One-Day Seminar on Response of Buildings to Excavation-Induced Movements

GEOTECHNICAL ENGINEERING TECHNICAL DIVISION

reported by

Ir. Dr Gue Chang Shin

IEM's Geotechnical Engineering Technical Division (GETD) invited Er. Dr Oskar Sigl of Geoconsult Asia Singapore and Er. Dr Goh Kok Hun of Land Transport Authority of Singapore, to deliver a talk at the Hilton Petaling Jaya Hotel on 22 August, 2017. The seminar, chaired by Ir. Dr Gue Chang Shin, was attended by 128 participants. It covered four key areas:

- Evaluating the impact of underground construction on buildings.
- Analysis of ground movements: Simplified approaches for difficult situation.
- Influence of building stiffness and case studies of building response to underground construction.
- Analysis and impact assessment of underground construction on existing rail infrastructures.

Dr Goh began the first session by showing that main movements due to underground constructions are typically from tunnelling and deep excavations. Ground movements, particularly settlements from tunnelling, can be reasonably predicted using Gaussian curves based on volume loss (volume of surface settlement trough over the volume of excavated tunnel).

For deep excavations, Finite Element Method (FEM) is valuable in modelling construction processes where various stages of excavations can be simulated. It is also useful to verify FEM using empirical correlations. He then introduced the framework for a 3-staged risk assessment of building damage as depicted in Figure 1. It is important to note that categories of damage are related to induced tensile strains.

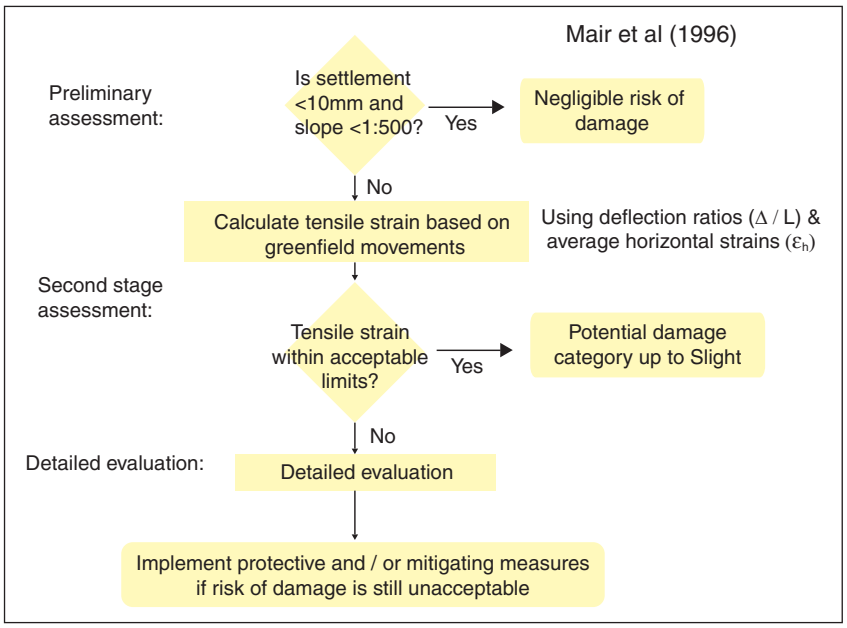

Figure 1: Framework for 3-staged risk assessment of building damage

In the second session, Dr Sigl pointed out that conservatism is relative. Structural analysis is based on the Ultimate Limit State whereas geotechnical analysis is based on Serviceability Limit State, where both have divergent input requirements. He highlighted some limitations of 2D analysis which can be overcome by 3D analysis. However, 3D analyses become complicated for geometries with subdivisions.

He then moved on to a simplified approach for complicated situations. For estimating greenfield tunnelling-induced settlements, the use of volume loss approach (i.e. conventional tunnelling-induced ground settlement equations) can simplify 3D settlement analyses. The approach is to create a 3D model for a single excavation advancement for which the incremental settlement value in the 3D model is determined.

The equivalent volume loss is then back-analysed by matching the settlement troughs from both analyses. This calibrated volume loss value is subsequently adopted as an input for the conventional ground settlement analyses to extrapolate settlements for the entire length of tunnel within comparable geology.

The third session was on the influence of building stiffness that had significant influence on its response to excavation as well as tunnelling induced movements. Dr Goh presented the concept of modification factor as a means to quantify the relative building settlements to greenfield. He then showed a useful chart that indicated a consistent relationship between these modification factors and building relative stiffness from field monitoring. For example, buildings with relative stiffness of more than 1.0 is considered rigid and are expected to experience little or no differential settlements. Dr Goh said that, by assuming buildings conform to greenfield, settlement conditions will overestimate the damage category. He also said that horizontal strains induced in buildings are often very small. Some case studies were presented and these showed that tunnelling directly below buildings do not generally cause building to settle much more than the ground. The key is to limit ground deformations by applying good tunnelling controls.

In the fourth session, Dr Sigl shared the principles of impact assessment approach for existing rail infrastructure. The maximum movement limits applied to rail infrastructures in Singapore are typically less than 15mm, with a maximum gradient change (distortion) of less than 1:1000. It is interesting to note that Malaysia enforces an even more stringent criterion where distortion is limited to 1:2000, as stipulated in the Malaysia Railways Act 1999.

Dr Sigl also identified some of the limit states in tunnels and railway tracks and the potential effects. Some typical control values for "Alarm" and "Limit" levels were provided but he stressed that control values need to be assessed on a case-to-case basis, where pre-existing conditions need to be taken into account. Various cases studies, where complex analyses were carried out for the impact assessments, were then discussed.

The seminar ended with rounds of applause from the audience and then, GETD Chairman Ir. Lee Pier Tien presented tokens of appreciation to Er. Dr Oskar Sigl and Er. Dr Goh Kok Hun (Figure 2). ■

Figure 2: GETD Chairman Ir. Lee Pier Tien (centre) with Er. Dr Oskar Sigl (left) and Er. Dr Goh Kok Hun after presenting the tokens of appreciation