GEOTECHNICAL ENGINEERING MANUAL:
MICROPILE INSPECTOR GUIDELINES

GEM-25
Revision #1

STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING BUREAU

AUGUST 2015
# TABLE OF CONTENTS

1. INTRODUCTION .................................................................................................................................................. 3
   1.1 Purpose .......................................................................................................................................................... 3
   1.2 Role and Responsibilities ........................................................................................................................... 4
   1.3 Definition of Terms .................................................................................................................................... 6

2. CONTRACT REQUIREMENTS ........................................................................................................................... 7
   2.1 Specifications .............................................................................................................................................. 9
   2.2 Plans .......................................................................................................................................................... 9
   2.3 Contractor Submittal .................................................................................................................................. 9

3. MICROPILE PRECONSTRUCTION MEETING .................................................................................................. 12

4. CONTRACTOR SET-UP ...................................................................................................................................... 13

5. DRILLING .......................................................................................................................................................... 13

6. GROUTING ......................................................................................................................................................... 15

7. INSTALLATION OF REINFORCEMENT ......................................................................................................... 17

8. POST INSTALLATION ...................................................................................................................................... 18

9. FIELD RECORDS ............................................................................................................................................. 18

REFERENCES ......................................................................................................................................................... 20

APPENDIX ............................................................................................................................................................ 21
   A. Micropile Installation Log .......................................................................................................................... A-1&2
      Alternate Log ................................................................................................................................................. A-4&5
1. INTRODUCTION

1.1 Purpose

These guidelines were written for use by the NYSDOT and their consultants. In the event that the information in the guidelines is used by other municipalities, the responsibilities for the various tasks contained herein are to be borne by that municipality, and not by the NYSDOT.

A micropile is a small diameter reinforced and grouted pile, constructed within a previously drilled borehole that provides axial capacity, or resistance, for a substructure. Unlike a driven pile, where each pile is a “tested” pile, the resulting axial capacity of each micropile is not directly determinate unless a load test is performed on it. In addition, micropile capacity is very sensitive to installation methods. Therefore, the role of the inspector is vital to ensure that the final product meets the expectations of the designer and the owner. Proper design and installation of micropiles is as much art as science, and their use should not be employed by the inexperienced.

These guidelines provide the inspector or Engineer-In-Charge (EIC) with a basic understanding of what to record in micropile construction. These guidelines will provide the individual with information to guide inspection efforts and enhance the transfer of information from the inspector to the designer. The manual includes inspection forms on which to record this information.

To understand micropile installation techniques, a working knowledge of the methods and tools used by Contractors is essential, as well as an understanding of the effects that these have on the resulting performance of the micropile. This manual is not intended or designed to certify or qualify an inspector to perform micropile installation inspection. It is highly recommended that any inspector unfamiliar with micropile construction take NHI course No. 132078 Micropile Design and Construction.

There is no substitute for direct contact between the inspector and the engineer/designer who designed the micropile foundation. Contact with the micropile designer will give the inspector access to information he/she may not have possessed otherwise, as well as insight into why micropiles were utilized on this project.

The Geotechnical Engineering Bureau - GEB (or owner’s geotechnical engineer) and the EIC will be reviewing the construction information recorded by the inspector, and will use this information to evaluate the final product. For these reasons, it is prudent that the inspector/EIC and the GEB (owner’s geotechnical engineer) have a good working relationship. At the very least, the GEB (geotechnical engineer) should meet with the inspector/EIC before construction begins and discuss any concerns either has.

The New York State Department of Transportation (NYSDOT) currently employs the use of two special specifications for micropiles; Micropiles (Design Provided) and Micropiles (Contractor Designed). These specifications will be updated to incorporate LRFD, but the underlying principles will not change. The Micropiles (Design Provided) specification is typically used where the rock elevation and strength characteristics are well-defined. The Micropiles
(Contractor Designed) specification is used for all other conditions, in order to best take advantage of the specialty Contractor’s experience and methods. The information shown in the plans, and the information the inspector will be interested in will vary accordingly, along with the distribution of the risks. The owner should be thoroughly familiar with design and construction of micropiles before the owner or their design consultant attempts to design micropiles.

When the Micropiles (Contractor Designed) specification is used, the loads and pile locations are shown on the plans. The Contractor is responsible for the structural and geotechnical design, the construction methods and tools, and the load testing.

1.2 Role and Responsibilities of the Inspector

The role of the inspector is to ensure that construction is done in accordance with the plans and specifications, and the approved Contractor submittal, and to assure quality of each final foundation element. Thus it is imperative that the inspector is familiar with the plans and specifications, as well as with the approved submittal required by the specification. Any deviation from the plans, specifications or submittal should be promptly noted and reported to
the Engineer In Charge (or other proper authorities for non-NYSDOT jobs), who will determine the appropriate course of action.

Another important function is to record and transmit information. The micropile inspector is present to observe and document the Contractor’s installation of the micropile. In this regard he/she should also try to be as complete and as concise as possible when recording and transmitting this information to the EIC (or project manager, or other proper authority). The quality of this information must be very high as it will be used to make important decisions such as the approval or rejection of the micropile.

The role of the inspector differs somewhat depending upon which specification is included in the contract. For the Micropiles (Design Provided) specification, the inspector is verifying the pile is constructed according to the plans and specification. For the Micropiles (Contractor Designed), the contract documents, the contractor’s approved submittal, the contractor’s test pile construction methods, and the results of the load tested pile that successfully meets the contract requirements are all merged into the baseline for subsequent production pile installation. The inspector’s role is to help ensure that all subsequent piles are constructed in accordance with the above. By carefully documenting the pile installation and grouting processes, the inspector provides the construction staff with the information needed to determine the acceptability of the pile.
1.3 Definition of Terms

**Bond Breaker.** A device or special treatment incorporated into a length of a micropile that will allow no load to be transferred to the soil over that length. A bond breaker also provides full lateral support of the pile over the length of the bond breaker.

Grout placed in contact with the soil using gravity pressure only will not be considered to constitute a bond breaker.

**Bond Zone.** The gravity-grouted, pressure-grouted, and/or post-grouted length of a micropile that provides the pile's capacity.

**Design Load.** The load permitted on a pile. The design load is indicated in the contract documents.

**Drill Casing.** Steel pipe of flush joint type used in the drilling process to stabilize the drill hole.

**Duplex Drilling.** A method of progressing and cleaning out a hole for installing a micropile in which the outer drill casing is progressed simultaneously with an inner drill rod string. The drill casing is cleaned using reverse circulation. Intimate contact between the soil and an outer drill casing is maintained during drilling.

**Extended Length.** An additional pile length resulting from a requirement that the pile capacity be achieved below a given elevation. Typically, extended lengths are prompted by a conflict with subsurface elements (e.g., underground structure, utilities, etc.) or unreliable soil strata. Bond breakers may be required.

**Micropile.** A small-diameter (typically less than 12 inches) friction pile formed by removing material using non-vibratory and non-displacement methods to create a cased open, cylindrical hole in the ground, which is subsequently filled with grout and steel reinforcement.

**Non-production Pile.** Non-production piles are piles that are not incorporated into the substructure. For example, test piles which are abandoned after testing has been completed are non-production piles.

**Permanent Casing.** A steel casing installed in the upper portion of a micropile to increase the pile's moment capacity and lateral capacity against horizontal loads.

**Positive circulation or flush.** A method of progressing and cleaning out a hole for a micropile where drilling fluid is injected into the hole and returns upward along the outside of the drill casing.

**Post grouting.** A method used to increase pile capacity after the grout column has reached initial set by pumping grout at very high pressure (up to 1000 psi) through a sleeved port pipe (post grout tube). Each port location may be isolated using a device called a double-packer to better control the post grouting.
**Pressure grouting.** A method used to develop pile capacity wherein pressure is applied continuously to the top of the fluid grout column through the drill head as the casing is removed from the bond zone.

**Production pile.** A pile which will be incorporated into the structure's foundation as a load-bearing element.

**Recirculation.** A method of handling drilling fluid where the fluid coming back out of the hole is captured and reused.

**Reverse Circulation.** A method of cleaning the inside of the drill casing. Drilling fluid is circulated down through the drill rods and returns upwards through the inside of the drill casing to flush the drill casing clean.

**Rock.** Rock is identified in the boring logs. Rock may also be defined at the micropile installation site by a Departmental Engineering Geologist. The State defines rock by its load bearing capacity and often, the Contractor will define rock by the effort or tools required to progress the excavation through the material. These conflicting criteria will often result in different definitions of rock at a site. Refer to the Contract documents for guidance on how rock is defined for the project.

**Static Pile Load Test.** A test to verify design assumptions and the adequacy of the contractor’s installation methods.

**Telltale.** A simple mechanical device, a.k.a. “strain rod,” that is used to measure displacement in concrete or steel. The device consists of a small-diameter steel rod that is fixed at a selected point along or within the pile. This rod is encased, and free to move, in a
slightly larger pipe or tube which extends up to the pile top. Dial gages are used to measure the deflections at the top of the rod.

**Tremie Grouting.** A method used to place grout in a wet hole. A grout tube is placed to the bottom of the drill hole. While keeping the tube opening submerged in the grout, grout is pumped into the hole, causing the drilling fluid to be displaced.
2. CONTRACT REQUIREMENTS

2.1 Specifications

The specification contains the following information that will be essential for the inspector to consult during construction:

Materials Requirements – a description of material requirements, including drilling casing, steel reinforcement, grout, and centralizers and spacers.

Construction Tolerances - all the allowable micropile tolerances, such as location, and verticality (e.g. plumbness). Failing to meet these tolerances will result in a rejected micropile.

Drilling and Excavation Methods - the allowable procedures for the different drilling methods. They also provide the requirements of each procedure. The contractor must adhere to these requirements or the micropile may be rejected. The inspector should also be aware that the specifications prohibit certain operations, such as bentonite slurry and rock blasting.

Rebar and Grout Placement, and Casing Removal - The specification contains the allowable procedures and requirements for the above operations. The contractor must adhere to these requirements or risk rejection of the micropile.

The inspector should become familiar with the additional miscellaneous information on the micropile requirements contained in the specification.

2.2 Plans

The contract plans contain all of the specific requirements of that particular project as opposed to the specification which covers only general requirements. The specifications refer to the contract plans many times. The plans also refer back to the specification for direction where applicable (for example: ....as per Item xxx.xx...). When the Micropiles (Design Provided) specification is used, the contract plans should contain the actual micropile design and any and all requirements that are not covered in the specification. These requirements define the basis of the bid, and what the Contractor must construct. Any unauthorized deviation from the contract plans should be reported immediately to the EIC (or project manager).

2.3 Contractor Submittal

In accordance with the specification, the Contractor is required to submit information to the Deputy Chief Engineer – Structures (owner) for review and approval. The owner should make the inspector aware of which operations/equipment are crucial for the acceptance of the micropile. Each of these items should be reviewed in detail, so that all parties understand what to accept and what to look for during construction. This information includes the following:
1. Pile computations (for Contractor designed piles) and details for each design capacity including, but not limited to, nominal diameter, length, reinforcement, pile connections, post grout tube and grouting pressures.

2. Information on the proposed steel drill casing/pipe or rebar used as reinforcement. Note that any steel that becomes a permanent part of the micropile must meet Buy America requirements.

3. Details of equipment for pile installation.

4. Details of procedures for pile installation including, but not limited to, installation sequence and the approximate time required for each sequence step.

5. Procedures for advancing through boulders and other obstructions.

6. Procedures for mixing drilling fluid, containment of drilling fluid and spoil, and disposal of spoil.

7. Where applicable, drawings that show the specific work can be performed under limited headroom conditions and as close to obstructions, as site conditions warrant, to install the micropiles at the locations indicated in the contract documents. Provide information on the length of the casing sections to be used, as dictated by the length of the drill mast and by the available overhead clearance, and the resulting location of joints.

8. When steel drill casing/pipe is used as reinforcement, account for the reduced area of the threaded joint in the structural design of the pile, particularly for the capacity in tension and bending. Identify any joint location restrictions that must be followed in construction. Decide whether additional casing testing will be performed (casing used for reinforcement per design) to confirm either casing mill certification or coupon test data.

   a. Prepare the mix design for the grout and obtain documentation from an independent laboratory (approved by the Deputy Chief Engineer Technical Services) showing the following:
      i. The mix design conforms to the submitted mix and meets the strength requirements set by the Contractor.
      ii. The compressive strength of the mix, tested at 3, 7, 14, and 28 days.
      iii. The specific gravity of the mix.
   b. Identify a method for monitoring quality control of the mix. At a minimum, the Contractor shall use a Baroid Mud Balance in accordance with the American Petroleum Institute (API) Recommended Practice (RP) 13B-1: Standard Procedure for Testing Water-Based Drilling Fluids, to check the specific gravity of the mixed grout prior to placement of the grout into each micropile.
   c. Provide pressure gages accessible to the inspector capable of measuring the actual grout pressures used and such that actual pressure readings are within the middle third of the gage. The pressure gauge should be located as closely as possible to the pile top and the gauge location should not change for the duration of the project.
10. If proposed, details of post-grouting equipment and procedures, including the method, sequence of operations and equipment required.

11. Layout drawings showing the proposed sequence of pile installation. Coordinate this sequence with the proposed phasing and scheduling.

In addition, the Contractor performing the work described in this specification shall submit proof of the following:

1. Two projects in the past two years on which the Contractor has successfully installed micropiles or soil tiebacks using non-displacement methods, under similar site conditions to those indicated in the contract documents.

2. The proposed On-Site Supervisor for this work having supervised the successful installation of micropiles or soil tiebacks on at least two projects in the past two years.

**The inspector should collect and record the following final information:**

1. If design drawing or proposal lacks pile numbers, assign them now and relay this information to all parties involved.

2. Record wall thickness information, record mill certification or test coupon data results (compare results to $F_y$ of casing steel used in design calculations), and collect Reinforcing Steel Certification.

3. On all designs, note $F_y$ for Casing, $F_y$ of Reinforcing Steel, and $F_c$ for grout.
3. MICROPILE PRECONSTRUCTION MEETING

Since the acceptance or rejection of a micropile is usually based solely on results of inspection records and load tests (when performed) of the micropile installation, a micropile preconstruction meeting is essential. The primary focus of this meeting (or meetings, if more than one is necessary to resolve issues) is to review the contractor’s submittals and resolve any concerns. Attendees of this meeting should include the Engineer-In-Charge (EIC), the inspector(s), the owner’s technical experts (i.e. Geotechnical Engineering Bureau), the prime Contractor, the contractor/subcontractor who will be performing the work, and the micropile designer.

This meeting will allow the EIC, the inspector and the micropile designer to review the Contractor’s submittals to see if there are any concerns on either side. It will also alert the inspector as to what aspects of the submittal could potentially affect the performance of the micropile. The designer should have reviewed (and commented back to the Contractor, if necessary) these submittals prior to the meeting.
4. CONTRACTOR SET-UP

Preparation is vital to inspecting micropiles. Before work starts the inspector/construction staff should take the following actions:

- Review the plans, specifications and approved submittal to become familiar with the requirements. Note that there are different requirements depending on which specification is used. For the **Micropiles (Design Provided)** specification, the Contractor must install the micropiles to the design (reinforcement, grout strength, diameter and length) stated in the plans. For the **Micropiles (Contractor Designed)** specification, the Contractor prepares his submittal and design which is reviewed and approved. His design and methods must then be “proven” in the field through a load test, or tests. After the final design and methods are approved and proven, the Contractor must then install the remainder of the piles in the same manner in which the successful piles were installed. There may be more than one design and installation method, based on the loads and subsurface conditions at the project site. The inspector needs to become familiar with the design and site conditions at each location.
  - Review the micropile Contractor’s schedule
  - Inform the Contractor of quality assurance and testing requirements and frequency
  - Check the overall condition of the Contractor’s equipment
  - Become familiar with the subsurface conditions at the site by reviewing the available boring logs
  - Review and record all data and markings on the outside of micropile casings. For multiple lots and/or sublots, determine who will record which sublot (or combination of lot/sublots) were used on each pile.

5. DRILLING

Most micropile excavations are done using rotary drilling machines. These machines come in many different sizes and designs. The capacity of a drill rig is expressed in terms of the maximum torque that can be applied to the drilling tool, as well as the downward force, or “crowd”, that the rig can apply to the drilling tool. Torque and crowd are transmitted from the rig to the drilling tool by the drill casing. Drill rigs can be mounted on trucks, cranes, or crawlers.

The inspector/construction staff should verify that the micropile contractor:
  - Has submitted the requisite proof of experience and expertise, and that the personnel listed in the approved submittal are actually the personnel performing the work
  - Conducts his operations to minimize ground loss
  - Conducts his operations to prevent collapse of the borehole
  - Does not progress a hole, pressure grout or post-grout within a radius of 5 pile diameters or 5 feet, whichever is greater, of a micropile until the grout for that micropile has set for 24 hours, or longer if a retarder is used
  - Does not drill or flush more than 1 foot ahead of the casing during duplex drilling
  - Removes casing carefully, using methods so that the reinforcement is not disturbed, damaged, or is left in contact with the soil
- Keeps hole full of grout to prevent hole collapse, or leave casing in place to accomplish the same results, provided that doing so will not affect the performance or function of the pile.
- Keeps fluid level in hole above the external groundwater level to maintain balance of pressures and prevent flowing sand conditions. Special attention is needed when drilling into artesian conditions.
- Schedules drilling, reinforcement installation and grouting to suit ground conditions (keep process continuous)
- Plugs or covers drilled holes for safety and to prevent foreign objects and material from falling in
- Provides for the proper disposal and containment of spoil
- Meets construction tolerances (3 inches from plan location; rebar within 3/8” of center of pile; ¼ inch/foot or less variation from vertical or batter)

Additional tasks of the inspector during micropile construction include the following:
- Review the soil boring logs for each location
- Confirm stability of each hole and record specific methods used to maintain hole stability
- Verify and record the depth to top of rock, where encountered
- Verify the final depth of each hole by counting drill casings used, and/or by using a weighted tape
- Record casing type and length if temporary casing is used
- Record observations made during drilling. Pay particular attention to loss of drilling fluid, sudden drop of drill tools, and encountering boulders or other obstructions
- Verify that the drilling slurry/spoil materials are well contained and do not enter into nearby waterways.
- Pay close attention when drilling adjacent to bodies of water, as air pressure can follow underground fissures in rock and percolate into adjacent water. If this happens, the contractor should immediately halt the operation and develop a procedure to eliminate the possibility of silt or grout from entering the waterway or water body.
6. GROUTING

Grout for micropiles must be designed and placed in a manner that is unique to micropiles. The basic characteristics of grout for micropiles are:

- High strength
- Good Durability
- Low shrinkage
- Pumpability

There are four general methods for grouting micropiles:

a. Type A grouting is placing grout under gravity head only (tremie grouting).
b. Type B grouting is pressure grouting through the casing during withdrawal.
c. Type C grouting is when the primary grout is placed under gravity head (tremie placed), then applying one phase of secondary “global” pressure grouting.
d. Type D grouting is when the primary grout is placed under gravity head (Type A) or under pressure (Type B), and one or more phases of post-grouting are performed.

The inspector should ensure that the micropile Contractor:

- Provides continuous grout placement
- Ensures that the grout is mixed using a colloidal mixer, and is continuously agitated
- Prevents presence of air in the grout lines
- Does not draw down the level of grout in the agitation tank to below the crown of the exit pipe
- Excludes foreign matter during grout placement

Additional tasks of the inspector during micropile construction include the following:

- Verify the water/cement ratio and grout mix design
- Verify that all grouting equipment (pumps, gauges, hoses, etc.) are in good working order
- Record the initial volume of grout required to fill the hole
- Grout cubes shall also be taken for later strength testing, at a frequency of one set of three cubes taken for every 3 micropiles installed. They will be tested in accordance with NYSDOT NY 701-19E Test method for Grout Testing.
- Record grouting pressure and volume of grout ("grout take") pumped during pressure grouting for each micropile. Readings are typically recorded in 2 or 5 foot increments for the entire pressure grouted zone.
- Observe the quality of grout at the ground surface (i.e. when the hole is full of grout). Excess grout should be pumped until the flushing grout appears to be uncontaminated.
- Record the pressure required to crack the grout during post grouting. Record the grout pressure and grout take during post grouting.
Check and record the specific gravity of the grout using a baroid mud balance test (API Recommended Practice RP 13B-1), at a frequency of one test per micropile. The general procedure is as follows:

- Fill the cup to capacity with fresh, screened grout.
- Replace lid and rotate until firmly seated, making sure some grout is squeezed out the vent hole. Wipe or wash excess grout from the exterior of the balance, and dry. Then seat the balance with its knife edge on the stand and level it by adjusting the rider.
- Read grout density from the edge of the rider as indicated by marker on the rider. Use any of the four scales to express the grout density as required.
- Calibration should be checked by filling the cup with fresh water. It should read 8.34 lb./gal or 1.0 g/cm³.

The inspector should monitor the micropile contractor’s operations during grout placement to ensure that the following good construction practices are followed:

- Prevent heaving or ground distress by limiting grout pressures and/or the quantity of grout pumped.
- Prevent soil in bottom of hole from blowing in by ensuring that a positive head of grout is maintained at all times.
- Tie the tremie tube loosely enough to permit easy removal during or after grouting.
- Grout as soon as possible after drilling the bond zone.
- Place grout from the bottom-up to ensure complete filling of the hole.
- Maintain a positive head at the grout holding tank.
- Measure grout pressures close to the point of injection to account for line losses. The pressure gauge should be mounted on the drill rig and its location should not be changed for the duration of the project.
- Monitor grout pressures and volumes throughout all grouting processes.
7. INSTALLATION OF REINFORCEMENT

Tasks of the inspector during micropile construction include the following:

- Verify reinforcement size, type, length and condition just prior to insertion into the drill hole
- Verify size, type, and condition of bar couplers
- Ensure that the micropile contractor installs the reinforcement either before or after initial grout placement but before temporary casing (if used) is withdrawn
- Always record the total pile length and bond zone length
- Ensure that the micropile contractor inserts the reinforcement to the prescribed length without the use of force
- Verify location and spacing of centralizers/spacers, and locations of couplers
- Ensure that the micropile contractor takes precautions to not damage corrosion protection or centralizers/spacers during installation
- Make sure reinforcement is clean of any surface dirt, oil, mud, etc.
- Check the attachment and intervals of centralizers/spacers
- Ensure that the reinforcement remains centered in the borehole

![Diagram of micropile installation](image-url)

Figure 3. Multiple Bar Reinforcement with Bar Centralizer/Spacer.
8. POST INSTALLATION

- Verify pay quantities
- Record load test data. The procedures for conducting and inspecting load tests are addressed in separate documents. Remember that under the Micropiles (Contractor Designed) specification, the load test data verifies the Contractor’s design and construction methods, and forms the basis for all future construction of contractor-designed micropiles.
- Report any deviations from the Contractor’s approved installation methods.
- Report unacceptable load test results and micropiles that fail to meet specification requirements and/or tolerances to the EIC. The pile acceptance criteria includes:
  - Pile meets Construction Tolerance criteria
  - Pile was installed in accordance with the approved submittal
  - Pile is not damaged
  - Pile was installed using the same method, grout volumes, and pressures as the accepted test pile, if applicable
- Submit the required documentation (i.e. micropile installation logs, grout records, etc.) to the EIC.

9. FIELD RECORDS

The inspector should start the documentation process before the micropile installation process starts. The inspector shall complete a micropile installation log for every micropile installed.
Figure 4. Detail of a Composite Reinforced Micropile.
REFERENCES

2. NYSDOT Test Method NY 701-19E, Grout Cube Molding Procedure.
# Micropile Installation Log

<table>
<thead>
<tr>
<th>PIN, Project</th>
<th>Contract #</th>
<th>Inspector</th>
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<tbody>
<tr>
<td>Substructure</td>
<td>Pile #</td>
<td>Installation Date</td>
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## Pile Information

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<th>Casing Dia/Wall Thickness</th>
<th>Reinforcement Size/Length</th>
<th>Casing Length Below BOF</th>
<th>Cased Bond Length (Plunge)</th>
<th>Bond Length Below Casing Tip</th>
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## Drilling Information

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<th>Drilling Method</th>
<th>Drill Bit Type/Size</th>
<th>Drill Rig</th>
<th>Drill Operator</th>
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<table>
<thead>
<tr>
<th>Time</th>
<th>Elevation, or Depth Below BOF</th>
<th>Soil/Rock Description</th>
<th>Comments (Observations, changes, breakdowns, obstructions, etc.)</th>
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## Grouting Information

### Pressure Grouting:

- (Max) Grout Pressure
- (Avg) Grout Pressure

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<th>Grout Take</th>
<th>Time Began</th>
<th>Time Ended</th>
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### Post Grouting:

- Initial (“Cracking”) Pressure/Grouting Pressure
- Post Grout Tube Location(s):

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<th>Admixtures</th>
<th>Grouting Method (Type A, B, C, or D)</th>
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<th>Comments</th>
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## Pile Acceptance:

- Y
- N

### Quantity for Payment (see spec requirements)

- Each (Contractor Designed)
- Length (Design Provided)
Micropile Installation Log

D_________, PIN ________
Project Description 1
Project Description 2
________ COUNTY
Contractor: __________________

Substructure Description: _________  Pile #___

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<th>Depth (ft)</th>
<th>Casing #</th>
<th>Target Net Pressure (psi)</th>
<th>Pressure (psi)</th>
<th>Volume (gal)</th>
<th>Flow Rate (gpm)</th>
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Gross  Net  Total =

Notes: ►

DWR # ____________
DATE ____________
SHEET _______ OF ________
INSPECTOR ___________
### MICROPILE INSTALLATION LOG

#### INSTALLATION SUMMARY
- **Pile Inclination**
- **Permanent Casing Diameter/Thickness**
- **Permanent Casing Length**
- **Installation Casing Diameter**
- **Reinforcement Type / Size**
- **Reinforcement Length**
- **Cased Bond Length (plunge)**
- **Bond Length Below Casing**
- **Total Pile Length Below Cut-Off**
- **Casing Length Above Cut-Off**

#### DESIGN

#### AS-BUILT

#### PILE CAPACITY / RESISTANCE
- **Compression**
- **Tension**

#### INSTALLATION DATE / TIME
- **Date**
- **Time**
- **Start of Drilling**
- **Start of Grouting**
- **Pile Completion**
- **Total Duration**

### PILE DRILLING

<table>
<thead>
<tr>
<th>Time</th>
<th>Depth From BOF</th>
<th>Soil / Rock Description</th>
<th>Comments</th>
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### PILE GROUTING

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<th>Grout Plant # / Operator</th>
<th>Cement Type</th>
<th>Admixtures</th>
<th>W/C Ratio</th>
<th>Grout Specific Gravity</th>
<th>Grout Density</th>
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Detailed grouting record shown on reverse

Inspector
### DETAILED GROUTING RECORD

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Target Pressure (psi)</th>
<th>Measured Pressure (psi)</th>
<th>Flow Rate (gpm)</th>
<th>Time</th>
<th>Volume (gal)</th>
<th>Notes</th>
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#### Pressure Grouting

#### Post Grouting

<table>
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<tr>
<th>Depth (ft)</th>
<th>Target Pressure (psi)</th>
<th>Measured Pressure (psi)</th>
<th>Volume (gal) / phase</th>
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<td>Total Volume</td>
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SUBSTRUCTURE | PILE

Appendix A-5