

Chapter 5

Optimum Design of Carbon Fiber–Reinforced Polymer (CFRP) Beams for Shear Capacity via Machine Learning Methods: Optimum Prediction Methods on Advance Ensemble Algorithms – Bagging Combinations

Melda Yucel

Istanbul University-Cerrahpaşa, Turkey

Aylin Ece Kayabekir

Istanbul University-Cerrahpaşa, Turkey

Sinan Melih Nigdeli

Istanbul University-Cerrahpaşa, Turkey

Gebrail Bekdaş

Istanbul University-Cerrahpaşa, Turkey

ABSTRACT

In this chapter, an application for demonstrating the predictive success and error performance of ensemble methods combined via various machine learning and artificial intelligence algorithms and techniques was performed. For this reason, two single methods were selected, and combination models with a Bagging ensemble were constructed and operated with the goal of optimally designing concrete beams covering with carbon-fiber-reinforced polymers (CFRP) by ensuring the determination of the design variables. The first part was an optimization problem and method composing an advanced bio-inspired

DOI: 10.4018/978-1-7998-0301-0.ch005

metaheuristic called the Jaya algorithm. Machine learning prediction methods and their operation logics were detailed. Performance evaluations and error indicators were represented for the prediction models. In the last part, performed prediction applications and created models were introduced. Also, the obtained predictive success of the main model, as generated with optimization results, was utilized to determine the optimal predictions of the test models.

INTRODUCTION

Artificial Intelligence (AI) methods are effective in solving multidisciplinary engineering problems. Also, AI methods can be trained with optimization methodologies to provide the prediction of optimization results. In this chapter, the authors present a study showing the application of the predictive success and error performance of ensemble methods employing various machine learning and artificial intelligence algorithms. Two single methods were selected, and combination models with a Bagging ensemble were constructed. The optimal design is that of using concrete beams with a covering of carbon-fiber-reinforced polymers (CFRP) by ensuring the determination of design variables for the minimization of CFRP material in order to increase the shear capacity of the beam. For an RC beam using CFRP, the width, spacing, and application angle of the CFRP strip are the design variables. Their optimization has previously been done (Kayabekir, Sayin, Bekdas, & Nigdeli, 2017; Kayabekir, Sayin, Nigdeli, & Bekdas, 2017; Kayabekir, Sayin, Bekdas, & Nigdeli, 2018; Kayabekir, Bekdaş, Nigdeli, & Temür, 2018) by using several metaheuristic algorithms—namely, Flower Pollination Algorithm (FPA) (Yang, 2012), Teaching-Learning-Based Optimization (TLBO) (Rao, Savsani, & Vakharia, 2011), and Jaya Algorithm (JA) (Rao, 2016).

CARBON-FIBER-REINFORCED POLYMER (CFRP) BEAM MODEL

The Optimization Problem

The capacity of reinforced concrete elements may be insufficient due to reasons such as a change in the purpose of use of the structure (for examples, adding a new floor to the existing structure or retrofitting it for a capacity increase due to earthquake force mitigation; etc.). In such cases, various retrofit methods are utilized to increase the shear force, flexural moment, or axial force capacities. These methods generally necessitate the partial destruction of existing members; and the use of such structures may not always be possible in such case. Furthermore, since the total weight and rigidity of the structure are changed, a structural re-analysis is required. Another option is to use carbon-fiber-reinforced polymer (CFRP), having a linear deformation behavior with a large strain capacity, without changing the existing behavior of the structure. This method can be easily applied and provides for the use of the structure during its application.

In this chapter, optimal carbon-fiber-reinforced polymer design is presented with the goal of increasing the shear capacity of T-shaped RC beam members. This is done by considering the rules of regulation ACI 318 (Building Code Requirements for Structural Concrete); and by following various

17 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage:

www.igi-global.com/chapter/optimum-design-of-carbon-fiber-reinforced-polymer-cfrp-beams-for-shear-capacity-via-machine-learning-methods/238140

Related Content

Residual Life Estimation of Humidity Sensor DHT11 Using Artificial Neural Networks

Pardeep Kumar Sharma and Cherry Bhargava (2022). *Research Anthology on Artificial Neural Network Applications* (pp. 971-986).

www.irma-international.org/chapter/residual-life-estimation-of-humidity-sensor-dht11-using-artificial-neural-networks/288995

Improving Returns on Stock Investment through Neural Network Selection

Tong-Seng Quah (2006). *Artificial Neural Networks in Finance and Manufacturing* (pp. 152-164).

www.irma-international.org/chapter/improving-returns-stock-investment-through/5354

Data Classification Using Ultra-High Frequency SINC and Trigonometric Higher Order Neural Networks

(2021). *Emerging Capabilities and Applications of Artificial Higher Order Neural Networks* (pp. 303-345).

www.irma-international.org/chapter/data-classification-using-ultra-high-frequency-sinc-and-trigonometric-higher-order-neural-networks/277682

Application of Machine Learning Methods for Passenger Demand Prediction in Transfer Stations of Istanbul's Public Transportation System

Hacer Yumurtaci Aydogmus and Yusuf Sait Turkan (2020). *Artificial Intelligence and Machine Learning Applications in Civil, Mechanical, and Industrial Engineering* (pp. 196-216).

www.irma-international.org/chapter/application-of-machine-learning-methods-for-passenger-demand-prediction-in-transfer-stations-of-istanbuls-public-transportation-system/238146

Artificial Tactile Sensing and Robotic Surgery Using Higher Order Neural Networks

Siamak Najarian, Sayyed Mohsen Hosseini and Mehdi Fallahnezhad (2010). *Artificial Higher Order Neural Networks for Computer Science and Engineering: Trends for Emerging Applications* (pp. 514-544).

www.irma-international.org/chapter/artificial-tactile-sensing-robotic-surgery/41680