https://doi.org/10.32762/eygec.2025.33

DEEP BASEMENT EXCAVATION - PARK STREET, CAMBRIDGE, UK

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ABSTRACT

Card Geotechnics Limited (CGL) designed, in collaboration with Dawson Wam (DW) and Gilbert Ash (GA), the retaining walls, associated temporary works and the excavation/construction sequencing required to enable the construction of what is understood to be one of the largest and deepest basements in Cambridge to date. The value engineered basement solution was underpinned and informed through a detailed 3D FEA Ground Movement Analysis (GMA) and resulted in an optimised construction sequence and reduced programme and costs.

Keywords: basement excavation, 3D FEA ground movement analysis, value engineering, monitoring.

PROPOSED DEVELOPMENT

The proposed development comprised the demolition of an existing multi-storey car park and the construction of a new six-storey hotel building with a three-storey basement up to 13m deep, which is understood to be one of the largest and deepest basements in Cambridge to date (see Figure 1).

Figure 1 *Basement Excavation and Propping*

A number of sensitive assets and constraints are present around the basement, including party walls, neighbouring listed structures, Park Street, Round Church Street, as well as sewer and water pipe infrastructure below the roads (see Figure 2).

These existing party walls and constraints were a key risk and consideration throughout the design and construction of the proposed basement works.

GEOLOGICAL CONTEXT

Ground conditions on site comprised a variable thickness of predominantly granular Made Ground and River Terrace Deposits (~4m thick) underlain by Gault Clay (see Figure 3). Groundwater was approximately 2.5m below ground level.

Card Geotechnics Limited (CGL) characterised the underlying soils using laboratory and in-situ testing, as well as relevant literature (British Geological Survey, 1995) to derive 'moderately conservative' design parameters, particularly for retaining wall analysis where the strain level of 0.01% and 0.1% is appropriate (CIRIA, 2017).

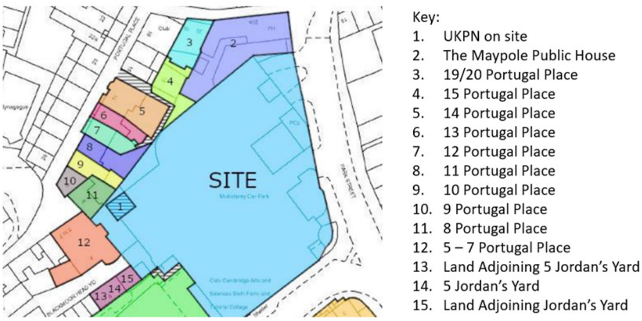

Figure 2 *Site Constraints*

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Potential variations in ground conditions (see Figure 4) locally associated with the 'Kings Ditch' (Cessford C and Dickens A, 2019) were de-risked through sensitivity analysis and consideration of potential design implications of this feature on relevant basement wall sections.

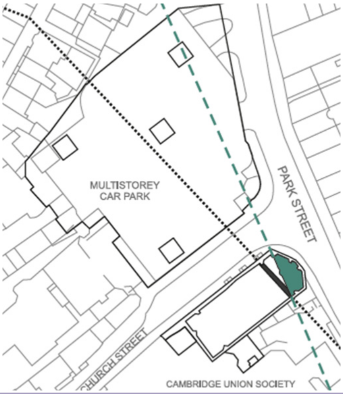
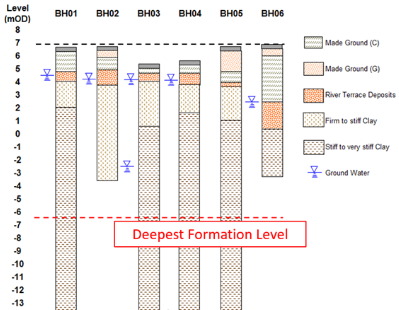


Figure 3 *Ground Model & Parameters*



Stratum	Approximate Level (mOD)	K_0	Density (kN/m³)	c' (kN/m²)	Cu (kN/m²)	Ø (°)	Eu (MPa)	E' (MPa)
Made Ground / River Terrace Deposits	7.5	0.47[a]	18	-	-	32		20
Gault Clay	3.5	1.0[b]	19	5[d]	55+6z[c]	20	42+ 4.5z [c]	31+3.4z[c]

Figure 4 *Potential for King's Ditch*

TENDER STAGE VALUE ENGINEERING

CGL, in conjunction with Dawson Wam (DW) value-engineered a 900mm diameter hard/firm secant piled wall with hard piles spaced at 1.35m c/c to a 750mm hard/hard secant pile wall, with male piles spaced at 640mm c/c.

This alternative optimised basement methodology also allowed for the removal of extensive enabling works, which was achieved by raising the capping beam levels around the perimeter and moving the perimeter wall pile line out, closer to the boundary. The latter was possible due to DW's vibration-free cased CFA system, which enables close proximity piling with improved installation verticality tolerances (see Figure 5).

CGL also optimised two levels of propping frames, including a new buttress wall, that enabled early excavation and erection of the tower crane, resulting in substantial programme benefits.

Figure 5 *Close Proximity Piling*

As part of this process, a detailed Ground Movement Analysis was undertaken (see Figure 6), which demonstrated that the alternative basement piled wall and propping methodology, as well as the refined excavation and construction sequencing strategy, provided consistent or improved results concerning predicted ground movements, and corresponding impact on the critical constraints/ assets assessed for the existing party wall agreements to remain appropriate.

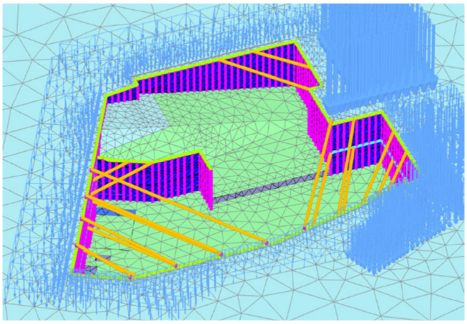


Figure 6 *Detailed FE Modelling*

DETAILED DESIGN

CGL refined the PLAXIS 3D FEA modelling, undertook verification checks using WALLAP, including running various ULS cases in accordance with EC7 (European Committee for Standardisation, 2004), and adopted the outputs to undertake a detailed geo-structural design of the hard/hard secant wall, temporary buttress wall and two levels of temporary propping.

It is noted that the temporary propping frames were ultimately adapted by the specialist proprietary propping provider.

In the detailed design process, CGL collaborated with Gilbert Ash (GA) and DW in developing an optimised construction sequence and reduced programme for the works (see Figure 7).

Figure 7 *Basement Excavation & Propping*

Additional efficiencies that were developed include:

- Designing the piled wall to cantilever up to 3m initially to enable efficient and unrestricted archaeology investigation and clearance.
- Optimising the foundation solution, adopting a raft with strategically placed tension piles.
- Refining the detailed monitoring strategy (comprising in-place inclinometers in the pile wall and arrays of 3D EDM survey targets on the façades of all neighbouring buildings) and trigger limits with associated contingency measures to control and manage risk during the works on site, in line with the principles of the Observational Method (CIRIA, 2001).

LIVE CONSTRUCTION SUPPORT

Reactive support and regular monitoring performance reviews were undertaken during the works, including site attendances and inspections, which enabled early prop removal locally through back analysis of the wall performance from the monitoring to allow the main core walls to progress to ground level earlier than planned, which unlocked further programme advantages for the contractor.

Also, reactive contingency prop design was undertaken in the localised area where the 'King's Ditch' was encountered, and wall deflections exceeded the amber trigger limit locally in the corresponding inclinometer location.

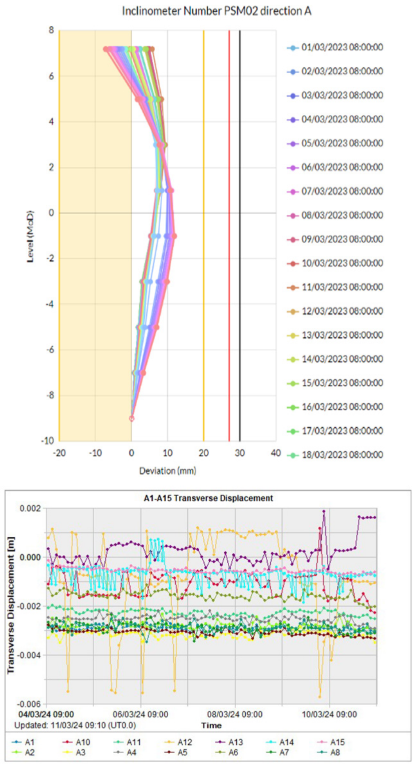


Figure 8 *Real Time' Monitoring*

NEXT STEPS

The information and experience gathered from this monitoring and scheme are intended to be used to produce a case study in relation to the ground movements and back analysis from underpinning, piling and retaining wall deflection monitored data, which can inform efficient design of future similar developments.

ACKNOWLEDGMENTS

The authors wish to express their gratitude to Madeleine Groves, former CGL Chartered Senior Engineer, and the wider project team (Dawson Wam, Gilbert Ash and Conquip teams).

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