Design and Construction of Drilled Full Displacement Piles using the Penetration Resistance Method

Peter Faust
Malcolm Drilling Company Inc.
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<th>Site</th>
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<th>OMEGA Pile</th>
<th>Design</th>
<th>Construction</th>
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Alexandria Parking Garage, San Francisco

Design – Build

- 321 Piles
- DIA = 18"
- 40 – 80 ft
- 620 kips C.
- 225 kips T.
Geotech Consultant

- 8 SPT Borings + 1 CPT Sounding
- Evaluation of Soil Bearing Capacity
- Test Program of various Foundation Systems
- Displacement Pile Recommendation

Client

- Cost/Time Effective Foundation System
- Low Environmental Impact (Noise/Vibration)
- Reduce Spoils (Landfill with Contaminants)
Design Build Contractor

- Additional CPT Soundings
- Test Pile Program
- Site Specific Pile Design
- Indicator Test Piles to confirm Assumptions
- Savings due to 'Pile-by-Pile Design'
- 8 SPT
- 25 CPT
- 5 Load Tests
- 20 Indicator Piles
Fill

Soft Clay

Dense Sand

Sandy Clay

Shale/Claystone
Displacement Piles

- **Definition**: A small diameter (< 36”) continuously drilled and grouted pile with or without steel reinforcement.
- **Axial Capacity**: up to 2,000 kips Ultimate in Soil
- **Friction**: High Tension & Compression Capacity
- **Slender**: Medium Lateral Capacity
- **Applications**: Foundation, Ground Improvement to Reduce Liquefaction Risk
Advantages

- Lateral Soil Compaction
  - Low Settlements
  - Higher Soil Resistance
- 50-100% Higher Capacity Than Conventional Pile
- Very little Spoils (Ideal in Contaminated Soils)
- No Vibrations and little Noise during Installation
- Fast and Efficient Installation
Soil Compaction will increase Shear and Base Resistance
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**MDCI is License Holder in the Western US**
Full Displacement Pile (FDP)

Omega Pile

Reverse Flighting

Soil Transport
Concrete Pressure Gage

On Board Software [B-Tronic]

Flowmeter (Opt.)

Stroke Counter
Site    Soil   OMEGA Pile   Design   Construction   QA/QC

Full Displacement Tool

Partial Displacement Tool

3 Feet

15 Feet
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**Drilling**

**Grouting**
Cage Installation

Pile Cap Work
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- 750 kip Compression Tests
- 225 kip Tension Test

Loadcell
Spherical Bearing
500T Jack

Telltail
Pile Length Adjustment

Load-Settlement Curve

CT-03
CT-10

CPT Sounding

Test Pile Movement
PL/AE
Davisson’s Failure Criterion
Telltale Movement

Site Soil OMEGA Pile Design Construction QA/QC
Design Considerations

1. SPT and/or CPT Soil Investigation
2. Direct Assessment of Bearing Capacity
   Van Impe, Bustamante, Ne Smith
3. Test Pile Installation with Electronic Monitoring of Installation Parameter (B-Tronic)
4. Static Load Test Program
5. Relate Test Results to Penetration Resistance
Geotechnical Site Report

Test Pile Installation and Recording of Penetration Resistance (ALPHA Value)

Pile Load Test (s)

Comparison of Test Load and ALPHA Value

Set Target ALPHA Value in Drilling Software (B-Tronic)

Adapted Pile Length (Pile-by-Pile Design) due to Self-Investigating Drilling System using the Target ALPHA Value
Pile-by-Pile Design

Pile Depth Variation should be accepted as intrinsic component

Adapted pile lengths due to self investigation system

1. investigated/ expected bearing layer
2. calculated pile lengths
red = zone of insufficient bearing capacity - not detected by soil investigation
ALPHA VALUE

[Penetration Resistance]

\[ \alpha = \frac{\text{torque}}{\text{penetration}} \]

\[ = \frac{240 \text{ kNm}}{0.03 \text{ m} / U} = 8000 [-] \]

The Alpha value is an index for the penetration resistance and shows the bearing capacity of the soil.
ALPHA Value

[Penetration Resistance]

- Site Specific
- Tool Specific
- Drill Rig Specific
- Real Time Display
- ‘Hole-by-Hole CPT’
Site    Soil    OMEGA Pile    Design    Construction    QA/QC

Soft Clay

Soft Spot

Soft Spot
• CPT Data
• Test Pile Data
• Indicator Piles

Installation Criteria

Alpha ≥ 2,000 for 4 meter

Alpha ≥ 5,000 for 1 meter

Alpha Value

~600 kips
(~4tsf * 4.7sf/lf * 16ft)
Time Related Penetration Resistance (ALPHA Value)

- Delay
- $\alpha = 5,000$
- $\alpha = 2,000$
- Request by inspector to exceed criteria
- Crowd Speed $< 0.4$ m/min = Drilling Refusal
- Crowd Speed $< 0.4$ m/min = Drilling Refusal
### ALPHA Value – Why?

- Optimize Drilling Progress
- Less Wear and Tear on Tools and Machine
- Enables Pile-by-Pile Design
- Reproducible ‘Test-Pile Conditions’
- Automatic QA/QC Protocols
- Pile Length Reduction
Drilling Log, FDP Piles

Malcolm Drilling

Job No.: AL-001
Client: Alexandria Real Estate

Inspection Log No.: 0205417
Date: Aug 6, 2008

Inspector: Barry Brown

Site Soil OMEGA Pile Design Construction QA/QC

Drilling Rig: 80-140
Rotary Drive: N/A

Drill Site: mm | kg/m³ | KPa
Consistency: SPT | W/C

Nominal pile dia.: 26.94 m
Nominal pile length: 26.94 m
Nominal pile length: 26.94 m
Empty hole length: 0 m
Ant. concrete column: 2.012 m²
Nail penetration: 2.43 m
Excess concreete: 0.182 m³

Drilling start: 12:00:00 PM
Drilling end: 14:45:57 PM
Total time: 00:45:57
Pumping speed: 1.40 m³/min

Concrete pressure: 0.00 MPa
Concrete strength: 0.00 MPa
Penetration resistance: 0.00 MPa/min

Remarks:

Malcolm Drilling Company, Inc. - 2503 Bunker Hill Ave, CA 90015

B-Tronic Log

Inspectors Log
OMEGA Piles by Malcolm Drilling

- Cost Efficient Pile System
- Environmental Friendly
- State of the Art QA/QC

Ideal for Design-Build
Thank You