Imperial College London

NUMERICAL STUDY OF THE INFLUENCE OF TUNNELLING ON A PILED STRUCTURE

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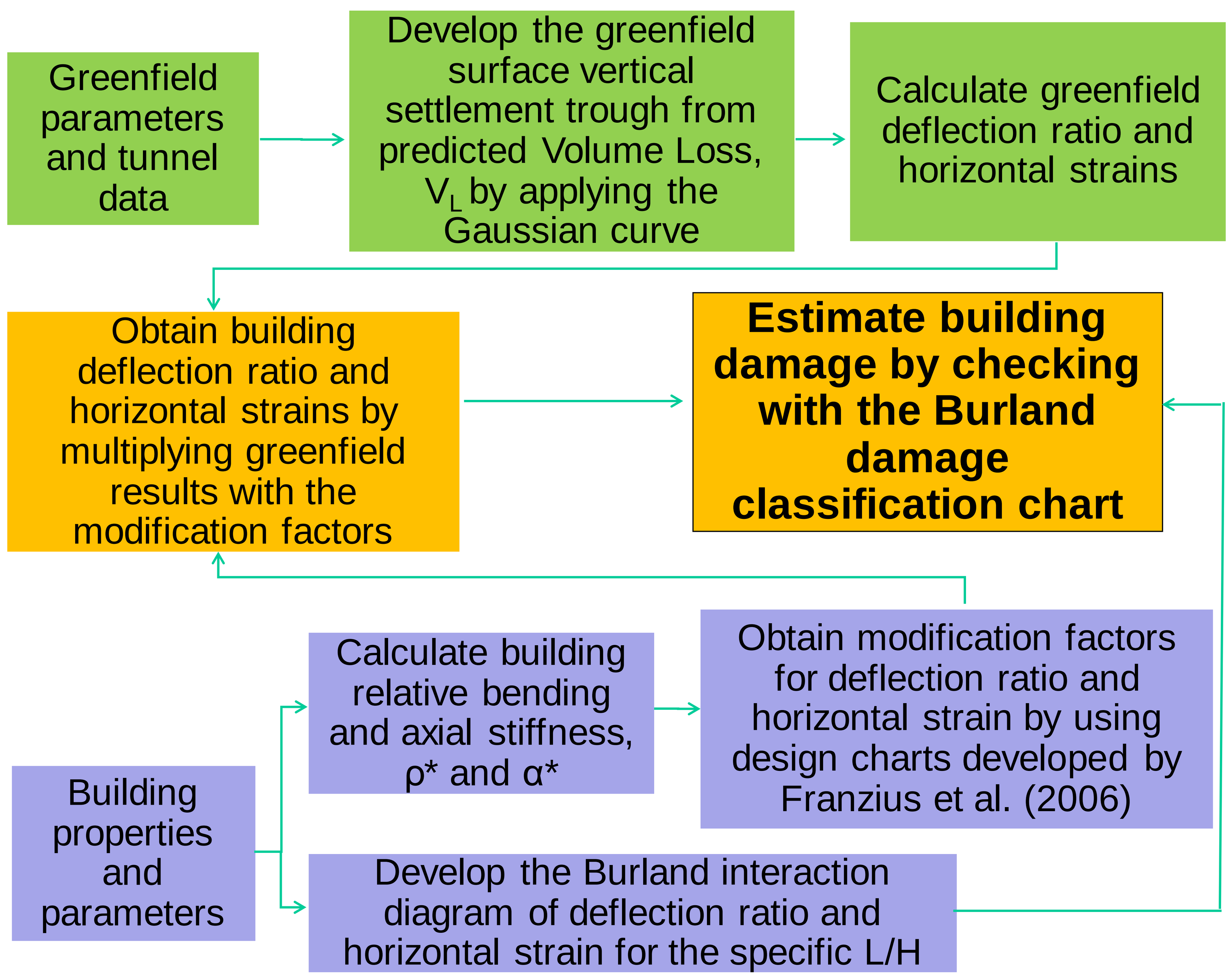
OVERVIEW

With the increasing number of tunnelling operations worldwide, understanding and predicting the influence of tunnelling on surface structures is becoming a necessity. Potts and Addenbrooke (1997) performed parametric numerical analyses to produce for the first time a set of design charts linking greenfield deflection ratios to those of a shallow foundation building, forming the relative stiffness approach (refined by Franzius et al., 2006). This project focusses on applying the relative stiffness approach to piled structures by performing numerical analyses using ICFEP of a Crossrail case study in Whitechapel, London.

CURRENT DESIGN METHODOLOGY



STUDY AREA

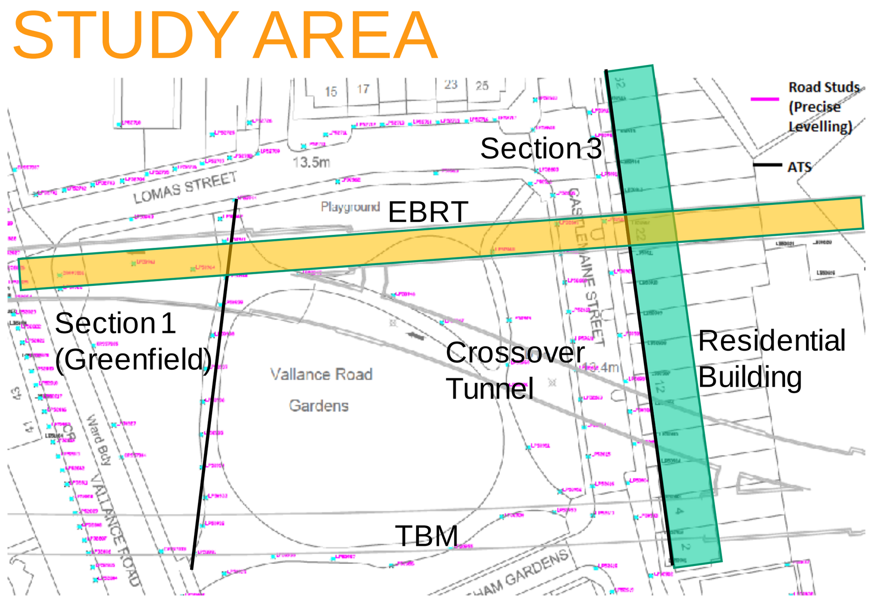
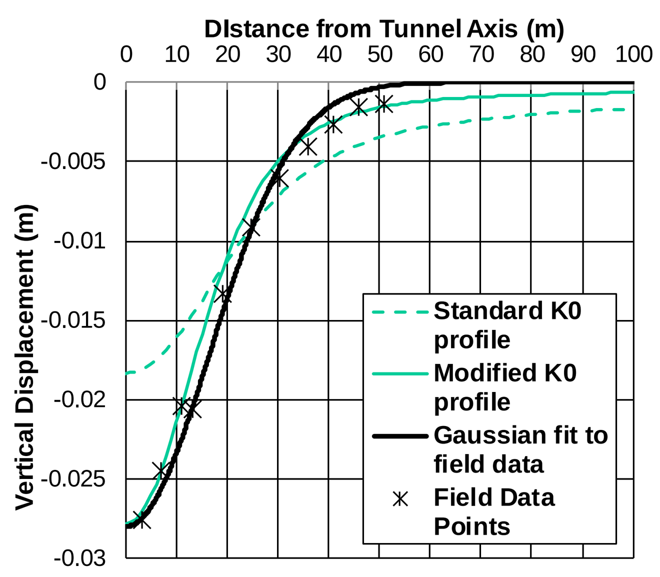


Figure 1: Study area at Whitechapel. The piled residential building is in blue and the EBRT tunnel in orange (Chong, 2015).

The study area is located at Castlemaine Street, Whitechapel, London, where three Crossrail tunnels beneath a piled residential building were constructed. Two cross-sections were investigated; a greenfield section and a building section based on available field data analysed by Chong (2015). Only the effects caused by the EBRT tunnel were investigated.

GREENFIELD NUMERICAL RESULTS



When adopting a standard K_0 profile of the site, the numerical surface vertical settlement trough is wider and less deep than the actual trough. If the K_0 profile is modified such that the K_0 surrounding the tunnel is reduced to 0.5 as stated by Potts and Zdravkovic (2001), the numerical and actual field data are near identical.

Figure 2: Comparison of greenfield numerical and field data.

PILED BUILDING NUMERICAL RESULTS

A new design curve that is different from the shallow foundation curve was established as shown in Fig. 3. The design curve indicates that flexible piled structures deform more compared to shallow foundation structures, while stiff piled structures deform similarly or less as compared to shallow foundation structures instead. Fig. 4 shows the pile load distribution for the flexible structure and indicates that building load is not redistributed, thus forcing piles above the tunnel to settle in order to generate shear stresses to overcome loss in end bearing capacity. Fig. 5 combines the normalised (against greenfield and against a shallow foundation analysis) settlement profile for the flexible building case with the zonation methodology developed by Selemetas et al. (2005) that is applied for individual piles.

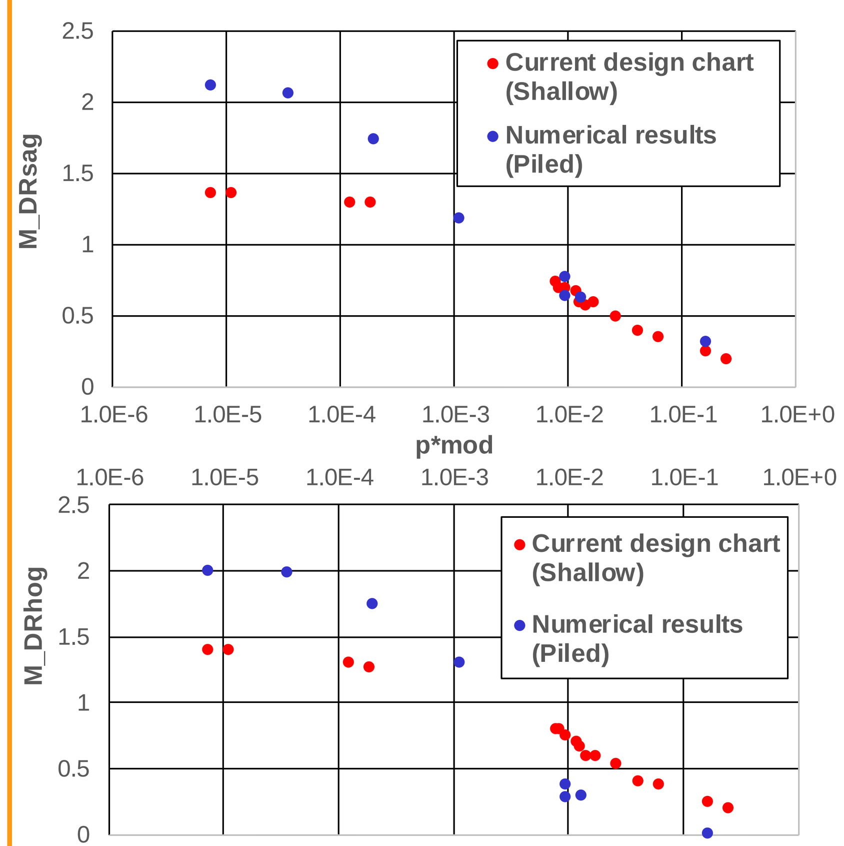


Figure 3: Comparison between design chart by Franzius et al. (2006) and numerical results.

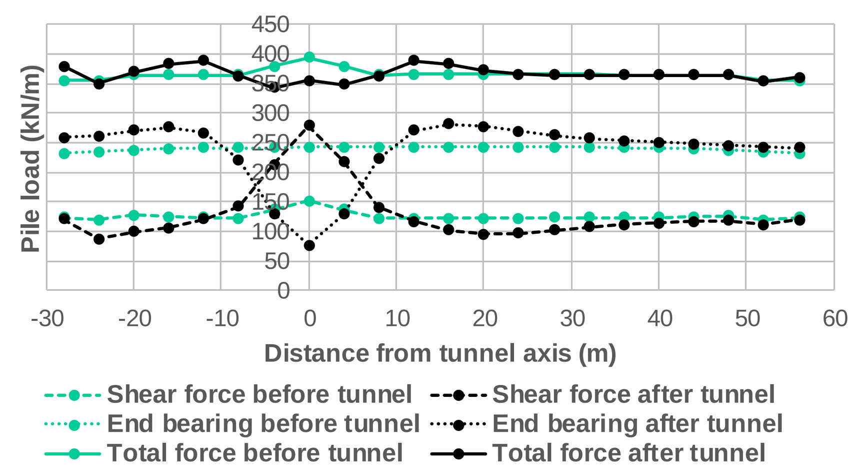


Figure 4: Pile load distribution for low ρ* building.

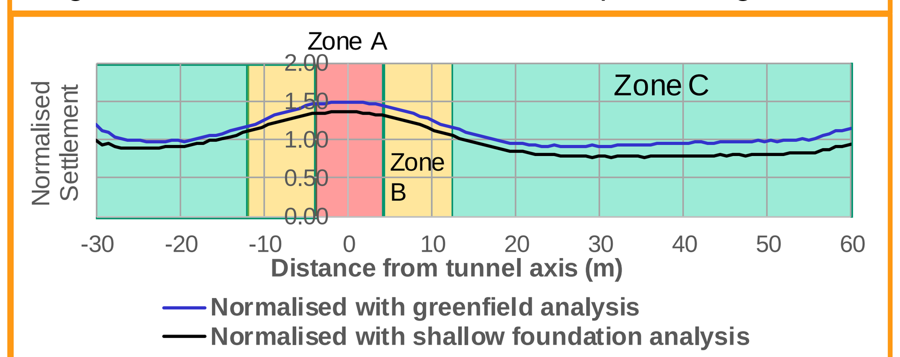


Figure 5: Combining zonation by Selemetas et al. (2005) to the normalised flexible settlements.

CONCLUSIONS

This numerical study indicates a need to update the design curves for piled structures. Further studies in understanding the influence of building eccentricity and pile configurations on the modification factors are needed. There is also positive agreements to the zonation design methodology developed by Selemetas et al. (2005).

PILED BUILDING MESH

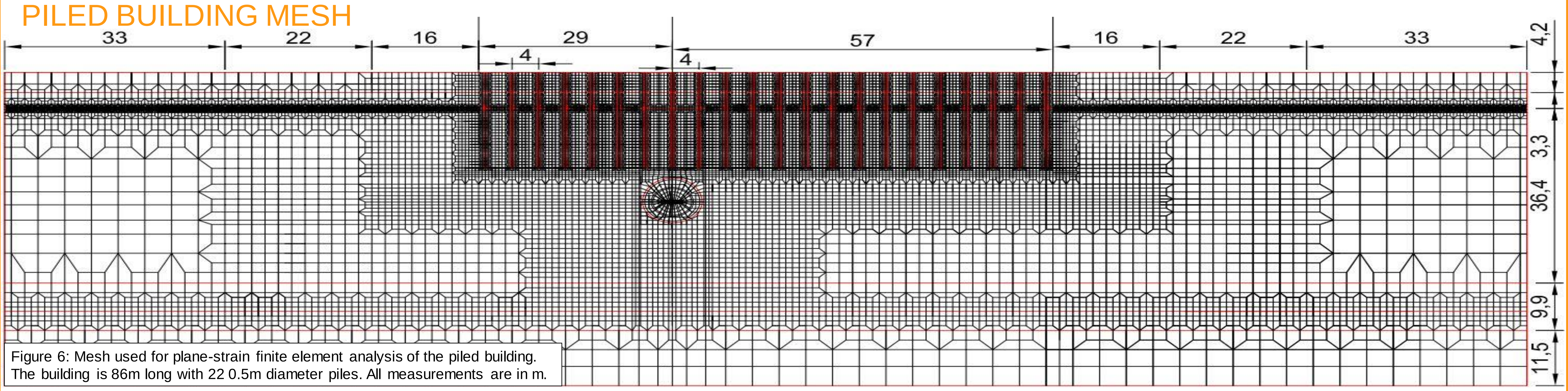


Figure 6: Mesh used for plane-strain finite element analysis of the piled building. The building is 86m long with 22 0.5m diameter piles. All measurements are in m.

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