Fugro LOADTEST

- LOADTEST Inc started in 1991
- Operating around the world from 5 LOADTEST offices
- 45 staff – mostly engineers
  - Some of our staff are recognised leading experts in various forms of pile testing
- €10 M turnover (1/2 USA)
- Portable test systems allow easy access to very remote locations
- LOADTEST acquired Fugro as new owners in Jan 2009 and LOADTEST can now operate from any of the Fugro offices around the world and call on the resources of Fugro where necessary.

Reaction systems for static load tests:

- Dead load (kentledge)
- A structure over the test pile
- Ground anchorage either by tension piles or ground anchors.
- Bi-directional (Osterberg-cell)

Oil-rig module used as Kentledge

Test on group of 9 precast piles to 20MN
Ready assembled reaction systems

2MN  4 MN  5.5 MN  10 MN

Reaction systems

GREAT MOSQUE ABU-DHABI

Zone of influence

Reaction beam on anchor piles

Zone of influence

Kentledge

Zone of influence

Kentledge on piles

Zone of influence

Bi-directional test
Safety considerations

Kentledge collapse
Due to platform/ground failure
From FPS Load testing handbook 2006

Reaction Beam collapse
Due to tension bar failure
From FPS Load testing handbook 2006

COMPLETELY AUTOMATED

BI-DIRECTIONAL O-CELL LOAD TESTS

- Introduction To Osterberg Cell technology
- Advantages & Limitations
- Examples
- Current usage and costs

How it works
Comparison of O-cell and Traditional Tests

- Very high loading capability
- Gets load into rock sockets (or other zone of interest)
- Cost, safety and space advantages
- No additional reaction system needed
- Doubles effective jack load
- Can measure directly skin friction and end bearing
- Post-test grouting techniques allow for testing of production piles

O-cell Static Load Test Advantages

O-Cell Instrumentation

Single O-cell – Bearing Plate Assembly

Top and Bottom Plates are Welded to the O-cell

O-cell / Plate System is Welded into the Rotor Cage
Once the Cage With Attached O-cell is Carefully Lifted, it is Installed into the Shaft Excavation.

O-cells can be Placed at two Levels in the Shaft to Isolate Distinct Shaft Elements. The O-cell Need Not be Attached to a Rebar Cage.

Multi-cell assembly - attaching O-cells to bottom plate.

Multi-cell assembly - attaching top plate.

Cone-shaped tremie guide.
Multilevel testing

Test is performed in stages

Multilevel testing Stage 1

Middle cell closed

Lower cell pressurised

Multilevel testing Stage 1

Downward movement below bottom O-Cell

Multilevel testing Stage 2

Middle cell pressurised

Lower cell draining

Multilevel testing Stage 2

Downward movement below middle O-Cell

Multilevel testing Stage 3

Middle cell pressurised

Lower cell hydraulically closed
Multilevel testing Stage 3

- Downward movement below middle O-Cell
  - End of Stage 2 testing, Bottom of O-cell hydraulic lines closed - allowing load transfer to end bearing.

- Upward movement above middle O-Cell

Equivalent top load-settlement curve

Test Setups

- World record – 160 MN

O-cell Test Limitations

- Preselected shaft
- Maximum load limited by weaker of end bearing or skin friction
- Test results need interpretation
- Top of the pile is not tested structurally tested
- Top load movement curve must be calculated
  - From the sum of measured behaviour;
  - From the sum of modeled behaviour;
  - Finite element;

Test Setups

- 3000 ton Conventional
- 2000 ton O-cell Test
- 3000 ton Conventional
- 2000 ton O-cell Test
Equivalent TLT Assumptions

- 'Rigid' shaft (includes OLT elastic compression)
- L-Movement compatibility, friction and end bearing
- Corrections for direction of skin friction
  - Factor = 1 clays, rock sockets
- Correction for direction of loading can be used
  - Factor = 0.80 Equivalent tension test
- Correction for additional TLT elastic compression
  - Conservative, iterations not needed
- Good practical agreements

Analysis of O-cell test results

Sum of measured results

Measured behaviour Sum of components

Measured plus additional elastic shortening

Comparison test curves
World Record History

<table>
<thead>
<tr>
<th>Location</th>
<th>Diameter</th>
<th>Depth</th>
<th>Maximum Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>St. Mary's River, Georgia</td>
<td>18.5m (61 ft.)</td>
<td>23m (76 ft.)</td>
<td>250 MN (2,300,000 tons)</td>
</tr>
<tr>
<td>Perama, Malaysia (1996)</td>
<td>18.5m (61 ft.)</td>
<td>9m (30 ft.)</td>
<td>87 MN (910,000 tons)</td>
</tr>
<tr>
<td>Appalachian West, Harris</td>
<td>7.5m (25 ft.)</td>
<td>35m (115 ft.)</td>
<td>123 MN (1,250,000 tons)</td>
</tr>
<tr>
<td>Tucson, Arizona (1995)</td>
<td>6.4m (21 ft.)</td>
<td>41m (135 ft.)</td>
<td>101 MN (1,050,000 tons)</td>
</tr>
<tr>
<td>Penang - Mason WV, Ohio River</td>
<td>2.4m (8 ft.)</td>
<td>26m (85 ft.)</td>
<td>102 MN (1,040,000 tons)</td>
</tr>
<tr>
<td>Incheon 2nd Crossing, Korea</td>
<td>2.4m (8 ft.)</td>
<td>6m (20 ft.)</td>
<td>276 MN (2,800,000 tons)</td>
</tr>
</tbody>
</table>

Advantage – High Loads

- High Loads
- Heavy Equipment
- High Tonnages
- Large Structures

Advantage – Rock Sockets

- Less Distribution Uncertainty
- All Load into Socket
- Can Test Full Scale
- Rock & Overburden
- Less Difficult to Interpret
- Uncertain Distribution
- Little or No Top Load Gets into Base
- May Need Model Shaft

Osterberg Cell Load-Movement Curves

- Overburden
- Rock
- TLT
- QL
- TL
- Overload Gross Load (MN)

Ub & Eb difficult to interpret

Incheon 2nd Link, Korea  
Incheon 2nd Link, Korea
Applications

- Bored piles (wet and dry)
- CFA piles
- Driven Piles
  - Cast in-situ (with and without permanent steel casing)
  - Precast
  - Steel tubular piles
- Barrettes

O-cells in CFA piles

Sizes tested to date
Pile Section
300 mm
450 mm
600 mm
750 mm

O-cells in CFA piles

Maximum size/loads tested to date

<table>
<thead>
<tr>
<th>Pile Diameter [mm]</th>
<th>600</th>
<th>750</th>
<th>900</th>
<th>1100</th>
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</thead>
<tbody>
<tr>
<td>Pile Length [m]</td>
<td>38</td>
<td>40</td>
<td>35</td>
<td>36</td>
</tr>
<tr>
<td>O-cell Diameter [mm]</td>
<td>405</td>
<td>540</td>
<td>680</td>
<td>8340</td>
</tr>
<tr>
<td>Mobilised Load [MN]</td>
<td>17.5</td>
<td>32</td>
<td>32</td>
<td>46</td>
</tr>
</tbody>
</table>
St. Petersburg, Russia

- 60 m deep
- 90 MN capacity

Kiev, Ukraine: 90 MN Barrette

- Multiple tremie pipes

Maximum size/loads tested to date

- 7.0m x 1.2m
- 50 m deep
- loaded to 110 MN

T shaped:
- 2.8 x 4.0 m
- loaded to 70MN

Applications: Bridges

- Copper River
- Jiangsu Sutong
- Confederation
- Panama 2nd Bridge

UAE: Multilevel; 80 m deep; 220 MN mobilised
Applications: Buildings

Venetian Hotel, Las Vegas, NV
Four Seasons Hotel Miami, FL
One Raffles Quay, Singapore

Osterberg Cells Installed

Conventional vs. O-Cell

Comparing Load Testing Costs

Bi-directional Testing

Advantages
• No external reaction system
• No anchor piles
• Little or no heavy transport requirements
• Only half the stresses applied to the concrete
• For large tests a significant cost saving

Disadvantages
• Pile test not exactly as a full load test.
• Maximum load applied limited
• Jack is expendable and needs fitting during pile installation

O-cell Tests World-wide

Conclusions
• Bi-directional testing routinely reveals more about the geotechnical behaviour than a traditional top-down loading test. (Over 1400 tests worldwide).
• O-cell testing much safer than traditional top-loading
• As the test loads increase the more cost effective and attractive O-cell testing becomes.
Providing confidence in foundations through load testing - around the world.

www.loadtest.com

A member of the Fugro Group of companies

Florida, USA  UAE  LONDON  SINGAPORE  KOREA

Thank You