



Geo-Congress 2024

GSP 350

Foundations, Retaining Structures, Geosynthetics, and Underground Engineering

Selected Papers from Geo-Congress 2024
Vancouver, British Columbia, Canada | February 25–28, 2024

Edited by

T. Matthew Evans, Ph.D.
Nina Stark, Ph.D.
Susan Chang, Ph.D., P.E.

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Preface

This Volume is the third of six Geotechnical Special Publications (GSPs) containing papers from Geo-Congress 2024: Bridging Government, Industry, and Academia for Resilient Mega-Communities, held in Vancouver, British Columbia, Canada on February 25-28, 2024. Notably, this was the first Geo-Congress held outside of the United States, and the Canadian Geotechnical Society and Vancouver Geotechnical Society served as partnering organizations. The conference hosted the Terzaghi, Peck, Seed, and Prakash Lectures, numerous invited presentations on selected topics addressing the state of the art and practice in geotechnical engineering, and many technical sessions, panel sessions, short courses, and student competitions.

The call-for-papers was distributed internationally and resulted in 885 submissions. Several strong technical themes were observed in the submissions. These included cold regions engineering, machine learning and artificial intelligence, and sustainability, in addition to other traditionally strong tracks such as deep foundations, geosystems, and geoenvironmental engineering. We see these tracks as a reflection of both the location of the Geo-Congress and the topics currently at the forefront of geotechnical research and practice.

This volume includes a collection of papers in the fields of Deep Foundations, Earth Retaining Structures, Geosynthetics, Shallow Foundations, and Underground Engineering. Each paper was subjected to a rigorous technical assessment by two or more independent peer reviewers. Acceptance required concurrence by at least two peer reviewers, and final decisions were made only after review coordinators confirmed that authors satisfactorily addressed any reviewer comments on their original submission. Ultimately, this resulted in acceptance of 366 papers in total, 53 of which are in this volume. All accepted papers are presented at the conference as posters or technical talks and are eligible for applicable ASCE Awards.

The success of this conference and proceedings would not have been possible without the participation and collaboration of many individuals, including the tireless staff at the Geo-Institute: Barbara Curtis, Lucy King, Krystina Scott, Sean Herpolsheimer, and Brad Keelor. We would also like to extend our gratitude to the Session Chairs and Reviewers, who provided thorough reviews and assessments of the submissions in a timely manner.

The Editors,

T. Matthew Evans, Ph.D.
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N. Vlachopoulos

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Prediction for Lateral Response of Monopiles: Deep Learning Model on Small Datasets Using Transfer Learning

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ABSTRACT

This paper presents a novel approach for predicting the lateral capacity of large-diameter monopiles in multi-layered soil using deep learning and transfer learning techniques. With the increasing interest in offshore wind energy, the cost-effective design of offshore wind turbine foundations is crucial. Traditional methods such as the p-y method have limitations in analyzing larger diameter monopiles. As an alternative to high-fidelity numerical models (e.g., finite element analysis and finite volume analysis), deep learning models have gained popularity for load response predictions and design purposes. Yet, one major challenge of deep learning models is that insufficient data can result in poor model performance. In this study, a deep learning model incorporating convolutional and fully connected layers was developed to capture the complex interactions between pile geometry parameters and soil conditions. To address the challenge of limited dataset size, transfer learning was employed, leveraging a pretrained model on a large dataset. The results demonstrate that the proposed model can provide accurate predictions, even with a small dataset. Transfer learning significantly reduces the required data size while preserving high prediction accuracy.

INTRODUCTION

With the rapid interest in the renewable energy sector to reduce the greenhouse gas emissions while sustaining secure supply of energy, wind energy has emerged as a plausible solution. The interest in offshore wind farms emerges as it produces higher energy compared to onshore wind farms, since they receive high wind speed (Díaz & Guedes Soares, 2020). In addition, the installation of offshore wind turbines helps in protecting the environment and reduce the destruction of lands (Jeon et al., 2013). However, the cost of constructing offshore wind farms is estimated to double that of onshore wind farms (Oh et al., 2018). The cost of their foundation is estimated to be between 19-36% of the total cost depending on the water depth (Oh et al., 2018). Therefore, the selection of foundation type and its design plays a significant role in reducing the cost. The monopile foundation, large-diameter steel pipe piles, is the most commonly used type of foundation for offshore wind turbines. This foundation type accounts for approximately 75% of all offshore wind turbine foundations globally (Díaz & Guedes Soares, 2020).

For the lateral design of monopiles, the p-y method is commonly used (Han et al., 2015, 2017). To simulate their interaction, this method models the pile and the soil surrounding it as a

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