# Referee #1

(1) "2. Numerical analysis". I think the section may be largely simplified. The level 2 subtitle "2.3 Allowable settlement of the roadbed" may be erased. All of the level 3 subtitle, e.g. 2.1.1, 2.2.2, may be erased.
Yes, I asked you to describe the principle of FLAC3D, but please note that the description should be briefly and clearly described. I think 1/3 page or so is enough which includes a text description on the principle of the FLAC3D and not more than three equations.
May "2.2 Conditions for numerical analysis" be simplified more? Is Figure 3 essential?

**P.3. Line 102-124:** All the level 3 subtitles are erased. The principle of FLAC3D is briefly and clearly described with 1/3 page and two equations. Section 2.2 describes conditions for numerical analysis clearly and Figure 3 represents an applied loading condition. If there is no harm to leave it, I may leave it as it is.

***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 expression is a set of partial differential equations, relating mechanical (stress) and kinematic (strain rate, velocity) variables, which are to be solved for particular geometries and properties, given specific boundary and initial conditions. An important aspect of the model is the inclusion of the equations of motion, although FLAC3D is primarily concerned with the state of stress and deformation of the medium near the state of equilibrium. Application of the continuum form of the momentum principle yields Cauchy's equations of motion:*

$$\sigma_{ij,j} + \rho b_i = \rho(d_{vi}/d_t) \tag{1}$$

*Where $\sigma$ is the symmetric stress tensor, $\rho$ is the mass per unit volume of the medium, [b] is the body force per unit mass, and $d[v]/dt$ is the material derivative of the velocity. These laws govern, in the mathematical model, the motion of an elementary volume of the medium from the forces applied to it. Note that in the case of static equilibrium of the medium, the acceleration $d[v]/dt$ is zero, and Eq. (1) reduces to the partial differential equations of equilibrium:*

$$\sigma_{ij,j} + \rho b_i = 0 \tag{2}$$

(2) "3 Roadbed Settlement and Stability". May we change the title to " 3 Results and discussion"? The section may be greatly enriched. So many figures are given and too few discussions are found. Besides the results you have calculated, you could also discuss the REASONS why the results are right, and the EFFECTS on the real engineering of the calculated results. I am sorry I do not agree to your opinion that "any observed data obtained from other references for roadbed settlement associated with cavity have not been found". PLEASE READ MORE REFERENCES AND THEN GIVE A MORE IN-DEPTH DISCUSSION.

**P.5. Line 196:** Title is changed to "3 Results and discussion".

**P.5. Line 200-228 & P.6. Line 214:** Nine references are added and more depth discussions are carried out. Previous researches related to settlement adjacent to excavation work are described and Figure 4 is added.

*The ground settlement in backfill area due to the excavation work has been estimated (Kojima et al., 2005; Kung et al., 2009; Ou et al., 2013) and its effect on responses of adjacent buildings has been investigated (Lin et al., 2017; Sabzi and Fakher, 2015; Schuster et al., 2009). Clough and O'Rourke (1990) have proposed the method to estimate settlement in clay and sandy soils for in-situ wall systems using field measurement data and finite element analysis (Fig. 4). H, d, $\delta_{vm}$, and $\delta$ represent an excavation depth, a distance from the wall, the maximum settlement, and a settlement with respect to the distance, respectively. The settlements tend to average about 0.15% H. $\delta_{vm}$ occurs in the middle of excavation depth near the wall and a settlement linearly decreases as d increases. Little settlement occurs as d = 2H. Empirical correlations of settlement with d proposed by Bowels (1988) and Peck (1969) were similar to the one proposed by Clough and O'Rourke (1990). Bowels (1988) suggested that the settlements tend to average about 0.13 ~ 0.18% H. The magnitude of settlements is influenced by the ground stiffness, the wall stiffness, and support spacing. In this study, although ground is not fully excavated and also there are no wall systems, the settlement resulting from stress release in ground similarly occurs.*

**P.6. Line 244-246:** The REASONS why the results are right are explained.

*As cavities with diameters of 8 and 6 m are generated, at distances less than 18 and 15 m, where d is close to or less than 2H (2D), it may exceed the allowable settlement resulting in an accident.*

**P.6. Line 249-254:** The EFFECTS on the real engineering of the calculated results are discussed.

*As D/d is greater than 0.2 and less than 0.3, the roadbed settlement is approximately 5 mm. It requires that a database of measurement sensors should be established for real-time monitoring of the roadbed, structures and groundwater to prevent disasters in advance. As D/d exceeds 0.35, the roadbed settlement substantially increases and is greater than 10 mm. Since it may result in highly probable traffic accident, train operation should be stopped and the roadbed should be reinforced or repaired.*

(3) It's better that the number values of the vertical coordinates in Figures 5 and 8 grow from the bottom to the top. Figure 6 is good.

**P.7. Line 255 & P.9. Line 295:** The number values of the vertical coordinates in Figures 6 and 9 are changed to grow from the bottom to the top.

## Referee #2

I suggest authors should try to perform more academic discussion in particular parameters calibration/sensitivity or providing the references of parameters calibrated in a similar geo-environment area.

**P.5. Line 200-228 & P.6. Line 214:** Nine references are added and academic discussion is carried out by providing the references of parameters calibrated in a similar geo-environment area. Previous researches related to settlement adjacent to excavation work are described and Figure 4 is added.

*The ground settlement in backfill area due to the excavation work has been estimated (Kojima et al., 2005; Kung et al., 2009; Ou et al., 2013) and its effect on responses of adjacent buildings has been investigated (Lin et al., 2017; Sabzi and Fakher, 2015; Schuster et al., 2009). Clough and O'Rourke (1990) have proposed the method to estimate settlement in clay and sandy soils for in-situ wall systems using field measurement data and finite element analysis (Fig. 4). H, d,* $\delta_{vm}$*, and* $\delta$ *represent an excavation depth, a distance from the wall, the maximum settlement, and a settlement with respect to the distance, respectively. The settlements tend to average about 0.15% H.* $\delta_{vm}$ *occurs in the middle of excavation depth near the wall and a settlement linearly decreases as d increases. Little settlement occurs as d = 2H. Empirical correlations of settlement with d proposed by Bowels (1988) and Peck (1969) were similar to the one proposed by Clough and O'Rourke (1990). Bowels (1988) suggested that the settlements tend to average about 0.13 ~ 0.18% H. The magnitude of settlements is influenced by the ground stiffness, the wall stiffness, and support spacing. In this study, although ground is not fully excavated and also there are no wall systems, the settlement resulting from stress release in ground similarly occurs.*

**P.6. Line 244-246:** The reasons why the results are right are explained.

*As cavities with diameters of 8 and 6 m are generated, at distances less than 18 and 15 m, where d is close to or less than 2H (2D), it may exceed the allowable settlement resulting in an accident.*

**P.6. Line 249-254:** The effects on the real engineering of the calculated results are discussed.

*As D/d is greater than 0.2 and less than 0.3, the roadbed settlement is approximately 5 mm. It requires that a database of measurement sensors should be established for real-time monitoring of the roadbed, structures and groundwater to prevent disasters in advance. As D/d exceeds 0.35, the roadbed settlement substantially increases and is greater than 10 mm. Since it may result in highly probable traffic accident, train operation should be stopped and the roadbed should be reinforced or repaired.*