Merdeka PNB118 Case Study: Analysis of Different Bore Pile Testing Methods

Merdeka PNB 118 专案研讨：基桩试验方法之采用分析

Peter Ramstedt, Project Director, Turner International LLC
彼得·兰斯特，项目总监，特纳国际
Warisan Merdeka Development – Master Plan

Owner:
- Permodalan Nasional Berhad (PNB)

Overview:
- Mixed use development project undertaken at 40 acres of stadia land
- Three phases across 19 acres

Phase One:
- Iconic 118 story tower and retail shopping mall
- GDV of RM5 billion
- First phase started in 2014, expected to be completed in 2020
Past Aerial Photo (August 2014)
Current Aerial Photo (August 2016)
Piling Testing – Purpose and Methodologies

Pile testing is performed to validate design parameters and to verify construction conformance to the specifications. Methodology used is dependent on the type of data required by the Engineer of Record.

Common Pile Testing Methodologies:
1. Statnamic Load Test
2. Static Maintained Load Test (via)
   a. Kentledge blocks
   b. Reaction Piles
3. Bi-directional Osterberg Cell (O-cell) Test
4. Pile Driving Analyzer (PDA) Dynamic Load Test (Not performed within the project)
Master Bore Piling Layout

Total 1,083 no. of piles:
- Main Tower 137 no.
- East Car Park 411 no.
- West Car Park 372 no.
- Linear Park 163 no.

Pile Testing Program:
- Statnamic 9 no.
- O-Cell 12 no.
- Reaction 9 no.
- Kentledge 1 no.
1. Statnamic Load Test – Overview

1. Controlled burn of set amount of solid fuel
2. Pressure builds in pressure chamber
3. Upward force pushes up on reaction mass
4. Opposite force pushes down on test pile
5. As reaction mass moves up, surrounding gravel falls under mass for stability
1. Statnamic Load Test – Project Data

- Highly specialized testing performed by a licensed explosives expert
- Requires relatively small open area to set up (6mx6m)
- Quick – approximately 1 week to set up, 2-3 days to demobilize
- Results are immediate
- Costly – one test equaled the installation cost of 3 main tower bore piles
1. Statnamic Load Test – Video

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2a. Static Maintained Load Testing (Kenglledge blocks) – Overview

- Commonly used pile test
- Pile center is located, top of pile is leveled
- Temporary reaction structure consisting of concrete blocks are stacked and balanced
- Load cell is placed at center of mass/pile
- Larger test loads require larger clear area and higher piles of blocks for larger reaction mass
2a. Static Maintained Load Testing (Kentledge blocks) – Project Data

- Approximately 3 weeks to set up, 2-3 days for testing, 1-2 weeks to dismantle
- Safe zone + clear area of 20mx20m was required for test
- Stacking sequence was key to prevention of tipping
- Safety risks with hoisting, load balancing, falls and crushing hazards
2a. Static Maintained Load Testing (Kentledge blocks) – Project Data

Tested to 3,000 tons
2b. Static Maintained Load Test (Reaction piles) – Overview

- Also a commonly used pile test
- Pile center is located, top of pile is leveled
- Additional sacrificial reaction piles with tendons are installed near pile to be tested
- Temporary structure is installed for connection of tendons at either end
- Load cell is placed at center of structure/pile
2b. Static Maintained Load Test (Reaction piles) – Project Data

- Reaction piles are needed (2 - 4 no.) depending on size of test pile and load to be tested
- Safety risks consisted of hoisting, installation of reinforcing cages with embedded tendons, loading and connection of tendons to temporary structures
- Preferred over Kentledge due to reduced height of reaction mass
3. Bi-directional Osterberg Cell (O-cell) Test – Overview

Precision of embedded items within pile cage can be complicated:

1. Predetermined (2-5 no.) of embedded hydraulic pistons (o-cells)
2. Various strain gauges installed within the pile cage
3. Hydraulic hoses installed to/from the o-cells
4. Numerous data transducers
5. Atypical inner and outer rebar cages required
6. Hydraulic pressure is used to activate the o-cells
3. Bi-directional Osterberg Cell (O-cell) Test – Project Data

- Good safety, no additional working area required as test apparatus is embedded within the pile
- O-cell assembly can be long lead (2-3 months)
- No access to malfunctions of embedded items once cage is set and concrete is placed
1. Testing specialist above and beyond normal pile test practices are required to perform PDA

2. PDA test must be compatible with the testing equipment and with size of piles to be tested

3. Pile test load limit is constrained by maximum weights available to conduct the test and maximum size of available testing structures (unless custom test structures are to be built)
4. Pile Driving Analyzer (PDA) Dynamic Load Test – Overview

1. A crane is used to lift a substantial ram mass, which acts as a hammer to cause small, permanent displacement to the pile

2. Transducers and gauges are placed at the top of pile

3. The weight mass is lifted to a predetermined height then dropped on the pile (several cycles may be done)
Pile Testing – Selection & Execution

- Pile testing was required early in the project for design validation:
  - Two (2) pile tests for tower piles (via o-cell)
  - Six (6) pile tests for car park piles (five via o-cell, one via Kentledge)
  - Confirmation of test results by the Engineer (along with different balancing fluids) enabled the car park piles to be reduced in length by 12% → substantial cost and time savings to the project

- During foundation installation, pile testing was performed for construction validation:
  - Testing methods were selected in concurrence with the Engineer of Record
  - Considerations were made for:
    - Desired test load & requirements
    - Test reliability
    - Site logistics
    - Safety
    - Cost
    - Schedule & Availability
Pile Testing – Selection & Execution (cont.)

- For main tower bore piles, high testing load was required
- Kentledge would be too massive and required a larger area

Previous testing to 3,000 tons

Assumed area for testing to 12,000 tons
Statnamic was chosen for construction validation due to:

- Space constraints (active pile installation was underway)
- Pile to pile spacing (no room for reaction piles)
- High test load (Kentledge would be too massive)
- O-cell was long lead, and if test failed, limited room to allow for a replacement working pile
- Quick test results desired
# General Comparison of Piling Testing Methodologies

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Program</th>
<th>Set Up Time</th>
<th>Availability</th>
<th>Logistics</th>
<th>Safety</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>Statnamic</td>
<td>7 to 10 days</td>
<td>(plus availability)</td>
<td></td>
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<tr>
<td>MLT with Kentledge Blocks</td>
<td>4 to 7 weeks</td>
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<tr>
<td>MLT with Reaction Piles</td>
<td>2 to 3 months</td>
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<tr>
<td>O-Cell</td>
<td>2 to 3 months</td>
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<tr>
<td>PDA</td>
<td>2 to 3 weeks</td>
<td>(plus availability)</td>
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Most: 〇〇〇〇〇 Least: 〇〇〇〇〇
Terima Kasih
Thank you
谢谢