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Forecasting the Bearing Capacity of the Driven Piles Using Advanced Machine-Learning Techniques

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Abstract: Estimating the bearing capacity of piles is an essential point when seeking for safe and economic geotechnical structures. However, the traditional methods employed in this estimation are time-consuming and costly. The current study aims at elaborating a new alternative model for predicting the pile-bearing capacity based on eleven new advanced machine-learning methods in order to overcome these limitations. The modeling phase used a database of 100 samples collected from different countries. Additionally, eight relevant factors were selected in the input layer based on the literature recommendations. The optimal inputs were modeled using the machine-learning methods and their performance was assessed through six performance measures using a *K*-fold cross-validation approach. The comparative study proved the effectiveness of the DNN model, which displayed a higher performance in predicting the pile-bearing capacity. This elaborated model provided the optimal prediction, i.e., the closest to the experimental values, compared to the other models and formulae proposed by previous studies. Finally, a reliable and easy-to-use graphical interface was generated, namely "BeaCa2021". This will be very helpful for researchers and civil engineers when estimating the pile-bearing capacity, with the advantage of saving time and money.

Keywords: pile-bearing capacity; machine learning; deep neural network; *K*-fold cross-validation approach; sensitivity analysis

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1. Introduction

Pile foundations are used to transmit construction loads deep into the ground in order to ensure structure stability [1,2]. Furthermore, computing the bearing capacity of piles is essential when designing economic and safe geotechnical structures [3]. To date, numerous approaches have been conceived for the sake of creating alternative methods and techniques that contain numerical, experimental, and analytical approaches aiming at predicting the bearing capacity of piles [4–6]. Among the most frequently used methods is the Cone Penetration Test (*CPT*), known for producing accurate results in a variety of situations [7,8]. This is probably due to the fact that *CPT*-based methods have been modeled in harmony with the *CPT* results, which were proven to estimate more effective different geotechnical properties, and make more precise pile capacity predictions [6]. Other semi-empirical methods have been widely utilized, such as Meyerhof's formula, which could yield an acceptable pile-bearing capacity [4]. On the other hand, the High-Strain Dynamic Load Test (*HSDLT*) and the Static Load Test (*SLT*) have been employed