
Melvin England
Fugro Foundation Testing (Loadtest)


Maarten Profittlich
Fugro Foundation Testing (Loadtest)

BI-DIRECTIONAL O-CELL® FOUNDATION TESTING: TO OPTIMISE FOUNDATION DESIGN SAFELY AND SUSTAINABLY

Introduction

Worldwide awareness of climate change continues to increase, as do calls for action. Reducing our carbon footprint is a priority if we hope to minimize the impact of global warming. Concrete production is responsible for 5% to 7% of total CO_2 emissions worldwide. The construction industry, and in particular the foundation industry, can take steps to reduce their contribution.

Accurate foundation design is a critical area for efficient use of concrete and steel in the ground. Calibration of the design of foundations can unlock huge savings in terms of material usage and project timescales and these are best done by full-scale load testing to evaluate the pile or barrette behaviour.

Bi-directional pile load testing

Full-scale static load testing can be performed by either applying the full test load at the head of the foundation in the traditional manner, with kentledge or a reaction beam and anchor piles, or performed bi-directionally by casting the loading element within the foundation itself. O-cell® bi-directional load testing can be used to verify the pile performance and compare it against the design in the most efficient, safe and cost-effective manner of all types of foundations – particularly for larger test loads.

The following project examples illustrate some of the benefits of using bi-directional load tests and how effective they are at reducing carbon emissions.

Two construction projects in Switzerland

Foundations for an extension to the Rolex factory are being constructed in Geneva. Ground conditions in the area are characterised by soft post glacial deposits with the moraine layer found at more than 50 m. With a traditional nominally cylindrical pile design the toe of the piles would be found in the moraine. Instead an alternative pile installation technique using a ream was considered and the behaviour of two test piles verified with O-cell® tests.

The reamed design piles have a significantly smaller diameter considerably reducing the volume of the piles and therefore the material extracted, concrete used, transport requirements etc. Table 1 below shows the comparison between the initial

	Initial Concept	**Alternative Concept**
	Classical cylindrical piles 41 piles dia. 1500 mm	Piles with base extention & bi-directional test 41 piles dia. 800 mm / 1850 mm base
Debris (only below excavation level)	**2307 m^3**	**726 m^3**
Truck loads debris (x 100 m^3 per truck)		
Concrete	**2416 m^3**	**757 m^3**
Truck loads concrete (x 100 m^3 per truck)		
CO_2eq total material debris, concrete	**620 t**	**200 t**

Tabel 1 – Savings due to base enlargement (Source: Implenia/ Fugro).

Photo 1 – Construction work in Geneva; the carbon footprint on the project was reduced by one third (420 tonnes) using, among other things, electric concrete trucks.

Photo 2 – Photo 2: BAUER Spezialtiefbau GmbH verified the foundation design for a more cost-efficient and less time-consuming solution.

Photo 3 – Artist impression of Birmingham Curzon Street Station where pile design is being verified with O-cell® bi-directional testing (source: hs2.org.uk).

traditional pile foundation plan and the alternative solution.
On another project for the Swiss private bank, Pictet, three barrettes were load tested, at different depths, to optimise their design. In addition to the benefits of using bi-directional load testing the contractor used electric concrete trucks (see photo1).

Elbtower Hamburg

Fugro has completed a successful load-testing programme on Germany's longest rotary bored piles as part of the foundation design verification for the planned Elbtower construction in Hamburg. On completion, the 244 m high Elbtower will be the third tallest skyscraper in Germany and forms part of a 157 hectare megaproject to redevelop the former harbour and industrial areas of HafenCity.

Located on low load-bearing ground near the Elbe river, the Elbtower's foundations will rest on long piles to transfer the load to a deep load-bearing soil layer and prevent long-term settlement. Deep foundation contractor BAUER Spezialtiefbau GmbH constructed several bored test piles up to 111.4 m long and 1850 mm in diameter, and Fugro provided unique load-testing and measurement technology for the pile-testing programme. The advantage of Fugro's in situ load testing, especially on piles of this size and ultimate load-bearing capacity, is that clients can verify and potentially optimise their foundation design without the need for costly and time-consuming installation of reaction piles used in traditional load testing.

High speed rail lines across Europe

Fugro is also involved at numerous sections of HS2, the UK's new high speed rail network, including foundation testing programs. HS2 will integrate new railway lines and upgrades across Britain's rail system to deliver faster travel to many towns and cities not directly on the HS2 route, including Liverpool, Sheffield, Leeds, Nottingham and Derby.

170 miles of new high-speed line is already under construction between Crewe and London, employing around 25,000 people. In total, the Government is planning over 260 miles of new high-speed line across the country. HS2 trains will be powered by zero carbon energy for a cleaner, greener future.

Some of the first contributions for the tests in the chalk of the Chilterns has provided a possible foundation size reduction of 70 % when compared with the original design. One of the most recent projects is the foundation test program at Birmingham Curzon Street Station (photo 3). This station will be at the heart of the high-speed rail network in the West Midlands. It will be one of the most environmentally friendly stations in the world. Two key benefits of our full-scale pile testing program are the saving on materials due to shorter pile lengths and increased design confidence.

Summary and conclusions

Worldwide awareness of climate change continues to increase, as do calls for action. Reducing the carbon emissions for buildings and infrastructure can help to limit global temperature rise and achieve a net zero future. Concrete production is responsible for 5% to 7% of total CO_2 emissions worldwide. The construction industry, and in particular the foundation industry, is able to take steps to reduce their contribution. One potential saving is through optimising the foundation of (high-rise) buildings, bridges and infrastructure projects.

Accurate foundation design is a critical area for efficient use of concrete and steel in the ground. Calibration of the design of foundations can unlock huge savings in terms of material usage and project timescales and these are best done by full-scale load testing to evaluate the pile or barrette behaviour. O-cell® bi-directional load testing can be used to verify the pile performance and compare it against the design in the most efficient, safe and cost-effective manner of all types of foundations – particularly for larger test loads. The project examples described in this article show that using full-scale static load testing with O-cell® bi-directional testing can reduce carbon emissions and improve project efficiencies. ●