



**Methodology used for assessment of the likely significant effects on
buildings from ground movement and settlement**

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Document history and status

Revision	Date	Description	Author	Checker	Reviewer	Approver
P01	06/03/24	Response to Charlemont	JK	PC	PC	PB

Response to Charlemont Residents

Methodology used for assessment of the likely significant effects on buildings from ground movement and settlement

In order to assess the likely significant effects on buildings from ground movement and settlement, a phased approach has been used on Metrolink. This sequential approach, which uses the methodology set out by Mair, Taylor and Burland, is one that has been used worldwide including in the UK, (Tideway, Crossrail and HS2) in the Copenhagen Metro and has commonly been used in Dublin for Basement Impact Assessments.

The use of this approach has enabled the identification of potentially affected buildings along the alignment using building and geotechnical information gathered during preparation of the EIAR, an assessment of the likely significant effects of any settlement on those buildings, and the selection of appropriate mitigation measures.

The main phases of this assessment, as set out in the EIAR appendix A5.17, can be summarised as follows.

Phase 1

The Phase 1 assessment involves drawing contours of the ground surface settlement using a worst credible volume loss and the methods set out by Peck¹ and refined by O'Reilly and New². This is a filter to identify buildings at risk³ and eliminates all buildings falling outside the 10mm contour where the slope is less than 1/500. This phase 1 assessment essentially involves a screening exercise and enables the identification of any buildings that *may* be at risk of damage from settlement.

Phase 2

The Phase 2 assessment then proceeds to assess the damage that may result to the buildings identified in Phase 1, and categorises the effects according to

¹ Peck (1969). Deep excavations and tunnelling in soft ground. In Proc. 7th Int. Conf. Soil Mech. Found. Engineering, 345–352, Stockholm

² O'Reilly, M.P. and New, B.M. (1982). Settlements above tunnels in the United Kingdom – their magnitude and prediction. Tunnelling '82. Ed Jones, M.J. pp 173-181. London, IMM

³ Moss, N.A., Bowers, K.H. (2005). The effect of new tunnel construction under existing metro tunnels. Proceedings of the 5th International Symposium Geotechnical Aspects of Underground Construction in Soft Ground. Amsterdam, 2005.

categories which relate to strain, slope and settlement. The categories are *negligible*, *very slight*, *slight* referring to cosmetic damage. The other categories are *moderate* and *severe* and correspond to serviceability, and *very severe* is for structural damage.

It is important to emphasise that the Phase 2 assessment calculates the maximum tensile strains induced in the assumed structure without any inherent stiffness. The maximum settlement, slope and tensile strain is calculated and used to obtain the corresponding potential damage category. The approach is conservative because the building is assumed to have no stiffness and to conform to the greenfield settlement profile. In reality, the inherent stiffness of the building will reduce both the deflection ratio and the horizontal strains.

The derived category of damage identified in the Phase 2 assessment is the possible level of damage. This Phase 2 assessment is based on a conservative scenario and overestimates the level of damage that is expected to occur. When the inherent stiffness of the building is considered, and if we draw on the experience from previous comparable projects, it is expected that the damage will be less than the Phase 2 assessment indicates. The conservative approach adopted ensures that all likely significant effects on the buildings arising from ground movement are identified. In practice, the observations of damage for masonry brick structures, such as the buildings in Charlemont, have consistently been demonstrated to be less than the Phase 2 predictions.

On the basis of the Phase 2 assessment, there are only 2 buildings which fall into the categories above *slight*, both falling into *moderate* category. These are identified in the EIAR and are both terraced properties south of Griffith Park. All other buildings along the alignment fall into categories *negligible*, *very slight*, *slight*.

The Phase 2 assessment has been used for the purpose of identifying appropriate mitigation measures. The mitigation measures provided for include limiting the settlement from tunnelling activity and are achieved by TBM design, TBM operational management as well as monitoring and systematic follow up. If the Phase 3 assessment for a particular building identified a need to lower the alignment, this can be achieved within the limits of deviation by way of mitigation. Where damage does occur, this will be cosmetic, and there is a procedure provided for building repair in such circumstances.

In order to facilitate building repair, provision is made for a pre-construction inspection and any subsequent damage can be benchmarked against this pre-

development inspection level. If there is damage, this can be mitigated by minor repair works. After the implementation of this mitigation measure, the residual impact on buildings from ground movement and settlement will be negligible.

Phase 3

The methodology adopted makes provision for a Phase 3 assessment which is carried out during the construction phase. The Phase 3 assessment will be carried out in respect of particular buildings which have been identified for an additional assessment in view of particular features or designation, for example buildings that are protected structures from statutory development plans. The Phase 2 will identify any particular sensitivity of a building and sets out the justification for a Phase 3.

Given the conservative approach adopted in Phase 2, it is anticipated that the Phase 3 assessment, which will refine the conservative assumptions made in the earlier assessments, will demonstrate a reduction in the level of impact identified.

The carrying out of a Phase 3 assessment is not required in order to identify the likely significant effects of the project for the purpose of the EIA process. The Phase 2 assessment is sufficient to identify the likely significant effects and identifies mitigation measures that will be appropriate in respect of the particular category of impact identified.

The method, extent and detail of the Phase 3 analysis will be determined on a case-by-case basis. However, factors that would be taken account of include three dimensional effects, construction and excavation methods and sequencing, structural continuity of the building, foundation and structural details including cladding, façade, basement waterproofing, building condition, orientation of the building, soil / structure interaction, settlement predictions at depth and previous movements.

With specific regard to the properties in Dartmouth Square, the impacts to those properties have been identified from the Phase 2 assessment and the need for a Phase 3 identified. Given the conservative nature of the approach, the Phase 3 assessment is likely to reduce the level of impact from that currently predicted. Indeed, if the buildings were not identified as protected structures there would be no requirement for a Phase 3 assessment.