Project Experience

Bi-directional O-Cell® testing of Working Piles

Fugro LOADTEST has been performing O-Cell® tests on both preliminary and working foundation elements for more than 30 years. O-Cell bi-directional testing is most appropriate when seeking to evaluate the geotechnical behaviour with the aim of optimising the foundation design. Notwithstanding this, the test is equally useful for checking the load-settlement criteria of working piles, and around the world, approximately 25% of all pile tests use this method.

Proof tests are generally intended to apply a maximum load of 1.5 times the working load, this is generally a structural limit requirement on stresses on the cross section. Since the bi-directional test applies half the load in each direction, the maximum test load of 3 times the working load only applies 1.5 times the working load structurally.

The application of O-Cell tests to working piles or barrettes is particularly applicable when wishing to capitalise on the advantages bi-directional testing provides, such as large loading capacity, minimum footprint, ease of testing over water, and not requiring an external reaction system with anchor piles or kentledge as with traditional top down loading tests.

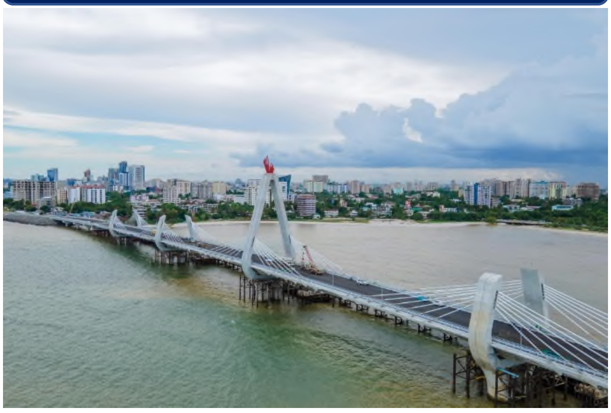
Lateral loading and bending moments need to be considered since there is no vertical steel reinforcement across the O-Cell assembly after testing. The elevation of the O-Cell can be placed at depth lower than the balance point, below any significant bending moments or effects of lateral loads. Post-test grouting will reinstate the compressive integrity.

Some examples of working test piles are illustrated below:

Bonny-Bodo Road, Rivers State, Nigeria

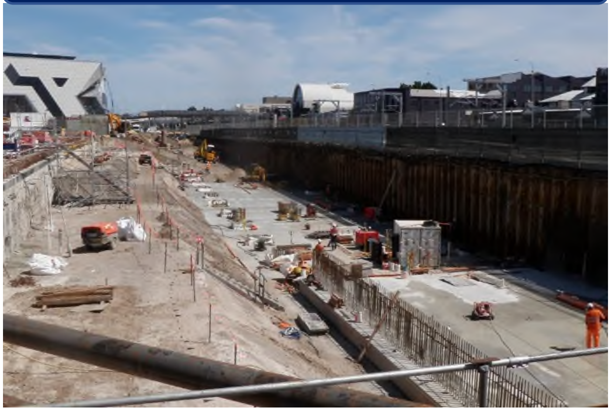
The Bonny to Bodo Road project in Nigeria consists of 39 km of new road, some 37.9 km of which are crossing through swamps. The project consists of 17 small and large bridges crossing rivers and streams and some of the most challenging terrain. As part of this major project, piling works were required for the bridge supports and due to the ground conditions, it was important to confirm the design of these foundations. Several working test piles were designated on this project, which were grouted after testing and incorporated into the bridge foundations. Installation and assembly of the test piles was undertaken with contractor Julius Berger. Three major crossings, Afa Creek bridge at 530 m long, the Nanabie Creek bridge at 640 m long and the Opobo Channel bridge at 750 m long, form the major crossings, supplemented by many other mini-bridges to form the completed highway works.

New Selander Bridge - Tanzania



The New Selander Bridge in Dar-es-Salaam spans the Oyster Bay and forms a vital infrastructure link between the Aga Khan Hospital and Coco beach. The bridge is just over 1 km in length.
To obtain geotechnical information necessary to verify and optimise the foundation design, an initial preliminary pile test was carried out to 47 MN gross load.
As the work progressed on the bridge supports, one working pile was designated to prove the design met the settlement criteria. The working piles were 50 m in length and founded in weak coraline limestone rock. The Ø1500 mm working test pile was tested to 13.4 MN gross load and grouted on completion of a successful test result so it could be incorporated into the bridge footings, which now carries a much needed 4 lane highway relieving traffic congestion in the area.

Eastern Bay Link – Cardiff - Wales



The Eastern Bay Link connects Queens Gate and Ocean Way Roundabout, improving access and connections to Cardiff Bay and the Cardiff Central Enterprise Zone from the M4 to the east within the Cardiff City Region.
As part of this construction works, three working piles were required to prove the load/settlement criteria of the nominal Ø1200 mm foundation bored piles. Loads of up to 4.11 MN were applied in each direction by a single O-Cell placed within each pile, giving gross equivalent top-down loading of over 8 MN. Testing bi-directionally using O-Cell technology allowed the piling company, Bauer Technologies, to install just the three test piles without the requirement for additional anchor piles which would have proved difficult with the site restrictions in place at the time of construction.

Sangachal Terminal - Azerbaijan

The Sangachal Terminal expansion works, located approximately 55 km south of the capital Baku, in Azerbaijan required the new structure's foundations to be proof tested with the minimal disturbance to the operating plant. The terminal process capacity is 1.2 million barrels a day of oil and 81 million m^3 of Shah Deniz gas.
Two working test piles were designated to be loaded to 4.75 MN and 6.30 MN respectively. The soils consisting of sands and clay deposits did not provide sufficient capacity for the construction of anchor piles to assemble traditional top down load tests and the site restrictions did not allow for kentledge type testing. The perfect solution was therefore, bi-directional static load testing using O-Cells.
The piles were constructed with single O-Cells of 330 mm and 430 mm and were grouted for inclusion into the foundations after testing.

Port of Barcelona - Spain

The Port of Barcelona is the ninth largest container port in Europe and is constantly expanding to meet an ever-growing demand. Since the area of the port is restricted by its geographical position, the expansion has been on reclaimed land, with sea walls constructed to hold back the waters of the Mediterranean.
In 2011, the first of these walls was constructed and Fugro Loadtest were asked to test 2 provisional test piles and one working pile in this initial phase. Since the land is reclaimed with sand fill, there is little friction to allow for conventional top-down anchors and provision of kentledge would have surcharged the fill during testing setup. The O-Cell bi-directional testing method of full-scale static load testing proved to be the ideal solution. Several other tests followed on the interior section of the fill and other port expansion developments.

Tripoli Tower – Libya

The 64 floor tower planned in the Libyan capital Tripoli required several load tests due to the nature of the founding strata and the variable nature of the underlying weakly cemented sands and calcarenite bedrock.
Four preliminary test piles were constructed as part of the initial design phase of the project, followed by a further 13 working test piles, which would be grouted and incorporated into the foundations once testing was completed.
The testing requirement was to determine both the compressive and the tension properties of the foundation elements. This was achieved by analysis of the upward and downward components and allowing for the additional elastic compression to be incorporated to model the pile head load displacement.

Farringdon Station - London

Farringdon Station lies at the centre of the hub of underground lines, The Elizabeth Line (originally Crossrail) with Thameslink passing in close proximity. Construction in the congested area with so many underground restrictions to consider was a civil engineering challenge which required careful planning and creativity to achieve.
To overcome the piling load testing challenge, positioned in a very restricted area between live overground lines, bi-directional testing using O-Cell technology was chosen. A preliminary test pile of Ø1500 mm was undertaken.
A further working pile was required in very tight triangular site, positioned between live overground train lines. This pile was later grouted and incorporated into the foundations. Several other working test piles followed on other sections of the Elizabeth Line construction.

Flame Towers – Baku - Azerbaijan

The iconic Flame Towers, form an impressive backdrop for the City of Baku, with the tallest tower at 182 m. The construction on the top of the hillside is visible from all parts of the city and especially prominent during the Formula One (F1) street race.
The three flame-shaped towers are intended to symbolize the elements of fire and are a reference to Azerbaijan's nickname "The Land of Fire", historically rooted in a region where natural gas flares emit from the ground and Zoroastrian worshippers considered flames to be a divine symbol. The impressive towers are lit at night with flame effects.
As part of the construction of the bored pile foundations, into the underlying hard silt formations, three test piles were required, the first being a preliminary test pile to 25 MN, followed by two further working test piles, providing one test for each of the towers.

River Mincio Viaduct – Lake Garda - Italy

The Genoa-Milan High-Speed, High-Capacity Railway Line, also known as Terzo Valico dei Giovi (Terzo Valico), is being constructed to improve the railway connections between the Ligurian bay ports and the northern Tyrrhenian Sea ports with railway lines in northern Italy and the rest of Europe. The high-speed trains will travel at speeds of up to 300 km/h. Estimates for testing the piles with kentledge were over six times the cost of the O-Cell test.
As part of this route, the new viaduct over the Mincio River required two working test piles, one at each end of the viaduct. The Ø2000 mm, 60 m long piles were installed into the clay, gravel and hard Tuff substrata. Gross test loads in excess of 17 MN were applied, proving the settlement criteria was within the limits set for this critical piece of Italy's infrastructure.

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 Ø1200 mm 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 Ø2000 mm 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 tests were over water.

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