Future-proofing foundations for reuse

Canary Wharf Group is implementing long-term structural and geotechnical monitoring at One North Quay to enhance the value of the constructed piles.

While the concept of foundation reuse is well established, Canary Wharf Group first applied it in practice during the 2016 redevelopment of the Shell Centre Building as part of the South Bank Place project in central London.

At the time, the approach followed industry best practice as outlined in *BRE: Reuse of Foundations for Urban Sites – A Best Practice Handbook (2006)* and *Ciria C653: Reuse of Foundations (2007)*. Several under-reamed piles dating back to the 1950s were successfully reused to support the new building.

One of the key challenges in foundation reuse is the reliability and completeness of historical records. To address uncertainties, intrusive investigations were carried out. These included vertical, horizontal and inclined coring to confirm pile geometry, sampling of concrete and adjacent soils for laboratory testing, and televiewer inspections of vertical cores to identify potential cracking in tension piles.

Reusing foundations in this way demands extensive investigative and analytical effort. Typically, the resulting pile capacities are constrained with safety factors based on original design assumptions. This is largely due to the statistical nature of the assessment, as it is rarely feasible to investigate every reuse pile in detail. While this approach contributes meaningfully to circular economy principles and sustainable construction practices, it remains challenging to implement. Success depends on a committed client willing to invest in the process and a highly experienced professional team capable of developing a robust assessment and design strategy.

A DIFFERENT APPROACH

Canary Wharf Group structures director Jonathan Ly explains: "Embedding long-term future considerations early in a project marks a crucial shift in mindset for advancing reuse strategies. That's why we've chosen to instrument and monitor the foundations of our latest landmark life science development at One North Quay [in London] using structural health monitoring and digital technologies. By recording the development of applied loads during construction and over the building's lifetime, we gain valuable insights into both structural and geotechnical performance.

"This forward-thinking approach enables us to really maximise foundation reuse in the future, with the added potential of achieving enhanced load capacities. Monitoring the interaction between the foundation and the soil will also generate a rich data set to inform adaptive design strategies for future developments."

Arup's geotechnical engineers and Ramboll's structural engineers collaborated with Canary Wharf Group to develop a "future-proof" foundation strategy. Additional expertise from Cementation Skanska and the University of Cambridge led to the installation of fibre optic cables in a representative selection of piles spanning both land and marine environments to monitor temperature and strain. These were complemented by conventional strain gauges for calibration and comparative analysis. Cambridge's fibre optic soil sensors were also grouted into position beneath the concrete basement slab and pile caps to measure ground bearing pressures onto the river terrace gravels, providing valuable data on soil-structure interaction.

Arup associate director Chris Barker says: "For a long time the geotechnical industry has monitored geotechnical structures with strain gauges, positional surveying and hydraulic jacks, but mostly only during construction. More recently, fibre optics is a game changer in the ability to undertake long term monitoring – not only of geotechnical structures but also of the structures which they support.

"Now being able to measure strains in concrete elements as well as soil and water pressures with fibre optics, One North Quay is an exciting opportunity to fully measure and understand the soil-structure interaction both during construction and in the long term. Improving our understanding of the long-term performance of our structures can better support foundation reuse and performance-based design."

Cementation Skanska senior design manager Anthony Fisher adds: "It is great to see new technologies maturing and finding applications on real projects. The North Quay project is a great example of forward thinking; where the inclusion of sensors at an early stage in construction can then play a role in the life of the structure and in furthering our understanding of how buildings behave. The practical and technical lessons learnt here will be of great value to future projects."

INSTRUMENTATION STRATEGY

The landside piles were constructed using the continuous flight auger (CFA) method, which can result in a varying concrete profile. To improve the accuracy of converting strain measurements into pile loads, the instrumented CFA piles were also designated as working load test piles. By correlating the known applied test loads with the measured strain during testing, the pile's Young's modulus (E value) can be determined. This enables translation of fibre optic strain readings into actual load values acting on the pile. Key milestones in pile load behaviour during construction, at completion and throughout live occupancy can then be accurately recorded and analysed.

The instrumented marine pile was constructed by installing permanent steel casing through the dock bed into the underlying clay stratum, followed by rotary bored piling using polymer support fluid to maintain bore stability.

Implementing the monitoring strategy presented significant logistical challenges. Fibre optic cables and soil sensors are delicate and susceptible to damage, requiring meticulous handling. Predetermined cable routes leading to either centralised or local access chambers had to be carefully planned and coordinated to align with concrete construction activities and pour sequences.

To protect the instrumentation