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Capacity Prediction of RC Beams Strengthened with FRP by Artificial Neural Networks Based on Genetic Algorithm

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ABSTRACT

In this paper, the ability of the artificial neural network which was trained based on a Genetic algorithm used to predict the shear capacity of the reinforced concrete beams strengthened with the side-bonded fiber reinforced polymer (FRP). A database of experimental data including 95 data which were published in literature was collected and used to the network. Seven inputs including the width of the beam, effective depth, FRP thickness, Young modulus, the tensile strength of FRP and also FRP ratio were used to predict the shear capacity of the reinforced concrete beams strengthened with the side-bonded fiber reinforced polymer. The best values of the weights and the biases were obtained by the Genetic algorithm. For increasing the ability of the model to predict the considered target, it was suggested that the predicted values considered smaller. The results indicated that the proposed neural network based on genetic algorithm was able to predict the shear capacity of the considered elements.

1. Introduction

Shear strength is one of the most powerful problems in the concrete elements [1]. In the recent years, the use of FRP material with the aim of rehabilitation or strengthening of reinforced

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concrete elements such as beams is a common tool. There are also much research about the suitable effects of this materials in RC structures. FRP is a fiber material which is based on carbon fibers (CFRP), glass fibers (GFRP) and also aramid fibers (AFRP). They are classified as the brittle material, but their sheets can be used for ductility goals.

Soft computing approaches such as Artificial neural networks (ANN) or fuzzy systems are very powerful tools which are used in the complex engineering problems and widely used in structural engineerings such as for earthquake [2,3] and some building material such as mortars [4]. ANN is a common approach which was widely used by researchers. Many researchers in several studies investigated the ability of this method for those problems with multi-variables. They are used for function approximation with high accuracy based on an observed dataset. In this paper, a database includes 96 pairs of data which were published in literature was collected to predict the shear capacity of RC beams strengthened with FRP sheets.

2. Experimental data

a neural network needs a database for training. For this purpose, the author used the 95 test results which were tested and published by researchers [5–23]. The details of the database are presented in Table. 1. In this table, input1, …, input7 are b (mm), h (mm), d (mm), FRP thickness(mm), Young modulus (GPa), tensile strength of FRP (MPa) and FRP ratio (calculated by Eq.1) respectively. The target is the shear capacity of the considered beams (KN). The Fig.1 showed the FRP parameters in a RC beam.

$$FRP\ ratio = {}^{W_f}\!\Big/_{S_f . sin_\beta} \qquad (1)$$

Table 1
Range of experimental date.

Type	Input1	Input2	Input3	Input4	Input5	Input6	Input7	Target
Mean	150	250	220	0	230	3290	1	50
Minimum	70	110	100	0	16	89	0	8
Maximum	380	500	420	3	390	4500	1	215
Standard deviation	58.11	109.71	96.84	0.74	73.83	1197.97	0.27	45.32

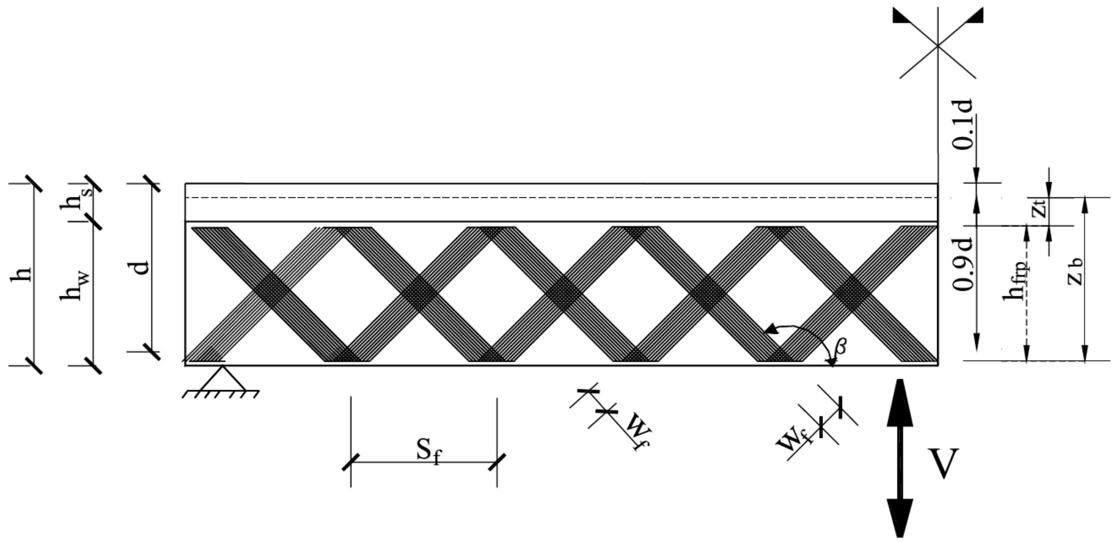

Fig. 1. FRP parameters in RC beams [24].

3. Artificial neural networks based GA

Artificial neural networks (ANN) is a very popular tool which is used for function approximation. It has some variables of neurons in several layers with biases. Each node (or neuron) has an unknown weight value. The biases of the ANN structure also are another unknown values. All of these parameters should be calculated by a learning algorithm. In this paper, all of the unknown parameters of the initial ANN extracted and optimized by the Genetic algorithm (GA) to find the best value for them. Also, in this paper; the author used to feed forward back propagation type of the neural networks in one middle layer. Tangent sigmoid and also Purlin were used as the transfer function of the middle layer and the output layer respectively. It was mentioned that the first layer has seven nodes as inputs. For the middle layer, eight nodes was considered. The results of the ANN was presented in the next section.

4. Prediction the shear capacity by ANN-GA

As mentioned in the previous section, in this paper 95 dataset were collected from experimental studies. Seven parameters used as inputs, while the target was shear capacity. 81 pairs of this database used for training the ANN while the remained data (14 pairs) used for testing the model. Figures 2 and 3 show the results for train and test phases.

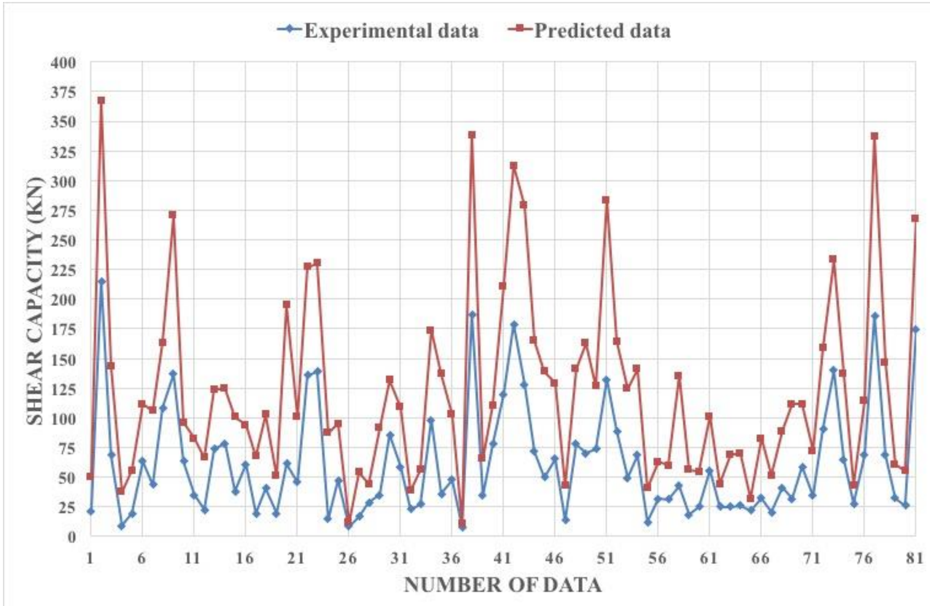

Fig. 2. The results for train data.

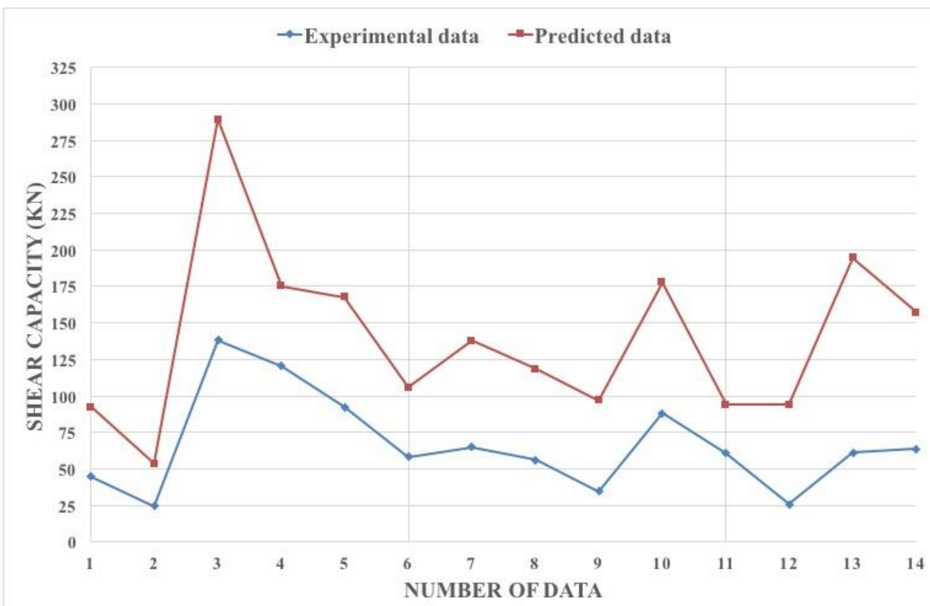

Fig. 3. The results for train data.

It was clear from the figures 2 and 3 that it was clear that the ANN-GA had suitable results and can be used for the shear capacity prediction.

5. Conclusions

An artificial neural network as a very useful tool was considered to predict the shear capacity of RC beams which were strengthened with FRP material. A network based on the Genetic algorithm including one middle layer and eight nodes with Tangent sigmoid transfer function, seven inputs and also Purelin function for the output layer was created and tested by the author. For increasing the ability of the model to predict the considered target, it was suggested that the predicted values considered smaller. However, the results of the proposed network showed that it could be used for the shear capacity of the RC beams strengthened with FRP.

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