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Discussions

Interactive comment on "Stability assessment of roadbed affected by ground subsidence adjacent to urban railways" *by* Ki-Young Eum et al.

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Referee #2

1. **P.1. 1.Introduction: more literature for assessment methods (numerical models)**

   P.1. Line 35-50.: Literature review for assessment methods (numerical models) is added

   Risk management associated with safety is a fundamental focus in railway operations. It has been integrated into global safety management system of railways (Berrado et al., 2010) and developed to allow a rapid risk assessment using a common risk score matrix (Braband, 2011). As roadbed settlements exceed the allowable limits, it may result in track irregularity and derailments of trains causing heavy loss of life. Therefore, risk management tools are developed to deal with track safety by controlling and reducing the risk of derailments (Zarembski et al., 2006). In this study, methods to secure the stability of roadbeds have been examined using numerical analysis.

   Numerical analyses have been widely used for risk assessment. Numerical analyses using three-dimensional geotechnical codes were carried out to predict the subsidence area and its interaction with buildings (Castellanza et al., 2015) and a three-dimensional groundwater flow model for risk evaluation was developed to be an effective management strategy (Ashfaque et al., 2017). The coupling of numerical models and monitoring data contribute to undertake efficient risk reduction policies (Bozzano et al., 2013). Especially using FLAC, which is a finite-difference numerical code especially specialized in the area of geotechnical engineering, numerical computations to simulate the influence of rainfall (Pisani, 2010), both acoustic emission (AE) activities at AE sensor locations of the Kannagawa cavern (Cai et al., 2007), and a comprehensive pump test at Sellafield (Hakami, 2001) showed good agreement with field monitoring results. In this study, $FLAC^{3D}$, which is a three-dimensional finite-difference numerical code especially specialized in the area of geotechnical engineering, is adopted for numerical analysis.

2. **P.2. 2. Case studies of ground subsidence, what kind of the cases are the simulated target in this paper?**

   P.2. Line 62-70.: The cases of ground subsidence occurred at nearby urban railways in South Korea are quite similar. Therefore, no specific case is selected for numerical analysis but the simulated cases cover historical events.

3. **P.3. 3. Numerical analysis, please add a section to briefly introduce this three-dimensional model such as theory base, essential parameters, input/output, boundary conditions, initial conditions, etc.**

   P.3. Line 97-189: FLAC3D is briefly introduced.

   2 Numerical analysis

   In the following sections, the $FLAC^{3D}$ given in this work are briefly described in the following sections by paraphrasing from those of Itasca Consulting Group (2002).

   2.1 Theoretical background of $FLAC^{3D}$

   $FLAC^{3D}$ (Fast Lagrangian Analysis of Continua in three Dimensions) is numerical modeling software for advanced geotechnical analysis of soil, rock, groundwater, and ground support in three dimensions. FLAC is used for analysis, testing, and design by geotechnical, civil, and mining engineers (Itasca Consulting Group Inc., 2002). It is designed to accommodate any kind of geotechnical engineering project that requires continuum analysis.

   The mechanics of the medium are derived from general principles (definition of strain, laws of motion), and the use of constitutive equations defining the idealized material. The resulting mathematical

Fig. 1.