1. Introduction

Pile Load Tests are needed to

1. Determine the bearing capacity of piles
2. Determine the settlement of pile when it is subjected to n times working load condition
3. Verify the soil parameters used in pile design (i.e. unit skin friction and unit end bearing capacity)
4. Check the quality of pile construction → Proof Load Test.

Traditional Pile load test – Static Maintained Load Test using Kentledge blocks or steel plates

More recently, in Malaysia and Singapore, due to rapid development, there is a drive and need to improve the productivity of construction industry

→ particularly, to reduce the time needed to verify the soil parameters used in pile design, and speed up the process of the “proof load” tests for many hundreds of piles per project.
2. Theory -- Concept and Basic Features of Rapid Pile Load Testing

Patrick Bermingham

Accelerating a mass and generating a push load on the pile head is called the Statnamic method.

Sir Isaac Newton 1642-1727

\[ F = m.a \]

Statnamic

Long duration load, quasi static pile and soil behavior
Deceleration of a mass from a drop mass onto a spring system to prolong loading time, and generate a push load on the pile head is called the StatRapid STR method.

\[ m \cdot a = F \]

StatRapid
Long duration load, quasi static pile and soil behavior

Modular and adjustable spring system
In Europe, there is a growing awareness that in Dynamics Test the pile capacities is determined by “signal matching techniques” which is heavily depend on the assumptions made by the person analyzing the test results and yield a wide range of results, especially for cast in situ piles (i.e. cross-section area non-uniform).

This is one of the reasons that in 2010 the Dutch CUR commission adopted the Rapid Load Testing technique (over the Dynamic testing method) as the results are consistent and virtually independent of the person analyzing the test data.

In Japan, The statnamic Pile testing method is accepted in Japanese Code since 2002.

In 2008 – This method is officially accepted as ASTM Standard Method -- ASTM D7383-08

<table>
<thead>
<tr>
<th>Comparison between Static, Rapid &amp; Dynamic Pile Load Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static</td>
</tr>
<tr>
<td>Unit Cost - For Marine Piles, $/Ton</td>
</tr>
<tr>
<td>Loading Duration</td>
</tr>
<tr>
<td>Reaction mass (% test load)</td>
</tr>
<tr>
<td>Total test Duration</td>
</tr>
<tr>
<td>Interpretation</td>
</tr>
</tbody>
</table>
Load Test Methods

DYNAMIC TESTING

STATIC
Dead weight 100 %

Load Displacement

Dead weight 100 %

Load Displacement

STATNAMIC
Reaction mass 5-10%

Strain Acceleration

Signal matching

Drop mass 1-2 %

High pressure gas

Strain Acceleration

Signal matching

Load Displacement

Unloading Point Method (UPM)

STATRAPID
Drop mass 5-10%

Soft cushioning

STATNAMIC and StatRapid), the loading duration is many times longer than the pile length such that the stress-waves effect can be ignored, hence the analysis of a Rapid Load Test is greatly simplified in comparison to a Dynamic Load Test.

Analysis of Rapid Load Test

In Rapid load test (e.g. Statnamic and StatRapid), the loading duration is many times longer than the pile length such that the stress-waves effect can be ignored, hence the analysis of a Rapid Load Test is greatly simplified in comparison to a Dynamic Load Test.

Although stress-waves may be ignored, the ‘dynamic’ effects of INERTIA, as well as DAMPING part of soil respond CANNOT!

3. Interpretation and Analysis of Rapid Load Test Results

Equation of motion -- single d.o.f model

\[ F_{RLT}(t) = ma(t) + cv(t) + ku(t) \]

where
- \( m \) = mass of pile,
- \( c \) = damping coefficient,
- \( k \) = spring constant,
- \( a(t) \) = acceleration at time \( t \),
- \( v(t) \) = velocity at time \( t \),
- \( u(t) \) = displacement at time \( t \),
- \( F_{RLT}(t) \) = applied Rapid Load Test force.
Typical response of a Rapid Load Test

- Load Disp
- Peak Force Point \((P_{pp}, \delta_{pp})\)
- Unloading Point \((P_{up}, \delta_{up})\)

Converting RAPID (STATNAMIC) to STATIC..

- Dynamic effects
- Rate effects

Unloading Point Method (UPM)

- Developed by Peter Middendorp and Patrick Bermingham in 1989
- Used for calculating the static bearing capacity of piles from rapid load tests
- Assumptions:
  - Long duration of the load in relation to the pile length
  - Rigid Pile
  - No wave phenomenon

Measurements Rapid Load Testing

- A: Load cells
- B: Reflector Plate
- C: Acceleration sensor
- D: Pile head
- E: Loading Plate
- F: Spring system plate

Load Cells -> \(F(t)\) (known)
Acc.Sensor -> \(a(t)\) (known)
Laser/Optical reflector plate -> \(u(t)\) (known)
Unloading Point Method (UPM)

- $F(t) =$ Applied force on the pile top
- $F_{SOIL}(t) =$ Reaction force of the soil on the pile. Shaft and toe.
- $F_{inertia}(t) =$ Reaction force of the mass of the pile.

Equilibrium:

$$F(t) = F_{SOIL}(t) + F_{inertia}(t)$$

- $F(t) =$ Measured load on the pile head [N]
- $F_{SOIL}(t) =$ Force from the soil on the pile [N]
- $F_{inertia}(t) =$ Internal force [N]
- $a(t) =$ Measured acceleration [m/s$^2$]
- $m =$ Mass of the pile [kg]

Therefore:

$$F_{SOIL}(t) = F(t) - m a(t)$$

$F_{static} = F_{RLT} - M \times a - C \times v$

Example:

$$F(t) = 2.8 \text{ MNm} = 3619 \text{ kg}$$

$$a = -30 \text{ m/s}^2$$

$$F_{static} = 2.8 - 3619 \times -30 / 1 \times 10^6$$

$$F_{static} = 2.8 + 0.11 = 2.91 \text{ MN}$$
Determining C

- C mean

![Diagram](image1.png)

Figure 2. UPL time window for C determination.

![Diagram](image2.png)

Figure 3. Variation in C between times (1) and (2).

Unloading Point Method is less accurate in pure clay soils

Rate effects are large in clay soils

Therefore the Sheffield Method is developed.

Sheffield Method (SHM)

- Uses all data points of the measured signals
- Analysis is performed numerically
- $F_{STR}$ is corrected with the inertia force $F_A$
- Then the force is corrected for rate effects with $\alpha$, $\beta$
- $\alpha$, $\beta$ depend on type of clay and pile velocity
- Preferred practice: $\alpha$, $\beta$ determined from Lab. Tests
- But practical factors are available
- For calculating the static load displacement also a loading rate $v_{\text{static}}$ and a reference velocity $v_{\text{ref}}$ is used.
RLT Test Criteria

- Inertia force < 20% of F(t)  
  (in Singapore, most of time <5%)

- $10 < \frac{T_f}{L/c_p} < 1000$
  - $T_f =$ Duration of the load [s]
  - $L =$ Length of the pile [m]
  - $C_p =$ wave velocity in the pile [m/s]

Loading duration requirement in ASTM D7838

Video showing the modelling of Dynamic vs Rapid load test – From Mr. Martijn van Delft, Allnamics Internation Ltd
Comparison of Load Tests

4. Practices – Case Study of RLT

-- A. Examples of projects using RAPID LOAD TEST

-- where and why it was used effectively?

3000 Tons Test at Jn P. Ramlee & Mont Kiara, Kuala Lumpur

500 Tons Tests at Jurong Port & Penang Port
3000 Tons Test at Second Link, Johor

Singapore Practices - STATNAMIC
Tuas West Extension : LTA C1687 & C1688
Barrette piles of up to 4,750 tonnes

Singapore Practices - STATNAMIC
Tuas West Extension : C1687 & C1688
Barrette piles of up to 4,750 tonnes

Singapore Practices - STATRAPID
HDB Yishun and Bukit Merah
4. Practices – Case Study of RLT

-- B. Case Study of projects using RAPID LOAD TEST

-- real number!!

Case Study 1 – Calibration of Statnamics Test via Static load test at Punggol East Contract 40

• 16th Aug 2012
Static Load Test – UTP 5

Pile ref. : UTP 5
Pile Diameter : ø 900 mm
Pile Length : 56.80 m
Ref. Borehole : BH-9
Pile installed : 2nd Dec 2011
Test commenced : 17th Dec 2011
Test completed : 24th Dec 2011
Working Load : 492.5 tons

*T1 & T2 - Telltales

UTP 5 - 1st & 2nd Cycle Load Transfer Curve

UTP 5 – Load vs Settlement Curve (Dial Gauge)

Permanent settlement = 4.1 mm

UTP 5 – 1st Cycle

UTP 5 – 2nd Cycle

Statnamic Test – UTP 3

Pile ref. : UTP 3
Pile Diameter : ø 900 mm
Pile Length : 55.20 m
Ref. Borehole : ABH-9
Test completed : 12th Mar 2012
Working Load : 477.0 tons
UTP 3 – Statnamic Load Transfer Curve

UTP 3 - Statnamic Pile Top & Toe Displacement vs Time Plot

UTP 3 – Statnamic Load vs Settlement Plot

Static & Statnamic Test Results Comparison

<table>
<thead>
<tr>
<th>Pile ref. No.</th>
<th>UTP 3</th>
<th>UTP 5</th>
<th>UTP 6</th>
<th>UTP 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load test method</td>
<td>Statnamic</td>
<td>Static</td>
<td>Statnamic</td>
<td>Static</td>
</tr>
<tr>
<td>Pile Diameter</td>
<td>φ 900 mm</td>
<td>φ 900 mm</td>
<td>φ 700 mm</td>
<td>φ 700 mm</td>
</tr>
<tr>
<td>Pile Length</td>
<td>55.200 m</td>
<td>56.800 m</td>
<td>41.505 m</td>
<td>46.098 m</td>
</tr>
<tr>
<td>Ref. Borehole</td>
<td>ABH-9</td>
<td>BH-9</td>
<td>ABH-16</td>
<td>ABH-20</td>
</tr>
<tr>
<td>Max. load applied (tons)</td>
<td>1,506.0</td>
<td>1,446.0</td>
<td>966.0</td>
<td>871.0</td>
</tr>
<tr>
<td>Max. static load (tons)</td>
<td>(3.15 x WL)</td>
<td>(2.94 x WL)</td>
<td>(3.35 x WL)</td>
<td>(2.95 x WL)</td>
</tr>
<tr>
<td>Max. Displacement at 3.0 WL</td>
<td>19.00 mm</td>
<td>15.13 mm</td>
<td>16.50 mm</td>
<td>11.25 mm</td>
</tr>
<tr>
<td>永久变形</td>
<td>3.74 mm</td>
<td>4.50 mm</td>
<td>2.74 mm</td>
<td>3.20 mm</td>
</tr>
</tbody>
</table>
Contribution from Mr Foo H K of RESOURCE PILING PTE LTD

Compare Statnamic Pile Load Test Result Against Kentledge Load Test Result

- UTP-3&6: Statnamic
- UTP-1,2,4,5,7&8: Kentledge
- Compare UTP-2 vs. UTP-3
- Compare UTP-6 vs. UTP-7

<table>
<thead>
<tr>
<th>UTP</th>
<th>PILE SIZE (mm)</th>
<th>DATE CAST</th>
<th>TEST DATE</th>
<th>SETTLEMENT (mm)</th>
<th>NEAREST BOREHOLE REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>700</td>
<td>5/12/2011</td>
<td>4/1/2012</td>
<td>3.50</td>
<td>ABH2</td>
</tr>
<tr>
<td>2</td>
<td>900</td>
<td>7/12/2011</td>
<td>23/12/2011</td>
<td>4.88</td>
<td>BH07</td>
</tr>
<tr>
<td>3</td>
<td>900</td>
<td>1/3/2012</td>
<td>12/3/2012</td>
<td>4.58</td>
<td>ABH09</td>
</tr>
<tr>
<td>4</td>
<td>700</td>
<td>9/12/2011</td>
<td>3/1/2012</td>
<td>3.50</td>
<td>BH10</td>
</tr>
<tr>
<td>5</td>
<td>900</td>
<td>2/12/2011</td>
<td>17/12/2011</td>
<td>4.75</td>
<td>BH09</td>
</tr>
<tr>
<td>6</td>
<td>700</td>
<td>2/3/2012</td>
<td>20/3/2012</td>
<td>3.24</td>
<td>ABH16</td>
</tr>
<tr>
<td>8</td>
<td>900</td>
<td>12/12/2011</td>
<td>7/1/2012</td>
<td>4.25</td>
<td>BH16</td>
</tr>
</tbody>
</table>
Summary

• Statnamic test works very well as compared with static load test in this site!

Case Study 2 – Calibration of StatRapid Test via Static load test at Punggol waterway C36 and At Geylang C16 Project

May-June 2013
StatRapid Setup at test Site

- Video of StatRapid Test in Singapore
Near BH3 and BH6
### Settlement using Scale Rule

<table>
<thead>
<tr>
<th>Load Settlement Curve - Scale Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test load (MN)</strong></td>
</tr>
<tr>
<td>0.00</td>
</tr>
<tr>
<td>1.00</td>
</tr>
<tr>
<td>2.00</td>
</tr>
<tr>
<td>3.00</td>
</tr>
<tr>
<td>4.00</td>
</tr>
<tr>
<td>5.00</td>
</tr>
<tr>
<td>6.00</td>
</tr>
<tr>
<td>7.00</td>
</tr>
<tr>
<td>8.00</td>
</tr>
</tbody>
</table>

- **StatRapid Results**
  - $P = 3.7\, \text{MN}$, $d = 4.5\, \text{mm}$
  - $P = 7.4\, \text{MN}$, $d = 9.0\, \text{mm}$

### Comparing with Static Load Test Results

#### Settlement using Scale Rule
- $P = 3.7\, \text{MN}$, $d = 4.5\, \text{mm}$
- $P = 7.4\, \text{MN}$, $d = 9.0\, \text{mm}$

#### Additional StatRapid Test done on this Settlement
- @2.0 WL = 9.2 mm
- @2.5 WL = 11.2 mm

#### Settlement @2.0 WL
- 9.2 mm
- 11.0 mm
- 7.0 mm
- 8.6 mm

#### Settlement @2.3 WL
- 12.3 mm
- 13.08 mm
- 12.3 mm
- 11.2 mm
Correlation of Statnamic vs Static test – Recent Malaysia Case

### 1. Pile and Testing Details

<table>
<thead>
<tr>
<th>Pile ID</th>
<th>Pile Dia. (m)</th>
<th>Pile Length (m)</th>
<th>Working Load (kN)</th>
<th>Test Load (kN)</th>
<th>Test Method</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP1</td>
<td>1.0</td>
<td>34.50</td>
<td>9,000</td>
<td>22,500</td>
<td>Statnamic</td>
<td>18\textsuperscript{th} July 2014</td>
</tr>
<tr>
<td>TP2</td>
<td>1.2</td>
<td>29.10</td>
<td>12,900</td>
<td>32,250</td>
<td>Static (Kentledge)</td>
<td>2\textsuperscript{nd} to 6\textsuperscript{th} July 2014</td>
</tr>
</tbody>
</table>

Testing conducted on 18 July 2014
N-Values of Boreholes near to test piles

Summary Result for TP 1 and TP2

1. Load Settlement Respond – Specific Settlement at Specific Load

2. Normalised Load Settlement Respond of Static Test Pile (TP 1) and Statnamic Test Pile (TP 2)
In summary, the overall load-settlement respond of “static equivalent” from statnamic compares very well with the conventional static load test results.

Note that the two piles TP1 and TP2 do not have the same length, not the same diameter, and not exactly the same soil profile, yet their normalised load-settlement performance are very rational and very close to one another.

3. Load Transfer Curves

Comparison of Load Transfer Curves from Static and Statnamic – Non-dimensional

Comparison of Load Transfer Curves from Static and Statnamic with Normalized Depth
4. Mobilised Shaft Friction for TP 1 (Statnamic test)

Mobilised Shaft Friction for TP 2 (Static test)

Mobilized End Bearing for TP1 and TP 2

1. The load-settlement behavior of the test piles subjected to Static test and Statnamic test was very similar.

2. Correlation between the two was found to be excellent in terms of (a) specific settlement values at specific load, as well as (b) non-dimensional load settlement respond, where settlement is normalized by pile diameter, and load is normalized by working load.

3. d. The load-transfer curves of the two test piles are very much the same in nature and again, correlation between the two test methods (Statnamic and static) were excellent.

4. The mobilized unit shaft friction and unit end bearing mobilized were found to be very consistent between results of static test and Statnamic test.
In conclusion, Statnamic Test was well correlated with the Static Test conducted at this particular site.

5. Correlation --

Summary of correlation tests conducted between Rapid Load tests and Static load tests in Singapore/Malaysia soils

A. Test sequence

- Four (4) possible arrangements of Correlation Tests
  - Same Pile: StatRapid load test -> Static load test
  - Same Pile: Static load test -> StatRapid load test
  - Different nearby piles (with same diameter) with similar soil profile
  - Different nearby piles (with different diameters) with similar soil profile.

B. Soil Profiles

- Typical ..Kallang, OA
- Kallang, Jurong Formation
- Residual Soils, Jurong Formation

HDB Punggol C36 – Pile 7C47/1 (STATIC -> STATRAPID)

<table>
<thead>
<tr>
<th>Load Cycle</th>
<th>Times of Load</th>
<th>Working Settlement from static test using Kentledge – Scale Rule (mm)</th>
<th>Settlement from static test using Kentledge – Dial Gauge (mm)</th>
<th>Settlement from StatRapid method (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 x WL (2.1MN)</td>
<td>2.75</td>
<td>3.15</td>
<td>2.9</td>
</tr>
<tr>
<td>2</td>
<td>2 x WL (4.2MN)</td>
<td>7.00</td>
<td>6.82</td>
<td>6.6</td>
</tr>
</tbody>
</table>

- Simplified Soil Profile

- 15m of loose silty sand
- 3m of firm clay (Kallang Formation)
- 3m of dense silty sand
- 3m of stiff sandy organic clay (Kallang Formation)
- 27m of dense to very dense silty sand (OA)
HDB Punggol C36 – Pile 7C47/1 (STATIC -> STATRAPID)

HDB Punggol C36 – Pile G74/5 (STATRAPID -> STATIC)

<table>
<thead>
<tr>
<th>Load Cycle</th>
<th>Times of Working Load</th>
<th>Settlement from static test using Kentledge - Scale Rule (mm)</th>
<th>Settlement from static test using Kentledge - Dial Gauge (mm)</th>
<th>Settlement from StatRapid method (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 x WL (3.8MN)</td>
<td>4.75</td>
<td>4.87</td>
<td>4.2</td>
</tr>
<tr>
<td>2</td>
<td>2 x WL (7.5MN)</td>
<td>10.00</td>
<td>10.58</td>
<td>10.00</td>
</tr>
</tbody>
</table>

74/5 Simplified Soil Profile

- 12m of soft to firm sandy silt (Kallang Formation)
- 12m of sandy clay (Kallang Formation)
- 22.2m of medium to very dense silty sand (OA)

Very good correlation for piles socketed in OA even with thick layer of loose silt on top!

Noted that there was very little permanent settlement in both piles during “virgin” load cycles by StatRapid or Static Test.
95 Marine Parade (STATRAPID -> STATIC (2 weeks later)

Pile BP-24

<table>
<thead>
<tr>
<th>Load Cycle</th>
<th>Times of working load [A]</th>
<th>Settlement from Static test using Kentledge</th>
<th>Settlement from Load-Settlement Curve (Figure 1 in IF Foundation Report Dated July 2014) [B]</th>
<th>Residual Settlement (mm) [C]</th>
<th>Settlement from StatRapid Method - As &quot;virgin&quot; pile (mm) [D]</th>
<th>Settlement from StatRapid Method - cumulative from Cycle 1 (mm) [E = C+D]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 x WL (3.45 MN)</td>
<td>1.9</td>
<td></td>
<td>0.85</td>
<td>2.3</td>
<td>3.15</td>
</tr>
<tr>
<td>2</td>
<td>2 x WL (6.90 MN)</td>
<td>6.9</td>
<td></td>
<td>3.5</td>
<td>5.3</td>
<td>8.8</td>
</tr>
</tbody>
</table>

Simplified Soil Profile

- 3m of sandy silt (fill)
- 3m of silty sand
- 9m of marine clay (Kallang Formation)
- 24m of sandy clay (Kallang Formation)
- 16.5m of sandy silt (OA)

Very good correlation for the pile socketed in OA even with thick layer of marine clay

Care is required for correlation as permanent settlement from "virgin" load by quasi-static test need to be accounted for. This is also true vice versa

Bukit Merah

Pile BP-24

<table>
<thead>
<tr>
<th>Load Cycle</th>
<th>Times of working load [A]</th>
<th>Settlement from Static test using Kentledge</th>
<th>Settlement from Load-Settlement Curve (Figure 1 in IF Foundation Report Dated July 2014) [B]</th>
<th>Residual Settlement (mm) [C]</th>
<th>Settlement from StatRapid Method - As &quot;virgin&quot; pile (mm) [D]</th>
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<td>1</td>
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<td></td>
<td>0.85</td>
<td>2.3</td>
<td>3.15</td>
</tr>
<tr>
<td>2</td>
<td>2 x WL (6.90 MN)</td>
<td>6.9</td>
<td></td>
<td>3.5</td>
<td>5.3</td>
<td>8.8</td>
</tr>
</tbody>
</table>

Simplified Soil Profile

- 4m of sandy clay Residual soil - fill
- 16.18m of hard silt (Jurong Formation)
Bukit Merah

- Very good correlation for the pile socketed in Jurong Formation after accounting for permanent settlement.
- Care is required for correlation as permanent settlement from “virgin” load by static test need to be accounted for. This is also true vice versa.

Yishun N5C6

<table>
<thead>
<tr>
<th>Pile - Testing Method</th>
<th>Pile Dia., D (mm)</th>
<th>Working Load WL (MN)</th>
<th>Cycle</th>
<th>Settlement @ Load (Settlement/pile diameter, %)</th>
<th>Soil Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;P9&quot; Static G41-1</td>
<td>900</td>
<td>4.7</td>
<td>1st</td>
<td>5.04 mm (0.56%)</td>
<td>6m of sandy silt</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2nd</td>
<td>-</td>
<td>6m of hard sandy silt</td>
</tr>
<tr>
<td>&quot;P10&quot; StatRapid G14-2</td>
<td>1000</td>
<td>5.75</td>
<td>1st</td>
<td>3.90 mm (0.39%)</td>
<td>11.3m of silty sand</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2nd</td>
<td>9.60 mm (0.96%)</td>
<td>4.91m of silty sand</td>
</tr>
<tr>
<td>StatRapid % - Static %</td>
<td></td>
<td></td>
<td></td>
<td>-0.17%</td>
<td></td>
</tr>
</tbody>
</table>

| "P11" Static G50-6    | 800               | 3.7                  | 1st   | 4.36 mm (0.55%)                             | 12m firm sandy silt |
|                       |                   |                      | 2nd   | 8.48 mm (1.06%)                             | 3m of very stiff sandy silt |
| "P12" StatRapid G3-2  | 900               | 4.7                  | 1st   | 3.80 mm (0.42%)                             | 6m of sandy silt |
|                       |                   |                      | 2nd   | 9.80 mm (1.09%)                             | 6m of sandy clay |
| StatRapid % - Static %|                   |                      |       | -0.13%                                        |              |

| "P13" Static G14-3    | 800               | 4.7                  | 1st   | 3.60 mm (0.42%)                             | 15.07m of dense silty sand |
|                       |                   |                      | 2nd   | 9.60 mm (1.09%)                             | 15.03m of silty sand |
| StatRapid % - Static %|                   |                      |       | -0.13%                                        |              |
CONCLUSIONS

Rapid Load Test (RLT) is a world wide accepted pile testing method, which is covered by many national and international codes, regulations and guidelines.

Statnamic (STN) and StatRapid (STR) are Rapid Load Tests (RLT) and generate similar pile testing results.

RLT in combination with the UPM analysis method, yields consistent and user-independent pile load test results comparable with static load tests. Creep phenomena however are not considered.

With the development of StatRapid (STR) a safe, productive and easy to use device has become available, which allows to perform several pile test per day economically and reliably.

CONCLUSION ON CORELATION WITH STATIC TEST

- Excellent correlation were obtained between Rapid Load test vs static test for various type of correlation sequence, and at typical Singapore soils (KF, OA, FJ).

- Care need to taken for same pile correlation test conducted for “virgin” load-settlement cycle vs “Unloaded-reloaded” cycles.

- Rate effect is negligible for Singapore / Malaysia piling practices as most of the piles design are well socketed into stiff soil/weathered rock. – NO pile embedded in stiff clay (floating friction pile).

- Productivity increase.

PRODUCTIVITY IMPROVEMENT – CASE STUDY OF STATRAPID TEST @PUNGGOL C36

<table>
<thead>
<tr>
<th>Activity</th>
<th>Kentledge Load Test Method</th>
<th>StatRapid Load Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction of kentledge base 1. Kentledge base</td>
<td>1 day</td>
<td>-</td>
</tr>
<tr>
<td>Mob / Setup 1. Test beam and leg setting up 2. Concrete block setting up 3. Equipment setting up 4. Testing Duration</td>
<td>1 set / 0.5 day 360 Ton / day NA 4 days</td>
<td>NA 1.5 day 1 day</td>
</tr>
<tr>
<td>Demol / Removal 1. Test beam and leg removal 2. Concrete block removal 3. Equipment removal</td>
<td>1 set / 0.5 day 360 Ton / day NA</td>
<td>NA NA 1 day</td>
</tr>
<tr>
<td>Trailer Trips</td>
<td>~40 tonnes per trailer, Hundreds of trips each way</td>
<td>Four trailer trips each way</td>
</tr>
<tr>
<td>ESTIMATED DURATION FOR 2,000 ton</td>
<td>~16 days</td>
<td>3.5 days</td>
</tr>
</tbody>
</table>

PRODUCTIVITY INCREASE OF ~400%!
Punggol East Contract 36 & Common Green

Original Piling Contract Duration:
6.5 months
(March – Mid-October)

Conventional Load Test (Est. Duration)
- 14 Nos of SLT
- 7 Nos of SLT were replaced with STATRAPID
  - (Selection of SLTs on the critical path)

PROJECT COMPLETION DATE:
All SLTs completed by end August

Project completed 1.5 months ahead of schedule!!
Productivity gain!!