Numerical Study of using Diaphragm Wall to Mitigate Mechanized Tunneling Induced Settlements

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ABSTRACT

Tunneling induced displacements could be dangerous for surface structures and urban infrastructure, if not controlled. Accordingly, different techniques are carried out to mitigate tunneling induced displacements. In this regard, using a diaphragm wall is a practical technique. In this study, the effect of using a diaphragm wall for mitigating the Madrid metro tunneling induced displacements was investigated. Despite mechanized tunneling of the Madrid metro extension, there is a considerable settlements due to a thick layer of made soil ground. In this regard, TBM-EPB tunneling of the Madrid metro tunnel has been modeled step by step and three-dimensional in the finite element code of ABAQUS. The main construction aspects of a TBM are modelled, such as the face pressure, the injection of grout behind the segments, the overcut produced by the gap between the diameters of the cutter-head and the shield. The diaphragm wall is also modeled three dimensional. For parametric study elastic modulus of the wall, length of the wall, friction between the wall and soil, distance of the wall from the tunnel axis and density of the wall are assumed to be variable. The results show the elastic modulus of the wall and the distance of the wall from the tunnel axis are the most effective parameters in mitigating of the tunneling induced surface settlements and horizontal displacements. In the distance of 0.7D between the wall and tunnel axis, a wall of 0.5D or C+1D length could be the optimum option to mitigate the settlements.

KEYWORDS

Mechanized Tunneling, Diaphragm Wall, Settlements, TBM, Numerical Modeling.

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1. Introduction

An important aspect of tunneling in urban areas is that tunneling-induced settlements may threaten stability or serviceability of surface structures and underground infrastructures. Thus, there are a number of techniques employed in projects to control ground movements. In this paper, using diaphragm wall for mitigating Madrid metro tunneling-induced settlements has been investigated. In this regard, mechanized tunneling of the Madrid metro tunnel has been modeled step by step and three-dimensional in the finite element code of ABAQUS.

2. Numerical Modeling

The FEM-based code ABAQUS was used for the numerical modeling and analysis. In this study, various aspects of TBM-EPB tunneling process has been modelled: steel shield, concrete precast linings and annulus grout which is injected at the backside of EBP. C3D8 element was used to model ground, diaphragm wall and grout. S4 element is also used to model steel shield, overcut and concrete lining. To simulate ground mechanical behavior elastic-perfectly plastic constitutive model with Mohr-Coulomb criteria is employed. However, linear elastic behavior is considered for shield, lining, overcut, grout and wall. Different parts of numerical modeling is shown in figure 1 and figure 2.

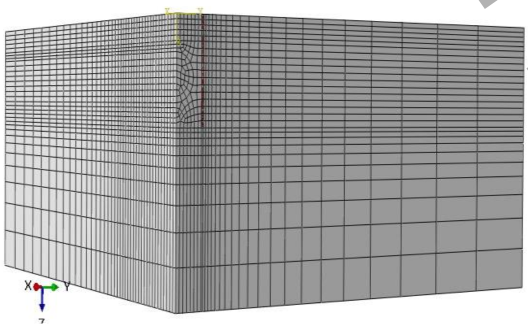

Figure 1. Model domain in ABAQUS

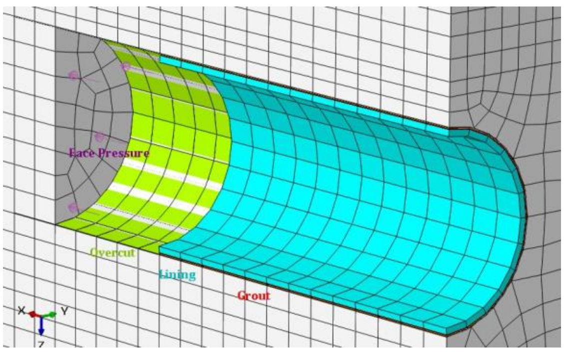

Figure 2. Different parts of TBM-EPB modeling

For parametric study elastic modulus of the wall, length of the wall, friction between the wall and soil, distance of the wall from the tunnel axis and density of the wall are assumed to be variable.

3. Results and Discussion

In the investigated segment of Madrid metro route considerably large settlements has been occurred due to the existence of a made fill layer. However, Using diaphragm wall has restrained ground movements behind the wall and settlements are reduced.

The results show the elastic modulus of the wall and the distance of the wall from the tunnel axis are the most effective parameters in mitigating of the tunneling induced surface settlements and horizontal displacements. In the distance of 0.7D between the wall and tunnel axis, a wall of 0.5D or C+1D length could be the optimum option to mitigate the settlements.

4. Conclusions

By using the optimum diaphragm wall as a mitigating technique in Madrid metro tunnel, the maximum surface settlements and horizontal movements have been reduced 15.77% and 17.40%, respectively. In addition to that, the defined efficiency parameter of wall, which expresses its ability to restrain settlements, has been obtained 0.629.

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