



# Automated framework for optimized path-planning for pile foundation drilling machines based on 4D BIM modelling

Martina Mellenthin Filardo, Rohith Akula, Tino Walther and Hans-Joachim Bargstädt

*Bauhaus-Universität Weimar*

Contact: [martina.mellenthin.filardo@uni-weimar.de](mailto:martina.mellenthin.filardo@uni-weimar.de)

## Abstract

While the Building Information Modeling (BIM) method allows accurate information modelling and thus more robust predictions, it often needs to be combined with tasks beyond the model or modelling phase, especially if the goal is a model-based construction phase. This study proposes an optimization workflow for the construction of pile foundations, since they are part of a varying range of building and infrastructure projects. Pile foundation drilling is an extensive construction process, which can be optimized significantly by reducing the execution length through an effective drilling path plan and automated data transfer. This was achieved through the combination of optimization algorithms, which were linked to the 3D BIM model and selected the shortest distance between piles using Ant Colony Optimization (ACO) algorithm, based on the Travelling Salesperson Problem (TSP). Subsequently the script created separate security distance-compliant tours for drilling machines, calculated construction times and converted the resulting paths into schedules, which in turn could be updated to the 3D BIM model to generate a 4D animation of the construction process. The developed optimization framework and script were tested with a construction company focused on special foundations based in Germany.

**Keywords:** Optimization, Pile Construction, Deep Foundations, BIM, Building Information Modeling, Travelling Salesperson Problem, TSP, Ant Colony Optimization, ACO, 2-Opt Moves

## 1 Introduction

Digitalization of the architecture, engineering, and construction (AEC) industry is a tool, a method for achieving higher efficiency in the industry. It encompasses not only the Building Information Modeling (BIM) method, but also a range of efficiency improvement measures based on optimization. Since various decision-making problems in the construction phase, such as planning of site layout, crane selection, machine path, etc., can be described as optimization problems, with different variables restricted by existing conditions and constraints [1], this paper

offers a workflow for integrating common practice optimization algorithms to construction processes such as deep foundation construction. The proposed workflow focuses on planning an optimized and therefore more efficient path for pile drilling machines, reducing not only time but also labour, material and cost. Consequently, it is one of the most valuable optimization problems in construction. The BIM method provides a suitable framework to support the decision-making process by aggregating the necessary information and clarifying details and conditions [2], therefore it is used to assist during the path-planning for pile drilling machine routes, as described below.