Research on the stability of tunnel floor in tunnel excavation with the application of ground improvement methods

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1. Introduction

In recent years, urban areas have become overcrowded due to population growth and economic development. In particular, many tunnels and pipes for railroads, gas, telecommunications, water, and sewage systems are buried underground. Therefore, there are concerns that tunnel construction in urban areas may affect existing lifelines and surrounding landmasses. As a solution to these problems, the pipe roof method using the pipe jacking method is expected to be applied. Pipe roof method is a ground improvement method in which pipes are placed at regular intervals around the tunnel to limit the surrounding ground deformation. In most cases, the pipe roof method is used only for the top and side walls of tunnels. However, it is considered necessary to improve the ground at the tunnel floor as well when tunnels are constructed in soft ground. In this study, the applicability of the Metro Jet System (MJS) method as an alternative to the pipe roof method for tunnel floor during tunnel construction was investigated using the two-dimensional stress analysis software RS2.

2. Methodology

In this study, a finite element analysis software was used to understand the effectiveness of the MJS method in suppressing ground deformation caused by tunnel excavation. The 2D finite element analysis software RS2 was used for the analysis.

In the analysis steps, pipes were first constructed, followed by ground improvement under the new tunnel using the MJS method. Afterward, the construction of the new tunnel itself was carried out. As shown in Figure 1, a two-dimensional area of 50 meters in length and 60 meters in width was used. The cover depth of the upper pipe roof was 3 meters, the pipe diameter was 0.8 meters, with 11 pipes above the tunnel and 7 pipes on the each side wall. The MJS method was applied to the floor slab section in the model.

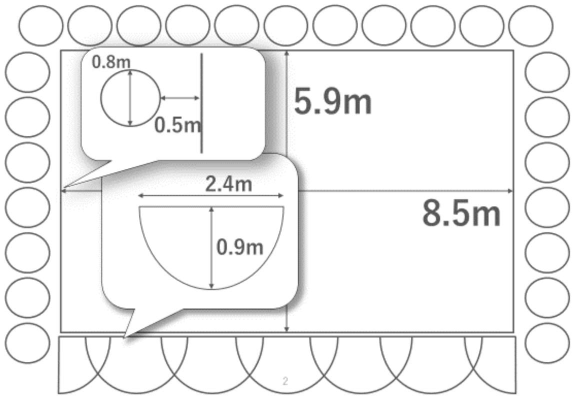

Figure 1: Analysis Model

The deformation of the tunnel floor was obtained by changing the Young's modulus of the ground, the aspect ratio of the tunnel, and the conditions of the overlying soil, and the effect of those parameters on the stability of tunnel floor was discussed. The effectiveness and risks of the MJS method were evaluated. It is concluded that while overlap of the improvements is important, the risk associated with the MJS method is quite small.

3. Results and Discussions

Figure 2 shows the deformation of the tunnel floor. These results show that the deformation of the tunnel floor is smaller when the ground improvement method is applied to the tunnel floor compared to the only gate type. This indicates that the ground improvement by the MJS method suppress the effects of tunnel excavation, and the effectiveness of the MJS method is recognized.

Figure 3 shows the deformation of the tunnel floor when the MJS method was applied without overlap.Regardless of the presence or absence of overlap, a certain suppression effect was obtained. It was also confirmed that, depending on the tunnel construction site, overlaps do not need to be considered so important, which may lead to reductions in construction costs and construction time.

Based on the above results, the ground deformation suppression effect of the tunnel floor slab using the MJS method was confirmed. Additionally, a certain level of suppression effect was observed regardless of the precision of the improvement body formation. It can be concluded that the MJS method is an effective construction technique.

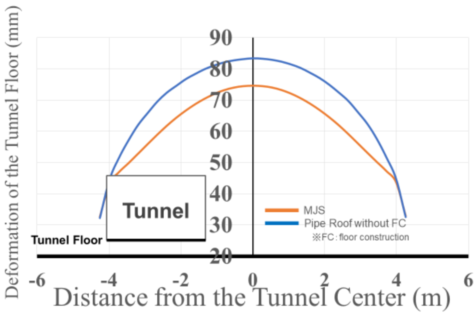

Figure 2: Deformation of Tunnel Floor

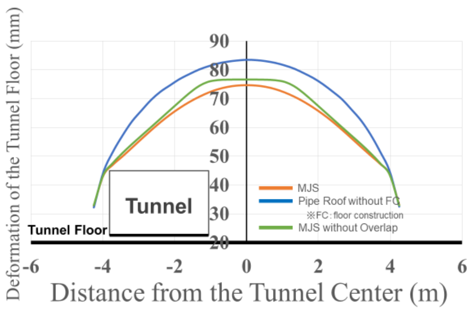

Figure 3: Deformation of Tunnel Floor (without Overlap)