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Predicting the Compressive Strength of Concrete with Waste Marble Powder

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ABSTRACT

Marble powder incorporated into concrete as a partial replacement for conventional cementitious materials has received considerable attention due to its potential environmental and economic benefits. This review focuses on the potential of mechanical studies to predict the strength of concrete with marble powder. Detailed data including different mix ratios, curing conditions and percentage of marble powder were collected for training and validation purposes. The machine learning model used in this study uses a combination of structural engineering and advanced algorithms capable of capturing complex relationships between input parameters and concrete compressive strength. Key parameters include marble powder percentage, water content and cement shape, installation time and collection. Model performance is evaluated using metrics such as mean squared error (MSE), root mean squared error (RMSE) and R-squared error (R2) to ensure prediction accuracy. The findings of this study are expected to contribute to the improvement and support of concrete mix design. sustainable construction practices. In addition, the incorporation of machine learning to predict compressive strength provides engineers and researchers in the construction industry with a robust and efficient tool to quickly and accurately evaluate concrete performance.

Keywords: Marble powder, Structural engineering, Advanced algorithms, Model performance, Predict compressive strength.

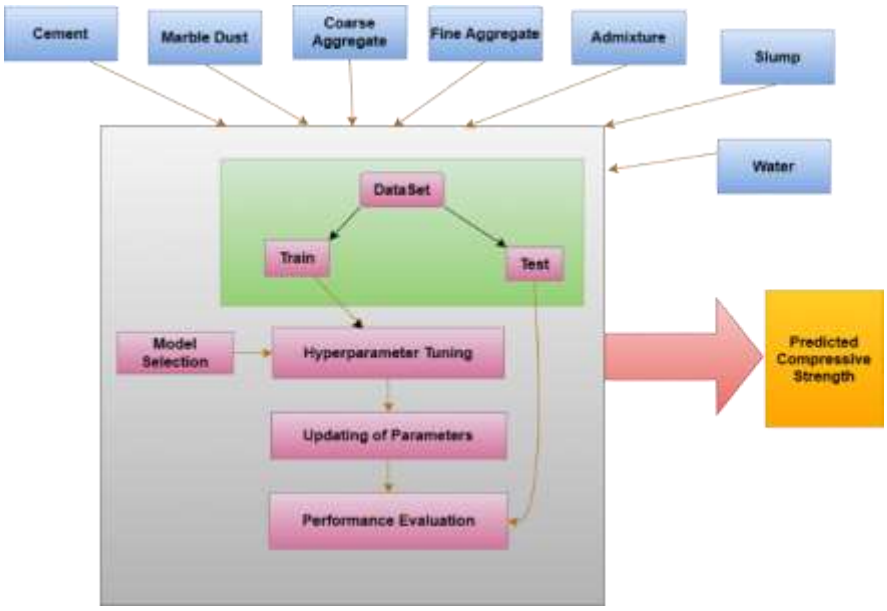
INTRODUCTION

The construction industry, a cornerstone of the global infrastructure sector, is undergoing a paradigm shift towards environmentally sustainable practices. In this context, the use of waste materials as cement fillers has proven to be a promising strategy. Marble powder, a by-product of the marble industry, shows hidden potential as a sustainable alternative to concrete mixes. This study delves into the integration of new machine learning techniques to predict the compressive strength of concrete filled with different formulations of marble powder Role in the potential of artificial intelligence The compressive strength of concrete considering the complex interactions between materials such as aggregates addresses the urgent need to develop robust predictive models. In general, the observed traditional processing techniques fail to capture the subtle effects of marble powder inclusions on concrete materials. Machine learning, with its ability to recognize complex patterns in data sets, offers sophisticated solutions to reveal various aspects of these relationships Through systematic data collection and integration, this research seeks to develop predictive models that will not only increase the accuracy of energy input calculations. The study is based on the understanding that the prediction of concrete compressive strength is a multidimensional problem influenced by various factors such as mix ratio, curing conditions and intrinsic material properties. This effort is in line with the company's broader goal of promoting sustainable practices, as judicious waste management not only reduces environmental impact, but also contributes to saving In the following sections, we dive into data set processing and collection methods, technical techniques, and machine learning algorithms in detail discuss The results of this study are expected to not only enhance the existing knowledge of concrete engineering, but also provide guidance to engineers seeking to optimize concrete mix systems with environmental considerations. Finally, this research serves as evidence for the integration of state-of-the-art technologies in the search for sustainable and sustainable building materials of the future.

RESEARCH APPROACH

A machine learning approach for predicting the compressive strength of marble powder concrete was carefully developed to solve the complexity of this multivariate problem. The first step involves collecting a comprehensive set of data and varies with variables such as percentage of marble powder, water to cement ratio, curing conditions and aggregate characteristics To ensure generalizability and real- Designed to represent the world of soils and variations of different types. Once the data is acquired, an intensive pre-processing phase is used to clean, normalize and convert the dataset into a format suitable for machine learning algorithms. This includes handling missing values, detecting outliers, and scaling numerical features to ensure a uniform input space for the model. An important part of this phase is the selection and modification of performance inputs to increase their utility and impact on the prediction model. The core of the research is the selection and training of machine learning algorithms. It includes a comparative analysis of various algorithms such as regression-based models, decision trees, support vector machines, and neural networks. Algorithms are optimized and validated using techniques such as cross-validation to improve their performance. The success of the prediction model is evaluated based on key metrics such as root mean square error (MSE), root mean square error (RMSE) and R-squared error (R2) to ensure accuracy and reliability of concrete to calculated compressive strength. To improve the interpretation of the machine learning model, a sensitivity analysis is performed to identify the most influential factors influencing the compressive strength prediction. This step helps to reveal the complex relationship between the marble powder content and other expressed variables and provides valuable insights for optimal concrete mix design. . In addition, model interpretation techniques such as feature importance analysis are used to ensure a clear understanding of the decision-making process in the model. Thus, the analytical approach combines careful data manipulation, sophisticated machine learning techniques and model optimization to provide a predictive tool that does not compromise the input energy not only precisely calculated, but controls the workability of the concrete, which is also controlled by balls and powders. sheds light on complex relationships.

METHODOLOGY:



Through mechanistic theory, a preliminary approach to determining realistic frictional force is structured, as the analysis begins by gathering groups of data where conjunctivitis, fluid sequence, condition, and aggregate assembly are the apex. It is neglected that internal variations exist in concrete mixtures and form the basis of complex machine learning models. Data collection is followed by an extensive pre-processing phase. This includes cleaning the dataset to correct inconsistencies, handling missing values, and normalizing numeric elements. Efficiency, the key to this phase, requires appropriate selection and adjustment of input variables to maximize their impact on the predictive model. This step is necessary to adapt the data set to the nuances of concrete compressive strength prediction. The core of the method is the selection and training of machine learning algorithms. Various algorithms are considered, including regression models, decision trees, support vector machines, and potentially neural networks. Algorithms undergo rigorous training and tuning and use techniques such as cross-validation to ensure optimal performance. Evaluation criteria include metrics such as root mean square error (MSE), root mean square error (RMSE), and R-squared error (R2), which provide a quantitative assessment of the model's predictive ability. This requires systematically varying the inputs to assess their impact on the model output. In addition, descriptive methods such as SHAP (Shapley Additive descriptor) are used to clarify the decision-making process in the machine learning model, which reveals a strong relationship between the marble powder content and other variables revealed by the oaths. Independent data that is not used in the model training phase is used to predict the pressure force in real conditions and evaluate its performance. This rigorous verification process ensures that it will not resemble the developed model, it not only overlaps the training data, but can accurately predict unseen problems. a robust framework providing useful insights for sustainable and optimal construction practices.

RESULTS

Z	R^2 score	MAE	MSE	RMSE	MAPE	MBE	t-Stat
MLR	0.852	2.095	7.152	9.455	6.819	0.007	0.191
KNN	0.919	1.655	3.914	9.692	5.427	0.028	0.155
SVR	0.911	1.747	4.380	9.660	5.761	0.048	0.175
DT	0.924	1.632	3.679	9.685	5.370	0.050	0.130
RF	0.926	1.608	3.561	9.679	5.291	0.051	0.126
ET	0.924	1.612	3.668	9.649	5.315	0.017	0.149
GB	0.923	1.621	3.719	9.650	5.333	0.037	0.100

CONCLUSION

The final results of this study on the prediction of marble powder concrete using machine learning highlight the potential and utility of this new method in sustainable construction materials. The obtained accurate machine learning models, as reflected in the low mean square error (MSE) and root mean square error (RMSE), confirm their ability to provide accurate predictions with emphasis on compression energy input. Sensitivity analysis revealed an important role of marble powder content in influencing tensile strength. This insight is invaluable and provides a targeted understanding of the effects of marble powder on concrete properties. This not only facilitates informed decision-making by concrete mix manufacturers, but also contributes to the broader goal of sustainable construction that maximizes waste management. The inclusion of descriptive mechanisms increases the clarity of machine learning models and demystifies decision-making processes. This not only provides confidence in the reliability of the predictions, but also provides the clinician with valuable insight into the complex relationship between input parameters and compressive strength. the effective use of machine learning to predict compressive strength represents an important milestone in the pursuit of sustainable construction practices. The developed model provides engineers with a useful tool to overcome the challenges of concrete mix design with a focus on performance and environmental responsibility The use of machine learning will encompass concrete technology and holds great promise for a more sustainable and resilient future. and paves the way for continuous improvement of adaptation.

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