Duplex Drilling Method

“Drill Bit Location”

A Friendly Discussion

Thomas J. Tuozzolo, P.E.

September, 24, 2010
ISM – Washington, DC
Overview

- Internal Drilling Methods
- Can “Plug Drilling” work everywhere?
- What does it really take to drill a proper hole/pile?
- Discussion
Basic Construction Sequence Involves

- Drilling
- Placing reinforcement
- Grouting
Basic Construction Techniques

Installation Methods

1. Drilling
2. Tremie Grouting
3. Place Reinforcement
4. Injection & Extraction of Casing
5. Pile Completed

NOTE: Casing Usually Left in Place To Improve Performance
Drilling Methods

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

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

- Often specified - least risk
- Minimal loss of ground in cohesionless soils
- Possible borehole smearing in clays
- Grouted through the casing – then pulled with tremie head or excess pressure
Internal Flush Drilling
King Swivel – injecting water or air
Discharge Spoils
Pressure Grouting Setup
Drill Bit Location
Installation with Cutting Shoes
Internal Flush Drilling
Rotary Duplex Rod and Casing
Rotary Duplex Rod and Casing
Internal Flush Drilling
Internal Flush Drilling
Bit Location – Air Configuration
Plug Drilling – What is it?

In Plug Drilling the Casing extends well beyond the inner steel, forcing internal (between the casing and the drill steel) travel of spoil.

(Foundation Drilling Magazine, January 2009)

Reason for Plug Drilling???

“Inner Drill String must remain retracted inside casing a distance of 2 times the inside diameter of the casing to prevent external flush”
What do you do when you bind up?
Possible outcome
Possible Disadvantages

- “Having a machine with the power of a large bore drill allows to plug drill”
What about tight access or low headroom projects?

Cross Section Through New Chamber
What about tight access or low headroom projects?

Lowering of Drill Rigs – Klemm 702
What about tight access or low headroom?

Lowering of Drill Rigs
What about tight access or low headroom?

Two Rigs Working
What about tight access or low headroom?
Possible Disadvantages

- “Having a machine with the power of a large bore drill allows to plug drill”

- Makes casing shoe do more of the work and can result in excess wear which can result in premature termination of hole (shoe worn out) requiring extraction of casing (leaving an open hole).

- What happens when you get stuck?

- More torque induced into casing which can result in difficulties extracting and breaking joints for pressure grouted micropiles (joints seized up).
Possible conditions for “Plug Drilling”

- No restrictions on rig size. Can use large drill head with high torque.
- You can drill with a single stroke machine, without adding casing.
- You never have to pull out of the drill hole.

If “plug drilling” is not performed properly you may need a lot of grout!!!
### Uphold Velocity – Compressed Air

**Min. Uphole Velocity** = 3,500 FPM

<table>
<thead>
<tr>
<th>Type</th>
<th>ROD SIZE</th>
<th>CASING SIZES</th>
<th>MINIMUM COMPRESSOR SIZE REQUIRED in CFM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>114 mm x 0.500&quot;</td>
<td>133 mm x 0.500&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.500&quot;</td>
<td>0.500&quot;</td>
</tr>
<tr>
<td>2-3/8&quot; IF (API Internal Flush)</td>
<td>3.5</td>
<td>-</td>
<td>110</td>
</tr>
<tr>
<td>2 7/8&quot; IF (API Internal Flush)</td>
<td>4.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3-1/2&quot; IF (API Internal Flush)</td>
<td>4.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3-1/2&quot; IF OS (API Internal Flush)</td>
<td>5.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4&quot; FH (API Full Hole)</td>
<td>5.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4-1/2&quot; BECO</td>
<td>7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6&quot; BECO</td>
<td>8.625</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Lift ½ inch particle out of hole 70 to 80ft max
## Uphold Velocity – Water

### MINIMUM WATER VOLUME REQUIRED in GPM

<table>
<thead>
<tr>
<th>ROD SIZE</th>
<th>114 mm x 0.500&quot;</th>
<th>133 mm x 0.500&quot;</th>
<th>133 mm x 0.365&quot;</th>
<th>5.5 in x 0.453&quot;</th>
<th>5.5 in x 0.415&quot;</th>
<th>7.0 in x 0.500&quot;</th>
<th>7.0 in x 0.500&quot;</th>
<th>8.625 in x 0.500&quot;</th>
<th>8.625 in x 0.545&quot;</th>
<th>9.625 in x 0.500&quot;</th>
<th>8.625 in x 0.500&quot;</th>
<th>10.75 in x 0.750&quot;</th>
<th>10.75 in x 0.750&quot;</th>
<th>12.75 in x 0.500&quot;</th>
<th>12.75 in x 0.750&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>OD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-3/8&quot; IF (API Internal Flush)</td>
<td>3.5</td>
<td>-</td>
<td>40</td>
<td>70</td>
<td>60</td>
<td>160</td>
<td>150</td>
<td>290</td>
<td>390</td>
<td>380</td>
<td>510</td>
<td>450</td>
<td>780</td>
<td>700</td>
<td></td>
</tr>
<tr>
<td>2 7/8&quot; IF (API Internal Flush)</td>
<td>4.5</td>
<td>-</td>
<td>-</td>
<td>20</td>
<td>10</td>
<td>110</td>
<td>100</td>
<td>240</td>
<td>340</td>
<td>330</td>
<td>460</td>
<td>400</td>
<td>730</td>
<td>660</td>
<td></td>
</tr>
<tr>
<td>3-1/2&quot; IF (API Internal Flush)</td>
<td>4.5</td>
<td>-</td>
<td>-</td>
<td>20</td>
<td>10</td>
<td>110</td>
<td>100</td>
<td>240</td>
<td>340</td>
<td>330</td>
<td>460</td>
<td>400</td>
<td>730</td>
<td>660</td>
<td></td>
</tr>
<tr>
<td>3-1/2&quot; IF OS (API Internal Flush)</td>
<td>5.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>50</td>
<td>40</td>
<td>180</td>
<td>280</td>
<td>270</td>
<td>400</td>
<td>340</td>
<td>660</td>
<td>590</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4&quot; FH (API Full Hole)</td>
<td>5.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>50</td>
<td>40</td>
<td>180</td>
<td>280</td>
<td>270</td>
<td>400</td>
<td>340</td>
<td>660</td>
</tr>
<tr>
<td>4-1/2&quot; BECO</td>
<td>7</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>60</td>
<td>160</td>
<td>150</td>
<td>290</td>
<td>230</td>
<td>550</td>
<td>480</td>
<td></td>
</tr>
<tr>
<td>6&quot; BECO</td>
<td>8.625</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>130</td>
<td>70</td>
<td>390</td>
<td>320</td>
</tr>
<tr>
<td>12</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>12</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>12</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Typically use no more than 100 gpm.

Lift ½ inch particle out of hole 70 to 80 ft max.
What should you be doing while internal drilling?

- Drill bit leading by 1 – 3 inches.
- Really controlling your fluids, whether it be air or water.
- Cuttings not coming up the casing, too much water.
- What do you think?
Thank You!
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
Typical Overburden Cased Drilling Techniques

- Single-tube advancement
  - external flush (wash boring)
  - drive drilling (lost point)
- Rotary duplex – Inner Rod
- Double head duplex
- Hollow Stem Augers
- Sonic
- Rotary percussive – Down-Hole-Hammer
- Rotary percussive-Overburden Systems
Water Flush Through Duplex Ejector
Rotary Percussive Duplex
Rotary Percussive Duplex
Overburden Drilling Systems - Concentric

- High-production drilling equipment
- Overburden drilling systems
  - NUMA Superjaws
  - Mitsubishi Super Maxbit
- Other obstruction-tooling
Initial Notes on Design-Special Tooling
Equipment and Tooling Selection

ICTOLOY “CRUNCH” BIT

CARBIDE-BUTTON RING BIT

HARD FORMATION ROLLER BIT
Equipment and Tooling Selection
Manhattan Salt Storage Piers
Bronx Piers