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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 Genetic algorithm, used to prediction the shear capacity of the reinforced concrete beams strengthened with side-bonded fibre reinforced polymer (FRP). A database of experimental data including 95 data which were published in literatures was collected and used to the network. Seven inputs including width of the beam, effective depth, FRP thickness, Young modulus, tensile strength of FRP and also FRP ratio were used to predict the shear capacity of the reinforced concrete beams strengthened with side-bonded fibre reinforced polymer. The best values of the weights and the biases was 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 rehabilitations or strengthening of reinforced concrete elements such as beams is a common tool. There are also many research about the suitable effects of this materials in RC structures. FRP is a fibre material which is based on carbon fibres (CFRP), glass fibres (GFRP) and also aramid fibres (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 a very powerful tools which are used in the complex engineering problems and widely used in structural

engineering 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. The ability of this method for those problems with multi-variables were investigated by many researchers in several studies. They are used for function approximation with high accuracy based on an observed dataset. In this paper, a database includes 96 pairs data which were published in literatures was collected to predict the shear capacity of RC beams strengthen 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 is 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.

$$FRP\ ratio = {W_f}/{S_f.sin_\beta} \quad (1)$$

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

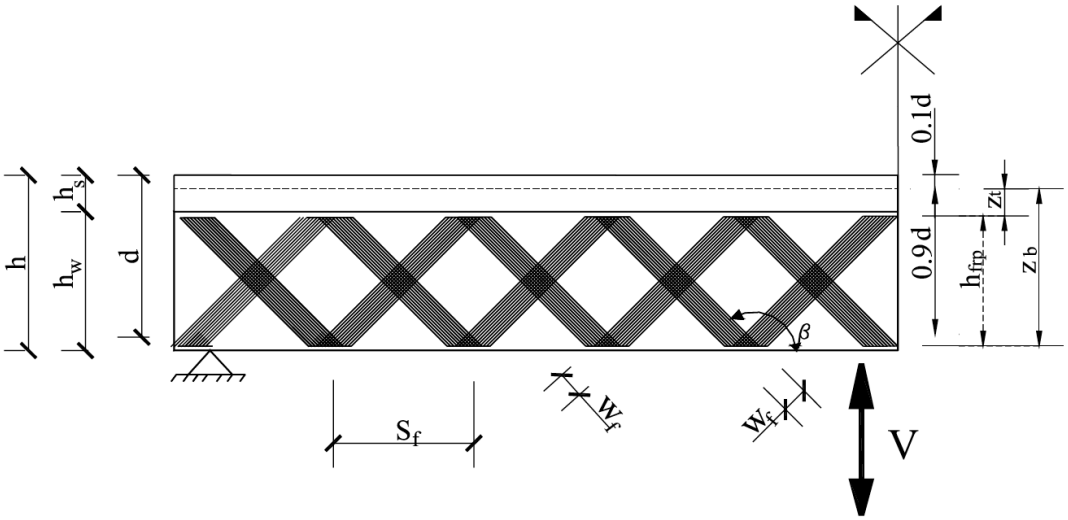

Figure 1.FRP parameters in RC beams [24].

3. Artificial Neural Networks based GA

Artificial neural networks (ANN) is a very popular tool which is used for function approximation. It has a number of variables as neurons in several layers with biases. Each node (or neuron) has an un-known weight value. The biases of the ANN structure also are another un-known values. All of these parameters should be calculated by a learning algorithm. In this paper all of the un-known parameters of the initial ANN extracted and optimized by Genetic algorithm (GA) to find the best value for them. Also, in this paper; the author used feed forward back propagation type of the neural networks in one middle layer. Tangent sigmoid and also Purlin were used as 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 data set collection 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 shows the results for train and test phases.

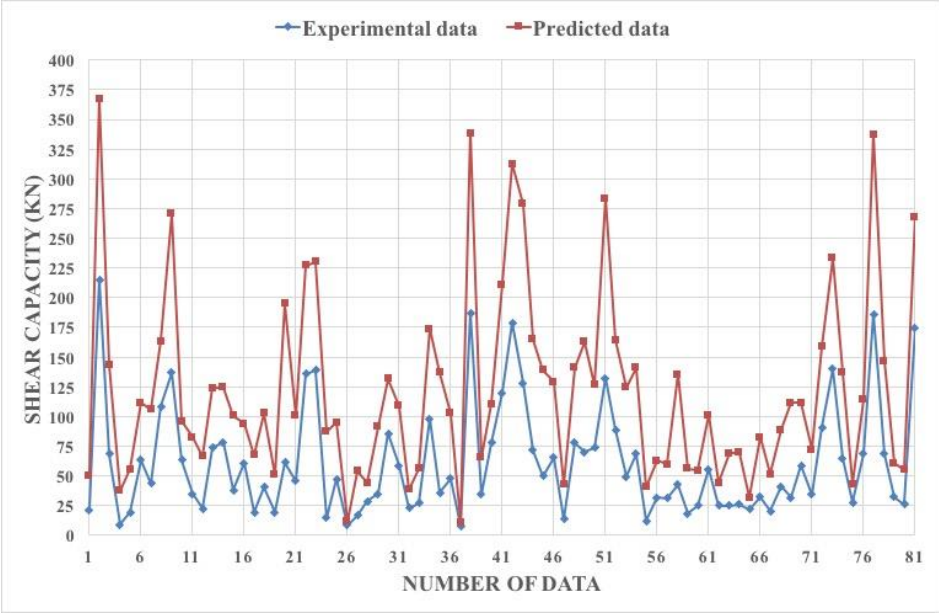

Figure 2. The results for train data.

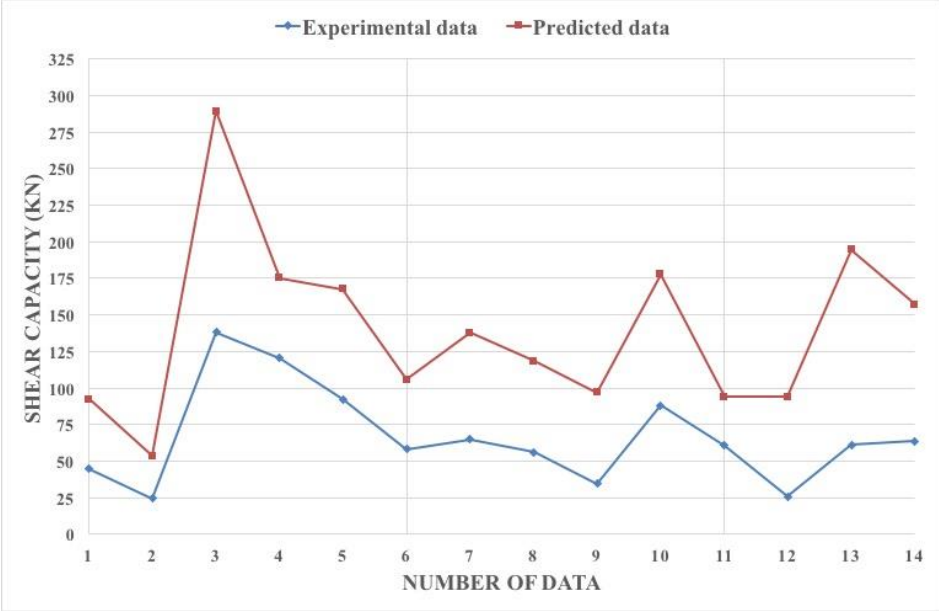

Figure 3. The results for train data.

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.

6. Conclusions

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 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 can be used for the shear capacity of the RC beams strengthened with FRP.

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