MetroLink - Module 1

1. Tunnelling, Excavation Related Issues (Groundborne Noise & Vibration, Hydrogeological and soils impacts, settlement, property damage
2. Airborne Noise & Vibration

Monday 4th March

Charlemont & Dartmouth Community Group
(Paul Quigley) Presenter.

Witness Statement by Paul Quigley on Behalf of Charlemont & Dartmouth Community Group in relation to Soils and Hydrogeology

1. Introduction

This statement is submitted on behalf the Charlemont & Dartmouth Community Group (DCDG). DCDG made submissions on behalf of

- Dartmouth Road Residents
- Dartmouth Square West Residents
- General Area

This statement relates to soils and hydrogeological concerns and principally concerns impacts upon Dartmouth Road properties 26-28 and 32-35 and Dartmouth Square West Nos. 1, 3, 5, 7, 9, 10, 11, 12, 13, 14, 15 & 16.

2. Qualifications

Paul Quigley is Chartered Engineer and a Director with Gavin and Doherty Geosolutions in Dublin. He has over 26 years of experience working on major infrastructure projects such as tunnels, ground movement and basement impact assessments both in Dublin and internationally. He is a former Chairperson of the Geotechnical Society of Ireland and is a member of the UK Register of Ground Engineering Professional at Advisor Grade.

3. Cross Reference with TII Response

Dartmouth Road Submission (TII Response 40)

Dartmouth Square West Submission (TII Response 41)

Themes	TII Response Item No.
Overview	
Theme 1 Building Damage Assessment	TII Submission 40 – Point 2,3,
Theme 2 Hydrogeology	
Overall Conclusions	

4. Overview

Overall, the geotechnical risk management strategy appears inadequate for this project's advanced stage, with significant design and clarification on key assumptions and constraints required following the assumption of granting the Railway Order. The scale and magnitude of the ground movement predictions made by TII are excessive for the nature and age of the buildings surrounding the proposed Charlemont Station.

We are concerned that a more site-specific analysis and risk management strategy for the predicted building damage is unavailable. The current submission contains a screening analysis of the ground movements with, in my opinion, excessively high settlements of up to 45mm under building constructed in the 19th Century, which are not adequately mitigated.

The proposed design evolution is deferring further analyses to the next phase (Phase 3), even though there appears to be limited, if any, reasons not to advance the prediction exercise at this stage. TII and their designers are currently in a position to make assumptions, as all designers must, about the geometry, geotechnical properties and other inputs required for the design process to develop a more realistic prediction of the ground movements. The submission has the current location, proposed excavation depth, wall type and construction sequence to enable the analysis. Instead, this important phase of work is being deferred to the next phase of the project when An Bord Pleanala does not require disclosure and statutory review and acceptance of the analysis and risk management strategy.

No reference to an independent check of the ground movements and geotechnical elements of the submission appears to have been made. Documentation such as the Geotechnical Interpretative Report and Geotechnical Design Report, which are referenced in multiple appendices of the EIAR, are not provided as part of the submission. Consequently, transparency about the design process and constraints assumed in the analyses is lacking.

The consequences of these actions for the stakeholders around Charlemont Square are:

1) The design process does not appear to attempt to eliminate risk in the first iteration, or limit risk in subsequent design iterations. The magnitudes of the proposed ground movements are excessive, in my opinion.
2) The validation of future design iterations against a flawed ground movement prediction could allow TII and their design partners to proceed to construction using published horizontal and vertical ground movements in the Railway Order which would not be tolerated on many other urban schemes.
3) There is significant uncertainty about the basement construction proposed, with no details on mitigation measures to minimise structural distress to properties, other than an undertaking repair works at a future date. The current ground movement predictions exposes the residents along Dartmouth Road and Dartmouth Square West to considerable uncertainty and they are liable to be drawn into the contractual cross-fire between TII and the contractor in the event of structural damage to the houses.

5. Theme 1 – Building Damage Assessment

The Building Damage Assessment report is set out in Appendix 5.17 to the EIAR and is surprising for the lack of references to numerous published case histories on recent basement construction in Dublin. The report is limited to a screening assessment of anticipated ground movements using empirical methods developed for basement construction in London. For example, only one paper on ground conditions (Farrell et al., 1995) has been referenced in the Building Damage Assessment. Relevant papers such as Gillarduzzi (2014)[1], which described property damage associated with the construction of the Dublin Port Tunnel associated with tunnelling, are absent. This case history is particularly relevant, as the extent of ground movement predicted using techniques similar to those used by TII failed to predict the widespread construction-induced damage to residential buildings in north Dublin.

The submission fails to adequately calibrate within XDisp the models developed for basement construction derived in Ciria report C760[2] from case studies primarily based in London for Dublin ground conditions and the known issues associated with tunnelling in Dublin. Consequently, the predictions are highly unlikely to be representative of actual ground behaviour for the proposed development.

The Building Damage section set out in Appendix 5.17 raises numerous concerns about the maturity of the proposed design. Jacobs IDOM JV has developed a preliminary assessment using the software package XDISP. The designer has noted in the Executive Summary for the Building Damage Assessment report that more sophisticated models may results in '*being in a position to confidently use less conservative assumptions to assess the impact of construction generated ground movements*' but failed to validate the likely improvements. The potential overprediction maybe advantageous for TII as subsequent design iterations may use these deformations as an allowable ground movement envelope for the project's design phase. Mr Brian Kavanagh of Garland Consulting Engineers will provide more detail on the impact of these movements on tall, masonry buildings along Dartmouth Square West and Dartmouth Road. It appears unfair that the failure to use more sophisticated modelling of the basement construction may result in a heightened risk profile for the homeowners alongside Charlemont Station if more flexible solutions are used to form the excavation.

The software package XDISP is an empirical screening tool for ground movements associated with tunnelling and deep excavations based on case histories, largely published on case histories in the Greater London area. Some of the largest ground movements occur close to the deepest excavations, such as at Dartmouth Road, where approximately 45mm of movement is predicted at the front of the building and 30mm at the rear, resulting in a differential settlement. Typically, in my experience, ground movements under brittle masonry structures in excess of 10mm would be a concern and potentially trigger mitigation measures in the retaining wall design solution. The recent published report Ground Movement

[1] Gillarduzzi, A. (2014) Investigating property damage along Dublin Port Tunnel alignment, Proc. ICE Forensic Engineering, Volume 167 Issue 3, August 2014, pp. 119-130
[2] Gaba et al. 2017 Ciria guide C760: guidance on embedded retaining wall design

Monitoring Information Paper (ML1-JAI-COM-ROUT_XX-PL-Z-00001) uses a similar threshold for monitoring buildings for structural damage.

The designer appears to have failed to acknowledge that improved parameters and more sophisticated methods may improve the total settlements but may result in equal or larger differential settlements due to Dublin Boulder Clays' higher small strain stiffness than the default London clays used in the XDISP analyses. These differential settlements, in turn, could increase the tensile strains in the building.

Why was XDISP used to estimate settlements instead of more sophisticated finite element packages such as Plaxis? The designer used Plaxis for dewatering estimates but not ground movements, which appears to be a missed opportunity to calibrate and validate the XDISP model. Consequently, the current submission will result in significant uncertainty about the building movement analysis.

There are some concerning drawing conflict and quality issues associated with the Building Damage Assessment report. For example, the outline of the basement construction for Charlemont station has been simplified as a rectangle in ML1-JAI-EIA-ROUT_XX-DR-Y-21150, whereas the extent of the retaining wall shown on the plan drawing ML1-JAI-SRD-ROUT_XX-DR-Y-0209 and cross section drawing ML1-JAI-SRD-ROUT_XX-DR-Y-02097 appears more realistic. The impact of the ground movement contours along Dartmouth Square West could significantly change the damage impact rating.

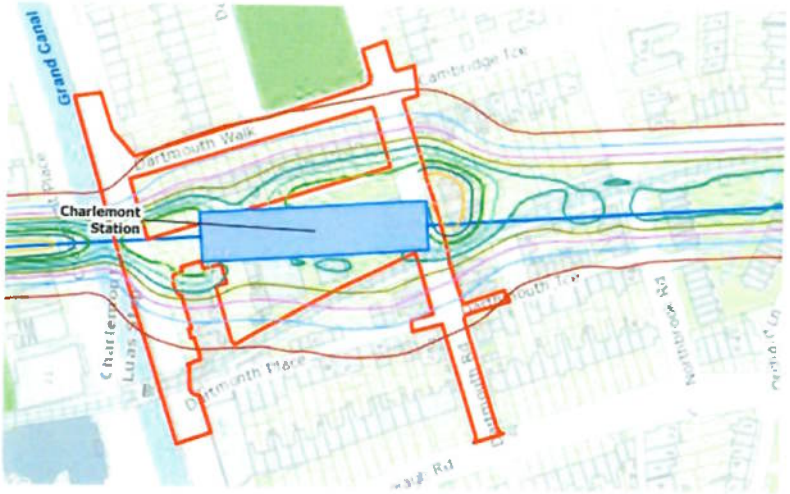

Figure 1 Extract from A5.18 showing a rectangular footprint of Charlemont Station

Figure 2 Extract from CEMP showing the irregularly shaped footprint much closer to Dartmouth Walk

There are workflow processes shown in Figure 4.2 of A5.17, which appear to screen out any intervention. The Stage 2 process seems to be incomplete or incorrect. We note that TII has used a similar screening process developed for the design and planning stage for tunnelling projects such as Crossrail and High Speed 2 in the UK. However, there are no requirements to limit the planning process to this screening process.

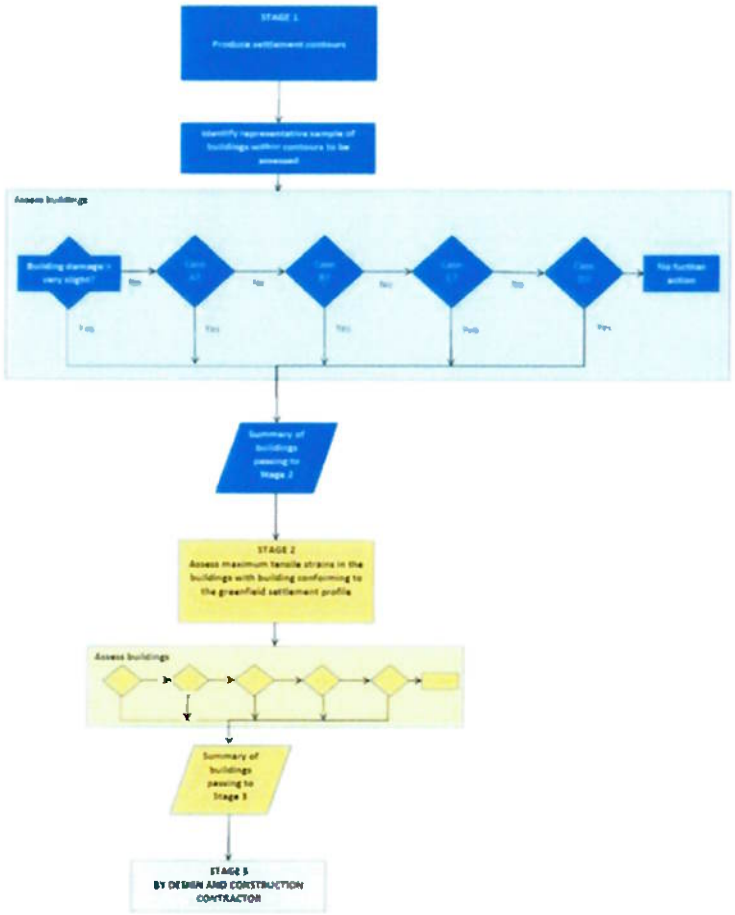

Figure 3 Screening methodology extracted from A5.17

There is some uncertainty about the proposed basement construction solution for Charlemont Station. TII suggests that diaphragm walls will be used for the next phase of the works, although '*other techniques may be used if they meet or improve on the health and safety, technical, consenting and programme assessments*' (A5.12, Section 1, pg.3). We are unaware as to what these constraints are, as envisaged by TII, for this project. At Charlemont Station, due to the development of the site, secant piled walls have been preinstalled and will be used interchangeably with the diaphragm walls. Presumably, the use of diaphragm walls has been proposed for the enhanced dewatering and integrity of the wall. However, diaphragm walls are rarely used in Ireland due to the higher costs and limited depth of many basement projects in Dublin. Consequently, secant pile walls are the default solution for deep excavations in Dublin. There have been issues with long secant pile walls failing to interlock adequately. We note that TII has not described how they will manage this risk.

There is a concern, based on text within Chapter 20, that the resources necessary to develop the ground engineering design were extremely limited. Section 20.2.3.2 suggests that there was a site walkover by a member (singular) of the soils and geology team on 8 November 2018. The report does not confirm that the soils and geology team had been part of Jacobs's three-day walkover in July 2018. It is surprising that no photographs of buildings likely to be severely affected by the works, such as along Dartmouth Road and Dartmouth Square West, are included in the report to provide context to the environment where the works will be undertaken.

In conclusion, the Building Damage Assessment's strategy for dealing with ground movements appears inappropriate for the ground conditions, tolerates ground movements which are not consistent with preventing significant building damage to historical buildings along Dartmouth Road and Dartmouth Square West, and is wholly inadequate in describing site specific mitigation measures for managing geotechnical risk at the proposed Charlemont Station.

6. Theme 2 – Hydrogeological risks

The risks to the structures are primarily associated with ground movements associated with vibrations, ground movements associated with the construction of the basement structures, and hydrogeological effects to the foundations of the 19th Century houses adjacent to the proposed station. These destabilizing effects may occur at different stages of what is envisaged to be a significant construction period.

The EIAR suggests in Section 5.4.11.3 that '*No external dewatering is therefore anticipated during the construction of the station boxes. Any settlement due to the lowering of the water table outside the boundaries of the site will be therefore insignificant*'. Case histories associated with the construction of the Dublin Port Tunnel have indicated that the tunnelling-induced dewatering effects have occurred in the past and may occur again, especially considering that similar equipment, tunnel diameter and tunnelling techniques to those used on the Dublin Port Tunnel are being proposed.

Chapter 18 of the EIAR describes some of the buried and hidden watercourses in the vicinity of the proposed Charlemont station. The source of the information is from Sweeney (1991) and an extract is shown on Figure 4. However, Chapter 19 does not address the potential impact of the station box interrupting any preferential flow paths within the buried watercourse, nor does the Building Damage Assessment associate the potential locations of loose deposits as a risk factor.

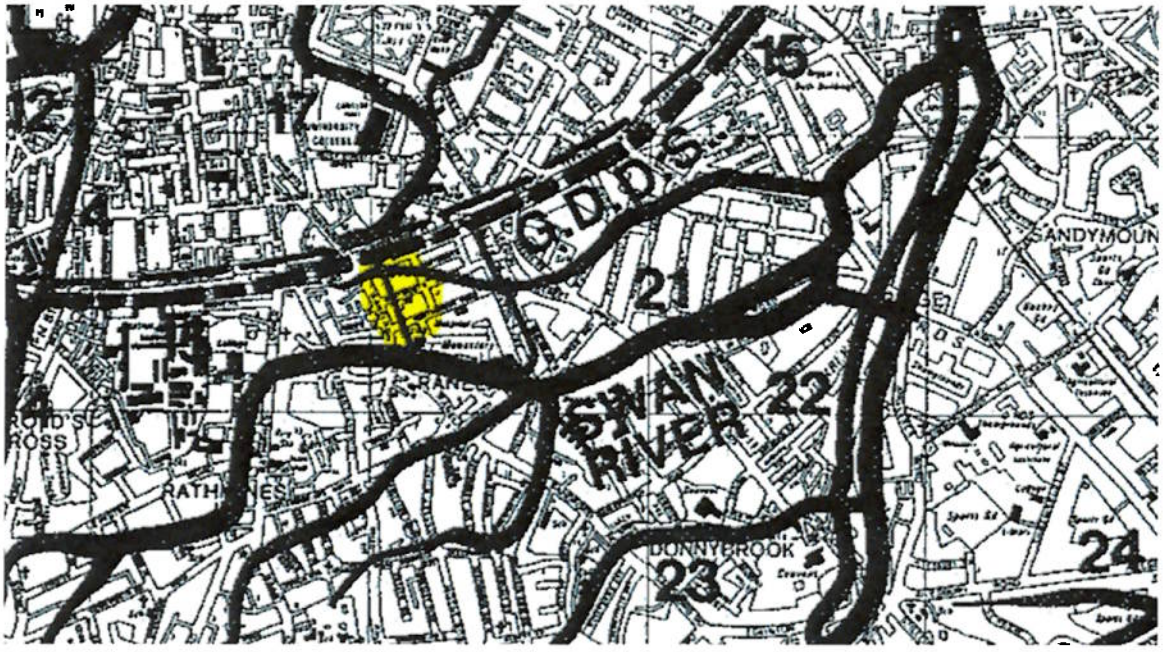

Figure 4 Extract from 'Rivers of Dublin[3]' showing buried river systems in the vicinity of Charlemont Station

The assessment also does not appear to acknowledge the variable thickness of made ground at the proposed site and the potential preferential pathways for water to flow. It would be reasonable to me to assume that groundwater flows go from west to east, heading towards Dublin Bay. The construction of a barrier aligned approximately north-south along the main axis of the proposed station will form of an impermeable concrete box could have impacts on dewatering effects. The wider impact of Charlemont Station forming a barrier to groundwater flow has not been included in Section 19.4.12.4 of the EIAR and consequently the impacts on buildings, in particular along Dartmouth Square West, have not been addressed in the EIAR.

7. Conclusions

Neighbouring homes to a major development should expect that the design of major infrastructural works should, in the first instance, eliminate risk to their homes where possible, or reduce risk to tolerable degrees when elimination of risk is not possible. The TII Railway Order submission does not adequately achieve this. Furthermore, the submission has the following major defects:

1. The ground movement assessment methodology used by TII is not compatible with ground modelling of basement construction in Dublin. The use of XDisp to model

[3] Sweeney, C.L. 1991. *Rivers of Dublin*, Dublin Corporation

ground movements in Dublin is not reliable for the ground conditions and the results lack credibility due to the underlying methodology used in the models.

2. The magnitude of TII's predicted movements and differential settlements under historical masonry structures exceed what would normally be deemed acceptable for most developments. TII has not provided evidence of adequate mitigation measures to either eliminate or reduce the risk to these structures through design.
3. Ground related risk has not been adequately addressed during this phase of the scheme and is being transferred to other parties (i.e. design and build teams) who are not currently stakeholders in this planning process. The current process requires subsequent designers to validate the preliminary assessment. This presents the risk of the current excessive tolerances for ground movements being preserved in the assessment process. The current design is insufficiently developed to adequately assess the impacts on Dartmouth Road and Dartmouth Square West.
4. A hydrogeological assessment of the impact of the deep station box at Charlemont has not been addressed in the EIAR.

In my opinion, the current methodology and design proposed by TII at Charlemont Station is not adequately mature for the Railway Order to proceed.

5. Queries /Questions.