Lesson 4
Construction Techniques and Materials

Learning Outcomes
- Describe sequence of construction for a micropile
- Identify materials used to construct a micropile
- Describe principle function of these materials
- Describe key elements to good grouting

Basic Construction
Sequence Involves
- Drilling
- Placing reinforcement
- Grouting
Typical Micropile Construction Sequence with Casing

**ADDITIONAL GROUT**

**COMPRESSIBLE STRATUM**

**BEGIN DRILLING &/OR INSTALLATION OF TEMPORARY CASING**

**COMPLETE DRILLING TO DEPTH**

**REMOVE INNER DRILL BIT & ROD (IF USED)**

**PLACE REINFORCEMENT & GROUT (BY TREMIE)**

**REMOVE TEMPORARY CASING, INJECT FURTHER GROUT UNDER PRESSURE AS APPLICABLE**

**COMPLETE PILE (CASING MAY BE LEFT IN PLACE THROUGH THE COMPRESSIBLE STRATUM)**

**Bearing Stratum**

Drilling Method: Principles of Selection

The method selected must:
- Provide a stable hole of the required dimensions and within stated tolerances
- Be compatible with project access and environmental constraints, e.g., noise and vibration thresholds
- Allow completion of each hole within a single day
- Be compatible with spoils handling requirements
- Consider presence of hazardous materials

Drilling Method: Principles of Selection

The method selected must:
- Be capable of drilling in all soil and rock conditions
- Be able to drill subhorizontal, vertical, and inclined holes
- Be able to drill beneath the water table
- Not impart damage to ground or existing foundations
- Be able to be controlled and monitored
Typical Overburden Cased Drilling Techniques

- Single-tube advancement
- External flush (wash boring)
- Drive drilling (lost point)
- Rotary duplex
- Rotary percussive duplex (concentric)
- Rotary percussive duplex (eccentric)
- Double head duplex
- Hollow stem auger
- Sonic

Single Tube End of Casing Flush

Rotary Duplex Rod and Casing
Duplex Drilling

Rotary Percussive Concentric Duplex

Rotary Eccentric Percussive Duplex Drilling

This one is called Tubex
Overburden Drilling Methods
(FHWA, 1997)

Legend
- Percussion (Casing)
- Percussion (Rod)
- Rotation (Casing)
- Rotation (Rod)
- Flush Casing
- Crown
- Shoe
- Rod
- Bit

1. Single Tube Advancement (End of Casing Flush)
2. Rotary Duplex
3. Rotary Percussive Concentric Duplex
4. Rotary Percussive Eccentric Duplex
5. “Double Head” Duplex
6. Hollow-Stem Auger

Figure 4-9

High Speed, Low Torque Drilling

Low Speed, High Torque Drilling
Rotary Percussive Drilling
(Down-the-Hole Hammer)

Grouting and Grout Function

- Transfers loads from reinforcement to surrounding ground
- May be load-bearing portion of pile
- Protects steel reinforcement from corrosion
- May be used as drill fluid during initial drilling
- Secondary/Post grout enhances soil/grout bond further

Typical Grouting Characteristics

- Neat cement grouts with water/cement ratios of 0.40 to 0.50
- Potable water used to reduce corrosion potential
- Type I/II cement (ASTM C150/AASHTO M85), in bag or bulk form
- Additives to improve pumpability in special cases
- Compressive strengths of 28 to 35 MPa (4 to 5 ksi)
Design Guidelines: Neat Cement Grout

Grouting Equipment

- Mixers
  - High-speed, high-shear colloidal mixers recommended
  - Low-speed, low-energy mixers (paddle mixers) are occasionally still used
- Pumps
  - Constant pressure, rotary-screw type pumps (Moyno)
  - Fluctuating pressure piston or ram pumps
- Agitation Tanks
- Combined Units
- Batching and Injection Monitoring Equipment (i.e., QA/QC)

Principles of High Speed High Shear Mixers
Typical Mobile Mixer/Pump Unit

Various Types of Paddle Mixers/Agitators

Pumps
- Moyno Pump (Primary grouting) – high volume, low pressure
  - [50 gpm at up to 300 psi]
- Piston Pump (Secondary, post grouting) – low volume, high pressure
  - [15 gpm at up to 1200 psi]
Keys to Good Grouting

- Grout Batching
  - Water added to mixer using calibrated tank or flowmeter
  - Cement is batched by weight, either in bags or bulk from a silo
  - Additives are usually proportioned in relation to weight of cement

Keys to Good Grouting

Grout Mixing

- Grout mixing sequence: water, cement, additives
- Grout colloidally (high shear) mixed for a maximum of 2 minutes and then held in a paddle agitation tank until needed
- Safe workability time typically not in excess of 1 hour

Grout Monitoring

Principle of Tube à Manchette Method

Postgrouting (i.e., Type D)
**Structural Steel**

Types
- Reinforcing steel bars (rebar)
- Continuous-thread solid steel bars
- Continuous-thread hollow-core steel bars (injection bore)
- Steel pipe casing
- Composite reinforcement

**Materials - Steel**

[Image of steel materials]

**Close up of Bit on Injection-bore Threaded Bar**

[Image of close-up view of a threaded bar]
**Reinforcing Core Steel**

- Placed either before or after initial tremie grouting (but always before the temporary casing is withdrawn)
- Reinforcement must be clean of surface soil and mud
- Centralizers used to maintain the specified grout cover

**Casing/Pipe**

- Typical
  - Mill Secondary Oil Field Casing
  - Flush threaded joints
  - 80 ksi min Yield Strength

**Casing**

The image contains a diagram of a casing with dimensions and material specifications. It also includes a table with dimensions and material properties.
Grooved Oversized Hole in Existing Foundation

Composite Reinforcement

Learning Outcomes

- Describe a few key drilling methods
- Identify materials used to construct a micropile
- Describe principle function of these materials
- Describe key elements to good grouting

Courtesy: Hayward Baker