（様式第６号）

論　文　要　旨

2025 年　1 月　7 日

※報告番号	第　　号	氏　名	SHAKYA SUDIP

主論文題名

Advanced Numerical Simulation and Optimization of Jet-Grouting Using MPS-CAE for Sustainable Ground Improvement

(持続可能な地盤改良に向けた MPS-CAE を活用したジェットグラウトの高度な数値シミュレーションと最適化に関する研究)

内容の要旨

Jet grouting technology is among the most widely used ground improvement methods, with applications ranging from excavation support, groundwater barriers, foundation stabilization to prevent contaminant inflow, bridge protection against scour, slope stability, and underpinning existing structural foundations. Originating in Japan in the 1960s, it has since gained global popularity. Over the years, significant improvements have been made to enhance the productivity and efficiency of jet grouting technology and various methods have been developed to evaluate its construction efficiency. However, despite its importance in geotechnical engineering, there remains insufficient research into the comprehensive evaluation of jet grouting technology. One of the primary challenges is that it occurs below the ground, which makes it difficult to observe the process during construction. Furthermore, there are limited opportunities to modify outcomes once construction begins. As a result, most research has focused on the strength and dimensions of the resulting soilcrete. Traditional evaluation methods to monitor these parameters are typically destructive in nature and are applicable only to preliminary trial constructions. Meanwhile, real-time monitoring does offer potential advantages, but it often involves complex processes that require skilled personnel. However, even with real-time monitoring, the guidelines for the construction to achieve best results are largely based on empirical in nature, based on the field experience and intuition of construction engineers.

While these guidelines are updated over time based on field results while making consideration for the workability and output strength and size of the construction, they evolve slowly, often taking decades to optimize all possible parameters. For example, improving benchmark jet grouting guidelines requires a deep understanding of the intricate interactions between grout and the surrounding soil—a process that is not easily achieved. Modern evaluation technologies, while promising, are often limited to specific tasks only and lacks universality. The high resource demands and risks associated with deviating from established benchmark guidelines further constrain the innovation in jet grouting evaluation. Prediction-based studies offer an alternative option as they are less resource-intensive, but their utility is limited due to the absence of visual data and project-specific challenges. Such studies often focus solely on end results, neglecting the developmental stages, which are critical for comprehensive understanding and improvement.

※印欄記入不要

（様式第６号）

論　文　要　旨

2025 年　1 月　7 日

※ 報告番号	第　　号	氏　名	SHAKYA SUDIP

内容の要旨

To address these limitations, this study introduces an innovative simulation-based approach to recreate the entire jet grouting process from scratch. By the help of Computer-Aided Engineering (CAE) technology and the Moving Particle Semi-Implicit (MPS) method, the study aims to provide both visual and analytical data to uncover previously unknown aspects of jet grouting technology, and the scope for the development of overall jet grouting technology can be further explored. The methodology involves creating an accurate simulation model using CAE technology and then will be numerically analyzed by Moving Particle Semi-implicit (MPS) method. Initially, construction specifications from real-world test cases are replicated in the model. Material parameters are then adjusted to reflect the rheological properties of the materials involved. The simulation results are compared to real-world outcomes, and the model parameters are fine-tuned to achieve real world results.

In this study, the soil particle is assumed to follow the rheology of Bingham fluid bi-viscosity model. Due to the difficulty of directly measuring soil properties even with the sophisticated rheological devices, reverse parameter fitting was conducted through unconfined compression test simulations. Once the simulation parameters are calibrated to replicate real-world results, these benchmark settings serve as a detailed guideline for future studies on jet grouting technology using the MPS-CAE method. Finally, using the established benchmark settings, the scope of simulation is explored for optimizing overall jet grouting technology. Construction specifications are modified from standard practices, and the results of these simulations are compared against the benchmark simulations.

※印欄記入不要