have been attached to the nails, tighten each nut until they have reached a torque reading of 265 ft-lbs.

### C. Soil Nail Installation

Install soil nails in the same way as acceptable verification test nails. Drill and grout soil nails the same day and do not leave drill holes open overnight. Install supplemental soil nails, as directed by the Engineer, to a depth of 10 feet beyond the slope face through the wire mesh to improve contact with the slope face.

Control drilling and grouting to prevent excessive ground movements, damaging structures and fracturing rock and soil formations. If ground heave or subsidence occurs, suspend soil nail slope stabilization construction and take action to minimize movement. If structures are damaged, suspend construction and repair structures at no additional cost to the Department with a method proposed by the Contractor and accepted by the Engineer. The Engineer may require a revised soil nail slope stabilization installation and testing plan when corrective action is necessary.

#### 1. Drilling

Use drilling rigs capable of drilling through whatever materials are encountered to the dimensions and orientations required for the soil nail slope stabilization design. Drill straight and clean holes at the locations shown in the accepted submittals. Drill hole locations and inclinations are required to be within 6" (150 mm) and 2 degrees, respectively, of that shown in the accepted submittals unless approved otherwise by the Engineer.

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.

Using manufacturer approved methods, increase the opening in the wire mesh to allow installation of the soil nail through the mesh.

#### 2. Soil Nail Bars

Use centralizers to center steel bars in drill holes. Securely attach centralizers at maximum 8 ft (2.4 m) intervals along bars. Attach upper and lowermost centralizers 24" (450 mm) from the top and bottom of the bars.

Before placing soil nail bars, allow the Engineer to check location, orientation and cleanliness of drill holes. Provide steel bars as shown in the accepted submittals and insert bars without difficulty or forcing insertion. Do not vibrate or drive soil nail bars. If a bar can not be completely inserted easily, remove the bar and clean or redrill the hole.

#### 3. Grouting

Remove all oil, rust inhibitors, residual drilling fluids and similar foreign materials from holding tanks/hoppers, stirring devices, pumps, lines, tremie pipes and all other equipment in contact with grout before use.

Place grout with a tremie in accordance with the contract and accepted submittals. Inject grout at the lowest point of drill holes through a tremie pipe, e.g., grout tube, casing, hollow-stem auger or drill rod, in one continuous operation. Fill drill holes progressively from the bottom to top and withdraw tremie at a slow even rate as the hole is filled to prevent voids in the grout. Extend tremie pipe into grout a minimum of 5 ft (1.5 m) at all times except when grout is initially placed in a drill hole.

Provide grout free of segregation, intrusions, contamination, structural damage or inadequate consolidation (honeycombing). Cold joints in grout are not allowed except for soil nails that are tested. Extract temporary casings as grout is placed. Monitor and record grout volumes during placement.

Bar threads should be kept clean to allow tightening of the anchor plate and nut.

## **6.0 CONSTRUCTION RECORDS**

Provide 2 original hard copies of soil nail slope stabilization construction records including the following within 24 hours of completing each lift.

1. Names of Soil Nail Slope Stabilization Contractor, Superintendent, Nozzleman, Drill Rig Operator, and Project Manager.
2. Description, county, NCDOT contract, TIP and WBS element number
3. Stations and lift location, dimensions, elevations and description
4. Soil nail locations, diameters, lengths and inclinations, bar types, sizes and grades, corrosion protection and temporary casing information
5. Date and time drilling begins and ends, soil nail bar is placed, grout is mixed and/or arrives on-site, grout placement 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
9. All other pertinent details related to soil nail slope stabilization construction

After completing all lifts for a soil nail slope stabilization or a stage of a soil nail slope stabilization, submit electronic copies (pdf or jpg format on CD or DVD) of all corresponding construction records.

## **7.0 SOIL NAIL TESTING**

For this provision, “verification tests” are performed on test nails not incorporated into the work, i.e., sacrificial soil nails “Verification test nails” refer to soil nails on which

verification tests are performed and “proof test nails” refer to soil nails on which proof tests are performed.

One verification test is required at each soil nail slope stabilization location, or as directed by the Engineer. The Engineer will select the test location in the field. Proof tests on 5 percent of production soil nails with a minimum of 1 test per nail row are required. More or less soil nail testing may be required depending on the subsurface conditions encountered. The Engineer will decide the actual number and specific locations of each verification and proof test required.

Do not test soil nails until grout achieves the required 3 day compressive strength. Do not begin construction of any production soil nails until verification tests are satisfactorily completed.

#### A. Testing Equipment

Use testing equipment that includes the following.

- 2 dial gauges
- dial gauges rigid supports
- hydraulic jack and pressure gauge
- electronic load cell
- jacking block or reaction frame

Provide pressure gauges graduated in 100 psi (690 kPa) increments or less. Use dial gauges capable of measuring to 0.001” (0.025 mm) and accommodating the maximum anticipated movement. Submit identification number and calibration records for each load cell, jack and pressure gauge with the soil nail slope stabilization installation and testing plan. Calibrate the jack and pressure gauge as a unit.

Align testing equipment to ensure uniform loading. Use a jacking block or reaction frame that does not damage the slope or contact the slope face within 3 ft (1 m) of test nails. Align dial gauges within 5 degrees of the test nail axis. Place dial gauges opposite each other on either side of the test nail. Set up test equipment and measuring devices such that resetting or repositioning the components before completing testing is not required. A load cell is not required for proof tests if the same jack and pressure gauge are used for verification tests.

#### B. Test Nails

Test nails have both bonded and unbonded lengths. Grout only the bonded length before testing. Minimum bonded and unbonded lengths of 10 ft (3 m) and 5 ft (1 m), respectively, are required.

Soil nail bars for production soil nails may be overstressed under higher test nail loads. Use larger or higher grade steel bars to allow for higher loads instead of shortening bond lengths to less than the minimum. Any costs associated with higher capacity bars will be considered incidental to the soil nail testing pay items.

### C. Verification Tests

Install sacrificial soil nails in accordance with the accepted submittals and this provision. Use the same equipment, methods and drill hole diameter for sacrificial soil nails as will be used for production soil nails.

Use the following equation to determine maximum bond length for verification test nails,  $L_{BVT}$  (ft or m).

$$L_{BVT} \leq \frac{C_{RT} \times A_t \times f_y}{Q_{ALL} \times 3}$$

Where,

$C_{RT}$  = reduction coefficient, 0.9 for Grade 60 and 75 (420 and 520) bars or 0.8 for Grade 150 (1035) bars,

$A_t$  = bar area (in<sup>2</sup> or m<sup>2</sup>),

$f_y$  = bar yield stress (ksi or kPa) and

$Q_{ALL}$  = allowable unit grout/ground bond strength (kips/ft or kN/m).

Use the following equation to determine design verification test load, DTL (kips or kN).

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

Calculate DTL based on as-built bond lengths. Perform verification tests by incrementally loading test nails to failure or a maximum test load of 300 percent of DTL according to the following schedule.

Load	Hold Time
AL*	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 (creep test)
1.75 DTL	10 minutes
2.00 DTL	10 minutes
2.50 DTL	10 minutes
3.00 DTL	10 minutes
AL*	1 minute

\*Alignment load (AL) is the minimum load required to align testing equipment and should not exceed 0.05 DTL.



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 test nails for creep at the 1.50 DTL load increment. Measure and record test nail movement during the creep portion of the test at 1, 2, 3, 5, 6, 10, 20, 30, 50 and 60 minutes. Repump jack as needed to maintain the intended load during hold times.

#### D. Proof Tests

Use the following equation to determine maximum bond length for proof test nails,  $L_{BPT}$  (ft or m).

$$L_{BPT} \leq \frac{C_{RT} \times A_t \times f_y}{Q_{ALL} \times 1.5}$$

Where variables are as defined in Item C of this section.

Use the following equation to determine design proof test load, DTL (kips or kN).

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

Calculate DTL based on as-built bond lengths. Perform proof tests by incrementally loading test nails to failure or a maximum test load of 150 percent of DTL according to the following schedule.

Load	Hold Time
AL*	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	10 or 60 minutes (creep test)
AL*	1 minute

\*Alignment load (AL) is the minimum load required to align testing equipment and should not exceed 0.05 DTL.

Reset dial gauges to zero after applying alignment load. Record test nail movement at each load increment and monitor test nails for creep at the 1.50 DTL load increment. Measure and record test nail movement at 1, 2, 3, 5, 6 and 10 minutes. When the test nail movement between 1 minute and 10 minutes exceeds 0.04" (1 mm), maintain the maximum test load for an additional 50 minutes and record movements at 20, 30, 50 and 60 minutes. Repump jack as needed to maintain the intended load during hold times.

#### E. Test Nail Acceptance

Test nail acceptance is based on the following criteria.

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

Maintain stability of test nail unbonded lengths for subsequent grouting. If the test nail unbonded length of a proof test nail can not be satisfactorily grouted after testing, do not incorporate the test nail into the work and replace the nail with another production soil nail at no additional cost to the Department.

#### F. Test Nail Results

Submit 2 original hard copies of test nail records including load versus movement curves within 24 hours of completing each test. The Engineer will review the test nail records and associated construction records to determine if the test nail is acceptable.

If the Engineer determines a verification test nail is unacceptable, the Engineer may revise the soil nail slope stabilization design and/or installation methods. The Engineer will have up to 10 working days to revise the soil nail slope stabilization design and/or installation and testing plan at no additional cost to the Department.

If the Engineer determines a proof test nail is unacceptable as a result of the contractor's activities, then either additional proof tests on adjacent production soil nails or a revision to the soil nail slope stabilization design and/or installation methods for the production soil nails represented by the unacceptable proof test nail may be required at no additional cost to the Department. If required, remove representative production soil nails and provide new production soil nails with the revised design and/or installation methods at no additional cost to the Department.

After completing all soil nail testing, submit electronic copies (pdf or jpg format on CD or DVD) of all corresponding testing records.

**8.0 MEASUREMENT AND PAYMENT**

*Soil Nail Slope Stabilization* will be measured and paid for at the contract unit price per square yard (square meter) of the slope stabilization system measured along the surface of the slope that has been incorporated into the completed and accepted work.

Include in the unit bid price for *Soil Nail Slope Stabilization* all costs for submittals, furnishing labor, tools, equipment and materials, excavating lifts, installing soil nails, grouting, wire mesh and any incidentals necessary to design and construct soil nail slope stabilization in accordance with this provision.

*Supplemental Soil Nails* will be measured and paid for at the contract unit price per each to construct additional soil nails into the completed and accepted work. Include in the unit bid price all costs for furnishing labor, tools, equipment and materials, installing soil nails, grouting, and any incidentals necessary to construct supplemental soil nails in accordance with this provision. No payment will be made for supplemental soil nails that are required due to Contractor negligence during excavation.

*Soil Nail Verification Tests* and *Soil Nail Proof Tests* will be measured and paid for per each, depending on the type of test. Include in these unit bid prices all costs for soil nail testing in accordance with Section 7.0 of this provision. The Department will only pay for the initial verification or proof test on an initial test nail required by the Engineer; no payment will be made for subsequent tests performed on the same test nail or replacement test nails.

<b>Pay Item</b>	<b>Pay Unit</b>
Soil Nail Slope Stabilization	Square Yard (Square Meter)
Supplemental Soil Nails	Each
Soil Nail Verification Tests	Each
Soil Nail Proof Tests	Each

