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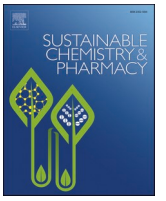

Predicting compressive strength in cement mortar: The impact of fly ash composition through machine learning

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A R T I C L E I N F O

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A B S T R A C T

This study investigates the significant impact of fly ash's chemical composition on cement mortar's compressive strength, employing advanced machine-learning models to enhance prediction accuracy. As the demand for sustainable construction materials rises, utilizing fly ash, a byproduct of coal combustion, as a partial substitute for Portland cement, is crucial for reducing environmental impacts. The research analyses a comprehensive dataset comprising 481 unique observations, focusing on critical variables such as aggregate-to-binder ratio, fly ash-to-binder ratio, water-to-binder ratio, curing period, and chemical constituents of fly ash (CaO, SiO_2, Al_2O_3, Fe_2O_3, and equivalent alkali). Through the application of various machine learning algorithms, including Artificial Neural Networks (ANN), K-Nearest Neighbors (KNN), Support Vector Regression (SVR), and Extreme Gradient Boosting (XGB), this study effectively models the intricate relationships between these variables and compressive strength. Also, three data processing techniques are used: raw, normalized, and standardized. Machine learning models with normalized datasets provided better results than raw and standardized datasets. Also, key findings reveal that higher SiO_2 content significantly enhances strength, while a careful balance of chemical components is essential for optimizing performance. Feature importance analysis indicates that the curing period and fly ash-to-binder ratio are critical in accurate predictions. This research underscores the importance of chemical composition in material performance and highlights the potential of machine learning to facilitate the design of more effective cement mortars using fly ash. This study advances sustainable construction practices by contributing to optimizing construction materials. The findings and methodologies presented herein are relevant to international research, emphasizing the novelty of integrating machine learning approaches in material design. This work addresses environmental challenges and promotes innovative solutions for future construction technologies.

1. Introduction

Cement mortar is a mixture of cement, sand, and water, primarily used in construction for masonry block production and binding materials like bricks, stones, and concrete blocks (Sathiparan et al., 2023a). The typical ratio of cement to sand can vary; for general-purpose mortar, the usual ratio is 3–6 parts sand to 1 part cement (Venkatarama Reddy and Gupta, 2008). The need for a large amount of cement in mortar arises from several factors, including greater compressive strength in load-bearing structures, enhanced durability against moisture and chemical exposure, reduced shrinkage during curing, and improved overall stability (Nawab et al.,

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