Case Study:

Long-term Monitoring of a Piled Raft Foundation



Edge London Bridge site, London, UK

Background

Pile raft design relies on models that make assumptions about soil, load distribution, and pile-soil interaction. Without utilising the opportunity to calibrate numerical models with actual field data field data, these assumptions go untested, leading engineers to add conservative safety factors.

Piles can represent 10-30% of a building's embodied carbon. Smaller or fewer piles can significantly reduce carbon emissions. To address this, engineers at London-based Tyréns AKT, decided to monitor selected critical piles and a section of the raft during construction to assess how closely actual behavior matched model predictions. Depending on the outcome, future projects could see reductions in concrete use.

The chosen candidate for long-term, continuous monitoring was Edge London Bridge: a 27-story reinforced-concrete building with a four-story basement, founded on a piled raft to control differential settlement. Notably, during the top-down basement excavation, individual piles were subjected to substantial loads prior to raft casting.

The structures instrumented were two 35 m piles of 1.5 and 1.8 m diameter, two plunge columns at basement level, and a 90 m^2 area of the 1.5 m-thick raft.

The team identified Brillouin Distributed Temperature and Strain Sensing (DTSS) as the ideal system to measure the temperature and strain behavior of the selected piles. With over 21,500 measurement points at 80 mm sampling interval, they could observe the full strain and load distribution along the entire depth, which conventional point-based instrumentation cannot achieve.

Monitoring Objectives

The monitoring scheme was designed to generate high-quality field data to calibrate numerical models. Three key objectives guided the setup:

- Record the evolution and distribution of strain within the piles throughout top-down excavation and superstructure construction.
- Quantify load sharing between the piles and the raft at each stage of construction.
- Identify localized stress concentrations – tension driven by ground heave and compression from imposed load.



Figure 2: Pile cage instrumented with temperature and strain cables

Installation

To achieve this, armored fiber-optic sensing cables were attached to reinforcement cages prior to pile installation. Cable routing required close coordination with the contractor to ensure the cables would survive the excavation and construction processes.

The fibrisTerre interrogator measured the full fiber length, delivering strain and temperature profiles with ±2 microstrain precision. An 8-channel fT X switch enabled the monitoring of multiple sensing cables from the different parts of the instrumented foundations. Data were automatically uploaded, processed and visualized in real time, using Epsimon's cloud-based platform, eliminating the need for on-site presence.



Figure 3: In the basement, the rack-mounted instrumentation comprises the fibrisTerre distributed fiber optic sensing interrogator, switch, computer, and accessories.

Measurement Schedule

The monitoring commenced in June 2023 and ran continuously for 30 months through every stage: pile installation, the top-down basement excavation, raft construction, and the construction

and initial fit-out of the superstructure. Throughout the monitoring, strain, displacement, and temperature profiles of the instrumented piles and raft were recorded every hour.

The design team analysed the evolution of strain in the piles and raft throughout the construction sequence and used the findings to optimize foundation designs of other building sites.

Results

The Brillouin DTSS was instrumental in verifying design assumptions.

- Ground heave engaged the piles in tension to depths that varied with excavation level – measured directly for the first time to this level of detail, thanks to this project.
- Load sharing between the piles and raft was calculated at every construction stage, enabling progressive model calibration rather than a retrospective end-state comparison.



Figure 4: Single pile strain profile evolution recorded during the basement excavation and displayed on Epsimon's Real-Time Monitoring System dashboard

These findings are derived from direct measurements at centimeter-intervals resolution over the full 35 m pile depth, continuously recorded throughout the 30-month period – offering insight not possible with sparse point sensors.

Conclusion

Testing geotechnical models with high-resolution field data revealed that actual behavior is more nuanced and efficient than predicted.

For Edge London Bridge, this recalibration – thanks to distributed fiber-optic monitoring data – enabled Tyréns AKT to calibrate advanced numerical models based on actual field performance. Subsequent projects have benefited, with significant reductions in pile dimensions and direct savings in concrete volume, time, cost, and carbon.

Since the sensing cables remain in place, future measurements can further characterize long-term heave effects and evolving load sharing between the piles and raft.

Contact fibrisTerre to discuss your project's requirements with a specialist.

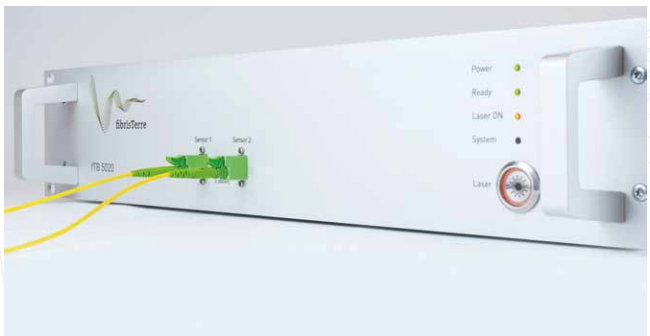

Figure 5: fibrisTerre's fTB 5020 strain and temperature monitoring interrogator

Acknowledgements

fibrisTerre extends its heartfelt thanks to those who made this project possible:

Tyréns AKT, London, UK – Structural engineering consultancy
https://tyrensakt.com

Edge London Bridge, London, UK
https://edge.tech/portfolio/london-bridge

Epsimon Ltd, Cambridge, UK – Infrastructure monitoring specialists
https://www.epsimon.com/

Mace Construct, London, UK – Global construction company
https://www.macegroup.com/

Tyréns Group, Stockholm, Sweden – 'an independent consultancy group creating sustainable and innovative solutions and customer value within the fields of urban development and infrastructure'
https:// www.tyrens.com/

All photos, except Figure 5, are courtesy of Epsimon Ltd