

Coupling tunnel information models and numerical simulations in mechanized tunneling

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ABSTRACT

Mechanized tunneling is a complex engineering process which comprises a number of detailed interdependent sub processes such as excavation, grouting, and material handling. These sub processes are often analyzed within different simulation models by separate teams to study the effects on mechanized tunneling and their performance. To evaluate the risks in mechanized tunneling more accurately and to control the critical factors influencing the risks, the interactions between these sub models have to be considered. However, due to lack of understanding about interactions between the processes, they are either assumed or not considered. Another important aspect is the availability and change of data while performing these investigations. Each simulation needs different prepared data and provides results as new inputs for the next simulation.

This paper introduces a flexible and extendable interaction modeling concept to couple complex simulations and the required data in the context of mechanized tunneling. It consists of three main parts, the Interaction Modeling Framework (IMF), the 4D-Tunnel Information Model (4D-TIM) and the Interaction Platform (IP). The required data is organized and stored in so-called partial models. A schema for linking the partial models, such as the ground data model, the tunnel model, the tunnel boring machine model and the built environment model, is specified in the 4D-TIM. To support the coupling of simulations, a formal description of the interactions is necessary. The IMF is a three layer framework that provides the vocabulary for defining a so-called interaction model. The standard interaction modeling language describes the structure and behavior of the system based on the IMF. Modeling the interactions explicitly improves understanding and simplifies coupling. The IP executes the interaction model described using the interaction modeling language. It reads and instantiates the individual simulations and interactions and enables the exchange of data between them. The results of the simulations are stored back in the 4D-TIM. The simulations themselves are installed on different systems. Therefore, the communication is performed via messages in a network as provided by the Java Messages Service (JMS). Simulations in mechanized tunneling are usually commercial software tools which do not allow the manipulation of their simulation model. Therefore, the individual simulation models are configured by generating required input files. A tool developed based on the IMF can be used by interdisciplinary teams to capture the interactions in a complex system and thereby support simulation coupling.

The coupling of three simulations (excavation, grouting and logistics) in mechanized tunneling is presented in a case study. The interactions are modeled and provided to the interaction platform. As a result the excavation simulation generates different, more accurate settlements on the surface than an independent analysis without considering results of the other simulations.