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Prediction of compressive strength of fly ash blended pervious concrete: a machine learning approach

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ABSTRACT

This study presents a prediction model for estimating the compressive strength of pervious concrete through the utilisation of machine learning techniques. The models were trained and tested using 437 datasets sourced from published literature. This work employed a collection of six machine learning algorithms as statistical evaluation tools to determine the optimal and dependable model for forecasting the compressive strength of pervious concrete. Out of all the models considered, the eXtreme Gradient Boosting model had greater performance in predicting the compressive strength. The coefficient of determination value for the train data is 0.99, indicating a strong correlation between the predicted and actual values. The root mean squared error for the train data is 0.86 MPa, representing the average deviation between the predicted and measured values. Similarly, the coefficient of determination value for the test datasets is determined to be 0.95, accompanied by a root mean squared error of 2.53 MPa. The eXtreme Gradient Boosting model's sensitivity analysis findings suggest that the aggregate size is the greatest parameter on forecasting the compressive strength of pervious concrete. This study delivers a systematic assessment of the compressive strength of pervious concrete, contributing to the current knowledge base and practical implementation in this field.

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1. Introduction

Pervious concrete is a distinct variant of concrete that consists of cement, coarse aggregates, and water. Additional supplemental cementitious materials and admixtures are used in pervious concrete when deemed essential. In contrast to traditional concrete, pervious concrete utilises either a minimal amount or eliminates the usage of fine particles. Due to the higher proportion of empty content in pervious concrete (pores), water can readily permeate through it. The collective volume of interconnected voids typically comprises approximately 15–30 percent of the entire volume. Pervious concrete has attracted significant attention in study and application due to its multiple favourable properties that effectively mitigate the adverse effects of impermeable catchments. The considerable porosity of pervious concrete necessitates a comparatively large quantity of cement to get favourable mechanical properties, particularly in compressive strength.

Cement, a widely utilised construction material, concurrently releases extensive carbon dioxide emissions into the Earth's atmosphere. The pursuit of a more environmentally sustainable condition is significantly impeded by carbon dioxide emissions (Poorveekan *et al.* 2021). In 2021, the global production of cement amounted to approximately 4.4 billion tons (Sathiparan 2021). The majority of construction materials, such as diverse forms of concrete, necessitate the utilisation of cement as a binding agent, notwithstanding the notable contribution of cement manufacture to carbon dioxide emissions. Scholars are currently directing their attention towards the identification of appropriate substitute cementitious materials as a means to address this issue. The utilisation of a specific supplementary cementitious material is frequently contingent upon many aspects, such as the quality, accessibility, and transportation expenses associated with it.

Fly ash is a substance that is frequently utilised as a supplementary cementitious material in the construction industry. Globally, the combustion of coal for power generation results in the annual production of over 500 million tons of fly ash, with only 25–30% of this quantity being effectively reused in various industries (Mathapati *et al.* 2022). The disposal of the residual fractions in dump yards has adverse effects on the environment, as well as incurring administration costs. The existing body of literature demonstrates that the utilisation of fly ash as a substitute for cement yields favourable mechanical characteristics in cement-based products, including concrete (Sahmaran and Yaman 2007, Kunchariyakun *et al.* 2015, Mayooran *et al.* 2017, Seevaratnam *et al.* 2020, Sundaralingam *et al.* 2022). The workability of wet mortar is enhanced by the spherical shape, smaller particle size, and smooth texture of fly ash (Sahmaran and Yaman 2007, Yoon *et al.* 2014). The inclusion of fly ash as a substitute for cement in concrete has resulted in an increased rate of water absorption and porosity. However, it has been observed that this does not have a significant effect on the long-term durability of the concrete (Gesoğlu *et al.* 2009, Yerramala and Ganesh Babu 2011, Younsi *et al.* 2011, Mardani-Aghabaglou *et al.* 2013, Shaikh and Supit 2014, Yanbo and Francisco 2014).

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