



TEXAS TECH UNIVERSITY

Multidisciplinary Research in Transportation

Non-destructive Testing of Installed Soil Nails Using Sonic Echo Test Method

Specifications for Grouting Mixtures and Procedures for Soil Nail Installations

Research Project Number 0-4484
Research Product Number 0-4484-P3

Priyantha Jayawickrama and John Turner

Performed in Cooperation with the Texas Department of Transportation
and the Federal Highway Administration

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SPECIAL SPECIFICATION

4116

Soil Nail Anchors

1. **Description.** Construct reinforced soil nail anchors in place.
2. **Materials.** Provide materials conforming to the following requirements.
 - (1) **Hydraulic Cement Concrete.** Use materials that meet the requirements of Item 421, "Hydraulic Cement Concrete." Provide a neat cement or sand cement mixture for the grout for soil nail anchors with a 7-day compressive strength of 3,000 psi. Determine grout strength by testing the grout used for the test soil nail anchors in cubes in accordance with Test Method Tex-307-D or cylinders in accordance with Test Method Tex-418-A. Test further as directed or if the grout mixture is modified. If allowed, use test results from previous projects using an identical grout mix.

When a sand cement mixture is used for grouting soil nail anchors, the grout mixture shall have a minimum slump flow of 20-inches. The slump flow of the grout shall be tested in accordance with ASTM C 1611-Test Method for Slump Flow of Self-Consolidating Concrete.

Do not use mobile continuous volumetric mixed grout.

- (2) **Reinforcing Steel.** Use materials that meet the requirements of Item 440, "Reinforcing Steel." Provide epoxy-coated reinforcing steel bar of the size and grade shown on the plans.
 - (3) **Nail Centralizers.** Provide expanded slit PVC centralizers with a minimum diameter of 1 in. less than the nail-hole. Wheel type centralizers will not be allowed.
3. **Equipment.** Furnish suitable equipment to drill the holes to the specified diameter, depth, and line. Provide a continuous flight auger. On walls where open-hole grouting cannot be accomplished, use hollow stem auger equipment.

If an auger becomes worn to the degree that the drilled hole is less than the required diameter, remove the auger from service. Do not return the auger to service until it is repaired and can provide a hole of at least the required diameter.

Furnish a hydraulic jack and reaction frame for stressing test soil nail anchors.

Furnish a grout mixer and pump of sufficient capacity to place grout properly in the required quantities. The grout pump volumetric flow rate should be compatible with the flowability characteristics of the grout mixture used.

4. Construction.

- (1) **Drilling.** Drill the hole so that its diameter is not smaller than the diameter shown on the plans or established by test soil nail anchors. Control hole alignment so that it varies no more than 5 degrees from the line specified on the plans.
- (2) **Grouting.** Place the soil nail anchor with centralizers that are spaced no more than 8 ft. apart in the hole. Set the centralizers to position the soil nail reinforcing bar within 1 in. of the center of the hole. Grout each nail within 8 hr. of the completion of drilling. Whenever conditions permit, grout the hole before nail insertion. However, if the grout mixture is too stiff, it will be necessary to insert the tendon fitted with the centralizers into the hole first and then grout the surrounding annular space. To grout, advance the grouting pipe to the bottom of the hole, and leave it there until the hole is filled with grout and a return is evident at the top of the hole. Withdraw the pipe slowly while grouting continues, filling the void left by the grout pipe.

If unstable hole conditions develop and prevent open hole grouting, furnish hollow stem auger equipment, and place the nail reinforcing bar and grout through the auger.

Use grouting methods that result in complete filling of the hole at the ground surface. Methods may include placement of grout in multiple stages, use of a packer or soil to dam the hole to retain grout, or other approved methods. Completely remove any soil or device used to dam the front of the hole immediately after the grout takes an initial set.

Record the following information concerning the grouting:

- (a) Type of mixer
 - (b) Water-cement ratio
 - (c) Types of additives
 - (d) Type of cement
 - (e) Volume of grout
- (3) **Soil Nail Anchor Test.** Construct and test the soil nail anchors as indicated on the plans. Test the soil nail anchors before installing any production soil nail anchors. Within 6 months before stressing the test soil nail anchors, calibrate the jack and gauge used together as a system, and furnish certified copies of load calibration curves for all jacks and gauge systems to be used in the work. Recalibrate stressing systems when required.

Provide an adequate reaction pad large enough to resist the required load without sinking into the soil or shifting laterally during the test. Do not use a

reaction pad that sinks into the soil more than 2 in. or that allows the free end of the soil nail reinforcing bar to move laterally more than 2 in. Failure to provide an adequate reaction pad will void the soil nail anchor test. Provide additional test soil nail anchors until an adequate reaction system is achieved. Furnish additional test soil nail anchors, required due to inadequate reaction pads, at no expense to the Department.

Provide a reaction pad with a center opening larger than the hole diameter to ensure that no bridging or interaction occurs between the grout column and the reaction pad. Similarly, remove all pneumatically placed concrete, excess grout, or other foreign material to expose the full face of the grout column. Ensure the reaction system does not contact or interfere with the soil nail anchor reinforcing bar during the test. Conduct the following testing method:

- (a) Apply test loads to soil nail anchors in increments of approximately 10% of the required test load. Hold each load increment long enough to obtain the gauge readings. Hold the final maximum test load for 10 min.
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- (b) Perform initial tensioning to take the slack out of the testing apparatus at 5% of the required test load unless otherwise directed.
- (c) Provide suitable means for measuring the movement of the soil nail anchor to the nearest 0.001 in. Provide gauges that extend and retract freely and move smoothly throughout their range. Provide a rigid and secure system to support the gauge independently of the jack or reaction system.

In the event that the test soil nail anchors fail to provide the minimum pullout capacity specified on the plans, modify construction methods or procedures. Then install and test additional test soil nail anchors until adequate pullout capacity is achieved. Test soil nail anchors, in addition to the number specified on the plans, are subsidiary to the Item, "Soil Nail Anchors."

If the Contractor chooses to modify construction procedures after test soil nail anchors are completed and approved, the Engineer may require additional testing. This additional testing is subsidiary to the Item, "Soil Nail Anchors."

- 5. Measurement.** Soil nail anchors will be measured by the foot of acceptable soil nail anchor in place. The soil nail anchor length measured is the length of the drilled and grouted hole as specified in the plans or modified by the Engineer. Soil nail anchor tests are subsidiary to this Item.
- 6. Payment.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Soil Nail Anchors." This price is full compensation for materials, equipment, labor, tools and incidentals.