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INFLUENCE OF THE MECHANICAL BEHAVIOR OF NATURAL STRUCTURED SOILS ON THE SYSTEM RESPONSE IN MECHANIZED TUNNELING

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Summary. Within the present study the influence of the behavior of natural structured soils on the system response in mechanized tunneling with tunnel boring machine (TBM) is investigated. Reliable predictions of ground settlements and lining forces induced by mechanized tunneling require complex numerical soil-structure interaction models. Therefore, a sophisticated three-dimensional numerical model for the simulation of the physical aspects of mechanized tunneling process is developed. In addition, the complex non-linear behavior of natural structured soils is modeled using an adequate constitutive soil model based on the Bounding Surface Plasticity concept.

1 MOTIVATION

Mechanized tunneling is a very common method employed to conduct infrastructural projects particularly in urban areas. Important engineering aims for tunnel projects are safe and economical design as well as adaptive construction of the tunnel. For those reasons, reliable predictions of ground settlements are essential. The adequate prediction requires deep and precise understanding of the mechanical soil behavior and the interaction processes between subsurface materials, underground structures and rising buildings due to tunnel excavation. Especially in natural structured soil deposits mechanized tunneling poses a geotechnical challenge because of the complex mechanical behavior of those types of soil. The constitutive behavior of natural soils lead to the question: Are the anisotropy and the destructuration of natural soil deposits critical for the design of the mechanized tunneling process?

Therefore, the main objective of this research is the evaluation of the influence of the complex mechanical behavior of natural structured soils on the system behavior in mechanized tunneling processes. To achieve this objective numerical modeling is employed and focus is set on investigating the influence of inherent and stress-induced anisotropy and

soil destructuration by analyzing the evolution of selected numerical model responses (e.g. displacements in different observation points, stress paths and evolution of the state variables in the nearfield around the TBM.

2 ADEQUATE NUMERICAL MODELING OF MECHANIZED TUNNELING IN NATURAL STRUCTURED SOILS

The analyses are conducted using finite element simulations. For appropriate approximations of the real physical system behavior an adequate three-dimensional simulation model for mechanized tunneling is required (see Fig. 1 [6]). The simulation model has to consider the decisive submodels like sequential advance of the TBM, grouting of the annular gap, support of the tunnel face and installation and embedding of the lining.

Furthermore, an adequate constitutive soil model is fundamental to accurately approximate the complex non-linear mechanical behavior of natural structured soils. Based on the Bounding Surface Plasticity (BSP) concept, a series of hierarchical constitutive models (introduced in [1, 5, 4, 2, 3]) is calibrated and validated using data from experiments conducted on structured and reconstituted soil samples under isotropic and anisotropic boundary conditions and stress paths. The BSP concept offers the opportunity of modeling complex stress paths and cyclic consolidation typical for mechanized tunneling. To conduct the numerical simulation of mechanized tunneling the developed constitutive model is efficiently implemented in a state-of-the-art finite element code.

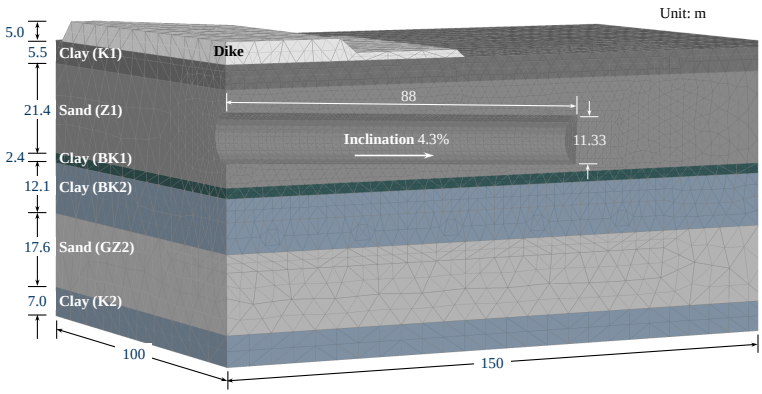

Figure 1: 3D simulation model for mechanized tunneling: The Western Scheldt case, The Netherlands [6]

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