Project Experience

Bi-directional O-Cell® testing of Bridge Foundations

Fugro LOADTEST have been performing O-Cell® tests for Bridge foundations for more than 30 years and participated directly in some of the most challenging projects globally. From pedestrian bridges to some of the longest suspension bridges in the world and repeatedly breaking records for the highest applied load in a full scale static load test.

The O-Cell method of testing the foundation capacity of piles used for bridge foundations 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.

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 of the world class crossings 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 and probably still a record test load mobilised over water.

Hong Kong – Zhuhai - Macao Bridge

For the 9.4 km viaduct part of this bridge-tunnel structure, a change in the pile design philosophy was required, modifying the design of some of the piles to include shaft grouting.
The intention of the test programme was to obtain geotechnical information specifically from 2 stratum layers, by testing a 114 m deep preliminary pile.
A multilevel O-Cell test arrangement was used to ensure that sufficient movement of the pile shaft could be mobilised within each specified stratum to obtain the relevant geotechnical parameters which would not have been possible with a single level O-Cell test.
Each O-Cell assembly had a gross loading capacity of over 80 MN. Capitalising on one of the numerous advantages of using O-Cells on a test over water and without the need for external reaction.

Atlantic Bridge – Panama

The Atlantic Bridge connects both sides of the Panama Canal with a vertical span of 75 m allowing Post-Panamax container ships to pass below.
Fugro Loadtest was commissioned to provide full scale testing and equipment for instrumenting six bored piles, three on each side of the canal. The piles were between 1500 mm and 2500 mm diameter and up to 54 m deep.
The load test results confirmed the suitability of the designs for construction with the largest test mobilising more than 160 MN. Instrumentation throughout the pile, including multiple levels of strain gauges, allowed analysis of load distribution within the various soil layers, with the information providing valuable design optimisation of the bored piles and associated savings in terms of time and money.

Okavango River Bridge - Botswana

Numerous piles were tested using O-Cell methodology for the Okavango Bridge which connects villages on the east of the Okavango River. The bridge site lies close to Botswana's border with Namibia just to the north and the project will improve transport connections between the two countries.
The 1.2 km cable bridge consists of two towers for the cable stayed portion and 18 piers beside the old ferry landing sites.
All the test piles were successfully loaded up to 150% of the desired test load allowing the client to validate the structural design resulting in a reduction in the total number of tests to be performed.
The minimal test instrumentation needed for an O-Cell test was crucial for this project, taking into consideration the site location (1100 km from the capital Gaborone) and the access roads conditions.

Sheikh Zayed Bridge – United Arab Emirates

This suspended deck arch bridge, part of the Sheikh Zayed bin Sultan Al Nahyan highway, connects Abu Dhabi and Saadiyat islands across the Maqta Channel.
Designed by Iraqi architect Zaha Hadid, the spectacular 850 m long bridge was challenging for all the involved and Fugro Loadtest provided essential help to assist with the confirmation of the complicated geotechnical design.
Several O-Cell bi-directional tests, the first in the region at the time, were executed to obtain the necessary in-situ soil behaviour under loading.
During the testing of the preliminary piles, loads of over 88 MN were achieved, a record for Abu Dhabi at the time.

Stan Musial Veterans Memorial Bridge - USA

The 450 metre cable-stayed bridge was part of a $640 million project to connect both sides of the Mississippi river in St. Louis. Two large concrete footings, one near each bank, anchor the bridge below. Each pier rests on a series of concrete-filled drilled shafts, extending over 30 metres, socketed into the limestone bedrock.
The bi-directional test executed for this project set a new world record for the highest load ever recorded during a static load test. 320 MN was applied to a 3.50 metres diameter and 36.30 metres deep test pile, loaded using 4 x 860 mm O-Cells.
The results of the O-Cell test confirmed the use of an optimized engineering design, allowing a much more economical alternative to the original conventional design with significantly less penetration into the bedrock.

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Louisville-Southern Indiana Ohio River Bridge - USA

By increasing cross-river mobility, improving safety and connecting highways, this project was a fundamentally important crossing of the Ohio River. The project includes both the Downtown and East End Crossings and foundation design requirement for each required with O-Cell methodology to confirm the geotechnical parameters and allow for both economising the design and risk management.

The test pile required at the Downtown Crossing was to not only test the pile capacity but also the piling technique. The dedicated test pile was drilled though overburden soils and socketed into the underlying limestone. The loading arrangement had a maximum rated test load of 212 MN. However, by over pressurising the O-Cells beyond their rated capacity, a maximum test load of 322 MN was achieved, a new World Record for a static load test of a single foundation element.

1915 Çanakkale Bridge – Turkey

Çanakkale Bridge is the first fixed crossing of the Dardanelles in north-western Turkey. It is considered the longest suspension bridge in the world at just over 2 km.

In total, 5 piles, with a diameter of 1500 mm and lengths ranging from 41 metres to 69 meters, were tested by the Osterberg bi-directional static load testing method on both the Asian and European sides. All the executed tests offered valuable information for the client and designers.

In addition, a large sized 6575 mm x 1200 mm barrette was tested to allow design confirmation of the cable anchor block. The 20.95 m deep barrette was installed with 5 x 430 mm O-Cells to allow assessment of the tensile resistance.

The Bridge Pavilion – Spain

Situated on an artificial peninsula in the river Ebro, this project was part of the Expo construction in Zaragoza and consisted of a 270 metre long bridge holding an exhibition pavilion. It was a challenging and award-winning project for all the involved.

The geotechnical design required the piled foundations to support a substantial load in relatively poor soils and requiring some of largest piles ever constructed in Spain. One O-cell bi-directional load test exceeded 40 MN on a pile of 2000 mm diameter. Two 620 mm O-cells were located approximately 9.5 m above the toe of the 63 m long pile. The test succeeded in providing the Client with confidence that the pile design and construction was sufficient for the loads required enabling the building of this unique bridge structure to proceed.

Mersey Gateway Bridge – United Kingdom

Mersey Gateway is a 2.4 km crossing between Runcorn and Widnes including a cable-stayed bridge.

To verify the suitability of the foundation design at the viaduct approach, three preliminary piles were tested by O-Cell methodology and an additional one by traditional top-down method at a lesser load was used to confirm the O-Cell test results.

Two 1500 mm diameter piles were tested on the North and South approach viaducts mobilising loads of 57 MN and 39 MN.

Two 1050 mm diameter piles were constructed at the same location but tested with two different methods: Bi-directional and traditional Top-Down. The results obtained had excellent correlation between them especially the interpreted mobilised skin friction.

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Northern Spire Bridge – United Kingdom

Sunderland's Northern Spire 336 m cable-stayed bridge is the first crossing of the Wear to be constructed in over 40 years.
The pylon base is supported by ten 1.5m diameter, bored piles, each pile socketed into the underlying Coal Measures.
The use of the bi-directional O-Cell load test method has assisted greatly in providing actual full scale behaviour results, specifically for high loads, in a safer and more cost effective manner than is possible with traditional top down loading tests.
A multilevel loading arrangement was designed to utilise two levels of 2 x 530 mm O-Cells located 1.3 m and 5.8 m above the pile toe, with each loading assembly being capable of applying 20 MN in each direction at rated pressures.

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 of a 530 mm O-Cell, of 40 MN nominal total capacity.

Amelia Earhart Bridge - USA

The Amelia Earhart Memorial Bridge is a network tied arch bridge on U.S. Route 59 between Atchison, Kansas and Buchanan County, Missouri. It replaced a previous truss bridge with the same name.
To facilitate the design of the new bridge, and possibly eliminate the mid-river support column required for the old bridge, a first-ever Triple-Level O-Cell test was performed.
Three levels of 27 MN capacity O-Cells were installed on a purpose built carrying frame, along with the necessary instrumentation. The top and middle O-Cells were positioned at the boundary between the upper, middle and lower shales. The combined load mobilised during the four stages of testing was 158 MN allowing the designer to investigate other scenarios and optimize the pile foundation design, using actual measured response as the model input.

Gordie Howe International Bridge – USA - Canada

The 2.5 km New Trade Crossing, named after Canadian ice hockey player, is a cable-stayed bridge across the Detroit River will provide uninterrupted traffic flow, which is responsible for 25 % of commercial traffic between Windsor and Detroit by linking Interstate 75, Interstate 94 and Interstate 96 in Michigan with Highway 401 in Ontario.
The project's foundation contractors, GFL Environmental in Canada and Malcom Drilling in the US, engaged Fugro Loadtest to confirm that the massive 3000 mm, 35 metre deep foundations met the design requirements.
Osterberg Cell (O-cell) bidirectional load tests were performed to over 160 MN and were combined with SONICaliper™ inspection, thermal integrity profiling and cross-hole sonic test on sacrificial test piles on each side of the river.