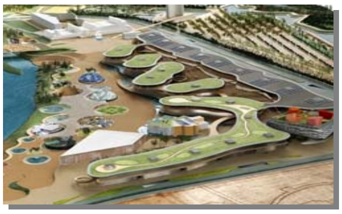
LOADTEST
O-Cell® Technology in Zaragoza, Spain

Project:	**The Bridge Pavilion**
Location:	International Exposition 2008, Zaragoza, Spain
Contractor:	Dragados S.A.
Foundation Contractor:	Terrabauer S.A.
Geotechnical Co.:	Ove Arup & Partners

Project Description:

Zaragoza is Spain's fifth largest city with a population exceeding 650,000 inhabitants. As host of Expo 2008, this project became a centerpiece of the International Exposition.

Situated on an artificial peninsular into the River Ebro, the test site was part of a very prestigious and technically challenging pedestrian bridge project. Architect Zaha Hadid and Arup partnered to design and oversee construction of this unique bridge.



Expo 2008, aerial view

This 270 m long bridge held one of five pavilions for the exhibition. It has 6400 m^2 of exhibition space on 2 floors. The bridge pavilion was designed with the central water theme of the exposition in mind. The scale-like windows, resembling those of a shark, shimmer in the sunshine.

In order to make the design work, the piled foundations support a substantial load in relatively poor soils, requiring some of largest piles ever constructed in Spain. One test exceeded 40 MN on a working pile of 2000 mm diameter. Two 670 mm diameter O-cells were used to provide the required loading of 20 MN in each direction. The O-cells were located approximately 9.5 m above the toe of the 63 m long pile bored under bentonite slurry

Installation of O-cell arrangement within pile cage

Utilizing the O-cell method negated anchor piles (which would have proved both uneconomical and difficult to install within the confines of the site) or kentledge loading (which would have proved impossible to erect on the artificial peninsula).

Linear Vibrating Wire Displacement Transducers (LVWDT's) are used at the O-cell level to measure expansion. Close monitoring of the expansion was needed to ensure that the working pile was not loaded to excessive movements.

Test pile head and reference beam

Geokon Vibrating wire strain gauges were used along the pile shaft to monitor strain which assists in deducing unit skin friction.

A combined bi-directional loading of over 40MN was applied, with displacements of 20 mm in the downward direction and 8mm upwards.

The test succeeded in providing the Client with confidence that the pile design was more than sufficient for the loads required enabling the construction of this unique bridge structure to proceed.

Bi-directional test in progress

The Pavilion Bridge

Source: bdonline.co.uk

www.fugro-loadtest.com

LOADTEST
O-Cell® Technology San Sebastian, Northern Spain

Project: **New Bridge over the River Urumea**

Location: San Sebastian – Donostía, Northern Spain

Foundation Contractor: Rodeo-Kronsa Group

Geotechnical Co.: University of Madrid

Project Description:

In the North of Spain, overlooking the Bay of Biscay, lies the beautiful Basque city of San Sebastian-Donostía. This city was the location of a research project undertaken by the University of Madrid with the help of O-cell Technology. The project was situated on the site of the construction of a new bridge over the River Urumea. The underlying Flysch rock made this location ideal for a research project undertaken by the University of Madrid assisted by Rodeo Kronsa Group.

In order to further research on pile design in rock, Professors Olalla and Serrano have been investigating the behaviour of the shaft friction of piles in rock. The research was planned to check a new empirical design theory with a secondary objective to determine the pile end bearing resistance. To obtain useable data for this research, controlled loading of a fixed shaft length in the rock was required. Two levels of O-cell were placed so that the mid-section was a know length and therefore the skin friction area was readily quantifiable.

The pile bore was constructed 17m long and one O-cell level was set very close to the toe to measure the end bearing properties. The second upper level was placed exactly 2.5 metres above this level. A zero shear sleeve section was inserted into the top section of the pile to give a second 2.5 metre section between the upper O-cell level and the zero shear zone. An arrangement of two 330 mm diameter O-cells at each level was chosen. These provided a 7.8 MN loading to the base and to the rock sections below and above the upper O-cell levels. It was considered that this loading should provide sufficient capacity to obtain ultimate values of both the end bearing resistance and skin friction in the rock.

The pile was loaded in two stages, the initial stage loading the toe of the pile using the upper section of the pile as resistance. Once the toe of the pile moved downwards, the bottom O-cell level provided zero resistance to downward movement when the upper level of O-cell was loaded in the second stage. Stage one loading provided a total maximum of 8.5 MN to the base, but the ultimate end bearing had not been mobilised sufficiently to fully characterise the base behaviour. Loading of the upper O-cell level was then performed, loading an independent section of pile above and below the O-cell arrangement of 2.5 metres. At the maximum rated O-cell capacity, the rock still held steady and even with increasing the pressure by an additional 50%, the friction could not be fully mobilised in the rock; achieving less than 1.5 mm movement above and below the upper O-cell level.

The maximum mobilised reaction from the bi-directional test was 32.5 MN, far in excess of the value predicted before testing commenced. Values of skin friction obtained for the rock, were significantly higher than predicted by nearly an order of magnitude. As such, it was not possible to provide ultimate values of either the end bearing or for each of the 2.5 m sections of the shaft friction during this test. Post test analysis of the behaviour using Cemsolve predicted the ultimate end bearing to be in excess of 20 MN (twice the scheduled test capacity). The predicted ultimate values of the combined rock socket above and below the upper O-cell would be of the order of 40 MN.

The testing has proved that sometimes even the most pessimistic of design parameters taken still results in very conservative values for pile design in rock.


Playa De La Concha, San Sebastian


Multi-level cage layout before installation


University of Madrid, Rodeo Kronsa and Fugro Loadtest personnel.

LOADTEST
O-Cell® Technology in the Port of Barcelona, Spain

Project:	*Terminal Muelle Prat, Port of Barcelona*
Location:	*Barcelona, Spain*
Client:	*Ferrovial Agroman S.A. & Comsa S.A.*
Project Description:	*Port Redevelopment*

Port of Barcelona

O-cell Cage preparation

Installation of reinforcement

Pile testing on reclaimed land

Location:

The Port of Barcelona has a history going back some 2000 years. The port, situated in Catalonia is Europe's ninth largest container port, with a trade volume of 2.57 million TEU's in 2008. It is also one of the most important ports in the Mediterranean. The port is managed by the Port Authority of Barcelona and the area of 7.86 km^2 (3 sq mi) is divided into three zones: Port Vell (the Old Port), the commercial/industrial port and the logistics port (Barcelona Free Port). The port is undergoing several developments, this container handling facility will be semi-automated and will double its size by diverting the mouth of the Llobregat river 2 km (1¼ mi) to the south, and slightly pushing back the Llobregat Delta Nature Reserve to make way for development.

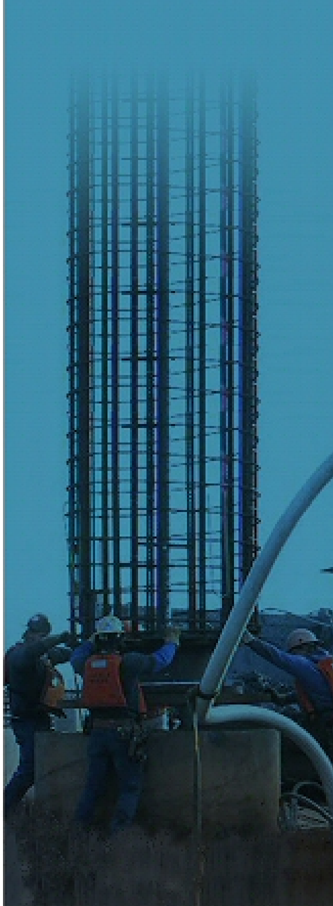
Project:

In 2011 Fugro Loadtest tested the first of 3 piles installed for construction of the port side walls. These walls were not only to hold back the sea but also to carry the tracks for the 37 wharf cranes.

The site location was made up of reclaimed land with a substantial depth of sand fill overlying a varying thickness of soft to firm silty clay. In some locations stone drainage layers had been used. The nature of the upper layers made traditional top down testing difficult to perform with either anchor piles or kentledge loading.

The foundation contractor, Ferrovial Comsa, engaged Fugro Loadtest to carry out a testing program using Osterberg Cell bi-directional testing method on the 1200 mm diameter bored piles with a length of up to 40 m. A total of two preliminary test piles and one working pile were installed and tested with bi-directional test loads being applied to the piles using a combination of 330 mm and 405 mm O-cells.

Since the working test pile was intended to carry structural loading, the O-cells and annular void created as a result of the expansion of the O-cells, were grouted to reinstate the compressive structural integrity.



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