AUSTRALIAN JOURNAL OF STRUCTURAL ENGINEERING
https://doi.org/10.1080/13287982.2023.2254035

Development of Prediction Models for Shear Strength of FRP Reinforced Fibrous Concrete Beams without Stirrups Using ANN and Nonlinear Regression

Ghazi Bahroz Jumaa [a], Ghafur H. Ahmed[b] and Nasih Habeeb Askandar[c]

[a]Civil Engineering Department, University of Garmian, Kalar, Kurdistan, Region-Iraq; [b]Highway Engineering Department, Technical Engineering College, Erbil Polytechnic University, Erbil, Kurdistan, Region-Iraq; [c]Civil Engineering Department, University of Halabja, Halabja, Kurdistan, Region-Iraq

ABSTRACT

The shear behaviour of fibre-reinforced polymer reinforced concrete (FRP-RC) beams without web reinforcement suffers from low strength, low stiffness, more brittleness and wide and quick propagated cracks. Fortunately, the addition of various types of fibres could improve most of these weaknesses. On the other hand, the shear strength prediction of FRP-RC beams with various types of fibres is one of the most complex cases in structural engineering applications. Developing generalised, precise and consistent prediction models are necessary and very limited. This paper investigates the impacts of various types of fibres on shear strength and presents proposing four new prediction models, utilising artificial neural networks and empirical nonlinear regression analysis, and modifying the combination of available models based on a collected database of 49 shear test results of FRP-RC members with various types of fibres. The comparison of the developed models with the available equations from the literature indicates that the developed models yielded excellent performance, great efficiency and a high level of accuracy over all other existing models. Additionally, the parametric study confirmed that all the developed models have great abilities to accurately predict the actual response of each parameter, in spite of its complexity, on the shear strength of FRP-reinforced fibrous concrete beams without stirrups.

ARTICLE HISTORY
Received 22 April 2023
Accepted 10 August 2023

KEYWORDS
Shear strength; types of fibres; fibre-reinforced polymer; artificial neural network; empirical equation; database

1. Introduction

Since its emergence, reinforced concrete (RC) gets popularity and becomes the most widely used material worldwide due to its availability, low cost, performance, long service life and versatility (Michel et al. 2011; Montemor, Simoes, and Ferreira 2003; Shi et al. 2012). While RC structures suffer from deterioration, due to many factors, corrosion is the most negative one which shortens the durability and integrity, particularly in structures subjected to a severe environment (Berrocal, Lundgren, and Löfgren 2016; Zhou et al. 2015). The corrosion problem of steel RC structures costs about 2.5 trillion dollars annually (Procópio 2019). Therefore, researchers seek to find a solution to this issue; among the suggested solutions, the use of a recently developed material namely fibre-reinforced polymer (FRP) material is a widely accepted one. Many types of FRP composite materials are manufactured nowadays using epoxy resin and various types of fibres like glass, carbon, aramid and basalt in variable forms: bars, sheets, laminates and others. Studies on FRP rebars showed that it offers an excellent replacement for traditional steel rebars in structures located in severe environments like marine structures, bridge decks, chemical storage tanks and parking garages. The most attractive and structurally important characteristics of FRP materials are as follows: non-corrosive, non-magnetic, high fatigue strength and high tensile strength-to-weight ratio. These properties make FRP materials a reliable option in structures subjected to corrosion, where the magnetisation of steel bars is prevented. However, there is no material in nature with ideal properties; FRP material has some drawbacks, as it is an anisotropic material, has a low modulus of elasticity, is elastic until failure and has a relatively poor bonding characteristic. Therefore, the strength and structural behaviour of FRP-RC structures are different from traditional steel structures, particularly in shear response. Consequently, many studies (Jumaa and Yousif 2018, 2019) have been carried out to investigate the shear strength and behaviour of FRP-RC members, which resulted in proposing many models to predict its strength and conducting many guidelines and codes (ACI-440 2015; CSA 2012; JSCE 1997; International Federation for Structural Concrete (fib) 2012) to regulate its use in engineering structures.

The mechanisms of shear resistance in FRP-RC members are different from those of steel-RC members due to the low elastic modulus, low transverse strength and relatively poor bond strength of FRP rebar. The experimental shear tests on FRP-RC

CONTACT Ghazi Bahroz Jumaa ghazijumaa@garmian.edu.krd Civil Engineering Department, University of Garmian, Kalar, Kurdistan, Region-Iraq