AUTOMATED MONITORING EQUIPMENT FOR ACIP AND DD PILES

Presented by:

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Overland Park KS
Berkel & Company Contractors, Inc
Founded by Mr. Charles J. Berkel in 1959

San Francisco
Kansas City
Corporate Office
Louisville
Atlanta
Houston
Baltimore / Washington D.C.
Orlando
• Scope of Presentation
  ✓ ACIP (APG) and DD Pile construction
    (similarities and differences)
  ✓ Parameters to monitor
  ✓ Monitoring equipment
  ✓ Real time use of drilling data
Cast-in-place piles installed by single-pass, rotary drilling processes

Continuous Flight Auger

ACIP aka Augercast (APG)

European Screw Piles

Displacement Pile (APG-D)

European CFA

Intermediate (Partial) Displacement
Gaspar Coelius granted patent for cast-in-place screw pile in 1960

Analogous to augered... .. And to displacement

From De Cock and Imbo, Transportation Research Record 1447
Auger Pressure Grouted (APG) Pile System

- Cast-in-place piles grew out of pressure-grouting processes at Intrusion-Prepakt, late 1940s, early 1950s
- Patent granted to Raymond Patterson for construction of cast-in-place piles by pumping grout through a hollow-stem auger.
- Licenses granted to Lee Truzillo and Charles Berkel
APG Pile Example Installation

(1) Stem augers hole

(2) Grout pumped under pressure

(3) Build up grout head prior to withdrawing auger

(4) Hollow stem auger retracted while grout pumped into hole
APG Pile Installation

(1) Auger drills hole

(2) Grout is injected under pressure

(3) Build up grout head prior to withdrawing auger

(4) Hollow Stem Auger is retracted while grout is pumped into hole
Typical APG Pile Rig
Gearbox

- Torques range from about 15,000 ft-lbs to 90,000 ft-lbs
- Weighs 2,000 to 10,000 lbs (down force)
Hydraulic Power Unit

Provides hydraulic power to turn the gearbox and auger
Fixed-Mast Platform

Crane-Mounted Platform

4’-0” +/-

30’-0” +/-
PLATFORM FEATURES

- 150,00 to 200,000 ft-lb torque
- 40,000 to 80,000 lb crowd
Displacement leads to increased horizontal stresses (and densification) for higher shaft resistance in many soils.

Grout/soil interface is a more effective load transfer interface than pre-cast or steel/soil.
DD PILE INSTALLATION METHOD

- Tool advances as a screw in low to medium consistency soils.
- In dense soils, material transported up the auger to the displacing element. Material in auger flights is compressed; thus no stress relief in the zone adjacent to the auger.
DD PILE GROUTING

- When the target level has been reached, pumping of grout is begun. Grout pressure is monitored by the operator. Lift off and withdrawal rate are varied to maintain pressure where possible.

- Tool is rotated during withdrawal and material which falls around stem is captured and displaced.

- Typically get grout return only after tip is at or near ground surface.
Grout Pump

- Hydraulically operated, positive displacement piston-ball valve pump
- Pump pressures typically around 350 psi at pump outlet
- Stroke vols. typically range from about 0.4 to 1.0 cubic feet per stroke (up to 1.7)
- Grout hoses typically 2 to 3 inch diameter
- Can pump grout several hundred feet
- Grout typically delivered by ready mix trucks
Schematic of AME on APG pile drilling platform
Figure 2. Main Control Unit including:
(a) motherboard (vertical in red outline on photo on left) and signal conditioning  
(b) real-time viewing and control panels in Operator’s cabin
• Depth is monitored by measuring rotations of a wire spool – the spool is mounted on the boom and the wire is connected to the top of the gear box driving the rotation of the drill stem.
a pressure transducer is used to monitor the hydraulic fluid pressure (referred to as KDK Pressure) applied to the motor driving the rotation of the stem of the continuous flight auger. Hydraulic pressure is measured to the nearest 0.1 bar.
Drilling Stem Rotation is monitored by measuring the flow of hydraulic fluid applied to the motor driving the rotation of the stem of the continuous flight auger. Stem rotation is calibrated to the hydraulic fluid flow and measured to the nearest RPM.
ROTATION – Proximity Switch
Grout Flow may be measured by means of a 3-in (inside diameter) magnetic flow meter with a Teflon liner inserted in the grout line between the pump and entry-point of the hollow drilling stem. Grout flow is recorded to the nearest 0.1 ft³.
Notes on Flow Meters

Flowmeters typically have exposed electrodes that must be in contact with the conductive fluid (grout). If non-conductive sand particles take up space on the surface of the electrode, this interferes with the flow of electrical current. If the amount of electrode in contact with the fluid is variable, calibration with pump strokes is not possible. Berkel has noted difficulty in maintaining calibration in some areas of the country.
Grout Pressure

A dial gage is attached to the grout pump outlet to verify the grout pressure from the pump; however, this is available for manual inspection only and is not digitally recorded as part of the AME system.

Grout Pressure may be monitored digitally at the point where the flow meter is connected to the grout line by a sensor attachment to the flow meter. Although grout pressure is monitored during pile casting for consistency, it is considered non-essential.
Grout Pressure

Some discussion of using in line grout pressure to count pump strokes but this is in its infancy.

Rumours of using in line stroke counters but have only seen this for jet grouting to date.
Use of Awesome Data

real-time graphical display of drilling and grouting parameters in control cabin

real-time numerical display of same parameters on remote display unit for inspector
screen shot of drilling and grouting parameters displayed in control cabin

screen shot of drilling and grouting parameters displayed on remote display unit for inspector
REPORTING
Fixed Mast Platforms

Overview of Drilling Platform and Sensors
Primary Drilling Parameters
(Recorded at 1 Reading per Second)

- **Time**: Recorded by an internal counter and referenced to the initial date and time input by the operator at the beginning of the project.

- **Depth**: From proximity switch that measures rotation of the main winch supporting the drilling turntable and drilling tools.

- **Hydraulic Fluid Pressure driving turntable** (i.e. KDK Pressure): From in-line pressure transducer.

- **Rotations** (of drilling tools): From proximity switch on turntable.
Depth

Depth is monitored through the use of a proximity sensor which measures the rotations of the main winch, which supports the drilling stem.
The rotation of the drill stem is monitored through the use of a proximity sensor which directly records stem rotation.
A dial gage is attached to the grout pump outlet to verify the grout pressure from the pump; however, this is available for manual inspection only and is not digitally recorded as part of the AME system.

A fluid pressure sensor is located at the top of the turn table where the grout enters the hollow drilling stem. Grout pressure at the top of the drilling stem is measured to the nearest 0.1 psi.
When the target level has been reached, pumping of grout is begun. Grout pressure is monitored by the operator Lift off and withdrawal rate are varied to maintain pressure where possible.

- Tool is rotated during withdrawal and material which falls around stem is captured and displaced.
- Typically get grout return only after tip is at or near ground surface.
REPORTING
Intermediate (Partial) Displacement Pile System
Intermediate Displacement Tooling

CONVENTIONAL ACIP TOOL

INTERMEDIATE (PARTIAL) DISPLACEMENT TOOL

DRILLED DISPLACEMENT TOOL
REPORTING
Instantaneous Installation Effort

\[ T_I = 2.78 \left( \frac{T_{fp}}{T_{Base}} \right)^{1.36} \]

\[ PRI = \left( \frac{PR}{PR_{Base}} \right)^{0.5} \]

\[ IE = \frac{T_I}{PRI} \]
Repeatability?
Calculation of Cumulative IE

- **Incremental IE < 10 typically indicative of fine grained soils**
- **Increase in IE in coarse grained material**
- **PROBLEM**
  - Exaggerated increase in SumIE in denser sand strata
- **New Cumulative IE**
  - Integration of incremental IE vs. Depth curve - change in scale of estimation of total effort
- **Original SumIE**
  - Summation of incremental IE values
- **More appropriate representation of shaft load distribution with depth**
Database of IE vs. Capacity

3 test results from project site plotted as red triangles
On Board - Operator Monitor

Depth: -0.00 ft
Max Depth: -0.00 ft
Time: 00:00
Pen. Rate: -0.0 ft/min
Rotation: 0 RPM
Cum. IE: 0
Strokes: 0 min 0 act

P-Grout: AaBbCc

P-Rotary Head: AaBbCc

Torque: 0 kip*ft

Pile Number: AaBbCc
Berkel&Co.
0 MM.DD.YY HH:MM:SSa

Check Pile Nr
Three load tests installed in homogeneous soil to different depths to determine site IE vs Capacity relationship - taken as plus one Standard Deviation line for this project.

- Lower shaft and toe in sand yields more "typical" toe component for capacity.
- Shaft in silt, toe in silty sand yields "slight" toe component for capacity.
- Shaft and toe in silt yields little to no toe component for capacity.

Mean IE vs Capacity relationship with +/- 1 standard deviation.

EXAMPLE PROJECT A
EXAMPLE PROJECT B
Use of Cumulative IE

Use upper curve to estimate resistance “lost” in deep excavations from working surface.

Use final value to estimate total pile resistance.

Use curve to estimate resistance of piles with less energy.