ESTIMATION OF CONCRETE COMPRESSIVE STRENGTH USING IMAGE PROCESSING WITH A HYBRID METHOD (CNN AND FUZZY LOGIC)

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ABSTRACT

Concrete is a highly important construction material due to its strength, particularly compressive strength, which determines the feasibility and safety of a structure. However, conventional compressive strength testing is destructive, time-consuming, and requires significant costs as well as specialized laboratory equipment. This research aims to develop a more efficient, faster, and non-destructive method for predicting concrete compressive strength by combining digital image processing technology and artificial intelligence. The study was conducted by preparing 60 concrete cube samples with a design strength of 27.5 MPa and dimensions of 15×15×15 cm in accordance with SNI standards. The concrete surfaces were documented using a high-resolution camera and converted into RGB visual data. The image data were then processed using a Convolutional Neural Network (CNN) to detect visual surface patterns such as texture and color, which correlate with compressive strength values. The initial predictions from CNN were further refined using Fuzzy Logic to produce smoother, more realistic results that closely approximate the actual values. The results indicate that the hybrid CNN-Fuzzy method can provide compressive strength estimation with a relatively high level of accuracy. CNN effectively recognized visual patterns on the concrete surface, while Fuzzy Logic played a role in smoothing the uncertainties in CNN

outputs. Compared to laboratory test results, this hybrid model showed relatively small prediction errors. Therefore, this method can serve as an alternative for compressive strength testing that is faster, cost-effective, and non-destructive.

***Keywords**: Compressive Strength of Concrete, Image Processing, CNN, Fuzzy Logic, Estimation, Non-Destructive.*