STATIC LOAD TESTING
O-cell® Bi-directional testing
State of the art

Dr Melvin England
Fugro LOADTEST

Introduction

- Fugro LOADTEST Overview
- Static load tests
  - Previous/existing technology
  - Developments
- O-cell® static loading tests
- Conclusions

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

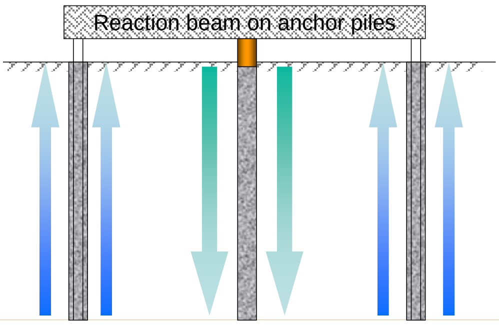
10 MN

Reaction systems

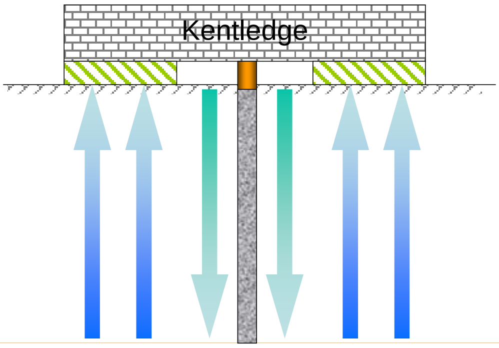
GREAT MOSQUE ABU-DHABI

SHEIKH ZAYED BRIDGE
ABU-DHABI

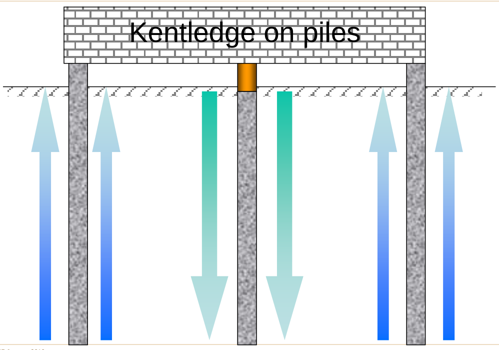
Zone of influence



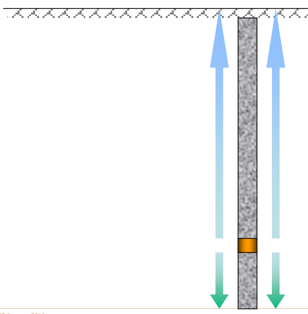
Zone of influence



Zone of influence



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

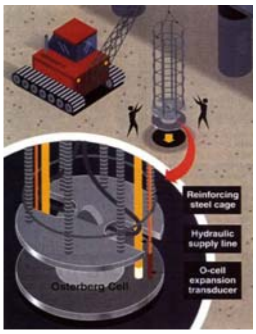
From FPS Load testing handbook 2006

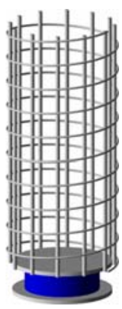
COMPLETELY AUTOMATED

BI-DIRECTIONAL O-CELL LOAD TESTS

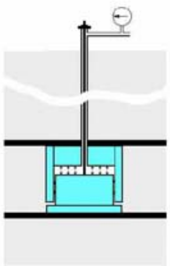
- Introduction To Osterberg Cell technology
- Advantages & Limitations
- Examples
- Current usage and costs

How it works

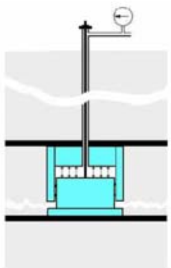




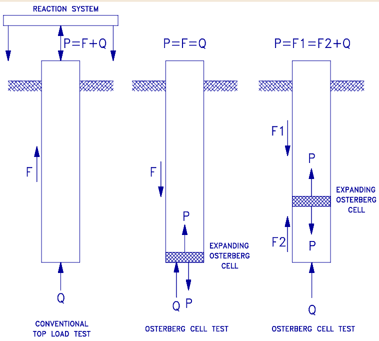
Bi-directional schematic



Bi-directional schematic



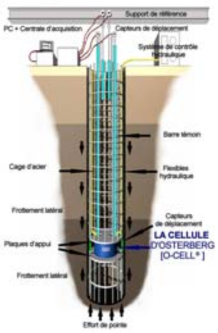
Comparison of O-cell and Traditional Tests



O-cell Static Load Test Advantages

- 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 Instrumentation



Single O-cell – Bearing Plate Assembly

Top and Bottom Plates are Welded to the O-cell

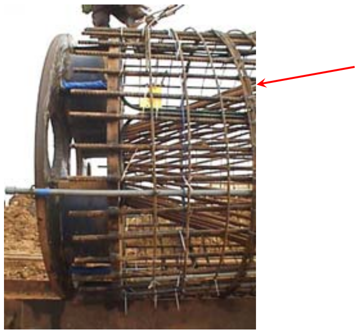
O-cell / Plate System is Welded into the Rebar Cage

O-cell Test Components

O-cell™ fitted with bearing plates attached to cage

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

Multi-cell assembly - attaching top plate



Cone-shaped tremie guide

Lifting the Cage and Attached O-cell Assembly

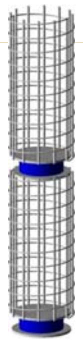
Once the Cage With Attached O-cell is Carefully Lifted, it is Installed into the Shaft Excavation

Other O-cell Assemblies

O-cells can be Placed at two Levels in the Shaft to Isolate Distinct Shaft Elements

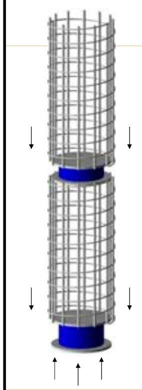
The O-cell Need Not be Attached to a Rebar Cage

Multilevel testing



Test is performed in stages

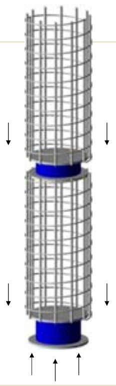
Multilevel testing Stage 1



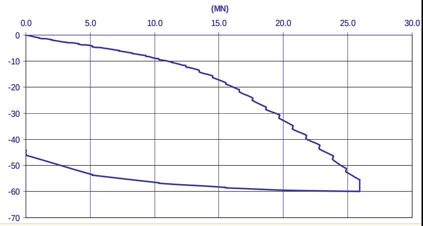
Middle cell closed

Lower cell pressurised

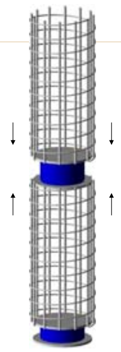
Multilevel testing Stage 1



Downward movement below bottom O-Cell



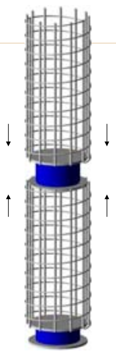
Multilevel testing Stage 2



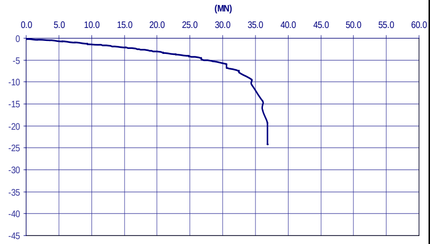
Middle cell pressurised

Lower cell draining

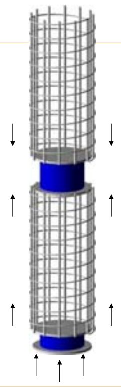
Multilevel testing Stage 2



Downward movement below middle O-Cell



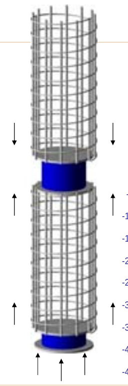
Multilevel testing Stage 3

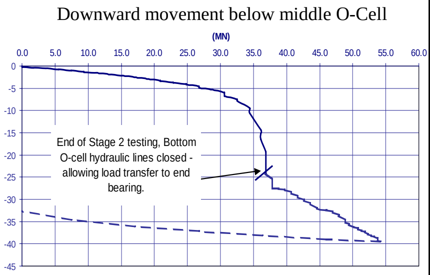


Middle cell pressurised

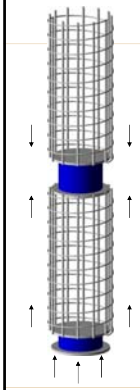
Lower cell hydraulically closed

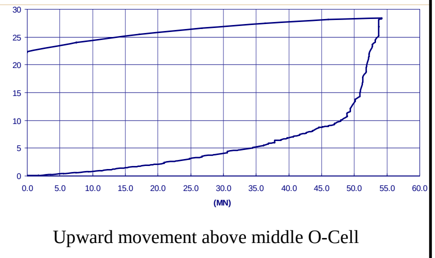
Multilevel testing Stage 3



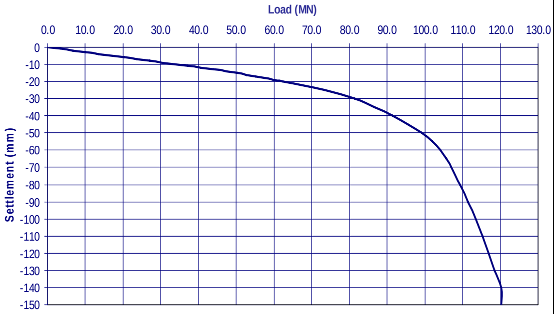


Multilevel testing Stage 3

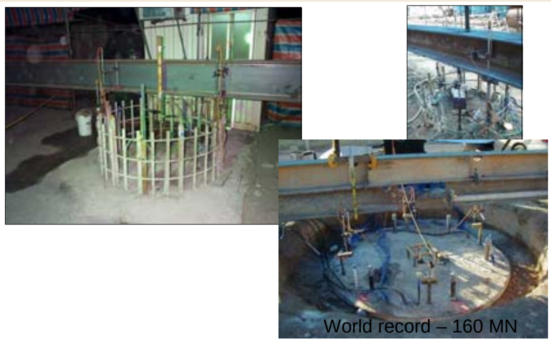




Equivalent top load-settlement curve



Test Setups



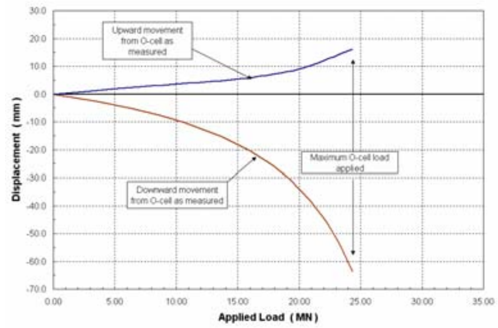
O-cell Test Limitations

- 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;

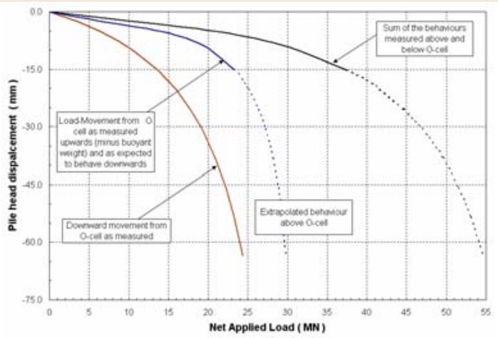
Equivalent TLT Assumptions

- '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

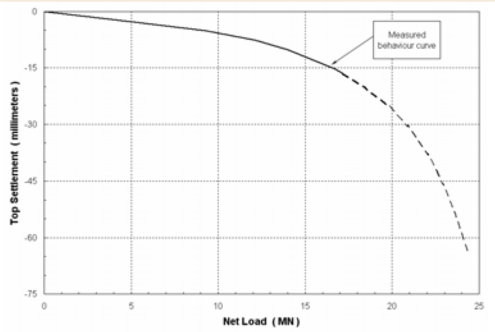
Analysis of O-cell test results



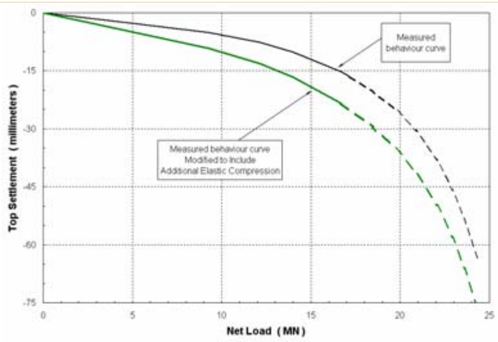
Sum of measured results



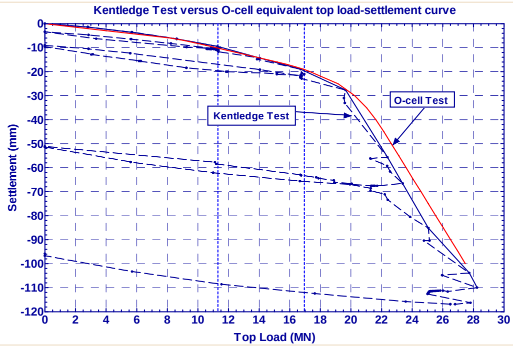
Measured behaviour Sum of components



Measured plus additional elastic shortening



Comparison test curves



Advantage – High Loads

World Record History

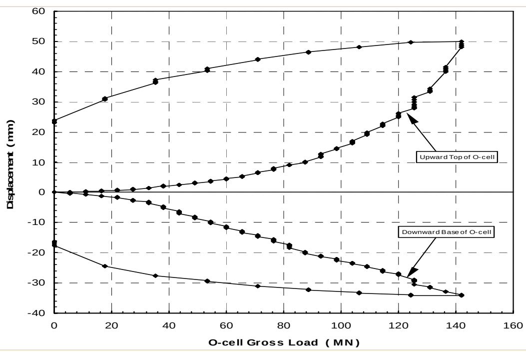
Location	Diameter	Depth	Maximum Load
Ohio River Bridge, Kentucky (1992)	1.8m (6 ft.)	36m (117 ft.)	**54 MN** (6,200 tons)
St. Mary's River, Georgia (1996)	1.5m (5 ft.)	23m (75 ft.)	**65 MN** (7,300 tons)
Penang, Malaysia (1996)	6x1m barrette	91m (300 ft.)	**97 MN** (11,000 tons)
Apalachicola River, Florida (1997)	2.75m (9 ft.)	39m (127 ft.)	**133 MN** (15,000 tons)
Tucson, Arizona (2001)	2.4m (7.9 ft.)	41m (135 ft.)	**151 MN** (17,000 tons)
Pomeroy - Mason WV, Ohio River	2.4m (8 ft.)	26m (86ft.)	**163 MN** (18,400 tons)
Incheon 2nd Crossing Korea	2.4m – 3.0m (8 ft. – 10ft.)	67m (220ft.)	**279 MN** (31,350 tons)

Incheon 2nd Link, Korea

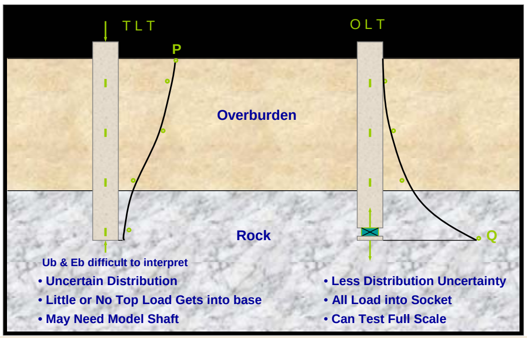
Incheon 2nd Link, Korea

Incheon 2nd Link, Korea

Osterberg Cell Load-Movement Curves



Advantage – Rock Sockets



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

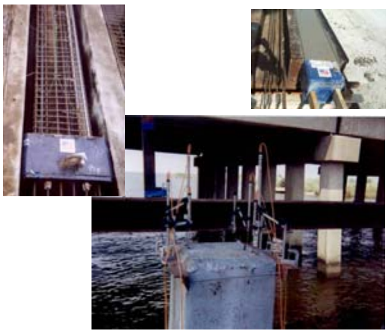


O-cells in CFA piles


O-cells in CFA piles

Maximum size/loads tested to date				
Pile Diameter [mm]	600	750	900	900
Pile Length [m]	38	40	35	36
O-cell Diameter [mm]	405	540	660	2x540
Mobilised Load [MN]	17.5	32	32	46

O-cells in PRECAST piles



Sizes tested to date

Pile Section

300 mm
450 mm
600mm
750 mm

Barrettes

St. Petersburg, Russia

- 60 m deep
- 90 MN capacity

St. Petersburg, Russia

90 MN O-cell test

30 MN Reaction system

Kiev Ukraine: 90 MN Barrette

Multiple tremie pipes

Maximum size/loads tested to date

7.0m x 1.2 m

50 m deep

loaded to 110 MN

T shaped:

2.8 x 4.0 m

loaded to 70MN

Maximum size/loads tested to date

UAE: Multilevel; 80 m deep; 220 MN mobilised

Applications: Bridges

Cooper river

Jiangsu Sutong

Confederation

Panama 2nd Bridge

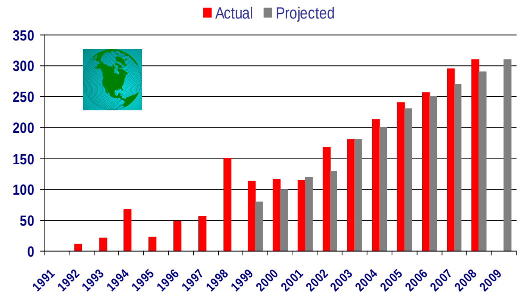
Applications: Buildings

Venetian Hotel,
Las Vegas, NV

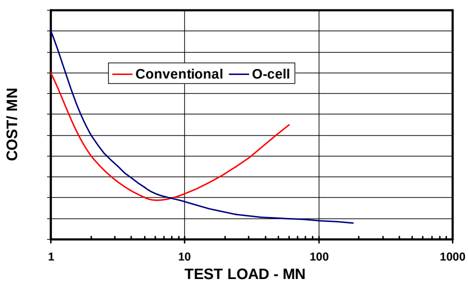
Four Seasons
Hotel
Miami, FL

One Raffles
Quay,
Singapore

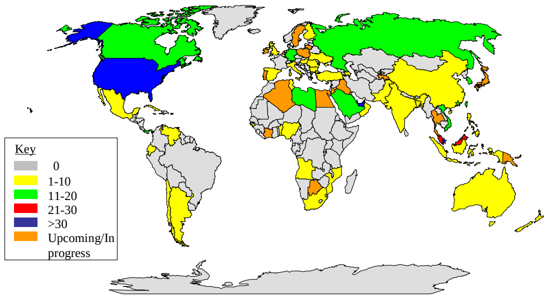
Osterberg Cells Installed



COMPARISON OF LOAD TESTING COSTS
CONVENTIONAL VS. O-CELL



O-cell Tests World-wide



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

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

LOADTEST

A member of the Fugro Group of companies

Florida, USA **UAE** **LONDON** **SINGAPORE** **KOREA**

Thank You