Investigating the 3D effect of spatial variability of Young modulus based on the probabilistic analysis of surface settlement in NATM tunneling (Case study)

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Engkish Extended Abstract

Summary

One of the problems with NATM tunneling in urban areas is the risk of excessive surface settlement during excavation operations. For real analysis and detailed study of surface settlement, it is necessary to pay attention to the real soil conditions. However, the conventional methods are always deterministic, rather than taking the natural spatial variability of soil properties into account. Therefore, in this study, an attempt has been made to model the real soil conditions by spatial variability of the soil young modulus based on a three-dimensional random field. By combining finite difference analysis with random field theory, a preliminary investigation has been performed into the surface settlement with spatially random Young modules. For this purpose, a combination of finite difference numerical method, random field, and Monte Carlo simulation is used which is known as the random finite difference method (RFDM). The procedure used is re-implemented by the authors in a MATLAB environment to combine it with The FLAC^{3D} program and a series of parametric analyses were conducted to study the effects of uncertainty due to the variability of soil Young's modulus on ground movements.

Introduction

Excessive surface settlement is one of the major problems we encounter when constructing shallow tunnels in soft grounds. For the analytical study of surface settlement, it is necessary to consider soil properties in design calculations with high accuracy. In this research, the complex RFDM method is used to express the spatial variability of soil properties so that we can show its effects on surface settlement. The results demonstrate that soil variability exerts an influence both on the magnitude and distribution of surface settlement. In addition, it is concluded that negligence of the spatial variability of soil properties in surface settlement probability analysis can lead to underestimation of tunnel design parameters.

Methodology and Approaches

To create a random field, the values of SOF are determined first. Then, a three-dimensional random field is created by the random field generation functions. The random field created is assigned to the finite difference mesh by the embedded FISH language in FlAC^{3D}.Finally, 1000 Monte Carlo simulations are performed and 1000 surface settlement curves for each SOF are generated.

Results and Conclusions

1- The mean values of the S_{max} in numerical stochastic analysis when the SOF is 60 m is approximately equal to the obtained S_{max} from the numerical model because with increasing SOF the spatial correlation of the Young modulus parameter increases and is closer to the soil characteristics of the tunnel. In addition, the COV of the S_{max} tends to be 0.3 with increasing the SOF, but in general, it increases significantly (from 0.01 to 0.3), which causes changes in the magnitude of the S_{max} (between 5 and 80). Mm) becomes.

2- The spatial variability of the Young modules causes the change in the magnitude of the surface settlement as well as a change in its location, so three-dimensional numerical analyzes can accurately display the maximum displacement of the S_{max} in both a vertical and longitudinal section of the tunnel.