
Project Experience

# Bi-directional O-Cell® testing of Foundations over water

Fugro LOADTEST has been performing O-Cell® tests over water for decades to provide design verification and optimization of the full scale foundations and to evaluate their ultimate capacity.

The O-Cell method of testing the foundation capacity of piles is a favoured method used for foundation tests over water as it provides numerous advantages over traditional top-down loading arrangements. A key benefit of using bi-directional testing is the elimination of additional anchor piles or external reaction systems which are even more challenging and costly to assemble over water. Also, the top of concrete can be left at depth at the mudline so just the steel may need to be cut off to ensure no protrusions from the foundation remain in the water.

As the technology for drilled shafts/piles develops and larger loads are demanded from each foundation element, the need to verify these design capacities increases. Loads applied using the O-Cell method often exceed 50 MN and can reach levels greater than 300 MN for some bridge foundations.

The following examples are just a small selection of some tests that have successfully used the O-Cell technology to test the foundation elements.

## Incheon Bridge – South Korea

The 12 km structure that connects the Incheon international airport located on the island Yongjing with the New Songdo International Business district has a cable-stayed span of 800 m, approach bridges and several viaducts.
This bridge across the Yellow sea is the longest in South Korea and the tenth longest in the world.
Four preliminary test piles with diameters between 2400 and 3000 mm and lengths between 63 and 69 metres were tested using the O-Cell methodology over water along the anticipated bridge trajectory.
The results achieved were fundamental as part of the pile design verification and optimisation, with applied loads of 279 MN in one of the test piles, a record load at the time.

## Curtis Island, Gladstone, Queensland

Two 1500 mm diameter driven tubular steel piles to depths of up to 35 m below sea level using O-Cell bi-directional maintained load test push out method.
Soil conditions at the test locations comprised soft alluvial soils overlying a Mudstone bedrock stratum.
Upon driving each steel test pile casing, soil was excavated to below casing toe level for construction of the concrete reaction pile and tension socket (tension pile only). The O-Cell loading assembly was fixed to the reinforcing cage before being lowered into the test pile and concreted. Strain gauges were used in addition to O-Cell instrumentation.





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## Halic Bridge Istanbul Turkey

The pile tests were performed on permanently sleeved 2200 mm working piles of 85.5 metres in length located 90 metres off-shore. The piles were permanently cased with a 2500 mm sleeve and the main reinforcement needed to deal with the requirements of seismic activity common place in Istanbul. The piles were tested to gross loads of 47 MN and 65 MN with very little movements being caused under the maximum test load. The off-shore location proved to be no problem for the load testing operation, the O-Cell instrumented cages were constructed on-shore and moved to the pile test location by barges. However, the logistics of providing tug boats and off-shore drilling in such a congested and busy waterway proved a little more challenging for the contractor, Astaldi-Gulermak joint venture. The pile was grouted after testing to allow for integration in the working structure.

## Komárom Bridge - Slovakia and Hungary


Featuring an inclined asymmetric cable tower, the two lane 600 m long Monoštor Bridge connects the towns of Komárom and Komárno, which lie on the Hungarian and Slovak sides of the Danube River, respectively.

To verify and improve the design of the bridge foundations, two preliminary test piles were required, which were installed close to the centre of the very busy and fast flowing river. Providing a traditional reaction system with anchors or using dead weight with kentledge to perform these pile tests was impractical. The O-Cell method of loading was chosen as the ideal static loading test method, using the pile itself to provide the reaction for the test.

Test piles were constructed with a single level assembly comprising a 530 mm diameter O-Cell, of 40 MN nominal total capacity.

## Hinkley Point Nuclear power station

As part of a temporary aggregate landing jetty. An initial design required a preliminary load test carried out on land to 35 MN.

Fugro completed construction of the proof pipe test pile over water. The 29.56 m long pipe test pile was constructed with a grouted length of 10.49 m into mudstone with the remaining pipe test pile freestanding above. The bore length was extended to include a reaction pile section beneath the test pile.

The sub-surface stratigraphy at the general location of the test pile is reported to consist of weathered mudstone becoming more intact with depth. The loading assembly consisted of one 530 mm diameter O-Cell capable of providing a gross load 20 MN, located 5.98 m above the bottom of the bore at an elevation of -12.49 m CD.

## Port of Richards Bay South Africa

As part of a new bulk terminal jetty some load tests were required. Using conventional top-down testing systems would have meant mobilising and building a kentledge arrangement offshore or construction of expensive reaction piles and loading frame.

Two single level O-Cell tests were performed on one 1200 mm and one 1800 mm nominal diameter piles constructed in 20 m of water to depths up to 66 m.

The cretaceous siltstone was overlain by silty sandy overburden. The O-Cell assemblies were located within the siltstone at a level calculated to provide a balance between side shear upwards and combined side shear and end bearing acting downward. The mobilised capacity for the two preliminary pile shafts was 17.3 MN and 24.3 MN respectively.





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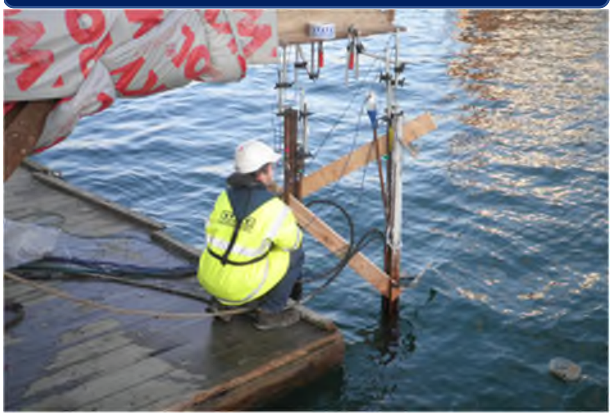
## Europe Bridge - Bulgaria and Romania

New Europe Bridge is a 3.5 km road and rail bridge between the cities of Vidin, Bulgaria, and Calafat, Romania. It became the second bridge on the shared section of the Danube between the two countries.
Fugro Loadtest performed numerous bi-directional static load tests using the O-Cell bi-directional testing method.
Preliminary piles of 1200 mm diameter were tested to determine their geotechnical behaviour and evaluate the soil parameters used in the pile design on both the Bulgarian and the Romanian sides of the river, some of which were 68 m deep and tested to 26 MN.
Testing of 2000 mm diameter working piles to similar depths and loads were carried out and were grouted after the test to reinstate their structural integrity allowing them to be incorporated into the bridge foundations. Some of these were over water.

## Mississippi River in St. Louis, USA

The new Mississippi River Bridge in St. Louis, Missouri would become the third longest cable-stayed bridge in the United States at 1500 feet. It set a new world record for the highest test load ever recorded during a static load test at the time.
To perform the world record test the shaft was drilled into sand and gravel underlain by solid rock.
The rock socket was about 7m (23ft) deep and 3350mm (11ft) in diameter in very hard limestone.
Four 870mm (34in) O-Cells placed at the base of the shaft were loaded to 150% of their rated capacity to achieve the record load of 320 MN.
The photo illustrates the pressure gauge in the hydraulic line at full scale indicating 15000 psi (1000 bar) being applied.

## Bridge inner harbour – Copenhagen Denmark



A new Inner harbour bridge to enhance the links around the various sectors of the Copenhagen port was being constructed. It will be an opening type for cyclists and pedestrians connecting the inner harbour to Christianshavn.
The 1000 mm test pile was constructed to a depth of 17.5 m of which 10.5 m was below the sea bed, with the top of the steel pile approximately 3.0 m below water.
The test pile was completely submerged and tested this way.
The sub surface stratigraphy at the pile location consisted of sand, sandy silt, sandy clay, clay, upper limestone and lower limestone.
A 510 mm O-Cell was used and all instruments, telltales and top of pile connections were brought to above the water level and tested with the reference beam cantilevered off the adjacent wharf.

## Danube Bridge PAKS – Hungary


Loadtest have performed O-Cell tests for the Paks Kalocsa Danube Bridge Project, a new bridge located featuring a 1,133 m long mid span, the longest in the area.
To verify and improve the design of the project’s foundations, two 1,500 mm nominal diameter preliminary expendable pile tests were requested. The sub-surface stratigraphy at the general location was reported to consist mainly of grey sandy gravel and gravelly sand.
O-Cell technology proved a perfect solution for static load testing of these test piles as the top of the pile concrete was at the river bed elevation, 11 m below the pile construction level with depths of 30 m were constructed by HBM Kft in the middle of the river.
Each pile was fitted with a 530 mm O-Cell allowing a potential 20 MN gross loading capacity.