

## LOADTEST

# World Record O-Cell® Static load testing of Foundations INCHEON BRIDGE (SOUTH KOREA)



Main Contractor : Samsung Corporation  
Foundation Contractors: Daewang E & C Co.



Test piles W6 and W8



Assembly of the 5x 870 mm O-cell arrangement



Assembly of the bearing plates for the O-cell arrangement



Final assembly of reinforcing cage with O-cells

### Summary:

The planned causeway and cable-stayed bridge structure to link the Incheon International Airport with the New Songdo City project got off to a record breaking start, with the static load testing of several preliminary piles along the proposed route.

Load testing for the 2.4 m to 3.0 m diameter bored piles, achieved a maximum loading force of 279 MN as part of the pile design verification.

### Project Overview:

Incheon Bridge (South Korea), located 10 km south of the Yeongjong Bridge, which has been in operation since November 2001. This signature bridge project is being constructed and financed through a Public Private Finance initiative. The concessionaire, KODA Development Co., Ltd. (KODA), a special purpose company, with 51% AMEC and 49% Incheon City ownership, will operate and maintain the bridge for 30-years period, after which time it would be transferred to the Korean Authorities.

The total bridge length, including cable-stayed bridge, approach bridges and viaduct bridges is approximately 12 km. The signature portion of the bridge is the steel box girder cable-stayed bridge has five (5) spans, with a maximum center span length of 800 m and a clearance height of 74 m for ship passage. The world's fifth longest.

Holding the bridge deck at a majestic 70m above the water are twin inverted-Y shaped 238.5 m tall pylons, the same height as Korea's tallest skyscraper in downtown Seoul.

The bridge has a 33.4 m wide road deck to accommodate three lanes of traffic in each direction.

A joint venture company, headed by Samsung Corporation had been awarded the contract for this project; including detailed design and construction. In order to reduce the construction period, the contractor has adopted a fast-track procedure, in which construction begins on one phase after it is approved, while the design work and construction planning is still in progress for the next phase.

Four preliminary test piles were proposed along the route in water between 5 – 14 m deep. These test piles were to be fitted with Osterberg cells (O-cells) to perform the static bi-directional load test as trying to achieve the desired test loads with kentledge or anchor piles was inconceivable.

Construction of the piles was with a permanent casing through the sea bed and into the soft rock, at 38-48 m, boring was carried out down to a maximum level of -56 m using reverse circulation drilling. Up to 9 levels of strain gauges and 3 sections of embedded telltales were employed.

An additional advantage of bi-directional testing is that concreting up to the top of the pile is not necessary, and for this project the concrete was brought up to the level of the sea bed.



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*Cage sections in preparation  
Several lengths of reinforcing cage had to be  
spliced together over the bore.*



*Bottom Cage being prepared for insertion into  
the bore from the jack-up barge*



*Top of pile instrumentation and reference  
beam as test on W8 was in progress*



*INCHEON BRIDGE Two sides of the bridge  
waiting to be joined*

## Bi-directional load test arrangement:

In order to achieve the test loads required, the only method available was the use of the patented bi-directional Osterberg Cell testing technique in which specially made sacrificial jacks (O-cells) are cast within the pile itself at a specific depth at which equal capacity exists above and below.

The O-cell is a hydraulically driven, calibrated, sacrificial jacking device installed within the foundation unit and derives all reaction from within the soil and/or rock system itself. Working in two directions, upward against skin friction and downward against end-bearing and skin friction, the O-cell automatically separates the resistance data. By virtue of its installation within the foundation member, the O-cell load test is not restricted by the limits of overhead structural beams and tie-down/anchor piles.

Load testing with the O-cell continues until one of three things occurs: skin friction is fully mobilised, ultimate end bearing capacity is reached or the maximum O-cell capacity or ram travel is obtained. Each O-Cell is specially instrumented to allow for direct measurement of the O-cell's expansion. By also measuring the top of shaft or pile head movement and compression, the downward movement is determined.

O-cells range in capacities from 0.7 MN to 27 MN. By using one or multiple O-cells on a single horizontal plane, the available test capacity can be increased to more than 220 MN. By utilizing multiple cells on different planes, distinct elements within a shaft or pile can be isolated for testing.

## Pile Tests:

The four load tests were carried out as scheduled and by request, continued loading beyond the planned maximum loads. The following summary shows the maximum loads applied:

Diameter [mm]	Approx. Pile length [m]	Gross Mobilised Maximum Capacity *
3000	67	279,000 kN
2400	69	130,000 kN
2450	65	166,000 kN
2400	63	236,000 kN

\* These values allow for the buoyant weight of the pile element above O-cell arrangement, the maximum load applied in each direction was 142,000 kN.

Three of these load tests exceeded the previous world record of 163,000 kN. The new world record of **279,000 kN** exceed the old one by 116,000 kN (13,000 tons) set by LOADTEST in 2003.

Using the O-cell bi-directional load testing method, LOADTEST has elevated the application of deep foundation load testing, from expensive, time consuming, small scale field tests to state-of-the-art, short duration, full scale static load testing of dedicated or production shafts and piles.



# LOADTEST

## O-cell Technology in PHC Driven Piles, Korea



Project **Lotte Castle Apartments**

Location Busan, Korea

Client Dong-A Geological Engineering Co. Ltd.

Consultant Lotte Engineering & Construction Co. Ltd.

Project Description

Fugro Loadtest was engaged to carry out an O-cell test on a 600 mm diameter Pre-stressed Spun High Strength Concrete (PHC) driven pile. O-cell testing had been used with several pile construction methods such as bored piles, continuous flight auger piles, driven cast-in-situ piles, barrettes and square precast concrete driven piles, however, for PHC driven piles, this was a new application for the O-cell bi-directional load test method. The method adopted was clever but relatively simple. The PHC pile was initially driven to the required depth or set with a specially designed driving shoe attachment at the tip of the pile.



Pile Testing in Progress



Test Instruments at Pile Head



As the O-cell test was conducted on a production pile, after completion of testing, the O-cell and annulus surrounding the O-cell were grouted by the foundation contractor to restore structural integrity to the pile and the pile element was incorporated into the works.

The O-cell assembly and related instrumentation (and strain gauges in this case) already fixed to a steel reinforcement cage was inserted into the hollow centre of the PHC pile and concreted into place to create a single composite pile. Load testing of the pile was carried out 28 days later by pressurizing the single 330 mm O-cell to a maximum gross bi-directional load of 6.6 MN.



# LOADTEST

## O-cell Technology in PHC Driven Piles, Korea



Project **Myung-Ji Queendom Apartments**

Location **Busan, Korea**

Client **Young Joe Engineering & Construction Co. Ltd.**

Consultant **Dong-A University**

Project Description

Fresh from the successful testing just one month earlier of the first PHC driven pile using O-cell bi-directional method and keen to further develop the technique, the foundation contractor for a new apartment complex development in Busan, Korea was offered the O-cell test method for testing of working piles on the project.

In early January 2007, Fugro Loadtest mobilized experienced test engineers to supervise the assembly works for three test piles. The tests were to be performed on 600 mm diameter PHC driven piles driven to depths of 30 m to 34 m. The maximum test load for each working pile was 3.6 MN (1.5 x working load) and a 330 mm O-cell with a rated capacity of mobilizing 7.6 MN was utilized.



Driving the PHC Test Pile



Installing the O-cell



Prior to driving the first section of pile, a special shoe was inserted into the hollow section of the PHC pile and welded in place. The shoe acts like the plug of soil that forms inside the PHC pile during open-ended driving conditions but also allows for a suitable bearing surface for the base of the O-cell. The O-cell, related instrumentation and strain gauges already fixed to a reinforcing cage were inserted into the hollow centre of the PHC pile and concreted in place.

Testing of the piles was conducted six weeks after installation. The tests were carried out as quick tests with each loading increment held for a period of 5 minutes. As the behavior of the soil resistance was unknown, loading was limited to small increments to make sure the load at which the pile skin friction fully mobilized was accurately determined. For the first two tests, the O-cells were loaded to a bi-directional load of nearly 4.2 MN (test load of 8.4 MN) before the capacity was fully mobilized whereas the third test pile was loaded to nearly 2.9 MN before being fully mobilized. For all three piles, end bearing was approaching ultimate capacity.



Concreting the PHC pile

