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STEERING OF MECHANIZED TUNNELING PROCESSES WITH HYBRID SURROGATE MODELS BASED ON NUMERICAL AND MONITORING DATA

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In mechanized tunneling processes, criteria and rules to make decisions on steering parameters are needed. Such decisions require the evaluation of limit states of the system response, e.g. expected surface settlements, by means of reliability analysis using computational models for mechanized tunneling taking inherent uncertainties of the geotechnical parameters into account. Concepts for reliability analyses in mechanized tunneling and corresponding applications are presented in [1] and [2], respectively. Due to limited information of the input parameters, e.g. the local geological conditions and the corresponding soil behavior, polymorphic uncertainty models are adopted considering epistemic and aleatoric sources of uncertainty, see e.g. [3].

Currently, numerical simulations are more commonly used in a deterministic framework to investigate and predict the system behavior of the tunneling process. In this paper, a comprehensive 3D finite element (FE) model for shield tunneling taking all relevant components of the construction process into account, see [4] and [5], is applied as deterministic solution for performing mechanized tunneling simulations with uncertain data. The consideration of uncertain data requires a large number of realizations. Since direct application of the 3D FE model describing the complex behavior of the tunneling-soil-interactions would lead to prohibitively long computation times, numerically efficient surrogate models are needed for real time reliability analysis in tunneling.

The focus of this work is to improve the prediction capability of the hybrid POD-ANN surrogate model, developed in [6], which is applied to compute surface settlements induced by mechanized tunneling processes. The hybrid POD-ANN approach, which contains a combination of surrogate models based on Proper Orthogonal Decomposition (POD) and Artificial Neural Networks (ANN), is enhanced by adding monitoring data. Within the hybrid surrogate model approach, recurrent neural networks (RNN), see e.g. [7], are used to predict settlement processes of selected points on the surface. An extended POD approach, i.e. the so called Gappy POD (GPOD) [8], is applied to generate the whole settlement field based on the selected RNN predictions. Monitoring data are included in the available data set to correct and to update the current state of the surrogate model. The reliability analyses based on the proposed hybrid surrogate model is well suited to provide a tool for choosing appropriate steering parameters for further steps in the tunneling process. This contribution presents an important step towards the challenge of computer-aided steering in mechanized tunneling.

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