



# Project Summary

Texas Department of Transportation

## 0-4484: Non-Destructive Evaluation of Installed Soil Nails

### *Background*

Soil nailed retaining walls are used extensively by the Texas Department of Transportation (TxDOT) in both temporary and permanent applications. Although most of these soil nailed walls have performed satisfactorily, occasional failures have occurred. Recent forensic studies that investigated failure of TxDOT soil nailed retaining walls revealed that incomplete grouting of soil nails was a common problem. Thus, the ability to assess the grout condition is vital for the safe performance of these structures. TxDOT has recognized that the current Quality Control and Quality Assurance (QC/QA) procedure that relies on load testing of two sacrificial test soil nails to determine their ultimate load capacity, may not necessarily ensure satisfactory quality of grouting in production nails that are not load tested. This report presents the findings from a research study that addressed concerns related to the integrity of soil nail grout columns.

### *What the Researchers Did*

The researchers examined the soil nail grout integrity problem from two different perspectives. The first involved the development of a non-destructive test (NDT) technique that could be used to detect any defects that may be present in a grouted soil nail. The second involved a study of construction variables (such as installation procedure, grout consistency, tremie insertion length, borehole diameter, soil nail angle, etc.) that may influence the integrity of the grout column.

To determine the effectiveness of various NDT methods for evaluating the integrity of soil nail grout columns, an experimental soil nail wall with 32 test soil nails was constructed. The lengths of nails were varied from 5 feet to 25 feet while nail angle was kept constant at 10° or 15°. The center steel tendons consisted of epoxy coated Grade 60 steel bars with a diameter of 1 inch with split PVC style centralizers. Two types of grout, a sand-cement-water mixture and a cement-water mixture, were used in these soil nails. Three types of artificial defects, including voids at the end of nails, voids in the middle of nails, and bird's mouth, were simulated at specific locations by using closed cell polyethylene foam. Once all of the necessary NDT was completed, the nails were exhumed and the grouted condition of each nail was directly observed and recorded.

To examine the influence of construction variables on the quality of grout columns, a series of experiments was conducted by pumping grout into 6-in diameter, 20-ft long PVC tubes. These PVC tubes were placed on a specially prepared ramp and covered with loose fill. Then No. 6 steel rebars fitted with split PVC centralizers were inserted into these tubes and the annulus filled with grout.

### *Research Performed by:*

Center for Multidisciplinary Research  
in Transportation (TechMRT),  
Texas Tech University

### **Research Supervisor:**

Priyantha Jayawickrama, TechMRT

### **Researchers:**

Jie Gong, TechMRT  
John Turner, TechMRT

### **Project Completed:**

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Different combinations of grout mix designs and other construction variables were used in different tubes. After the grout had hardened sufficiently, the tubes were opened up to examine the condition of the grout columns.

## What They Found

Sonic Echo (SE) was found to be the best NDT method for soil nail grout integrity testing. Optimum results were obtained when both the impact and the receiver were on the grout column. The accuracy of prediction was found to be better when the defects in the grout column were isolated. Poor head condition and/or multiple defects at shallow depth impaired the SE test's ability to probe the grout column to greater depths. The research findings also suggested that the SE test has the capability to measure grout column lengths of up to 20 or 25 feet under ideal conditions, but this capability is greatly diminished when multiple defects are present at shallow depths and/or when the head conditions are poor.

Findings from the second phase of the research that examined the impact of grout consistency and installation procedure showed that much better quality grouting can be achieved by filling the drillhole with grout before inserting the tendon. However, if the tendon is inserted first and grouting done using a tremie, then it is very important to have the tremie extend to the bottom of the hole. The findings from this research suggested that there is merit in introducing a requirement based on grout fluidity/flowability.

## What This Means

TxDOT Special Specification No. 4116: *Soil Nail Anchors* can be revised to include a flowability requirement for the grout based on ASTM C 1611: *Test Method for Slump Flow of Self-Consolidating Concrete* or other similar test procedure. A slump flow of 20 inches is proposed as a suitable threshold. In addition, necessary changes should be made in the specifications to encourage a nail installation procedure that involves filling the drillhole with grout prior to inserting the tendon.

Based on the findings, the SE test has potential to serve as an effective NDT procedure for soil nail grout integrity testing. Therefore, a SE test with a 0.2-lb modal hammer as the impact source and accelerometers with a frequency range between 1.0 to 10,000 Hz as receiver should be field trialed as a QC/QA procedure for production soil nails. Then if soil nails are suspected to be defective based on NDT results, they should be load tested to determine whether their load-carrying capacities have been impaired.

### For More Information:

Research Engineer - Tom Yarbrough, TxDOT, 512-465-7403  
Project Director - Mark McClelland, TxDOT, 512-416-2226  
Research Supervisor - Priyantha Jayawickrama, TechMRT, 806-742-3503

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Research and Technology  
Implementation Office  
P.O. Box 5080  
Austin, Texas 78763-5080  
512-465-7403

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