



GEOTECHNICAL CONSULTING GROUP

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██████████
Crossrail 2

Transport for London

55 Broadway

London SW1H 0BD

29th October 2015

Dear ██████████,

CROSSRAIL 2: INDEPENDENT OPINION ON GEOTECHNICAL ASPECTS OF THE PROPOSED SCHEME IN THE TOOTING AREA

1 INTRODUCTION

I am Robert Mair, the Sir Kirby Laing Professor of Civil Engineering and Head of Civil and Environmental Engineering at Cambridge University. I am also a Vice President of the Institution of Civil Engineers and previous Senior Vice-President of the Royal Academy of Engineering. It has been recently announced that I have been appointed to the House of Lords as an independent crossbencher. I have been involved in tunnelling infrastructure, deep excavations and geotechnical engineering for almost forty years. I have advised widely on civil engineering projects worldwide and have served as an expert for many tunnelling and metro projects around the world. I am one of the founding Directors of the Geotechnical Consulting Group, an international consulting company based in London that provides specialist advice on geotechnics, with particular emphasis on tunnelling and its effects on the surrounding environment.

2 SCOPE OF REVIEW

This work on the proposed Crossrail 2 Scheme has been commissioned by Transport for London (TfL) who asked me, working with GCG, to give a view, based on geotechnical concerns, on the appropriateness of TfL's decision to consider alternatives to a mined station at Tooting. Our opinion is offered following a careful, independent review of available information on the proposed scheme and ground conditions. We have reviewed information provided to us by TfL (refs [3] and [4]), but have also drawn on additional and relevant information in the public domain and in our project and research archives (e.g. refs [1] and [2]).

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3 CURRENT LUL PROPOSAL

The current TfL proposal has examined the expected ground conditions based on the very limited available information and includes a risk assessment that considers the likely ground conditions and its potential impact on construction. Based on this, TfL proposes the construction of a deep station at Tooting Broadway to interchange with the Northern Line. Construction would involve use of Tunnel Boring Machines (TBMs) for the running tunnel and Sprayed Concrete Lining (SCL) for platform and other tunnels, with box structures excavated from the surface at the limited locations where access is judged to be feasible. The SCL construction would probably have to be facilitated with Artificial Ground Freezing to treat the ground so as to cope with the water bearing sands, gravels and chalk that are likely to exist at the station location.

4 OUR INDEPENDENT OPINION

Our review confirms that the available geotechnical information in advance of project-specific investigations for Crossrail 2 is very limited. This is due to an absence of large developments with deep and detailed ground investigations in the area. However, the available information is sufficient to show that ground conditions over a large part of the route in the Tooting Area are complex and highly disturbed by faulting and folding. Strata at the location of the proposed Tooting Broadway Station works are likely to be highly variable, comprising sands, gravels and chalk, and subjected to high ground water levels. Existing published ground models are very simplified and do not fully explain the considerable variability seen in the available borehole information. This means that there is significant ground risk and further project-specific investigations are necessary to better understand the ground conditions and to better evaluate the risks of various construction options.

Due to the configuration of the faulting and folding in this area, the very variable Lambeth Group Formation and the permeable Thanet Sand and Chalk Strata exist within the region of the proposed tunnelling and excavation works at both Tooting Broadway and Tooting Bec Stations. Construction of deep tunnels and station structures at these two stations would be feasible with current technology, but work is likely to be slow, expensive and carrying significant geotechnical risk. However, current geological information also indicates that Balham Station is on the downthrow side of the fault. This means that the more benign London Clay stratum is likely to exist at and around the tunnelling works, if undertaken at Balham. There is a huge amount of experience of tunnelling in the London Clay (notably most recently on the Crossrail project), which is generally a strong and low permeability clay, facilitating faster, cheaper and safer construction.

A further likely impact of the poorer ground conditions at both Tooting Bec and Tooting Broadway Station is that it will be prudent to consider constructing the escalators within the box excavation for the station, rather than constructing these escalators as individual, inclined, SCL tunnels in poor ground. A consequence of this is that the station box would have to be much larger and the spoil that has to be transported by road for the station box excavation correspondingly more voluminous, with an associated increase in lorry movements. This contrasts



with Balham Station where the escalator tunnels can be constructed in London Clay as inclined SCL tunnels and spoil could be removed underground, via the already constructed running tunnels.

5 CONCLUSIONS AND RECOMMENDATIONS

We conclude the following:

- Based on geotechnical considerations, it is both sensible and prudent to investigate the possibility of a deep station at Balham Station instead of Tooting Broadway or Tooting Bec, as it is likely that the predominantly London Clay ground conditions are more favourable and less risky at Balham than conditions at these other two stations.
- It should be technically feasible to construct deep stations at all three stations, but the cost, programme, risk and potential environmental impact associated with Balham are likely to be much more favourable than at Tooting Bec or Tooting Broadway.
- Additional project-specific ground investigations are required to confirm and improve the existing ground model and to better define the project geotechnical, programme and financial risks.

I hope our opinion set out in this letter proves useful and would be happy to expand further on any aspects

Yours sincerely,

For Geotechnical Consulting Group,

A handwritten signature in black ink that reads "Robert Mair".

Professor Lord Mair

Senior Partner, GCG and Sir Kirby Laing Professor of Civil Engineering Cambridge University

REFERENCES

- 1 Davis A. G. (1928) The geology of the City and South London Railway, Clapham-Morden Extension, Proc Geologist's Association, 39(3), 339-IN13.
- 2 GCG (2008) Tooting Broadway Station Step Free Access, Report Prepared for Tube Lines Limited
- 3 TfL Scan # 1 to 11 (2015) containing backgrounds information on CRL2, geological and geotechnical information available to TfL, decision tree and programme information, construction options and hazards, drawings and sketches, alignment options, Hyder memo on possible ground conditions at Balham, received 28/8/2015.
- 4 TfL (2015) Tooting Broadway Station Geological Issues, dated 1/9/2015.