

# FUGRO LOADTEST

## Kingdom Tower (1km High) – Jeddah – Saudi Arabia



1000 m high World's Tallest Tower



Barrette reinforcing cage prior to installation



Construction of the barrettes using hydroraise and bentonite slurry



Pile reinforcing cage with O-cell instrumentation



Testing in progress

### Project

Owners Jeddah Economic Corporation and Kingdom Holdings planned to build, what will be the World's tallest tower at 1000 m, in Jeddah, Kingdom of Saudi Arabia. The challenge of building such a tall tower in unknown ground required a detailed investigation into the ground conditions and load carrying capabilities of the soils at varying depths. Geotechnical engineers Langan International was tasked with providing guidance for the foundation design and engaged Fugro Loadtest for a full scale load testing program.

### Foundation Testing Program

Several questions were asked of the testing program. Which would be the better option for the foundations, conventional piles or a barrette foundation solution and what would be the optimum depth of foundation? Would a bentonite or polymer slurry be preferable over a natural water slurry? As the tower would be situated in an active earthquake zone, would the soil resistance degrade with cyclic loading? In order to answer these questions, the foundation testing program was designed into two phases.

**Phase 1:** A test program of 2 piles and 2 barrettes was undertaken by Soletanche Bachy, one pile and barrette to be 45 m length and the other pair to be 75 m in length founding in siltstone and degraded sandstone deposits. Each pile and barrette was constructed with a multi-level O-cell arrangement consisting of two levels of loading and cyclic loading was planned into the testing schedule to ascertain the soil susceptibility to degradation under cyclic loads.

**Phase 2:** A test program of 2 piles was undertaken by Huta Foundation Works Ltd. The piles were 45 m and 75 m length and constructed with a multi-level O-cell arrangement. A fully instrumented lateral load test was also performed on one of the test piles with 10 levels of inclinometers to measure the lateral deflection. Lateral loads were applied at the pile head using a calibrated jack and load cell.

For the O-cell test piles, the excavation was calipered for diameter, shape and verticality profile after final clean-out using the **SONICALIPER**.

### Testing, Results and Conclusions

Once the testing had been completed, an evaluation was undertaken to enable a suitable foundation solution to be found. The results indicated that piles would perform adequately and that there was no indication of any friction degradation of the deformed sandstone strata under cyclic loading. Results of strain gauge analysis allowed the unit friction to be assessed and a preferred foundation solution to be put forward by Langan International based on the findings for a hybrid pile raft of varying pile length.



# FUGRO LOADTEST

## Kingdom Tower (1km High) – Jeddah – Saudi Arabia



Kingdom Tower Development

**Project:** Kingdom Tower  
**Location:** Jeddah, KSA  
**Client:** Saudi Bauer Foundation Contractors Ltd.  
**Developers:** Jeddah Economic Corporation and Kingdom Holdings  
**Designer:** Langan International  
**Consultant:** Dar Al Handasah



O-cell Assembly in Working Pile

**Project description:** 2013 saw the first permanent piles for the Kingdom Tower to be awarded to Saudi Bauer. Fugro Loadtest was commissioned as the deep foundation testing specialist for the foundation work for the tower. The preliminary test results from the six multi-level O-cell tests, during phase 1 & 2 of the project, allowed the unit friction and end bearing to be assessed. A preferred foundation solution was put forward by Langan International based on the findings for a hybrid pile raft of varying pile length.

### Foundation Testing Program



Lifting of O-cell Cage under supervision of Fugro Loadtest Engineer

As per the project specification requirements, three of the test piles were installed to 48 m depth and one test pile installed at 108 m depth. The excavation for each O-cell test pile was calipered for diameter, shape, profile and verticality after final clean-out using the **SONICALIPER**. The four O-cell proof tests were performed successfully at the required test load of 75 MN and the O-cells were grouted after testing to restore the structural integrity and for incorporation into the structure. The proof tests demonstrated reliability of the construction method and proved that the capacity of the piles could exceed the factor of safety required. The pile displacements were also within the criteria set by the project specifications.



Installation in Progress

In addition, sixteen piles were installed with Geokon model 4911-4 sister bar strain gauges as permanent instrumentation in the pile raft. 100% of the permanent piles were tested for integrity by using the Cross-hole Sonic Logging tests and Tomography 3D profiling.

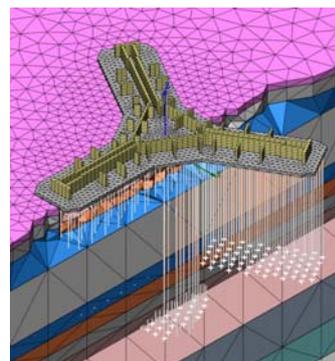
Fugro Loadtest is proud to have played a small but significant part in this project.



Steel Cage Splicing



Langan International preferred hybrid pile raft solution



# LOADTEST O-Cell® Technology in Jeddah, Saudi Arabia



Project: **Lamar Towers**

Client: Kasktas Arabia Ltd

Project Management: Turner Arabia

Consultant: Saudi Diyar Consultants (SDC)

Developers: Cayan Investment and Development

Foundation Contractor: Kasktas Arabia Ltd.

## Project Description:

2008 saw the first bi-directional load tests performed in The Kingdom of Saudi Arabia. Utilizing O-cell technology, two preliminary tests and six working tests were undertaken at the site of the new Lamar Towers project in Jeddah, situated by the shores of the Red Sea.



## Project:

Lamar Towers will be the first high rise development in Jeddah (artist's impression below) long known throughout the kingdom for its shops, restaurant and cafes. Positioned on the Red Sea coastline, this \$2.5 Billion SAR, 7 star luxury project will offer residential, commercial and retail space plus spa all as part of one project.

At 70 storey's, the structures would exert more loading at foundation level than ever experienced previously in the area. The characteristics of the coral founding strata under loading were not well known.

To verify the piles would have sufficient load bearing capacity, static load tests were required on two preliminary test piles to verify the design. The magnitude of load required would not be cost effective using traditional top-down techniques and the concrete cut-off level was almost 7 m below piling platform level, making the O-cell bi-directional test method ideal for this project.



Lifting of O-cell assembly prior to installation

## Bi-directional load test arrangement:

Two 540mm diameter O-cells were installed in each of the 1500mm preliminary test piles. Both test piles were grouted to a depth of 6 metres below the toe before testing commenced. The O-cell assemblies were positioned within the 58 metre long piles at approximately 33 metres and within the coral strata. To provide more detailed information regarding skin friction distribution characteristics, twelve levels of vibrating wire strain gauges (Geokon 4911-4 model) were placed within the pile section, 7 levels below the O-cell assembly and 5 levels above.

Two 405mm diameter O-cells were installed in each of the proof tests; three tests carried out in each of the two towers.



Installation of one of the O-cell assemblies

## Test Results:

A maximum gross loading of 30 MN was required to verify the load bearing capacity of the piles. The equivalent load settlement values proved to be well within the design criteria. The proof tests were also most successful and the O-cells were grouted after testing for incorporation into the structure.

## Conclusions:

The two test piles allowed the geotechnical design characteristics to be determined within the coral strata, previously unknown mobilised unit shaft friction values to be measured and successfully proved the piles could attain the factor of safety required. The proof tests demonstrated reliability of the construction method and settlements were well within the specified requirements.



Testing in progress sheltered from the elements



Artist's rendering

Source: skyscrapernews.com

