Machine Learning Based Optimization Techniques for Predictive Strength of High Performance Concrete: Enhancing Sustainable Development

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Abstract

The pursuit of sustainable growth in the construction sector needs a precise forecast of material characteristics to optimize resource consumption. This research focuses on utilizing the capabilities of well-known XGBoost regression algorithms to forecast the compressive strength of High-Performance Concrete (HPC). In this study, 2171 datasets were collected from literature containing input parameters that influence concrete strength, thereby creating a robust predictive model. The performance indices were assessed using root mean squared error (RMSE) and R^2 score. The findings indicate that the XGBoost model outperforms standard statistical techniques in predicting accuracy. This research intends to improve the precision of compressive strength estimation, facilitating the development of more durable and sustainable construction practices.

Keywords: High-Performance Concrete (HPC); Machine Learning; Prediction; XGBoost Regressor; Optimization Techniques; Compressive Strength; Sustainable Development.

1 Introduction

In recent years, the construction sector has seen a considerable paradigm change toward sustainable practices and environmentally responsible approaches. Concrete, being the most extensively used construction material, is critical in shaping modern infrastructures systems [1-4]. As the worldwide focus shifts to decreasing the environmental imprint of infrastructure projects, developing novel methods for optimizing building materials becomes critical. High-Performance Concrete (HPC) is vital due to its remarkable mechanical attributes and potential for improving construction durability and lifetime [5]. The compressive strength of HPC is an important measure of its quality and performance, impacting the structural integrity of many applications. Accurate prediction of HPC compressive strength is critical for optimizing material utilization, assuring structural integrity, and reducing environmental impact. Traditional compressive strength prediction methods may incorporate time-consuming and resource-intensive experimental approaches [6,7]. However, the development of data driven techniques has opened up new opportunities for forecasting material qualities quickly and effectively [8-10]. Several Machine learning approaches have proven effective in various engineering domains, including concrete strength prediction [11-13]. XGBoost Regressor and Random Forest have emerged as prominent

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