

**Lesson 7 & 8**  
Construction Inspection/ Quality Control (QA/QC)  
Load Testing



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**Learning Outcomes**

- Identify proper approaches to inspect, monitor and document construction and testing of micropile systems
- Understand the various load testing and interpretation methods for micropiles



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**Quality Assurance and Quality Control (QA/QC)**

- Critical importance
- Plans and specification development stage through final construction
  - Implementation of all requirements
  - Enforcement of qualifications
  - Submittal reviews
  - Installation



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### Quality Control

- Build the production piles like the test piles !
- Experienced drillers and inspectors
- Document test pile and production pile installation :
  - drill depth & similar soil
  - grouted length
  - grout pressure & volume
  - problems



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### Contractor Submittal Requirements

- Contractor and employee qualifications
- Materials anticipated to be drilled
- Performance criteria
- Location and orientation of the micropiles and tolerances
- Micropile size and configuration



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### Contractor Submittal Requirements

- Micropile capacity
- Drilling and grouting equipment
- Anticipated equipment loads on structure or adjacent ground
- General installation plan
- Grout mix design and pressures



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### Contractor Submittal Requirements

- Reinforcement including size, configuration and corrosion protection
- Postgrouting methods (if applicable)
- Documentation and protection of existing utilities and environment
- Plans to accommodate low headroom or obstructions



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### Contractor Submittal Requirements

- Testing criteria
- Testing and monitoring devices
- Details of connections to existing structures
- Criteria for implementing remedial procedures
- Spoils handling



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### Material Handling and Storage

- Grout
- Cement
  - prevent hydration, keep dry, avoid moisture
  - avoid overcompaction by overstacking
  - perform visual inspections (lumps and foreign matter)
- Admixtures
  - same as cement
  - check shelf life, manufacturer's recommendations
- Water
  - potable
  - no impurities



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## Material Handling and Storage

- Reinforcing Steel
- Store in a protected location
- Inspect steel when delivered to site
- Reject steel that exhibits flaky corrosion or pitting
- Extra care with corrugated protected/epoxy-coated bars



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## Construction Monitoring

### Drilling

- Minimize ground loss
- Prevent borehole collapse
- Remove casing so the reinforcement is not disturbed, damaged or in contact with the soil
- Keep hole full of grout to minimize hole collapse
- Keep fluid level in hole above external groundwater level to maintain balance of pressures



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## Construction Monitoring

### Drilling (cont.)

- Schedule drilling, reinforcement installation and grouting to suit ground conditions (keep process continuous)
- Plug or cover holes, project casing above the head elevation
- Provide for proper disposal and containment of the drilling spoils
- Ensure tolerances are met



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## Construction Monitoring

### Grouting – Mixing and Pumping

- Ensure continuous grout placement
- Ensure cement is colloiddally mixed and grout is continuously agitated
- Prevent presence of air in the grout lines
- Do not draw down the level of grout in the agitation tank below the crown of the exit pipe
- Ensure exclusion of foreign matter during grout placement



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## Construction Monitoring

### Grouting – Mixing and Pumping

- Fluid tests to confirm proper batching (in real time)
- Cubes for strength testing (retrospective)



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## QA/QC via Fluid Grout Tests



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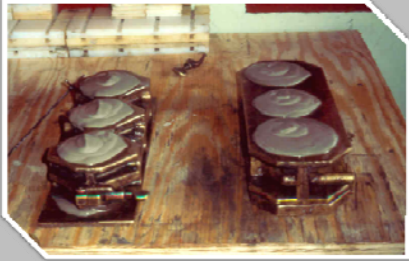
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### Use of Cubes as a QA/QC Tool



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### Construction Monitoring



#### Grouting – Placement

- Prevent heaving or ground distress
- Prevent soil in bottom of hole from blowing in
- Grout as soon as possible after drilling the bond zone
- Use tremie to ensure complete filling of hole
- Tie tremie tube loose enough for removal during/or after tremie grouting



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### Construction Monitoring

#### Grouting – Placement (cont.)

- Observe suitable grout return
- Maintain a positive head at the grout holding tank
- Measure grout pressures close to the point of injection to account for line losses
- Monitor grout pressures and volumes throughout both tremie grouting and pressure grouting (if used) processes
- Typical postgrouting pressures are 2 to 4 MPa
  - safety issue



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### Manual Monitoring of Pressure (Type B Micropile)



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### Construction Monitoring

#### Installation of Reinforcement

- Install either before or after initial grout placement but before temporary casing (if used) is withdrawn
- Record the total pile length and bond zone length
- Insert to the prescribed length without the use of force
- Do not damage corrosion protection or centralizers during installation



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### Construction Monitoring

#### Installation of Reinforcement (cont.)

- Ensure reinforcement is clean of any surface soil, oil, mud etc.
- Check attachment and intervals (typically 2.5 to 3 meters) of centralizers and spacers
- Center reinforcement in borehole
- Ensure full engagement of successive bar or pipe sections



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## QA/QC Documentation

### Pile Load Testing

- Ultimate and Verification load testing
- Proof load testing
  - Verifying:
    - design capacity
    - construction processes
- Check pile load test setup with the approved working drawings
- Perform pile load testing in accordance with the project specifications



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## Testing Specifications

- Number of “sacrificial” piles to be tested (Ultimate vs. Verification)
- Number of production piles to be tested
- Magnitude of test load
- Method of load application



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## Testing Specifications

- Duration of load hold steps (especially for extended creep testing)
- Acceptance criteria (load, movement, creep)
- Load test set up, instrumentation and measurement

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## Load Testing Requirements Determining Factors

- Number of production piles
- Magnitude and type of loading
- Sensitivity of structure / consequences of failure
- Geotechnical conditions and variability
- Access / headroom / constructability restraints
- Engineer / Contractor experience
- Factors of Safety

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## Development of Verification Load Testing Program

- Perform load testing in proximity to a soil boring
- Review critical load combinations for load testing

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## Acceptance Criteria

### For Verification Test

- Criteria 1:
  - Rate of Pile Head Movement at the Test Load
- Criteria 2:
  - Total Pile Head Movement at the Design Load
- Criteria 3:
  - Total Pile Head Movement Under Sustained Load (Creep)

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### Typical Compression Test Set Up



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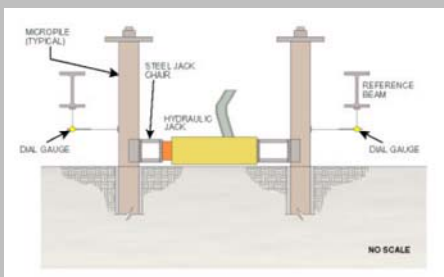
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### Set Up - Lateral Test



Lateral Load Test Arrangement (ASTM 3966-90)



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### Lateral Load Test Setup



Courtesy: Nicholson



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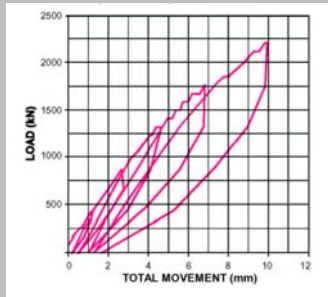
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### Total Movement – Cyclic Test (e.g. Ultimate or Verification Test on Sacrificial Pile)



Pile top displacement vs. pile load curve




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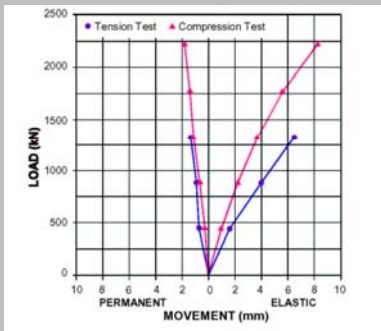
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### Partitioning of Cyclic Pile Test Data into Elastic and Permanent Components



Pile top elastic/permanent displacement vs. pile load curve




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### “Strange Results” or Failure

- Clarify possible reasons for “strange results” or failure in real time
- Options following failure
  - Modify design of individual pile
  - Modify construction
  - Reduce unit load requirements/increase number of piles
  - Additional testing




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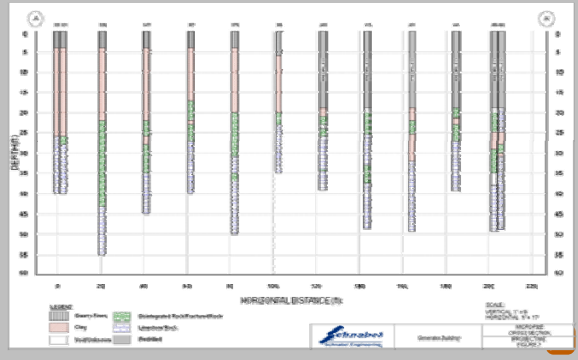
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## Data Management - Micropiles



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## Maintaining Good Photographic Records in Real Time



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## Learning Outcomes

- Key elements to be evaluated during construction
- Factors that affect development of a load testing program

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## Questions & Discussion

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