Modeling and Optimization for The Tensile Properties of 3D-Printed FRP using Artificial Neural Network and Artificial Bee Colony Algorithm

Wael Alhaddad, Khalil Yahya Mohammed Almajhali

Department of Structural Engineering, Tongji University, Shanghai 200092, China.

Yahia Halabi

School of Civil Engineering, Southwest Jiaotong University, Chengdu 610031, Sichuan, China.

Mohammed Elhassan

Department of Bridge Engineering, Tongji University, Shanghai 200092, China.

Contact: waelalhaddad90@gmail.com

Abstract

Fiber-reinforced polymer (FRP) has multiple applications as a primary material or reinforcing material for the structural elements. Controlling the quality of the 3D printed FRP is critical to guarantee a FRP material of high performance. In this research, machine learning (ML) model based on data collected from experimental studies was developed by artificial neural network (ANN) to control the quality of 3D printed FRP. ANN model predicts the ultimate tensile strength (UTS) of the FRP as function of 7 material and printing parameters. The UTS of the FRP was maximized via optimizing the printing and material parameters by using artificial bee colony (ABC) algorithm. ANN and ABC algorithms were coded by MATLAB. The results showed that the developed ANN model can predict with good accuracy the UTS of FRP. Moreover, it was found that the ABC optimization algorithm can design the input parameters such that a FRP with maximum UTS can be obtained.

Keywords: fiber-reinforced polymer composite; additive manufacturing; 3D printing; artificial neural network; optimization; artificial bee colony algorithm.

1 Introduction

Polymer-based composites, also called Fiber-Reinforced Polymer (FRP), are characterized by light weight and high performance in terms of mechanical and thermal properties. However, these properties are varies based on the type of polymer matrix and the reinforcing fibers of FRP. The polymer matrix of FRP can be either Thermoplastic, e.g., Poly-Lactic Acid (PLA), Nylon, or Thermosetting, e.g., Epoxy, Polyurethane; while the fibers reinforcing agent can be either Synthetic Fibers (SF), e.g., Carbon Fibers (CF), Glass Fibers (GF), Kevlar Fibers (KF), or Natural Fibers (NF), e.g., Jute, Flax, Wood, Bamboo (see Figure 1) [1]. The properties of the produced FRP not only based on the matrix and fibers types but also on fibers form whether it is continuous fibers, chopped fibers.

https://doi.org/10.2749/nanjing.2022.1119
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