CASE STUDY

Hutton Hub, UoH

GEOFEM

The University of Hertfordshire's new Hutton Hub building for the Student Union and other student services has a distinctive glass façade that demanded tight tolerances on foundation differential settlement. These were to be met by a stiff raft foundation but when the site investigation discovered a vast and complex network of solution and mining features in the chalk rock across almost the entire building footprint, the client was facing the prospect of a £1 million bill for foundation piling. Could advanced geotechnical analysis save the day?

AT A GLANCE

THE CHALLENGE

- Glass façade had tight tolerances on differential settlement of the building foundation.
- Site investigation encountered vast network of solution and mining features that covered most of the building footprint.
- Solution feature infill was very soft in places and highly variable. Conventional settlement calculation methods ruled out a raft foundation so piled foundations were recommended.
- Should a raft foundation be feasible, the structural engineers needed spring stiffness values for this variable ground.

THE SOLUTION

- The site had already been extensively investigated in multiple phases, so the infill properties were mapped precisely in three dimensions.
- The precise infill properties were transferred to a 3D finite element analysis (FEA) model of the raft foundation and supporting ground.
- Predicted settlements were very much lower and within acceptable limits.
- Raft bending moment and spring stiffness values for different raft options were provided to the structural engineers.

THE BENEFITS

- Terrible ground conditions that threatened the viability of the project were overcome with minimal changes to the design.
- The approximate £1 million additional cost of foundation piling, as well as the associated additional time and CO_2 emissions, were avoided.
- Further efficiencies in the raft design were gained through design optimisation and soil-structure interaction outputs from the 3D FEA model.

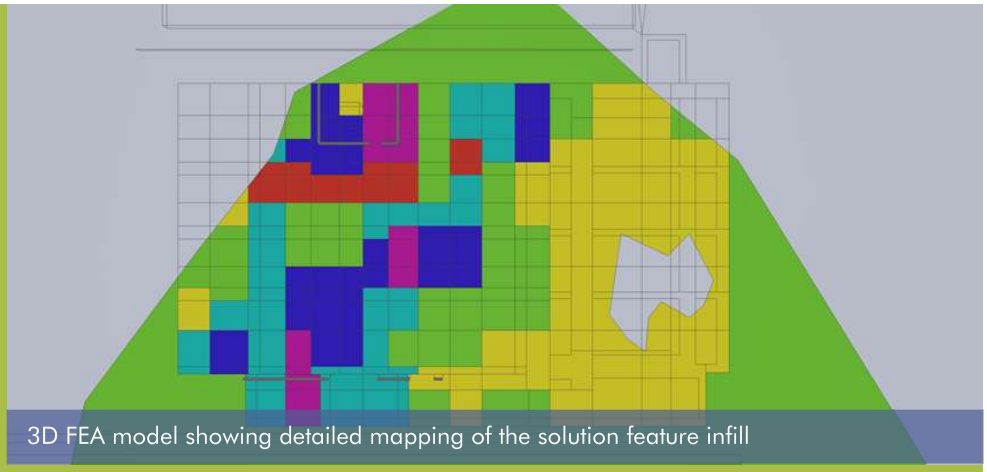
THE CHALLENGES

The distinctive glass façade to the proposed Hutton Hub building had low tolerance to building distortion which placed a tight limit on differential settlement of the foundation. This was to be satisfied by a stiff raft foundation on chalk rock, perhaps with the treatment of some small solution features.

However, site investigations encountered a vast network of solution and mining features covering most of the building footprint and with depths of up to 25m. The infill varied significantly from soft spots of clay to dense sand and even intact chalk – about the worst possible ground conditions for differential settlement.

Conventional settlement calculations, which cannot handle such variability, inevitably predicted large settlements that precluded the use of a raft foundation. The infill volume was too great for ground improvement so piled foundations were recommended with significant extra cost.

If a raft foundation were feasible, the structural engineers needed spring stiffness values and other soil-structure interaction outputs for these very complex ground conditions.



3D FEA model showing detailed mapping of the solution feature infill

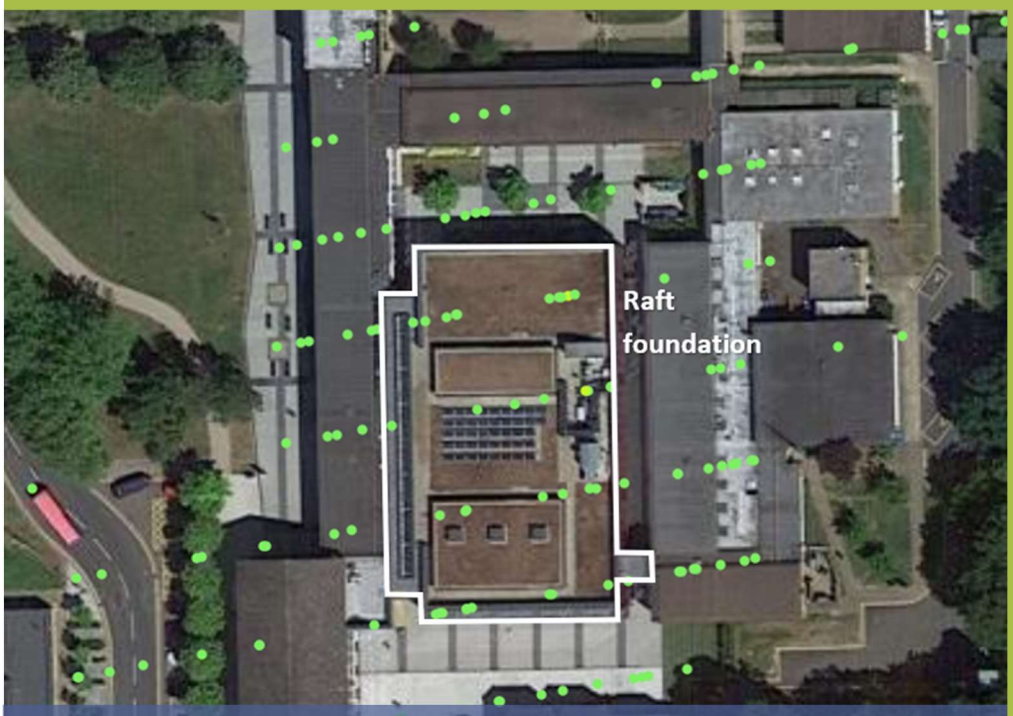
GETTING DOWN TO DETAIL

The challenging ground conditions meant that the site had already been extensively investigated in multiple phases using different investigation techniques. We performed an extensive study of all this information to map the top of chalk and infill properties precisely in three dimensions.

Geotechnical 3D FEA is one of the few techniques that can handle the soil-structure interaction analysis of a raft foundation on ground with such high variability in three dimensions, so the mapped infill geometry was transferred to such a model of the raft foundation and supporting ground. The model also included shear and core walls to add their stiffening effect and the structural loads were simulated.

It was found that the raft was able to span the soft spots in the infill and the predicted differential settlements were very much lower than those of the conventional analysis methods and within acceptable limits. This was reaffirmed by InSAR analysis data showing less than 3mm settlement in the 18 months following construction.

Once the raft foundation was deemed feasible, the 3D FEA model was used to explore different raft options, including with local thickenings, to optimise the design. Raft bending moment and spring stiffness values for the different raft options were provided to the structural engineers for their detailed design of the raft slab.



InSAR output showing insignificant settlement of the Hutton Hub building post-construction

THE BENEFITS

An impending additional cost of around £1 million for unplanned foundation piling was averted. The associated delays and higher CO_2 emissions of foundation piling were also avoided.

Further efficiencies in the raft design were gained through a value engineering exercise and by providing the structural engineers with improved soil-structure interaction parameters for their detailed design of the raft slab.

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