Resource Piling
Large Load Tests using a Reaction System
RESOURCE PILING’S BACKGROUND
Core businesses

- Bored Piles
- Reaction System Load Test
- Contiguous Bored Pile Wall
- Ancillary Services
- Secant Piles
- Kentledge Load Test

RESOURCE PILING
Achievements

• Over 30 years of Piling (since 1981)
• >489 piling projects completed
• Grade L6 (unlimited piling contracts value)
• Largest & deepest piles: Ø2.5m & 92m
• Largest Kentledge in Singapore: 5,700 ton
• Largest Reaction test in Singapore: 7,652 ton

Recent major projects: Sengkang Hospital, Marina Coastal Expressway, Garden by the Bay, Marina Barrage, Singapore Deep Tunnel Sewerage System, Business and Financial Centre, Tuas-A Power Station,
THE PROBLEM
Singapore is land scarce (~700 km$^2$). However it has an ever growing population (latest figures are above 5.3 million people). This dense population results in a change in infrastructure design. Hence a need for taller buildings and underground infrastructure.
Taller Buildings = Larger and deeper piles

BFC @ Marina South

The Sail @ Marina Bay
Deep Tunnel, soft soil = Larger & deeper piles
Therefore larger & taller load tests

These taller buildings and deep underground infrastructures (tunnels, basements, etc.) require larger and deeper piles. To ensure that these piles have sufficient capacity they are tested using load tests.

A kentledge using concrete blocks is one of the most common method of doing a load test in Singapore.

5700 ton Kentledge Test, Jun 10. Biggest in Singapore
If it is not properly carried out, the outcome can be catastrophic. Such an example is seen at the Gilstead road incident on 16 Jan 2011. A Kentledge load test failed and blocks landed onto a public road causing:

- Road closure & traffic congestion
- Gas pipe disrupted / leakage
- Church evacuated & Kindergarten temporary stop
- Negative public perception
- Deploy SCDF, SP Power Grid, Police, etc.
Reaction from authorities

- WSH Council’s alert
- GEOSS committee
  - Guidelines on good practices
  - Resource Piling (Mr. Foo Hee Kang) invited
THE TEAM
A team of management staff, operational staff, and safety personnel was gathered to work on a better solution to the Kentledge using concrete blocks for high capacity load test.

<table>
<thead>
<tr>
<th>Project Team</th>
<th>Name - Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chairman</td>
<td>Foo Hee Kang – MD</td>
</tr>
<tr>
<td>Technical Advisor</td>
<td>Tan Hock Seng - GM</td>
</tr>
<tr>
<td>Leader</td>
<td>Benjamin Lee - PM</td>
</tr>
<tr>
<td>Facilitators</td>
<td>Calvin Ng – Coordinator</td>
</tr>
<tr>
<td></td>
<td>Mitram Gopal – HSE Executive (Keller)</td>
</tr>
<tr>
<td>Members</td>
<td>Donald Choo – Plant Mngr</td>
</tr>
<tr>
<td></td>
<td>Kumaresan – Site Mngr</td>
</tr>
<tr>
<td></td>
<td>Prabakar – Site Engineer</td>
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</tbody>
</table>
SCHEDULE
Project planning

Schedule of project

- Schedule was developed to plan and monitor progress of the project.
- Corrective actions were taken when deadlines were not met.
- Overall progress was in line with plan.

Outline:
- Team formation
- Root cause analysis
- Design solution
- Implementation
- Review
- Oasis Hotel
- Gilstead rd collapse
ROOT CAUSE ANALYSIS
Root cause analysis

The Ishikawa model along with the 5 Why model were used to postulate the cause of the accident at Gilstead road.

The main conclusions were:
- Height of Kentledge leading to large toppling zone
- Inadequacy of design
ALTERNATIVE SOLUTIONS
4 alternative solutions to the Kentledge using concrete blocks were considered: Statnamic test, O-cell, Kentledge using steel plates, and Reaction system (using reaction from piles). The table above shows the test times and safety improvements. Further analysis of the solutions are on next slide.
### Alternative solutions

<table>
<thead>
<tr>
<th>Statnamic</th>
<th>O-cell</th>
<th>Steel plates</th>
<th>Reaction system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statnamic is an explosive test. There are inherent risks with the handling explosive material especially with increase of test loads.</td>
<td>2 main difficulties with O-cells are in terms of the design (accurate placement of the O-cell in the pile) and quality of construction (especially with the concrete just below the O-cell).</td>
<td>Estimated cost of steel plates for a 7,068 ton Kentledge test is S$7.8 million. This is a huge investment.</td>
<td>Estimated cost for a 7,068 ton Reaction load test is S$0.78. Hence this is the preferred option</td>
</tr>
</tbody>
</table>
Current Capacity Limitations

However, reactions systems capacities have so far been in the range of 1,500 tons to 2,000 tons. Hence the Reaction System load test would need to be re-designed to allow test of more than 4,000 tons.

Addition factors considered during the re-designing process were
- Ease of transport,
- Assembly technique,
- New safety risks (if any),
- Time of fabrication,
- Detailed cost calculations
- etc.
SELECTED SOLUTION
Reaction system

- Reaction Piles
- Test Pile
BENEFITS
Height reduction

A 7,068 ton Kentledge using concrete blocks (left) would require employees to work at a maximum height of 21.2 m whereas a Reaction load test of the same capacity would require employees to work at a much reduced 6.4 m.
A 7,068 ton Kentledge using concrete blocks (left) has a toppling area of 5,300 m² whereas a Reaction load test of the same capacity has a toppling area of 900 m².
### Benefits at a glance

<table>
<thead>
<tr>
<th></th>
<th>Height</th>
<th>Toppling Zone</th>
<th>Lifts</th>
<th>Traffic</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaction System</td>
<td>15 m</td>
<td>4,400 m²</td>
<td>3,900</td>
<td>425</td>
<td>S$ 182,000</td>
</tr>
<tr>
<td>(70%)</td>
<td>(83%)</td>
<td>Reduced</td>
<td>Reduced</td>
<td>Reduced</td>
<td>(94%) annual savings</td>
</tr>
</tbody>
</table>

- Figures are based on 7,068 ton tests
- Figures compares a Reaction System load test to a Kentledge load test using concrete blocks
- Savings calculations are based on annualized costs and includes estimates of life cycles of materials such as concrete, steel, jacks, etc.
DESIGN & STANDARDIZATION
Design & Standardization

The solution is standardized through the following methods:

- Engineering design
- Method Statement
- Risk Assessments
- Safe Work Procedures
IMPLEMENTATION
Communication

To ensure successful implementation of the solution, the work procedures, risks and hazards need to be communicated to the supervisors, and workers. The following are the main methods used to communicate the solution:

• Discuss with execution team
• Brief RA & SWP
• Brief lifting plan
• Pre-start talks
Execution

Having communicated the solution, the work is executed on site. Execution is monitored at several points to ensure that work being carried out complies to safe work procedures, risk assessments, permit-to-work (PTW), etc.
An example of the completed setup (a 7,652 ton) load test using the Reaction System at Ophir road, Singapore.
EXPANDABILITY
## Projects completed

<table>
<thead>
<tr>
<th>Project</th>
<th>Test Load</th>
<th>Done on</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oasis Hotel @ Peck Seah St.</td>
<td>5380t</td>
<td>2012 Aug.</td>
</tr>
<tr>
<td>M+S Project @ Ophir Road</td>
<td>7652t</td>
<td>2012 Nov.</td>
</tr>
<tr>
<td></td>
<td>7652t</td>
<td>2012 Nov.</td>
</tr>
<tr>
<td></td>
<td>6240t</td>
<td>2013 Feb.</td>
</tr>
<tr>
<td></td>
<td>5046t</td>
<td>2013 Apr.</td>
</tr>
<tr>
<td></td>
<td>6240t</td>
<td>2013 Mar.</td>
</tr>
<tr>
<td></td>
<td>7532t</td>
<td>2013 May</td>
</tr>
<tr>
<td>TRX(Tun Razak Exchange @ Malaysia)</td>
<td>7500t</td>
<td>2013 Oct</td>
</tr>
<tr>
<td></td>
<td>7500t</td>
<td>2013 Oct</td>
</tr>
<tr>
<td>Tampines Town Hub @ Tampines Ave.4</td>
<td>7068t</td>
<td>2013 Nov</td>
</tr>
</tbody>
</table>
RESULTS
Results

Tangible results
- Height of load test = Reduced
- Work-at-Height exposure height & hours = Reduced
- Number of lifts using cranes = Reduced
- Toppling zone = Reduced
- Vehicular movement on the road = Reduced
- Productivity = Increased

Intangible results
- Workers morale = Improved
- Safety awareness = Improved
- Public perception = Improved