The Asian Review of Civil Engineering
ISSN: 2249-6203 (P) Vol.2 No.2, 2013, pp.23-29

DOI: https://doi.org/10.51983/tarce-2013.2.2.2193

Experimental Investigation on Strengthening of Latex Treated Coconut Fiber in Concrete

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(Received on 05 June 2013 and accepted on 10 July 2013)

Abstract - **Coconut fibers have the highest toughness amongst natural fibers. The experiment has carried out to investigate the behavioural study of coconut fibre in concrete member. The Coconut fibre is treated using natural latex before using in concrete, so that it is not be affected by moisture content presented in concrete. In this experimental study 28 days of the compressive strength is carried out using different coconut fibre length of 20mm, 25mm and 30mm respectively with a different percentage as 0.5%, 0.75% and 1%. The selected input variables include the length of the fiber, percentage of the fiber, and maximum load of the specimen. In this paper, Back-Propagation Neural Network (BPNN) model has been developed to predict the Compressive strength of Concrete members. A parametric study is carried out using BPNN to study the influence of each parameter affecting the characteristic compressive strength of the concrete. The results of this study indicate that BPNN provide good predictions which are better than those from other available methods. These models can serve as reliable and simple predictive tools for the prediction of compressive strength of the members.**

Keywords: **Coconut Fibre, Adhesion Concrete Composites, BPNN**

I. Introduction

The indiscriminate infrastructural growth is leading to rapid environmental degradation. Steel, cement, synthetic polymers and metal alloys used for construction activities are energy intensive as well as cause environmental pollution during their entire life cycle. We have enough natural resources and we must keep on researching on these natural resources. Development of natural fibre composite has started to begin recently. Among the various natural fibres sisal fibres, bamboo fibres, Coconut Fibres and jute fibres are of particular interest. These composites have high impact strength besides having moderate tensile and flexural properties and it can be regarded as an environment friendly material.

Coconut Fibre is extracted from the outer shell of coconut. Coconut fibre is available in many countries such as India, Indonesia, Srilanka, Malaysia, and Thailand. Total world coconut fibre production is 2,50,000 tonnes. In India, mainly the coastal region of Kerala State produces 60% of the total world supply of coconut fibre. Together India and Sri Lanka produce 90% of the 2, 50,000 tons of coconut produced every year.

There has been growing interest in recent year in utilizing coconut fibre as low cost building materials. Investigations are carried out on the use of coconut fibre in cement paste, mortar and concrete. Incorporation of the fibre improves the ductility, flexural and tensile strengths, fracture roughness and crack inhibiting properties of the matrix.

In this investigation the different size of short coconut fibre is treated with natural rubber latex. The effect of fibre content, different fibre length, physical and mechanical properties of these composite have been analysed.

II. Materials and Methods

Coconut is an inexpensive fiber among the natural fibers available in the world. Furthermore, it possesses the advantages of a lignocelluloses fiber. In the present study brown coconut fiber is used. The important properties of the natural rubber and fiber are listed in the Table I and Table II. In this experiment M_{25} grade concrete is used. Concrete was made with 43 Grade cement with river sand and 20mm and down coarse aggregate. The quantity of materials used as per mix design as follows. Cement = 383 Kg/m^3, fine aggregate=571Kg/m^3, coarse aggregate = 1241Kg/m^3, Water = 191.6 Kg/m^3, water/cement ratio =0.45

Table I Typical Properties of Natural Rubber

Dirt content (% by mass)	0.03
Volatile mass (% by mass)	0.50
Initial Plasticity number	38
Plasticity retention index	78

Table II Typical Properties of Coconut Fibre

Colour	Brown
Fibre length, mm	10-200
Fibre diameter, mm	0.2-0.35
Bulk Density, kg/m^3	140-150
Ultimate tensile strength, N/mm^2	80-120
Modulus of elasticity, N/mm^2	18-25
Water absorption, %	30-40

A.Preparation of Composites

Coir pith and other undesirable materials are separated from the coconut fibre. It is then chopped to about different length of 20mm, 25mm and 30mm and subjected to chemical treatments.

Fig.1 Coconut Fibre

Coconut fibres are soaked in sodium hydroxide solution for 48 hours. Fibre were taken out, repeatedly washed with water and dried in the air. Latex compound is prepared by mixing 70% of natural rubber latex and 20% of sodium hydroxide solution and 10% of water. The latex compound and the resign solution were agitated to achieve homogenization. Then the coconut fibre is dipped in the mixture about 30 minutes and dried.

B.Casting of Specimen and Testing

Cubes that have a size of 150mm x150mm x150 mm are casted with M_{25} grade concrete as a control specimen. Then different percentage of coconut fibre is added to the concrete. First 0.5% of 20mm coconut fibre is added with concrete and specimens are casted. Then 0.75% and finally 1% of 20mm coconut is added with concrete for making specimens. Also the same procedure is repeated for the 25mm and 30mm fibres. After 24 hours the specimens are removed from the mould. For curing the specimens were kept in the water.

Fig.2 Testing Setup

After curing Compressive Strength of Concrete Specimens is tested in the $7^{th,}$ 14^{th} and 28^{th} days are determined using compression testing machine.

III. Neural Network Model

A neural network is a nonlinear system consisting of a large number of highly interconnected processing units, nodes or artificial neurons. Each input signal is multiplied by the associated weight value and summed at a neuron. The result is put through an activation function to generate a level of activity for the neuron. This activity is the output of the neuron. When the weight value at each link and the connection pattern are determined, the neural network is trained. This process is accomplished by learning from the training set and by applying for a certain learning rule. The trained network can be used to generalize for those inputs that are not included in the training set.

Compared to conventional digital computing techniques, neural networks are advantageous because of their special features, such as the massively parallel processing, distributed storing of information, low sensitivity to error, their very robust operation after training, generalization and adaptability to new information. Neural networks (NNs) are a powerful computational tool able to learn from a set of examples with known inputs and outputs. An artificial neuron is composed of five main parts inputs, weights, sum function, activation function and outputs. Inputs are information that enters the cell from other cells from the external world. Weights are values that express the effect of an input set or another process element in the previous layer on this process element. Sum function is a function that calculates the effect of inputs and weights totally on this process element.

This function calculates the net input that comes to a cell. The information is propagated through the neural network layer by layer, always in the same direction. Besides the input and output layers, there can be other intermediate layers of neurons, which are usually called hidden layers. The inputs to the j_{th} node are represented as an input factor, a, with component a_i (i = 1to n), and the output by b_j. The values w_{ij}, w_{2j} and w_{nj} are weight factors associated with each input to the node. This is something like the varying synaptic strengths of biological neurons. Weights are adaptive coefficients within the network that determine the intensity of the input signal. Every input ($a_1, a_2, \ldots, a_n$) is multiplied by its corresponding weight factor ($w_{1j}, w_{2j}, \ldots, w_{nj}$), and the node uses this weighted input ($w_{1j}a_1$, w_{2j} $a_{2,\ldots,}$ w_{nj} a_n) to perform further calculations. If the weight factor is positive, then (w_{ij} a_i) tends to excite the node. If the weight factor is negative, then (w_{ij} a_i) inhibits the node. In the initial setup of a neural network, weight factors may be chosen according to a specified statistical distribution.

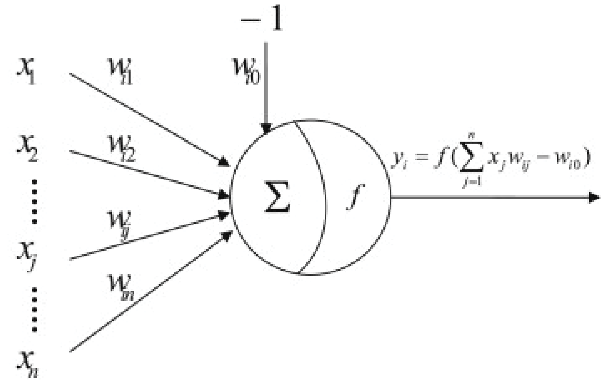

Fig.3 Single Neuron

Then these Weight factors are adjusted in the development of the network or ``learning'' process. The other input to the node is the node's internal threshold, $T_j$. This is a randomly chosen value that governs the ``activation'' or total input of the node through the following equation

$$\textit{Total Activation} = x_i = \sum_{i=1}^{n} (w_j) \times (a_i - T_j)$$

The total activation depends on the magnitude of the internal threshold T_j. If T_j is large or positive, the node has a high internal threshold, thus inhibiting node-firing. If T_j is zero or negative, the node has a low internal threshold, which excites node-firing. If no internal threshold is specified, a zero value is assumed.

This activity is then modified by transfer function and becomes the final output $b_j = f(x_i) = f(\sum_{i=1}^{n} (w_j) \times (a_i - T_j))$ of the neuron. This signal is then propagated to the neurons (process elements) of the next layer. Fig. 3 depicts this process. In the developed BPNN, there is an input layer, where input data are presented to the network and an output layer, with one neuron representing the compressive strength of the Specimen. Two hidden layers as intermediate layers are also included. The trials showed that the two-hidden layer network performs significantly better than the one-hidden layer network. The network with two hidden layers and eight nodes in the first hidden layer and four nodes in the second hidden layer have the optimal configuration with the minimum mean square error (MSE). Fig. 4 shows the structure of the proposed BPNN model. In this study three input variables are length of the fiber, Percentage of the fiber, and maximum load of the specimen. The back-propagation neural network is trained by feeding a set of mapping data with input and target variables. The main objective of ``training'' the neural network is to assign the connection weights by reducing the errors between the predicted and actual target values to a satisfactory level. This process is carried out through the minimization of the defined error function by updating the connection weights. Also, the number of hidden layers, number of hidden nodes, transfer functions, and normalization of data are chosen to get the best performance of the model. After the errors are minimized, the model with all the parameters including the connection weights is tested with a separate set of ``testing'' data that is not used in the training phase. At the end of the training, the neural network represents a model that should be able to predict the target value given the input pattern.

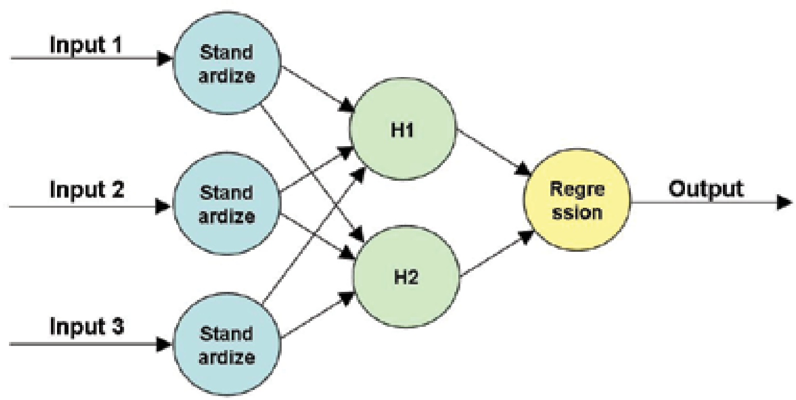

Fig.4 Structure of the proposed BPNN model

IV. Results and Discussion

The result shows that the addition of latex treated coconut fibre increase the compressive strength up to certain level. Addition of coconut fibre also arrest the micro cracks present in the concrete. Strength properties like compressive strength are shown in the following graph.

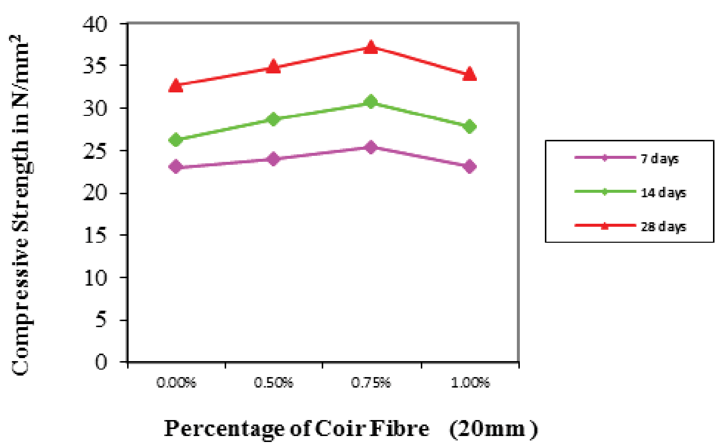

Fig. 5 Compressive Strength of Cubes using 20mm coconut fibre

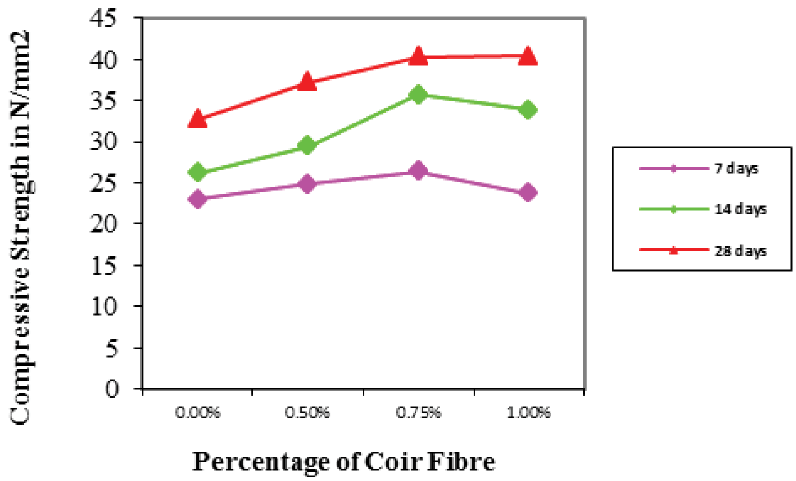

Fig. 6 Compressive Strength of Cubes using 25mm coconut fibre

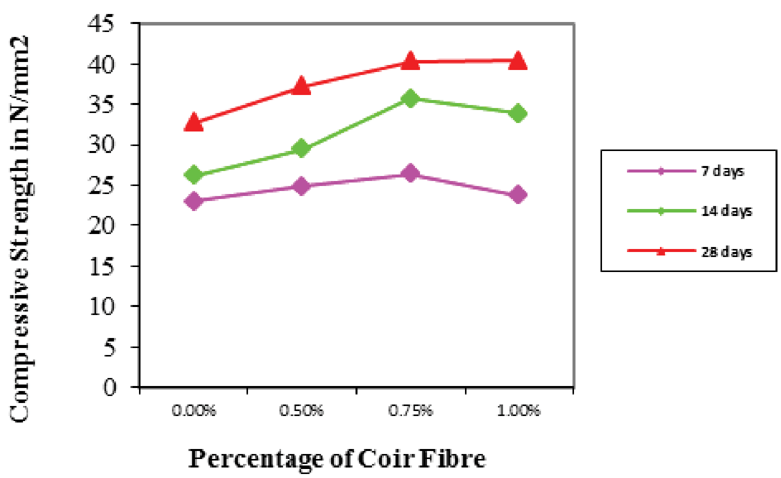

Fig. 7 Compressive Strength of Cubes using 30 mm Coconut fibre

The above graphs show that the different percentage of coconut fibre with different length gives different strength value. Initially the strength gradually increased up to 0.75% of coconut fibre then the strength is decreased. The maximum compressive strength is achieved using 25mm length fibre with 0.75% addition of coconut fibre.

The network has been trained continually through the updating weights until the error goal is $9.4x10^{-6}$ Fig. 8 shows the performance for training and generalization (testing) sets are simulated using the resilient back-propagation training algorithm, and the network was trained for 2000 epoch to check if the performance (MSE) for either training or testing sets might diverge.

The network performance with the resilient back-propagation training algorithm has been tested for training and generalizing patterns, as shown in Figs. 9 and 10 A good agreements has been noted in the predicting values compared with the actual (targets) values.

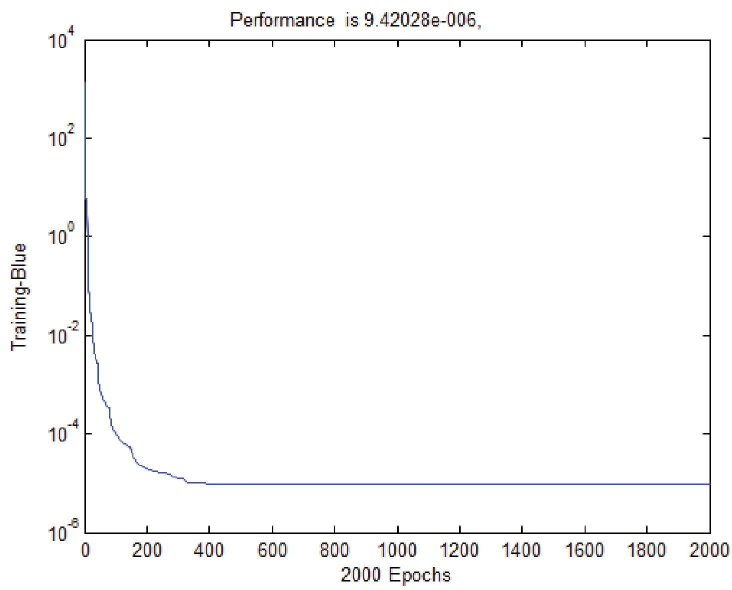

Fig. 8 Convergence of the BPNN for training and testing sets

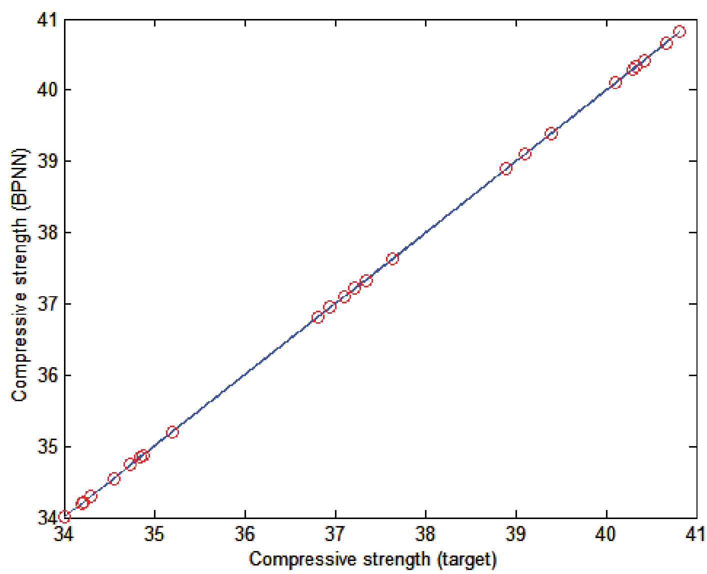

Fig.9 Comparison between BPNN results and target results for training patterns sets

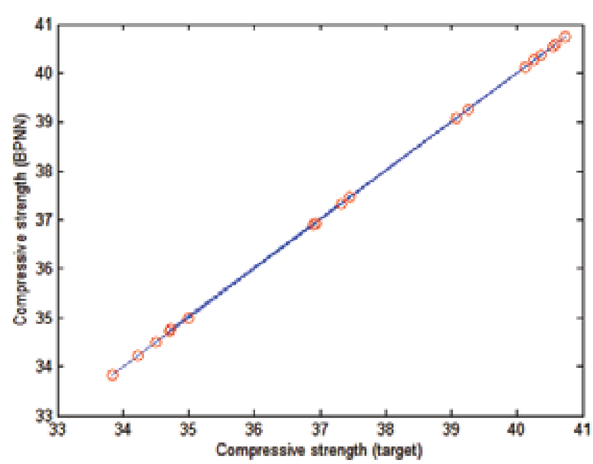

Fig.10 Comparison between BPNN results and target results for testing patterns sets

V. Conclusion

Using coconut fibre in civil construction reduces environmental pollution factors and may also bring several improvements in concrete characteristics. Coconut fibre used in cement improves the resistance of concrete from sulphate attack. Compressive strength is also improved up to certain percentage. Addition of coconut fibre also arrests the micro cracks present in the concrete.

In this study the back-propagation neural network (BPNN) model developed to predict the compressive strength of concrete. Three variables are selected as input to BPNN model.

In the developed BPNN, the predictions are made and they are also compared With actual values. From the comparison they are found to agree much better with the actual measured values.

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