Recent Advances in the Selection and Use of Drilled Foundations

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Overview

- Micropiles
- Continuous Flight Auger Piles
- Drilled Displacement Piles
- Drilled Shafts
Micropiles

- Typically <12" dia
- Relies on steel for structural capacity
- Installed with lightweight, versatile drilling equipment
- Effective in difficult ground conditions

World Trade Center, NYC

Advancements in Micropiles

- Standards for design & construction
- Higher capacity piles
- Improvements in drilling and more versatile drilling rigs
- Innovative applications
Micropiles – Design Details

- Casing near surface
- Center bar(s) through bond zone
- AASHTO Design Section 10.9

References:

Example Cross-sections
Micropiles in Difficult Ground Conditions

- Karst
- Till & Boulders
- Difficult Site Access
- Restricted Headroom

Cumberland River

Micropile VE solution for difficult access piers

Drilled through boulders
Slope Stability Concerns
Cumberland River

Bronx Whitestone Bridge, NYC

Innovative r/c percussion drilling techniques through boulders & till
Case History – Foothills Bridge

Foothills Bridge

Abutment 1
Area of Colluvium

Abutment 2
Foothills Bridge

- Cased zone
- Uncased bond zone
- Pier
- Anchor (to rock)
- Residual Soil
- Sound Rock
- Weathered Rock

Foothills Bridge

- Image of construction site
- Image of construction process
Foothills – Trestle Foundation

Foothills – Pier Foundations
Continuous Flight Auger Piles

- Drill rig capabilities – deeper, larger diameter
- Control of the drilling process in unstable soils
- Control of the casting process for quality control / quality assurance
Continuous Flight Auger Piles

Use of Automated Monitoring Systems

Drilled Displacement Piles
Drilled Displacement Piles

- Reduce or eliminate spoil
- Increased axial resistance
- Improve ground
- Eliminate risk of subsidence
- Drill effort related to axial resistance

Kentucky Hospital

- Drilled displacement columns for ground improvement
- Liquefaction mitigation
- Bearing capacity for spread footings
Drilled Displacement Piles

Bearing Tests
Drilled Shafts

- Larger, Deeper Machine Capabilities
  - Oscillator/Rotator Machines
  - Reverse Circulation
- Base Grouting
- Verification Testing

Oscillator Equipment
Rotator Equipment

Seating Casing into Rock
## Considerations

### Advantages
- Stability of fully cased excavation
- Minimal vibrations for casing installation
- Easy removal of spoil & obstructions
- Avoid or minimize slurry materials

### Limitations
- Mobilization cost
- Equipment support requirements
- Potential to become stuck for deep shafts
- Non-level base with hammer-grab excavation

## Slip-in Can for Column Connection

![Slip-in Casing and Oscillator Casing](image)
Rotator Construction
– Huey P. Long Bridge, New Orleans

Huey Long Bridge
Shaft/Cap Connection

Shaft Cutoff at -11

Isolation Casing
Completed Foundation

Surface Texture
Restricted Headroom with Rotator Casing

Moses Wheeler Bridge, Connecticut

Obstructions?

VE solution to cut through existing piling
Reverse Circulation Top-Drive Drill

Reverse Circulation Drilling
Wolf Creek Dam
Deeper Drilled Shafts

Case History: Wolf Creek Dam, Kentucky

Embankment wall

Secant pile wall

275 ft deep

Wolf Creek Dam Secant Piles
Base Grouting

Widespread Use of Polymer Slurry

- Disposal advantages
- Improved side resistance
- Benefits in degradable shales
Verification Testing

- Integrity Testing
- Load Testing

- Verification testing allows performance basis for specification
  - Design-build
  - Value engineering

ATC, Mississippi River Bridge, St. Louis

O-cells

Cored rock from test shaft excavation
Summary

Substantial advances across the broad spectrum of drilled foundations:

- Equipment & drilling capabilities
- More diversity in foundation solutions
- Verification testing, alternative project delivery allows implementation of innovation