Chapter 6

High Performance Concrete (HPC) Compressive Strength Prediction With Advanced Machine Learning Methods:

Combinations of Machine Learning Algorithms With Bagging, Rotation Forest, and Additive Regression

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ABSTRACT

In this chapter, the authors realized prediction applications of concrete compressive strength values via generation of various hybrid models, which are based on decision trees as main a prediction method. This was completed by using different artificial intelligence and machine learning techniques. In respect to this aim, the authors presented a literature review. The authors explained the machine learning methods that they used as well as with their developments and structural features. Next, the authors performed various applications to predict concrete compressive strength. Then, the feature selection was applied to a prediction model in order to determine parameters that were primarily important for the compressive strength prediction model. The authors evaluated the success of both models with respect to correctness and precision prediction of values with different error metrics and calculations.

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INTRODUCTION AND LITERATURE REVIEW

Concrete, which is a structural material frequently used in civil engineering, is composed from water, cement, and various mineral or chemical materials. Engineers use this material to connect structural components to each other. For instance, in a beam and a column, and each component in place during the construction of structures. In this regard, strength and quality of concrete is important for ensuring resistance and sustainability of structures to various factors.

This case causes a considerable problem related to determining concrete strength with precision based on the features of the materials themselves, together with their mixture rates, acting to quality of concrete (Küçük, 2000). However, the process of calculating the compressive strength of concrete is a time-intensive and expensive operation. Altogether, calculating and observing concrete strength takes 28 days (Turkish Standards Institute, 2000). On the other hand, various environmental effects, such as air and gas rates, temperature, humidity, and the properties of the sample tools or techniques used for measurement contribute to the strength of concrete. For this reason, the strength values could deviate from the real results and so, show change.

Nowadays, various advanced methods, which can be useful alternatives to traditional laboratory analyses and test methods, may be utilized in to effectively and rapidly calculate and determine numerical values for structural materials. Considering that these methods are frequently machine learning and artificial intelligence prediction techniques, serve the benefit of preventing loss of time and effort, with cost residuals.

In the first periods when researchers operated machine learning and statistical applications, non-destructive tests were greatly preferred by many researchers, and numerous studies were realized with these techniques. One example of this technique is the ultrasonic pulse velocity method, which may be beneficial to researchers because it uses its own values to predict compressive strength. With this aim, the authors carried out various studies in the literature review that follows:

Hoła and Schabowicz (2005) performed artificial neural networks (ANNs) implementation using the features obtained by means of the nondestructive testing as input variables for prediction of concrete compressive strengths. Next, Kewalramani and Gupta (2006) used multiple regression analysis and ANNs to predict the concrete compression strength of samples belonging to concrete mixtures that have two different sizes and forms in longtime, by used ultrasonic pulse velocities and weight values. In another study, the authors applied multilayer neural network, which is one kind of ANNs technique, to estimate compressive strength of concrete by values of ultrasonic pulse velocity besides concrete mixtures properties (Trtnik, Kavčič & Turk, 2009).

On the other hand, Bilgehan and Turgut (2010) presented an application regard to performing predictions for the compressive strength of concrete based on the ultrasonic pulse velocity method. In this study, the authors generated a great deal of data through the usage of different concrete parts of a variety of ages and concrete rates. The authors did this by taking samples from concrete structures with the aim of training of ANNs. Nevertheless, Atici (2011) performed a study that assessed compressive strength in different curing times of concrete mixtures containing several amounts blast furnace cinder and fly ash by depend on qualities and values. The authors obtained this information via rebound number from a non-destructive test, ultrasonic pulse velocity of additive agents forecasted via ANNs, and multiple regression analysis methods.