19th December 2017

A-squared | Studio

By Email
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For the attention of **Phillip Cracknell**

Ref: Pears Building Extension to the Royal Free Hospital, London
Review of Appendix 2 to Birketts Response to DBCP for Application 2014/6485/P

Dear Phillip,

As requested A-squared Studio Engineers Ltd (A-squared) has undertaken an initial high level review of Appendix 2 to Birketts response to the Detailed Basement Construction Plan for the proposed extension to the Royal Free Hospital, known as the Pears Building. This Appendix 2 of the response comprises a joint report by Messrs Eldred and deFreitas of Eldred Geotechnics Ltd and First Steps Ltd respectively. It was provided to A-squared Studio Engineers Ltd on 12 December 2017 and this high level review was requested on 18th December 2017.

We are surprised at the content of this Appendix 2 as this is opposite to what was verbally stated by Messrs Eldred and deFreitas in the meeting on 28th September 2017 when presented with the findings of the A-squared Geotechnical Design Report and the Ground Movement Assessment results. The phrase "done a good job" was used by deFreitas. We also recall that Eldred appeared to be asleep during part of the meeting.

We do not accept the inference within this Appendix 2 by Messrs Eldred and deFreitas that A-squared has not used reasonable skill and care in our work undertaking the Geotechnical Design Report and the Ground Movement Assessment for this development. In our opinion A-squared has undertaken its services at a higher level than reasonable skill and care.

Section 2 below describes similar experience A-squared has on comparable projects, including New End within the London Borough of Camden. New End was similar to the Pears Building project in that there were rigorous objections to the development and A-squared had undertaken the geotechnical services for the client. We request a similar list of comparable experience of undertaking complex Ground Movement Assessments from Messrs Eldred and deFreitas.

1. Initial High Level Responses to Messrs Eldred and deFreitas

We note that there are several misinterpretations or misunderstandings by Messrs Eldred and deFreitas. Some of these demonstrate a lack in understanding of modern Ground Movement Assessment methods and procedures. This document responds to the key points made in the paragraphs below.

The historical movements (both the limited factual and mostly anecdotal data) were considered in the numerical model. As was explained to Messrs Eldred and deFreitas on numerous occasions and in the meeting on 28th September 2017 the numerical model predicts ground movements from changes in stress within the ground. Historical developments around and on the site have previously changed the state of stress within the ground and have been considered. The Pears Building development will change the current state of stress within the ground both during construction and once built, and these have been considered. These movements have contributed to the damage but are not the sole cause. Other sources of ground movement on the neighbouring properties that are historical and/or current, and are significant, but will not be altered by the Pears Building development, (such as, but not limited to, from tree action and from localised ground instability) are not considered by the numerical model. The Burland calculation of damage has been used in accordance with standard industry practice. Historical damage is not assessed as being nil for St Stephen's Church or for the Church Hall.

We find it interesting that deFreitas is requesting an ex colleague of his from Imperial College London to become involved. We do not accept that Professor David Potts, whom we acknowledge is an expert in finite element modelling, can be considered independent. Also it would be considered highly unusual to introduce yet another party at such a late stage in the process. The A-squared work to date has been reviewed by Campbell Reith and by LBH, both of whom are well known to Camden Council. The A-squared work has been presented to Messrs Eldred and deFreitas on numerous occasions and A-squared has made every effort to take into account the concerns raised by them. It has to be said though that many of the concerns raised have no factual basis but are anecdotal, incorrect or presumptual. In addition they have both visited the A-squared office to see the numerical model.

The groundwater has been measured at several locations in the vicinity of the development. The monitoring data has been considered and conservatively used in the Ground Movement Assessment. The groundwater monitoring is designed to investigate the current distribution of groundwater pressure. This has been found to be less than hydrostatic within the mass of the slope. Near surface groundwater flow is transient and influenced by recent climatic events. Temporary and permanent drainage design for the Pears Building development will not change the existing groundwater conditions beneath St Stephen's Church or for the Church Hall. Drainage design is not by A-squared. Whether the existing foundations to these two buildings are adequate for the current ground and groundwater conditions is of debate.

Borehole 213 did show shear zones at some depth within the clay soils. Both A-squared and Campbell Reith visited Soil Consultants's office to inspect in person the core logs from this particular borehole. These are considered to be too deep to influence the behaviour of the relatively shallow excavation for the Pears Building. In addition there has been testing of the clay soils. These tests and the results are described in the Geotechnical Design Report. The Ground Movement Assessment uses the ground model and geotechnical parameters described in the Geotechnical Design Report.

Regarding engineering oversight Tony Suckling of A-squared has been appointed as the Geotechnical Adviser for this development and has been acting in this role during much of 2017. Tony Suckling is registered in the United Kingdom for such a role and his certificate is attached.

A-squared accepts that ground engineering, where consideration is being given to natural materials as well as to man-made materials, always has some level of uncertainty. This is true of all development that interacts with the ground. Hence a substantial amount of monitoring is being undertaken to validate the ground movement predictions and in addition it is planned to commence the excavation works furthest from St Stephen's Church and the Church Hall. The use of the monitoring and movement trigger levels for key demolition / excavation / construction stages are currently in preparation.

2. Project Team & Experience

We consider that our team is particularly experienced and capable for undertaking the Ground Movement Assessment for the Pears Building project. We have been involved in a number of comparable complex projects. Selected examples of London-based projects where we have delivered a comparable scope of services (either leading the substructure design, undertaking ground movement assessments or performing category 3 checks) include the following:

- **New End, Hampstead** (Client: Linton Group). Challenging urban redevelopment project in the London Borough of Camden comprising a deep basement in sloping ground. The ground engineering scope comprised the substructure analysis and design, including a detailed Ground Movement Assessment (GMA) and impact assessment of adjoining/surrounding properties, Hampstead Christ Church and other sensitive assets. The design assurance process included extensive independent reviews and liaison with stakeholders.
- **St Giles Redevelopment** (Client: Consolidated Developments). Substantial Over Site Development (OSD) at Tottenham Court Rd Station interfacing with numerous below ground assets.
- **Royal Mint Street** (Client: IJM Land). Particularly challenging OSD near Tower Bridge, which interfaces with the existing DLR enclosure, DLR encapsulation and substantial Network Rail viaducts.
- **Battersea Power Station Redevelopment** (Client: Buro Happold Engineering and Bauer Technologies). Landmark project comprising the redevelopment of the Grade II* listed Battersea Power Station comprising substantial below ground challenges and interface with Network Rail assets.
- **21 Hanover Square** (Client: WSP/Great Portland Estates). Substantial OSD interfacing with Bond Street Crossrail station and tunnel infrastructure.
- **Park Crescent West** (Client: AKT II). Sizeable redevelopment of a crescent near Regents Park, which interfaces with numerous existing tunnels beneath and around the site.

Other substantial ongoing and recently completed projects include:

- **Marble Arch Tower** (Client: Watermans Group).
- **Principal Place** (Client: Careys).
- **Meridian Gate** (Client: WSP).
- **Harbour Yard Redevelopment, Chelsea Harbour** (Client: Expedition).
- **Crown Place** (Client: AKT II).
- **Olympic Stadium Redevelopment** (Client: Buro Happold Engineering).
- **University College London Hospital Proton Beam Science Facility** (Client: Bouygues UK).
- **One Nine Elms, Market Towers** (Client: AKT II).
- **Lots Rd Power Station Redevelopment** (Client: Careys).
- **Caxton House** (Client: Anderson Global Investors Ltd).
- **Sloane Street** (Client: Watermans Group).

There are other such projects that cannot be named as we have signed a Non-disclosure Agreement.

A-squared brings a wealth of below ground design and construction experience extending over the full project lifecycle. As outlined previously, our technical and analytical expertise in the field of substructure design is supplemented by experience in buildability and implementation. Our varied skill-set is driven by the background and expertise of our leadership team and the structure of our practice. Key members of our team involved in the Pears Building project include:

Tony Suckling

Eur Ing BEng(Hons) MSc CEng FICE

Tony is a UK Registered Geotechnical Adviser, Chartered Engineer and Fellow of the Institution of Civil Engineers. He is the former Technical Director of Balfour Beatty Ground Engineering Ltd. He brings a wealth of experience to the A-squared team, with specific emphasis on design implementation and buildability. This facet of design development is critical from a design assurance perspective. Tony's complimentary skillset developed during his career at Balfour Beatty and Arup brings a unique strength to the A-squared team in tackling the delivery of complex substructure schemes in congested urban settings. He has been instrumental in delivering numerous urban redevelopment projects from a ground engineering perspective, supporting consultants and contractors alike. Aside from project specific experience, Tony has led the BS8004 authoring process, various CIRIA initiatives, ICE Piling Specification revision and chairs various committees. He spearheads numerous initiatives across academia, consultancy and construction sectors and is recognised as a leading figure in the industry in the field of basement design.

Angelo Fasano

Dott Ing CEng MICE

Angelo is an experienced Chartered Engineer with particular expertise in substructure engineering. Angelo brings together an exceptional skill-set in geotechnical and structural engineering. He remains engaged in research in the field of soil-structure interaction and fuels *the technical advancement of the continuously evolving numerical modelling capability at A-squared. Angelo has delivered numerous schemes across London, which included particularly complex interaction challenges and stakeholder approvals processes. Selected projects comprising successful design submissions and independent checks include Hornsey Rd development, Sainsbury's Whitechapel/Crossrail, Park Crescent West and Westfield Phase 2.*

Alex Nikolic

BEng(Hons) MSc DIC CEng MICE MSt(Cantab)

Alex is a Chartered Engineer with extensive experience in urban redevelopment. He is the former Head of the Ground Engineering discipline at Buro Happold Ltd. He has delivered numerous schemes comprising complex substructure interfaces with existing assets including London Underground, Crossrail, Network Rail, Docklands Light Railway and similar. Alex's role as discipline lead extended to the position of project director for the Ground Engineering Award winning Emirates Air Line (Cable Car), which included extensive interface with Docklands Light Railway and future Silvertown Tunnel assets. He has also led the multi-disciplinary tender design for the Northern Line Extension, coupled with the design of the proposed over-site developments at Battersea and Nine Elms. Alex has delivered exceptionally challenging projects from a stakeholder management perspective and brings a wealth of geotechnical and substructure interdisciplinary design experience to the team.

Yours sincerely

on behalf of A-squared Studio Engineers Ltd

Tony Suckling
UK Registered Geotechnical Adviser
Eur Ing BEng(Hons) MSc CEng FICE FGS
Director

UKREGISTEROFGROUNDENGINEERINGPROFESSIONALSUKREGISTEROFGROUNDENGI UKREGISTEROFGROUNDENGINEERINGPROFESSIONALSUKREGISTEROFGROUNDENGI

UK RoGEP

UK Register of Ground Engineering Professionals

This is to certify that

Tony Suckling

was admitted on 01 June 2011 and may be described as a

UK Registered Ground Engineering Adviser

A Register established to provide stakeholders with a means to identify individuals who are suitably qualified and competent in ground engineering.

UK Register of Ground Engineering Professionals UKRoGEP Est. 2011

Chair, RoGEP Panel

Registration number: 47026958

00000029

The Geological Society

IOM3 The Institute of Materials, Minerals and Mining

ice Institution of Civil Engineers

Annex A

Selected projects – outline summary

St Giles development, London.

The redevelopment of St Giles in central London comprises an intricate OSD overlying various elements of Crossrail and London Underground infrastructure. The proposed 14m deep basement bridges a newly constructed Crossrail tunnel and substantial elements of the Tottenham Court Rd Station Upgrade project, including a new 30m deep escalator.

The St Giles (Denmark Place) site footprint is shown in Figure 1 below.

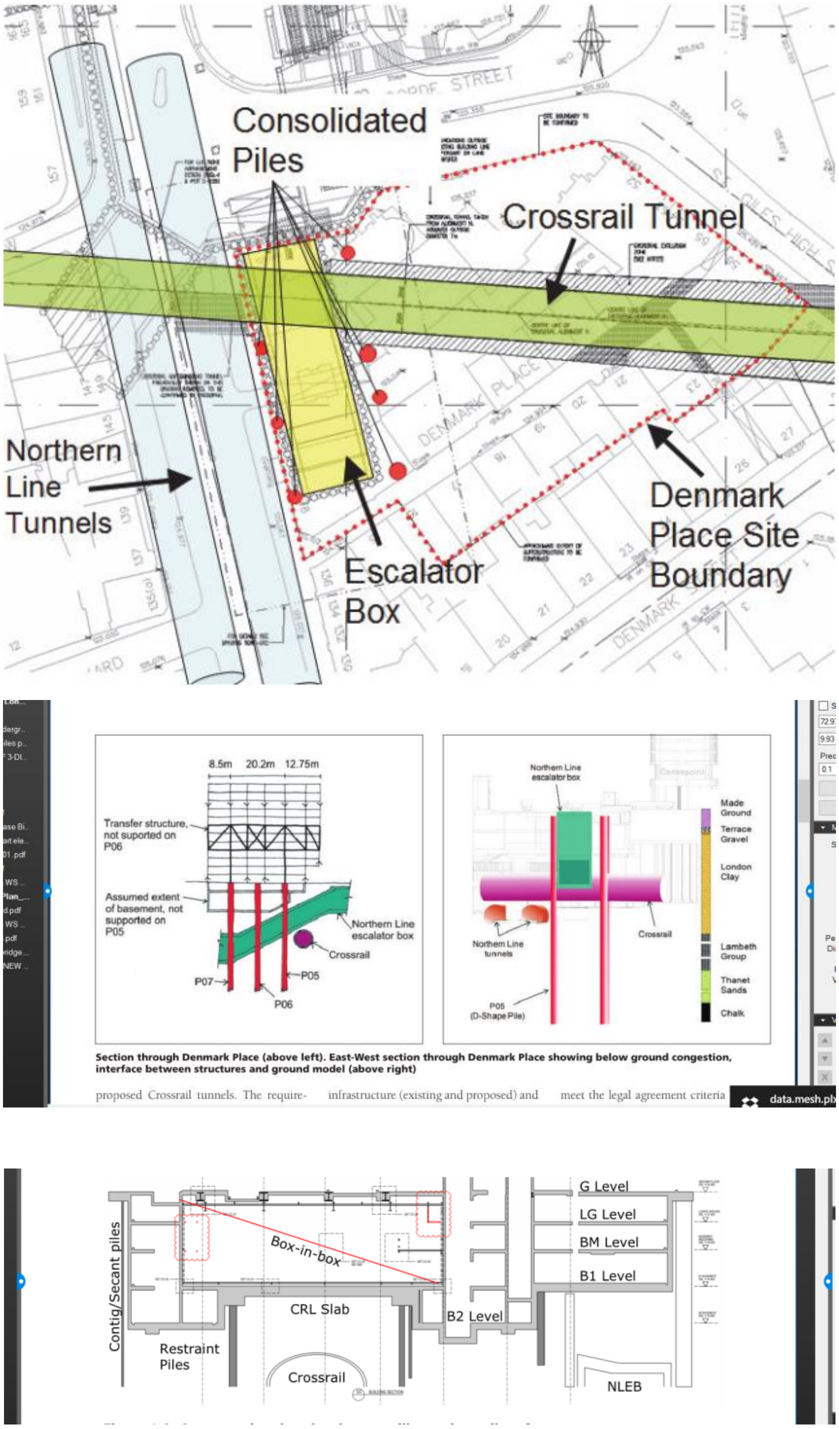

Figure 1 - St Giles (Denmark Place) site footprint and interface with primary below ground assets (top); indicative cross sections (middle and bottom).

The ground movement assessment and impact assessment on existing buildings, Crossrail assets and London Underground elements of infrastructure required the development of a complex three-dimensional model. The analytical efforts undertaken for this project, alongside the implementation of various user-define constitutive models for the soils, have yielded an industry bench-mark for this type of numerical simulation of soil-structure interaction effects. The finite element model is presented in Figures 2 and 3.

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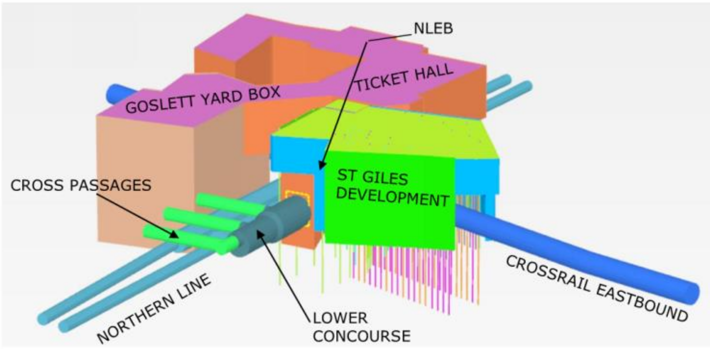

Figure 4.1: 3D finite element model overview (soil and selected structures removed for clarity of presentation)

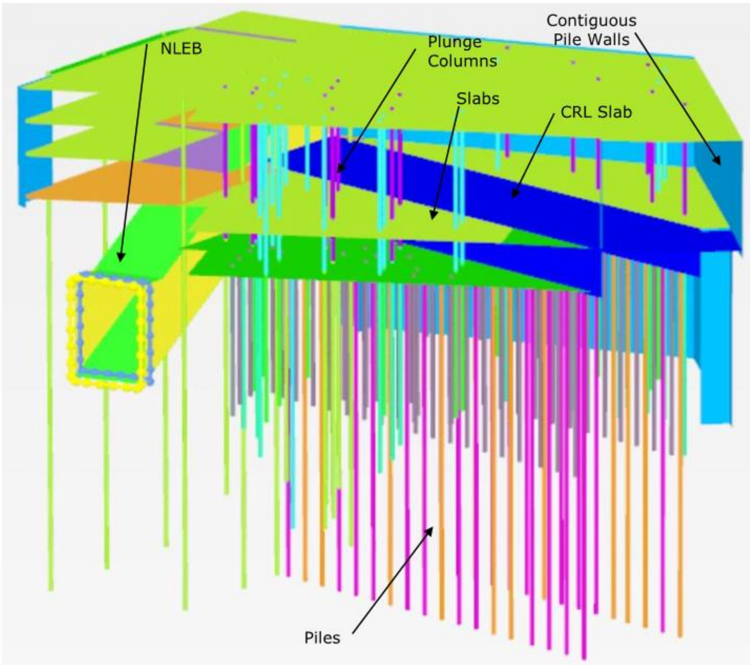

Figure 4.3: Piles, contiguous pile walls and slabs representation in the finite element model (soil and selected elements removed for clarity of presentation)

Figure 2 – Three-dimensional finite element model (general view – soil removed for clarity)

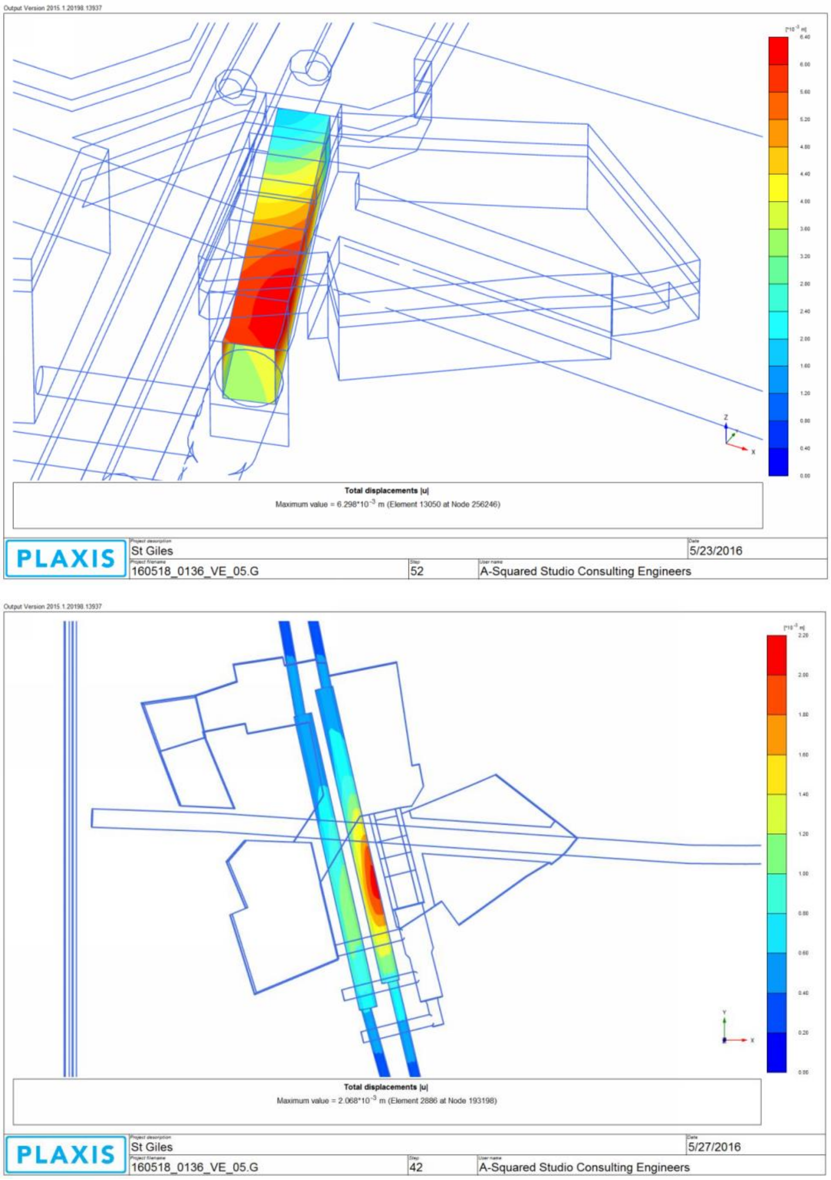

Figure 3 – Example output from the three-dimensional finite element simulation.

Park Crescent West, London.

The Park Crescent West project comprises the redevelopment of one half of a substantial crescent immediately south of Regents Park. The redevelopment includes the excavation of a two storey basement above existing tunnels. The site general arrangement is presented in Figures 4 and 5.

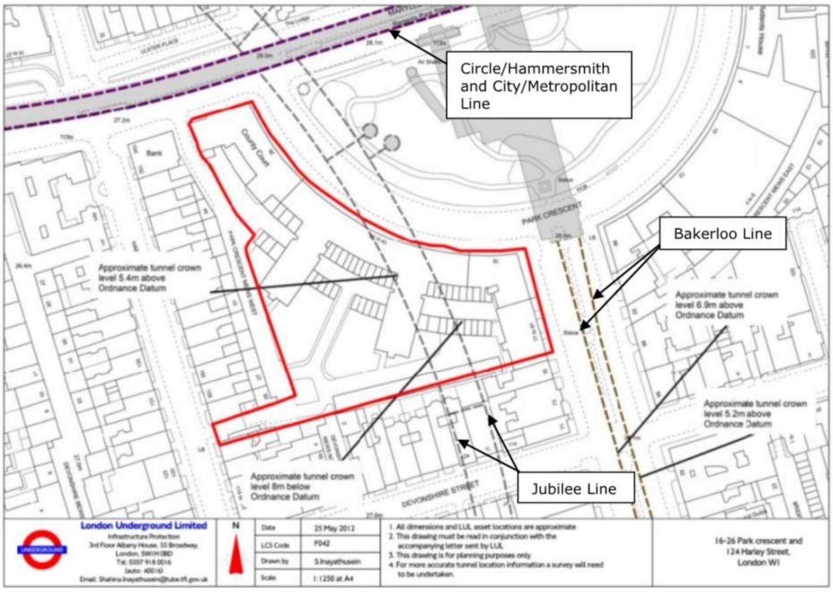

Figure 4 – Site footprint (shown in red) alongside interface with various existing tunnels.

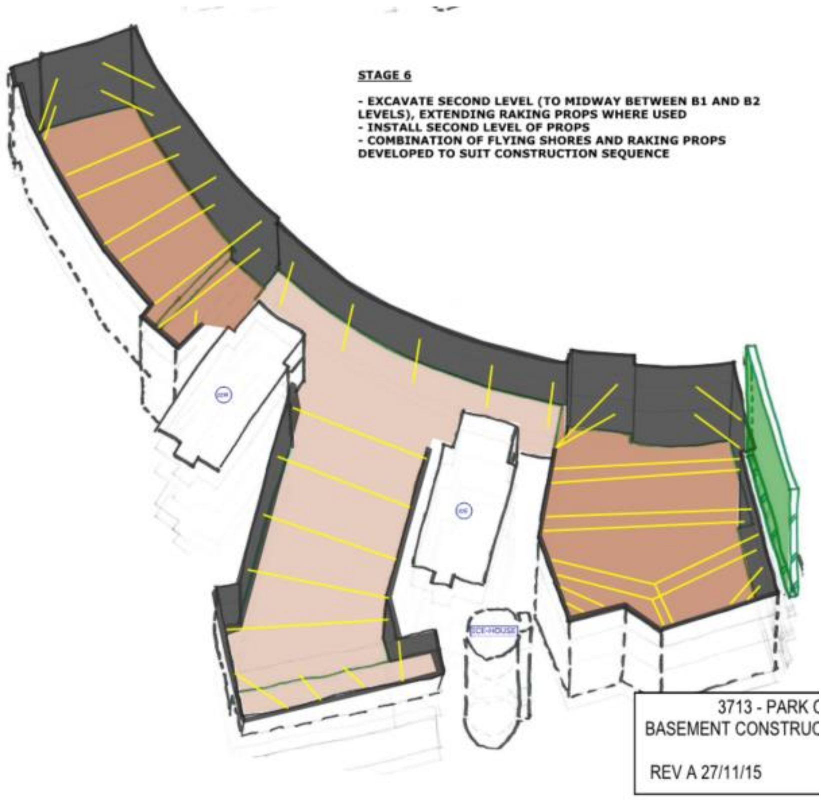

Figure 5 – Proposed basement excavation over and in proximity of existing tunnels

In light of the complex and irregular geometry, and interface with numerous existing structures (both buildings and infrastructure), the impact assessment was supported by means of a three-dimensional finite element simulation.

The models, which simulate the proposed multi-stage construction sequence, are presented in Figure 6.

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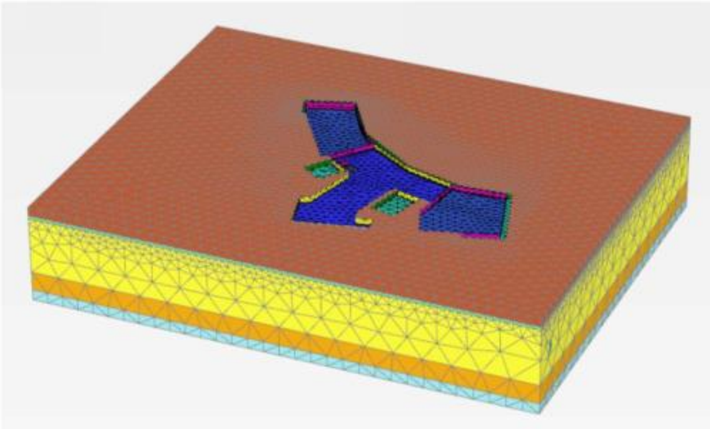

Figure 4.1 – Indicative view of 3D analytical model (looking north)

The London Clay and Lambeth Group strata have been modelled as undrained materials during demolition, basement excavation and proposed building construction works (i.e. representative of a short term condition applicable to cohesive strata). Long term conditions are achieved by performing a final consolidation analysis, in which all excess pore water pressures generated during the previous construction stages are dissipated.

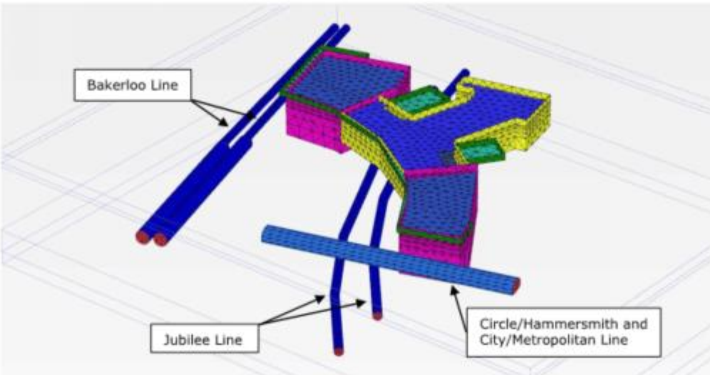

Figure 4.2 – Indicative view of 3D analytical model (soil continuum removed for clarity – looking south)

Figure 6 – Three-dimensional finite element models adopted for substructure design and impact assessment purposes.

Selected output is presented in Figures 7 and 8.

Figure 7 – Output plot showing plan view of tunnel structures in relation to basement footprint (shown in blue) and tunnel lining deflected profiles (shown in red). Scale exaggerated to facilitate mechanism inspection and review.

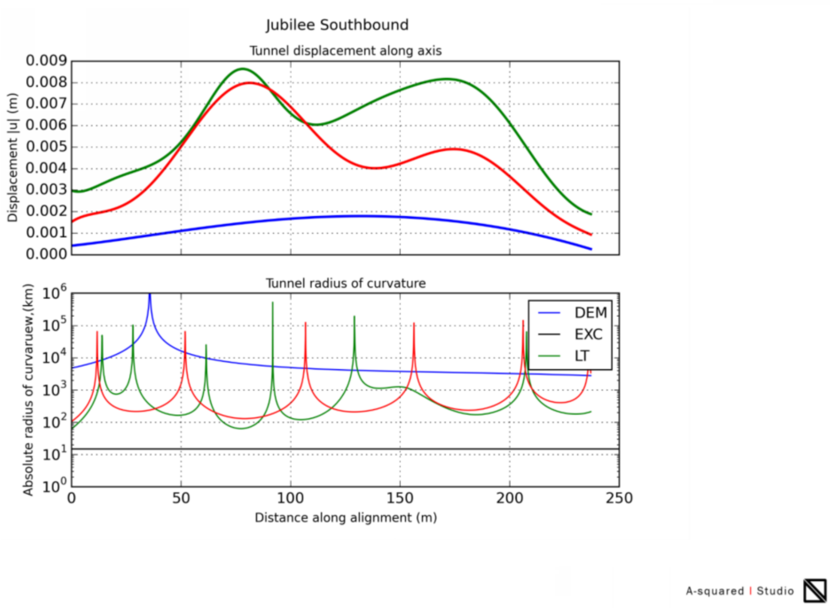

Figure 8 – Example output interpreted from the numerical simulation (showing deflection and curvature of example tunnel along alignment).

Royal Mint Street, London.

The Royal Mint project comprises an ambitious development near Tower Bridge on Royal Mint St. The proposed scheme encompasses a two-phase development, which includes a number of buildings bridging various existing below ground structures. The scheme embraces an elaborate substructure arrangement, including encapsulation of Docklands Light Railway infrastructure.

The site footprint and interface with existing Network Rail and Docklands Light Railway assets is shown in Figure 9. An image of the proposed development and cross-section through the scheme are illustrated in Figure 10.

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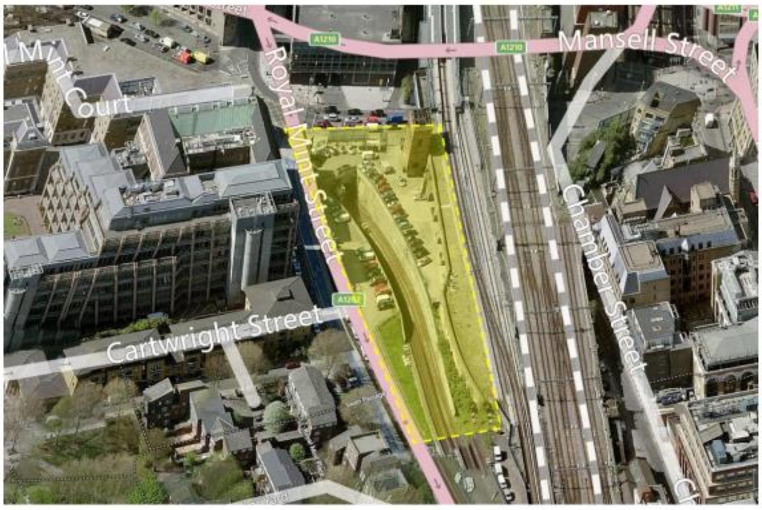

Figure 2 – Aerial image / bird's eye view of the broader Royal Mint Street project site (site footprint outlined in yellow, looking west) image courtesy of Bing Mapping

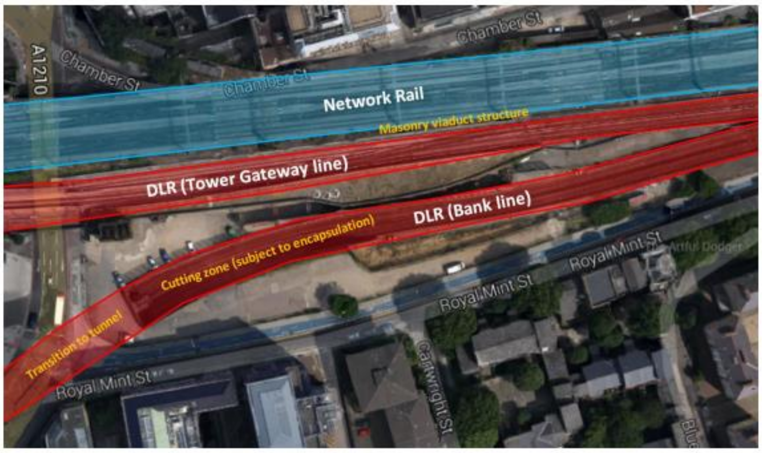

Figure 9 – Site footprint and arrangement of existing infrastructure assets

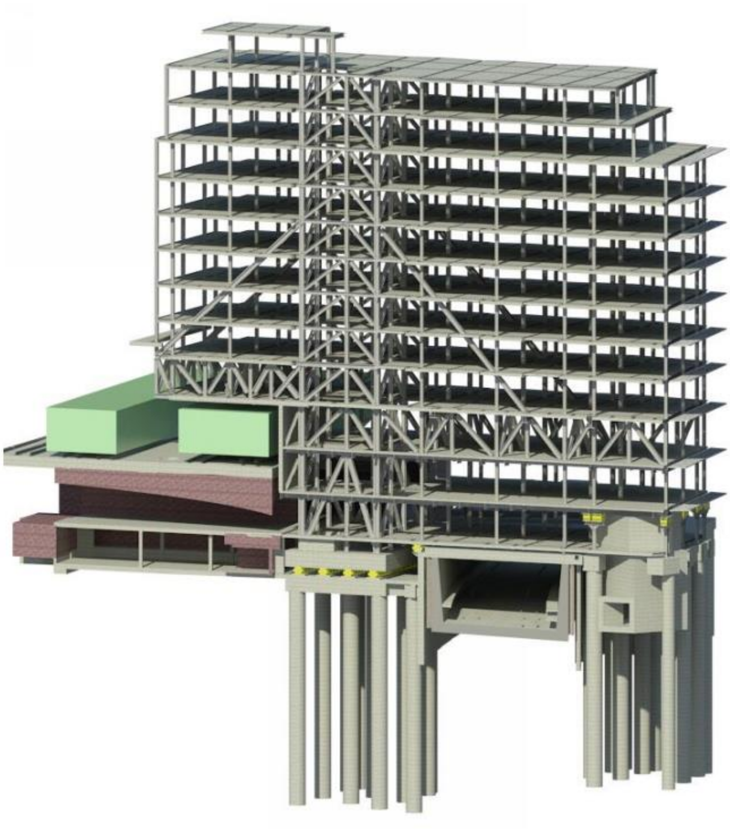

Figure 10 – View of proposed development bridging Docklands Light Railway tunnels and Network Rail viaduct (top); cross-section through development showing Docklands Light Railway encapsulation tunnel and viaduct integration into the scheme (bottom).

The complexity of the proposed scheme and construction sequence required a sophisticated three-dimensional simulation. The assessment modelled the construction sequence of the various phases of the development and yielded output to aid the impact assessment process and to inform the optimisation of the substructure design.

The impact assessment model and example output is shown in Figure 11.

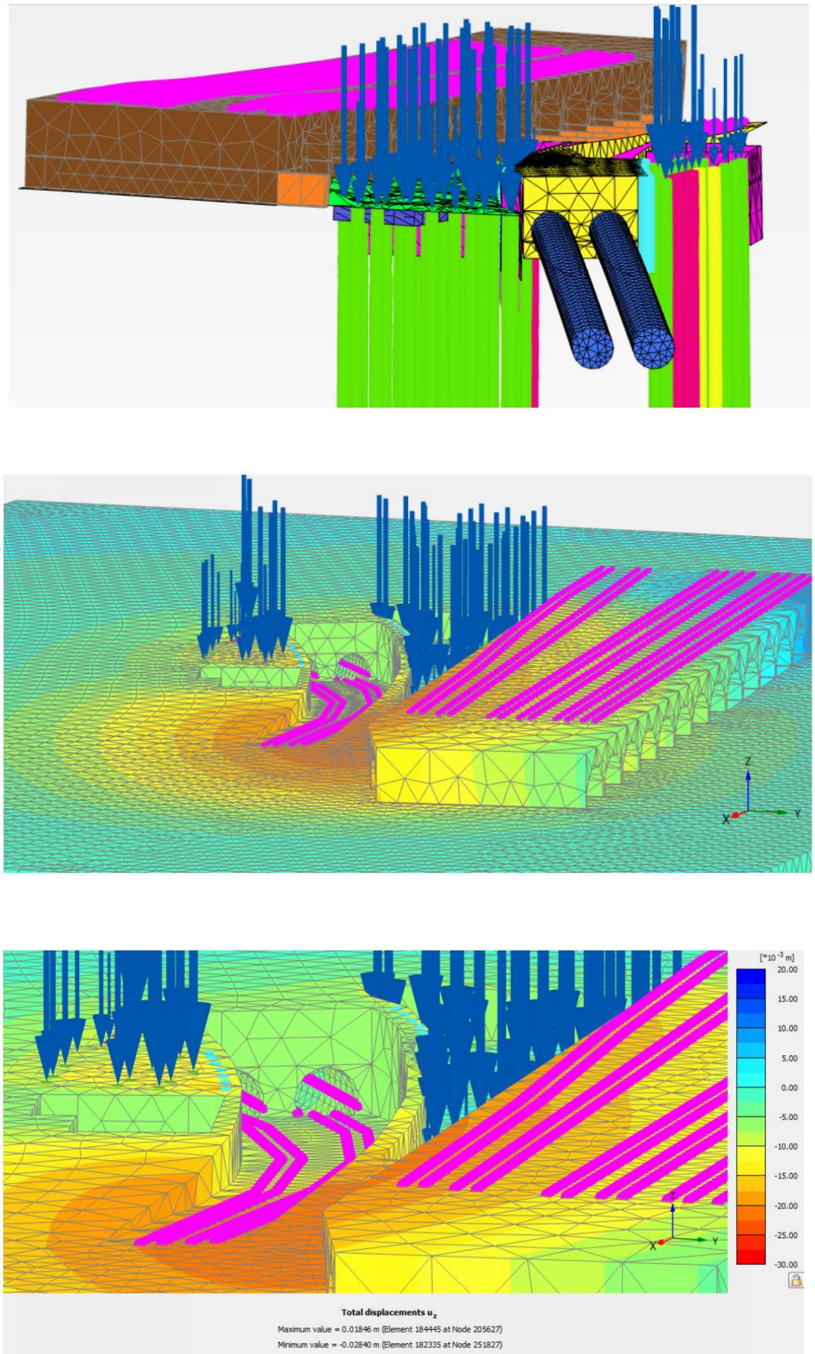

Figure 11 – View of three-dimensional finite element model showing existing tunnel and viaduct assets alongside proposed substructure (top); indicative output from model including key track elements shown in magenta (middle and bottom).

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