Health Monitoring of Concrete Structure with Nondestructive Testing using ANN Technique

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***Abstract*—The prediction of concrete compressive strength using Non-Destructive Testing (NDT) methods, such as the Rebound Hammer Test, has become increasingly popular in the construction industry due to their efficiency and non-invasive nature for Structural Health Monitoring (SHM) However, the accuracy of these traditional methods remains a concern, due to the higher percentage of error in the prediction of strength of concrete structures. This study proposes the application of Artificial Neural Networks (ANN) to enhance the accuracy of concrete strength predictions based on rebound hammer data. Using a dataset of Rebound Hammer Test samples, which is the rebound number, an ANN model was developed, trained, and validated. The results demonstrate a significant improvement, reducing the Mean Absolute Percentage Error (MAPE) to 8.27%. This research highlights the potential of ANNs in improving the reliability of NDT methods and recommends further exploration of artificial intelligence techniques for enhanced prediction accuracy in structural health assessments.**

***Keywords*— Structural Health Monitoring, Concrete Structures, Non-destructive Testing, Rebound Hammer, Artificial Neural Network**

I. Introduction

Concrete is one of the most widely used construction materials due to its strength, durability, and versatility. However, over time, concrete structures can suffer from deterioration due to environmental conditions, material fatigue, and other factors. As a result, many of the important structures have collapsed in recent years all over the world. Therefore, early detection of such deterioration is crucial for maintaining the safety and longevity of concrete structures. Traditional methods of Structural Health Monitoring (SHM) often involve time-consuming and labor-intensive processes. In the industry, to ensure structural health conditions, non-destructive testing (NDT) methods are becoming increasingly popular due to their ability to assess the properties of in-situ components without causing damage. NDTs are generally faster and more cost-effective compared to traditional destructive testing methods. This is particularly beneficial when estimating the strength of concrete on site, as it preserves the structural integrity. Among these methods, the rebound hammer test is a common non-destructive technique used to estimate the surface hardness of concrete, which can indicate its strength and overall condition [1]. By utilizing the rebound value generated from the test hammer, the compressive strength can easily be estimated using the conversion chart provided by the manufacturer [2].

The rebound hammer test, developed by Schmidt in the 1950s, measures the hardness of concrete by assessing the rebound of a spring-loaded hammer. This test provides a quick and easy method to estimate the compressive strength of concrete and evaluate its quality [3]. The rebound number obtained from the test is influenced by concrete mix, age, and surface conditions. The rebound hammer test provides a quick and efficient means to estimate the surface hardness and, by extension, the compressive strength of concrete. Several studies have explored the correlation between rebound hammer readings and concrete strength, highlighting the test's utility in quality control and evaluation of existing structures [4]. Despite its advantages, the rebound hammer test has limitations. The accuracy of rebound measurements can be affected by surface roughness, moisture content, and carbonation. Additionally, the rebound hammer provides only a superficial assessment of concrete strength, which may not reflect the internal condition of the material [5]. Despite its wide application, the rebound hammer test can produce estimations with significant variability, often resulting in a high mean absolute percentage error when compared to results from destructive compressive strength tests. These challenges necessitate the development of more sophisticated methods to interpret rebound hammer data accurately. To address these issues and improve the reliability of concrete health assessments, researchers have turned to advanced computational techniques, such as Artificial Neural Networks (ANNs) [2]. ANNs offer the ability to model complex, non-linear relationships between input data and target variables, making them ideal for processing noisy, multidimensional data, such as rebound hammer readings.

Recent advancements in artificial intelligence (AI) and machine learning (ML) techniques have opened new avenues for enhancing the accuracy and efficiency of concrete health monitoring. Artificial Neural Networks (ANNs), in particular, have demonstrated significant potential in predicting concrete properties and detecting anomalies based on various input data. By integrating ANN techniques with rebound hammer data, researchers aim to