ONE NINE ELMS

LOCATION

LONDON

PILING CONTRACT VALUE

£45M+

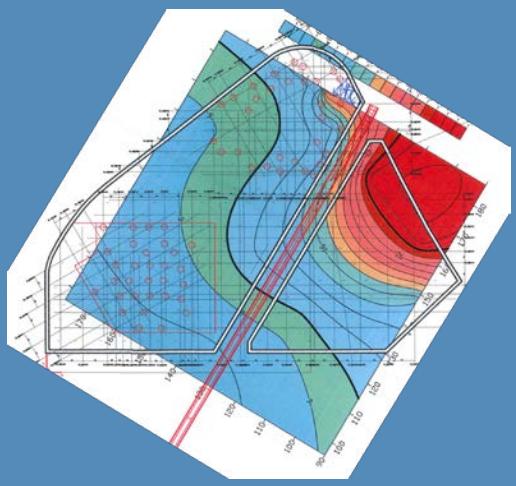
TECHNIQUES

Large diameter piles

Diaphragm Wall

Osterberg Cell

Periglacial feature



PROJECT AND SCOPE

The project involved the construction of two new towers of up to 56 storeys in height, with a three level basement at the site of Market Towers in One Nine Elms Lane, London.

The technical design scope that BBGE carried out included 250+ bearing piles of up to 2.1m in diameter, 150+ plunge columns, 5 osterberg pile tests and a diaphragm wall that created 2 boxes that were divided by a major Thames sewer.

GROUND CONDITIONS

Results of the soil investigation indicated the presence of scour feature in part of development. Significant variability in the levels as well as strength and stiffness of London clay led to the designer creating three distinct ground profiles to accommodate the difference.

The unaffected London Clay extending from -5mOD, to -35mOD with a water table at 1mOD. However, the worst case part of the scour, the London Clay had been completely removed.

The 2 towers sat in 2 different zones, therefore requiring very different design approaches but still adhere to overall specification limit and performance criteria. The City Tower sat directly on the scour feature whilst the River Tower sat on the unaffected London soil stratigraphy. Design by calculation and standard methods were used to calculate the pile resistance, and in the scour feature, various methods were used and the worst case was taken forward into design.

A key part of the methodology was to have a comprehensive pile testing philosophy to inform the design.

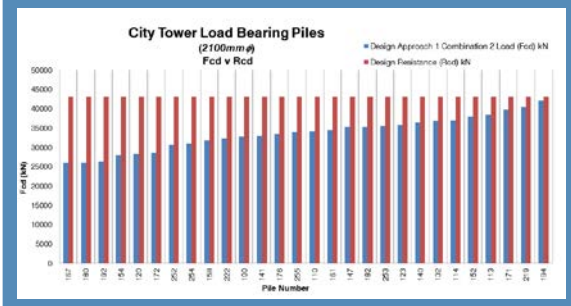
PILE TESTING METHODOLGY

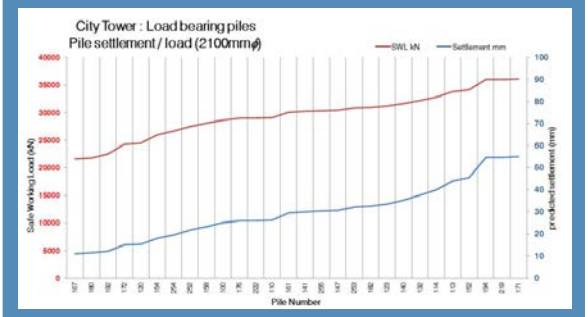
BBGE designed and carried out 5 bi-directional Osterberg test piles ranging from 1050mm to 1800mm in diameter. As the loads on the permanent piles exceeded 35MN, traditional testing methods were not viable.

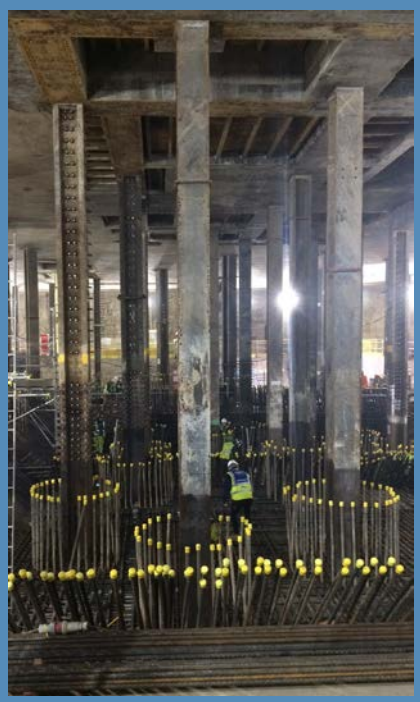
Main points where:

- Concrete only filled to COL (14m below ground level).
- The measured average unit shaft friction has been found to be higher than the values used in the original design. The mobilised end bearing pressure has been found to be lower in the area with scour feature.
- Results of the assessment show that the pile ultimate capacities are higher than the applied loads for the River Tower and City Tower piles. This proved that the piles as originally designed were adequate.
- All the River Tower piles have a factor of safety of more than 1.10 on shaft alone.
- BBGE's assessment indicates that a lower base stiffness for the Thanet Sand has to be used in the design of piles within the scour feature.
- Shaft friction in the Thanet Sand measures as between 223 and 319kN/m^3.
- End Bearing resistance in the Thanet Sand ranged from 28Mpa to 16.6MPA. The 16.6 MPA was measured within the Scour Feature. The 3 other test outside the scour featured from 20MPa to 28MPa.

Balfour Beatty
Ground Engineering







- Loads in excess of 30MN were measured being applied upwards, as well as downwards (60MN in total).
- A tension specific test was carried out, by placing the Ocell at the tension toe level of the permanent piles, and extending the pile into the Thanet Sand in order to pick up opposing resultant force.

The design was verified, and BBGE could provide clear single pile settlement response for all piles shown in different areas of the site, and provide clear instructions on how long a pile could be left open and still ensure the pile was compliant to EC7. The graph opposite demonstrates the capacity of the 2100mm diameter piles and redundancy in the design that enables the site team to select appropriate piles to start on a Friday and finish on a Monday (i.e being left open longer than usual).

LOAD BEARING PILES

The engineer AKT provided the loading for the piles to be designed to. BBGE had the geotechnical design responsibility (without SLS responsibility in the city tower) and STR reinforcement detailing design responsibility.

BBGE had 4 design stages to considered; Excavation stage, final stage, final stage under tension & temporary plunge column loading

- Individual compressive SWL in excess of 35MN.
- Maximum GEO ULS loads of 42407kN
- Majority of compressive piles extended to the Thanet Sand to pick up higher base resistance.
- Bending moment in the pile >28MN.
- Maximum shear within the pile of 7MN, requiring 20mm helical reinforcement at 105mm spacing.
- Temporary tension loads in excess of 10MN, without favourable compressive loading to counteract.
- Maximum temporary compressive loading of 17MN
- Cages that detailed paired 40mm main bars, and 30 x 50mm bars.
- Alpha value of 0.45 used in LC and LMG.
- Tension Partial factor on shaft resistance increased from 2 to 2.5 due to variability.
- No reduction in alpha value for the use of bentonite.

All piles in the River Tower were designed to a FOS on shaft alone of 1.1. BBGE removed the requirement of SLS performance from the contract after additional SI and test pile data for piles in the scour feature showed the shaft friction was not large enough to resist the loads on shaft alone. Design proceeded considering ULS only for the City Tower, with FOS on the shaft as low as 0.5 with predicited single pile settlement of 55mm. The STR Engineer undertook detailed group analysis and base stiffness analysis to determine foundation movement

The construction sequence at ONE was top down. Numerous piles had plunge columns installed within them, which resisted of up to 17MN of compression loading. Tolerances considered in the design of the piles, so calculate eccentric bending moment and shear weere:

Plunge column: 10mm in plan and 1 in 400 verticality

Pile: 25mm and 1 in 200 verticality

The bending moment and shear were considered as locked in when the slabs were cast. The additional load permanent load then attracted additional bending moment using pile eccentricity only.

Balfour Beatty
Ground Engineering