World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:19, No:09, 2025

Predicting Concrete Compressive Strength: A Transformer-Based Approach Leveraging Large-Scale Construction Industry Data

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Abstract : Concrete, the most widely used construction material globally, is valued for its versatility and strength. However, accurately predicting its compressive strength—a critical parameter for structural durability and safety—remains a persistent challenge due to its complex composition, diverse applications, and sensitivity to environmental conditions. Recent advancements in other scientific domains, such as the development of transformer models in computer science, which have revolutionized fields like natural language processing, biomedicine, and drug discovery, offer promising opportunities to address this challenge. Consequently, this study leverages a large-scale dataset to develop a transformer-based machine learning model that effectively exploits the underlying relationships among input parameters, such as total cementitious material, water-cement ratio, slump, percentage of air, and fly ash. Specifically, A dataset of 35,000 average compressive strength test results from the industry is introduced in this study. Each average compressive strength result is derived from two 4x8-inch cylinder tests, resulting in the analysis of 70,000 individual cylinder break results. This extensive dataset distinguishes the research, as no prior study has examined such a large sample size. The proposed model demonstrates superior accuracy through comprehensive experiments and analysis compared to traditional methods, including multiple linear regression, decision trees, random forests, and vanilla neural networks. Additionally, the transformer model's attention mechanism provides valuable insights into the relative importance of input factors influencing compressive strength.

Keywords : concrete compressive strength, transformer model, machine learning, concrete strength prediction
Conference Title : ICCCC 2025 : International Conference on Cement and Concrete Composites
Conference Location : San Francisco, United States
Conference Dates : September 27-28, 2025