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Prediction of FRP Contribution to the Shear Resistance of RC Beams Using Artificial Neural Networks

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Abstract

Shear strengthening of reinforced concrete (RC) beams using fiber-reinforced polymers (FRPs) has been studied intensively in the last decade, even if shear for simple RC beams is not actually fully understood. Three main configurations of FRP strengthening including side bonding, U-wrapping, and complete wrapping may be used for externally bonded reinforcement of RC beams. In the present study, the FRP contribution to the shear resistance of RC beams is predicted using available experimental data by applying artificial neural networks (ANNs). With known combinations of input and output data, the neural network can be trained to extract the underlying characteristics and relationships from the data. Then, when a separate set of input data is fed to the trained network, it will produce an approximate but reasonable output. Neural networks are highly nonlinear and can capture complex interactions among input/output variables in a system without any prior knowledge about the nature of these interactions. A database containing the results from more than 200 tests performed in different research institutions across the world was collected. Having parameters used as input nodes in ANN modeling such as beam dimensions, compressive strength of concrete, type of FRP fiber, ultimate tensile strength of FRP, angle of inclination of FRP fibers with respect to the horizontal axis and thickness of FRP, the target/output nodes was shear contribution of FRP. The transfer functions were assumed to be Tan-sigmoid and Log-sigmoid for hidden layers. The comparison of the new approaches with existing experimental data and available empirical models shows that the ANN model can accurately predict the shear contribution of FRP.

Keywords: FRP, Artificial Neural Network, Shear Resistance, RC Beam

1. INTRODUCTION

FRP systems have been shown to increase the shear strength of existing concrete beams and columns by wrapping or partially wrapping the members. Orienting FRP fibers transverse to the axis of the member or perpendicular to potential shear cracks is effective in providing additional shear strength. Increasing the shear strength can also result in flexural failures, which are relatively more ductile in nature compared with shear failures [1-5].

Shear strengthening of reinforced concrete beams using fiber-reinforced polymers has been studied intensively in the last decade, even if shear for simple RC beams is not fully understood. The design equations for RC beams used in the main current design guidelines are based on semi-empirical approaches. The shear capacity of the beams is computed by adding the contribution of the concrete and the steel stirrups. In many cases, using the same procedure, the shear strength of the RC beams strengthened with composite materials is computed by adding the contribution of the FRP. While the empirical design equations for RC beams were validated with extensive experimental results, the equations for predicting the shear resistance of FRP strengthened RC beams are often compared with a small number of experiments and using test series. The near surface mounted reinforcement has been also used for shear strengthening [6] but the application is limited to side bonding technique. The development of theoretical models began using the assumption that FRP materials behave like internal stirrups. Later, studies were focused on developing new theories based on the real strain field distribution. Even if a large effort has been focused on theoretical studies, the shear strength models are almost as many as the research studies performed. Chaallal et al. (1998) proposed the