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RESEARCH

Silica fume as a supplementary cementitious material in pervious concrete: prediction of compressive strength through a machine learning approach

Navaratnarajah Sathiparan[1] · **Pratheeba Jeyananthan**[2] · **Daniel Niruban Subramaniam**[1]

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Abstract
Utilizing silica fume as a substitute for cement in pervious concrete offers a viable approach to achieve sustainability within the realm of construction industry. The mechanical characteristics of pervious concrete are influenced by several factors, such as quantity of silica fume utilized as a replacement for cement, the cement content, coarse aggregate, sand, admixture and water used in the mix, aggregate size and the curing period. The present study introduces a predictive model that utilizes machine learning approaches to estimate the compressive strength of pervious concrete blended with silica fume. The models underwent training and testing procedures using 222 datasets from various literature sources. In this study, seven machine learning algorithms were used as statistical evaluation methods to identify the most suitable and reliable model for predicting compressive strength of pervious concrete. Among several models under consideration, the eXtreme Gradient Boosting model showed superior performance in forecasting compressive strength of pervious concrete. The coefficient of determination value obtained for training data is almost one, which suggests a robust correlation between the anticipated and actual values. The root mean squared error of training data is 0.28 MPa, which indicates the mean variation between the predicted and observed values. The coefficient of determination value for the test datasets is 0.97, along with a root mean squared error of 2.21 MPa. The outcomes of the sensitivity analysis conducted on the eXtreme Gradient Boosting model indicate that the parameter with the most significant impact on predicting the compressive strength of pervious concrete is the admixture content, followed by the curing period. This work provides a comprehensive evaluation of the compressive strength of pervious concrete, thereby enhancing the existing knowledge and facilitating its practical application in this domain.

Keywords Pervious concrete · Compressive strength · Silica fume · Learning · XGboost

Introduction

Cement, coarse aggregate and water are the main constituents of pervious concrete, a unique type of concrete. Additional admixtures and supplementary cementing materials are added to pervious concrete to optimize cost and performance. Compared to conventional concrete, pervious concrete uses very little or no fine particles (Subramaniam & Sathiparan, 2022). Water can easily be transmitted through pervious concrete because of its higher percentage of connected pores. Because of its many beneficial qualities that successfully lessen the negative consequences of impermeable catchments, pervious concrete has garnered much interest in research and application. Due to the absence of fine aggregates, pervious concrete requires a very high cement content to provide desirable mechanical qualities, specifically the compressive strength. Cement is one of the most widely used building materials that contributes to significant global carbon dioxide emissions (Mayooran et al., 2017; Poorveekan et al., 2021). Carbon dioxide emissions greatly obstruct the quest for a more environmentally sustainable solution to the construction industry. Around 4.4 billion tonnes of cement were produced worldwide in 2021 (Sathiparan, 2021; Sathiparan et al., 2023a). Most building materials, including various types of concrete, require cement as a binding agent, even though cement production

✉ Navaratnarajah Sathiparan
sakthi@eng.jfn.ac.lk

[1] Department of Civil Engineering, Faculty of Engineering, University of Jaffna, Jaffna, Sri Lanka

[2] Department of Computer Engineering, Faculty of Engineering, University of Jaffna, Jaffna, Sri Lanka