The Technical and Contractual Matters of Bored Piling Works

By
Wallace Yeung
Vibro (H.K.) Ltd.
- What is large diameter bored pile?
- How to construct a large diameter bored pile?
- Its advantages and limitation
- Common problems and disputes incurred
What is a large diameter Bored Pile?

- Replacement and Cast in Situ Pile
- Pile diameter greater than 750mm
- Formed by excavation or machine boring
- Pile core temporary support by steel casing or drilling fluid
How to Construct a Large Diameter Bored Pile?
Step 1 Predrilling (超前鑽)

- Carry out Predrilling at the centre of each bored pile location.
- Sunk at least 5m into the category of rock specified for founding or forming of rock socket, or the designed rock socket length of the pile, whichever is the deeper.
- To identify and locate the bedrock level
Grade IV rock

Grade III rock

Grade II rock
Major Plants commonly involved.

- Crawler Crane
- Oscillator
- Reverse Circulation Drill (RCD)
Crawler Crane
Oscillator
Reverse Circulation Drill (RCD)
Other Type of Boring Machine for Constructing Bored Pile – Rotary Drilling Rig
Setting out of the pile location.
Placing of Oscillator at pile location.
Installation of Temporary Casing by Oscillator/Rotator.
Coupling of temporary casing with casing joints.
Coupling of casing by welding.
Grabbing of soil by grab and jacking down the temporary casing
Types of grab

- Grab for excavation of soft materials
Grab for excavation through hard stratum and boulder layers
Set up RCD for rock socket drilling when Bedrock Level is reached.
Types of drill bit for different types of drilling

- Drill Bit
Bellout Bit (for formation of bellout socket)
BELL-OUT TOOL

INFERRED BEDROCK LEVEL

B (SHAFT DIA. IN ROCK SOCKET)

30° MAX.

BELL-OUT DIA.
Reaming drill bit
Stage 1: Encountering top of sandwich layer & temporary casing cannot be further advanced.

Stage 2: Make use of RCD & flat bottom drillbit to form advancing hole in hard layer.

Stage 3: Make use of RCD & underreamer to enlarge the diameter of advancing hole in hard layer.

Stage 4: Jack down the temporary casing into the advancing hole.
Repeat the reaming process until all the sandwich layers being overcome.

Stage 5
Installation of drilling bit
Air-lifting for cleaning the pile shaft.
Carry out Koden Test for verifying the verticality of the pile and bellout size
VIBRO (H.K.) LIMITED
Bellout Verification of Bored Pile
Ultrasonic Earth Echo (Koden) Test Record

Project: New World Centre Remodeling Project
K.I.L. 9844

Test Location: B-D28A
Date of Test: 6/11/2013

Pile Information:
Design Bell-out Diameter = 4.250 m

Test Results:

Internal Diameter Of The Casing (d) = 2.950 m

<table>
<thead>
<tr>
<th>Internal Diameter of Casing Measured From Calibration Chart (b)</th>
<th>37 mm</th>
<th>37 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration Factor = (d) / (b)</td>
<td>2.950/37</td>
<td>2.950/37</td>
</tr>
<tr>
<td>Bell-out Diameter Measured From Chart</td>
<td>55 mm</td>
<td>55 mm</td>
</tr>
<tr>
<td>Measured Bell-out Diameter Using above Calibration Factor</td>
<td>4.385 m</td>
<td>4.385 m</td>
</tr>
<tr>
<td>(Minimum value of X-X' and Y-Y' directions) Actual Bell-out Diameter</td>
<td>4.385 m</td>
<td></td>
</tr>
</tbody>
</table>

Inclination of Bored Pile:

X - X' = 0-0 = 0 mm (Refer to drawing)

Inclination = \frac{0}{37 mm} x 2950 mm = 0 mm

Depth of the Bored Pile = 23 m; i.e. Inclination = \frac{0}{23000 mm} = \frac{1}{999} < 1:100 (satisfactory)

Y - Y' = 0-0 = 0 mm (Refer to drawing)

Inclination = \frac{0}{37 mm} x 2950 mm = 0 mm

Depth of the Bored Pile = 23 m; i.e. Inclination = \frac{0}{23000 mm} = \frac{1}{999} < 1:100 (satisfactory)

Residual Deviation: \sqrt{(0^2)(0^2)+2950^2/37} = 0 mm

Overall Inclination = \frac{0}{23000 mm} = \frac{1}{999} < 1:100 (satisfactory)
Installation of Rebar Cage
Installation of permanent casing when required.
Airlifting for final cleaning
Concreting to the pile
Step 3 Pile testing

- Interface Coring Test for verifying the soundness of the interface
- The core drilling should be 1 m above and below the interface
Sonic logging test
Recap of bored pile construction
What are the advantages of using bored piles?

1. No risk of ground heave during bored pile construction.
2. Does not greatly affect ground water table and hence not induce settlement.
3. Spoil can be inspected and compared with site investigation data.
What are the advantages of using bored piles?

4. Large structural capacity
5. Construction with less noise and vibration.
6. Can be installed to great depths, more than 100m
7. Can overcome complicated geological stratum, eg. multiple layers of rock, and underground obstructions
Any Limitation?

1. Need large working space for bored piling plant to operate
2. The construction duration cannot be reduced substantially by simply increase the plant resources
3. Need proper access for mobilization of piling plant
Any Limitation?

4. Require large quantity of water supply for piling operation

5. Excavation material requires disposal

6. Concrete quality cannot be inspected as it is cast underground and under water, except by coring

7. Need good workmanship to ensure the pile integrity
Comparisons between bored pile, socket H-pile and precast prestressed concrete pile.
<table>
<thead>
<tr>
<th></th>
<th>Bored pile</th>
<th>Socket-H pile</th>
<th>Precast prestressed concrete pile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load bearing capacity</td>
<td>Higher</td>
<td>Lower</td>
<td>Lower</td>
</tr>
<tr>
<td>Number of piles required</td>
<td>Smaller</td>
<td>Greater</td>
<td>Greater</td>
</tr>
<tr>
<td>Noise level</td>
<td>Low</td>
<td>Low</td>
<td>High (By hydraulic hammer)</td>
</tr>
<tr>
<td>Vibration level</td>
<td>Low</td>
<td>Low</td>
<td>High (By hydraulic hammer)</td>
</tr>
<tr>
<td>Time of construction</td>
<td>Longer</td>
<td>Shorter</td>
<td>Shorter</td>
</tr>
<tr>
<td>Loading test</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Bored pile</td>
<td>Socket-H pile</td>
<td>Precast prestressed concrete pile</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------</td>
<td>---------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Overcome underground settlement</td>
<td>Yes</td>
<td>Yes</td>
<td>Pre-boring is needed</td>
</tr>
<tr>
<td>Ground movement/settlement</td>
<td>Not significant</td>
<td>May result in ground movement</td>
<td>May result in heave and ground movement</td>
</tr>
<tr>
<td>Depth limit</td>
<td>Can be &gt;100m</td>
<td>Approximate limit : 80m-90m</td>
<td>Approximate limit : 60m-70m</td>
</tr>
<tr>
<td>Damage to surrounding structure</td>
<td>No or little damage</td>
<td>May result in large damage</td>
<td>May result in large damage</td>
</tr>
</tbody>
</table>
Common Problems and Disputes.
1. Excessive pile heads above cut-off level.
2. Sound Concrete not found at cut-off level. Remedial Work required
3. Verticality problem and offset out of tolerance.

Offset no more than 75 mm
Verticality: no more than 1:100

Designated position

D > 10 m

Future basement / substructure

Cut-off level of bored piles
4. Poor concrete.
5. Poor pile base interface.
Examples of good pile base interface
6. Pile necking.
7. Where is Rockhead?

Case 1:

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>90.00</td>
<td>Weak, greyish pink spotted greyish brown, highly decomposed, medium grained GRANITE (Very dense, silty fine to medium SAND)</td>
</tr>
<tr>
<td>94.53</td>
<td>Moderately strong, brownish red spotted dark grey, light green, moderately decomposed, slightly altered medium grained GRANITE, with closely spaced, extremely narrow, smooth planar, clean, kaolin coated joints, dipping 30°–50° with occasional sub-vertically</td>
</tr>
</tbody>
</table>

Operation stopped at 92.58m
Case 2:

As sheet 7 of 9

Weak, brown, highly decomposed medium grained GRANITE. (Coarse GRAVEL with cobbles.)

Weak to moderately weak, brown spotted grey, highly decomposed medium grained GRANITE with subvertical joints.

No recovery, assumed to be completely decomposed GRANITE.

Weak to moderately weak, brown spotted grey and brown, highly decomposed medium grained GRANITE with subvertical joints.

Very weak, brown occasionally pinkish brown, completely decomposed medium grained GRANITE. (Fine to coarse SAND with much fine to coarse gravel.)

Moderately strong, brown spotted grey and white, moderately decomposed medium grained GRANITE.

No recovery, assumed to be completely decomposed GRANITE.

Moderately strong, pinkish brown and pink spotted grey and white, moderately decomposed medium grained GRANITE with occasional microcracks. Joints are closely to medium occasionally extremely closely to very closely and widely spaced, rough stepped and undulating occasionally planar, limonite and manganese oxide stained, calcite filled joints, dipping at 0°-10°, 20°-30° and 40°-50° occasional 35°-40° and 60°-70°.

Weak to moderately weak, highly decomposed. 76.99-79.87m: Subvertical joint. 77.07-77.17m: Subvertical joint.
Case 3:

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>occasionally planar, limonite and manganese oxide stained, oxide coated, dipping at 5°-10°, 10°-20° and 40°-50° exceptional 20°-30°, 60°-60° and 60°-70°. 69.19-70.06m: Weak to moderately weak, highly decomposed. 69.23-70.56m: Subvertical joint. 70.08-70.36m: Subvertical joint. 70.44-70.74m: Weak to moderately weak, highly decomposed. 71.42-72.52m: Weak to moderately weak, highly decomposed. 71.42-72.52m: Subvertical joint.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>73.52-74.23m: With subvertical joints. 74.33-74.82m: Subvertical joint. 74.41-75.17m: Weak to moderately weak, highly decomposed. 75.04-75.35m: Subvertical joint. 75.41-75.76m: Weak to moderately weak, highly decomposed. 75.56-76.18m: With subvertical joints. 76.06-77.37m: Weak to moderately weak, highly decomposed. 77.73-77.85m: Weak to moderately weak, highly decomposed. 77.88-78.22m: Subvertical joint. 78.09-79.07m: Weak to moderately weak, highly decomposed.</td>
<td></td>
</tr>
</tbody>
</table>
### Case 4:

<table>
<thead>
<tr>
<th>Water Level (m)</th>
<th>Sample</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3</td>
<td></td>
<td>As sheet 3 of 5</td>
</tr>
</tbody>
</table>

**Moderately strong, brownish grey, spotted black, moderately decomposed, medium grained GRANITE.**

- Joints are closely spaced, locally very closely spaced, rough planar and rough stepped.
- Extremely narrow, iron oxide stained, manganese oxide, chlorite and kaolin (<2mm) coated, dipping at 0°-10°, 20°-30°, 40°-50°, 60°-70° and subvertical.

33.60-33.87m: Moderately weak, moderately decomposed.

35.60-35.10m: Weak, highly decomposed. Recovered as angular fins to coarse GRAVEL and some cobbles.

36.10-36.28m: No recovery, assumed to be completely decomposed.

Strong, greenish grey, spotted black, slightly decomposed, medium grained GRANITE.

- Joints are medium to closely spaced, locally closely spaced, rough planar and rough stepped, extremely narrow, iron and manganese oxide stained, kaolin (<2mm) and chlorite coated, dipping at 0°-10°, 20°-30°, 40°-50°, 60°-70° and subvertical.
END
Q & A